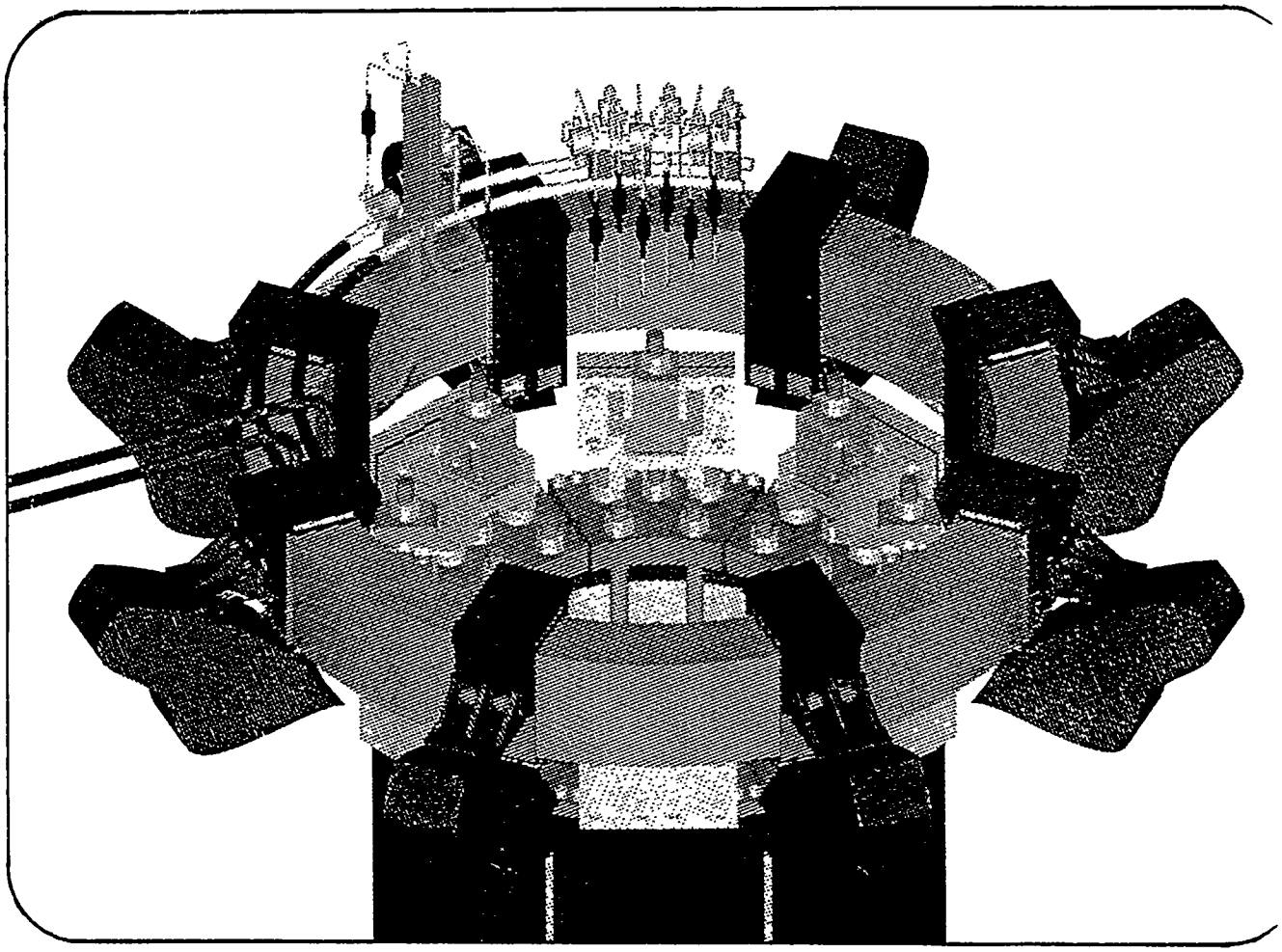
Tokamak Physics Experiment

TPX MAGNET SYSTEM

Poloidal Field Magnet Preliminary Design and Manufacturing R&D

CONTRACTOR PRELIMINARY DESIGN REVIEW
Volume 3 – Design and Analysis



DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

MASTER

Westinghouse ● Northrop Grumman Corp. ● Everson Electric

UCRL-CR--121739-Pt.3

Electromagnetic Analysis of TPX Poloidal Field Coils

Mark Krefta
STC Advanced Electromagnetic Systems Department

June 30, 1995

TPX 14-950630-WEC-MKrefta-01

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

APPROVED:

P. A. Sanger
Westinghouse TPX Chief Scientist

APPROVED:

D. R. Potter
Westinghouse TPX Engineering Manager

Westinghouse Electric Corporation
Electronic Systems Group

401 East Hendy Avenue, Sunnyvale, California 94088-3499

4.2.4 Force variations during worst case loading due to interactions with the TF coils 4-40

5. IMPACT OF COIL WINDING CONFIGURATIONS ON MAGNETIC FIELD ERRORS 5-1

5.1 MAFCO MODELS OF A CS CONDUCTOR PACK 5-1
5.2 SPIRAL VS CONSTANT RADIUS WINDING CONFIGURATIONS 5-7
5.2.1 Effect of radial transition interval on z-directed field errors 5-7
5.3 CO-LOCATED VS UNIFORMLY ANGULAR SPACED LAYER-TO-LAYER JOGGLES 5-11
5.3.1 Compensation of the vertical current with a helical return 5-13
5.4 ERROR FIELDS FROM GROSS COIL HORIZONTAL MISALIGNMENT 5-13
5.5 FIELD ERROR EXPRESSED AS FOURIER COMPONENTS ON "DEE-SHAPED" SURFACE 5-15
5.5.1 Calculation of the complex resonant, helical field component 5-15
5.5.2 Results for the PF5U coil designs 5-18
5.5.3 Discussion and recommendations 5-23

6. SUMMARY AND CONCLUSIONS 6-1

6.1 THE GLOBAL ELECTROMAGNETIC MODEL 6-1
6.2 ALGEBRAIC FORCE EXPRESSIONS 6-1
6.3 WORST CASE ELECTROMAGNETIC LOADING 6-2
6.4 FIELD ERRORS DUE TO HOOP COIL DESIGN 6-3

7. REFERENCES 7-1

APPENDIX A -ANSYS 3-D COMMAND FILE A-1

APPENDIX B - ANSYS 3-D FORCE CALCULATION ALGORITHM B-1

APPENDIX C - TABLES OF EM FORCES ACTING ON PF COILS FOR EQUILIBRIA #3 ..... C-1

APPENDIX D - ANSYS AXISYMMETRIC COMMAND FILE D-1

APPENDIX E - WESTINGHOUSE HOTMAP AXISYMMETRIC COMMAND FILE E-1

APPENDIX F - WESTINGHOUSE MAFCO 3-D INPUT FILE F-1

APPENDIX G - LISTING OF FORTRAN PROGRAM PFRC.F G-1

APPENDIX H - ANSYS AXISYMMETRIC COMMAND FILE: REFINED PF3U, NORMAL OPERATING CASE H-1

CONTENTS

Page

LIST OF FIGURES vi

LIST OF TABLES x

ABSTRACT xiii

1. INTRODUCTION 1-1

2. ANSYS THREE-DIMENSIONAL GLOBAL EM MODEL 2-1

2.1 MODEL DESCRIPTION 2-1
2.2 RESULTS FOR START OF FLATTOP - HC SCENARIO 2-5
2.2.1 Peak Magnetic Fields 2-5
2.2.2 Lorentz forces acting on CS coils 2-8
2.2.3 Lorentz Forces Acting on PF5, PF6 and PF7 2-10
2.2.4 Effects of the TF Interconnect on the PF Conductor Forces 2-12
2.2.5 Comparisons with other force calculations 2-14
2.2.6 ANSYS Calculational Errors 2-15

3. GENERAL ALGEBRAIC EXPRESSIONS FOR FORCES ACTING ON THE PF COILS 3-1

3.1 EXPRESSIONS FOR BODY FORCES 3-1
3.1.1 Verification via the twenty-three equilibria cases 3-6
3.1.2 HC scenario data 3-7
3.2 EXPRESSIONS FOR INTERNAL COMPRESSIVE FORCES 3-7
3.2.1 Internal force coefficients 3-10
3.2.2 Internal forces for 23 equilibria 3-14
3.3 FORCE VARIATIONS DUE TO TF COIL INTERACTION 3-16
3.4 FORCE VARIATIONS DUE TO PF COIL MISALIGNMENTS 3-19
3.4.1 Forces resulting from vertical and horizontal coil misalignments 3-19

4. SUMMARY OF WORST CASE EM LOADING ON PF COILS 4-1

4.1 MAXIMUM RADIAL AND VERTICAL LOADS 4-1
4.1.1 Body EM Loads on the Central Solenoid 4-1
4.1.2 Body EM Loads on PF5 4-6
4.1.3 Body EM loads on PF6 and PF7 4-8
4.2 SPATIAL VARIATION OF LOADS 4-9
4.2.1 Refined Model of PF3U for Analysis of Maximum Normal-Operating Radial EM Loading 4-9
4.2.2 Refined model of PF3U for analysis of maximum fault radial EM loading 4-24
4.2.3 Refined model of PF1L for analysis of maximum normal -operating vertical compressive EM loading 4-30

APPENDIX I - ANSYS AXISYMMETRIC COMMAND FILE: REFINED PF3U, FAULT CASE I-1

APPENDIX J - ANSYS AXISYMMETRIC COMMAND FILE: REFINED PF1L, NORMAL-OPERATING CASE J-1

APPENDIX K - WECAN/PLUS COMMAND FILES USED FOR ESTABLISHING THREE DETAILED MAFCO MODELS OF 60 TURN CS COIL K-1

APPENDIX L - LOCATION OF POINTS ON THE "DEE-SHAPED" SURFACE L-1

APPENDIX M - TABLE OF COMPLEX HELICAL COEFFICIENTS FOR FOUR DIFFERENT PF3 DESIGNS M-1

LIST OF FIGURES

Page

FIGURE 2.1 — PF SYSTEM AMPERE-TURNS VS TIME FOR HC SCENARIO. 2-3
FIGURE 2.2 — THREE-DIMENSIONAL VIEW ILLUSTRATING CURRENT SOURCES, GLOBAL COORDINATE SYSTEM AND CURRENT FLOW CONVENTIONS IN THE TPX GLOBAL EM MODEL 2-4
FIGURE 2.3 — CONTOURS OF CONSTANT MAGNETIC FIELD THROUGHOUT A TF COIL FOR EQUILIBRIA #3 (T=9 S OF THE HC SCENARIO). 2-8
FIGURE 2.4 — CONTOURS OF CONSTANT MAGNETIC FIELD THROUGHOUT PF7L AT T=9 S OF THE HC SCENARIO 2-9
FIGURE 2.5 — RADIAL AND COMPRESSIVE FORCES ACTING ON PF1-4 UPPER COILS PLOTTED AS A FUNCTION OF ANGULAR LOCATION. THE CASE OF FULL TF EXCITATION IS SHOWN. 2-10
FIGURE 2.6 — RADIAL AND AXIAL FORCES ACTING ON PF5 UPPER AND LOWER COILS PLOTTED AS A FUNCTION OF ANGULAR LOCATION. THE CASES OF FULL TF EXCITATION AND ZERO TF EXCITATION ARE SHOWN. 2-11
FIGURE 2.7 — RADIAL AND AXIAL FORCES ACTING ON PF6 UPPER AND LOWER COILS PLOTTED AS A FUNCTION OF ANGULAR LOCATION. THE CASES OF FULL TF EXCITATION AND ZERO TF EXCITATION ARE SHOWN. 2-12
FIGURE 2.8 — RADIAL AND AXIAL FORCES ACTING ON PF7 UPPER COIL PLOTTED AS A FUNCTION OF ANGULAR LOCATION. THE CASE OF FULL TF EXCITATION IS SHOWN 2-13
FIGURE 2.9 — CONTOURS OF CONSTANT MAGNETIC FIELD THROUGHOUT THE TOP HALF OF THE PF SYSTEM CALCULATED USING ANSYS STIF53 AXISYMMETRIC FINITE ELEMENTS 2-17
FIGURE 2.10 — BLOWUP OF CONTOURS OF CONSTANT MAGNETIC FIELD MAGNITUDE IN THE CENTRAL SOLENOID REGION CALCULATED USING ANSYS STIF53 AXISYMMETRIC FINITE ELEMENTS 2-18
FIGURE 2.11 — BAR GRAPH COMPARING VALUE OF PEAK MAGNETIC FIELD OBTAINED IN SEVEN PF COILS CALCULATED USING FIVE DIFFERENT SOLUTION METHODS. 2-19
FIGURE 2.12 — PLOT OF VERTICAL COMPONENT OF MAGNETIC FIELD OBTAINED USING ANSYS 3-D AND WESTINGHOUSE MAFCO PROGRAMS FOR ANALYSIS OF PF6. THE PLOT ILLUSTRATES THE FIELD ERROR AT THE OUTER SURFACE OF PF6. 2-20
FIGURE 2.13 — BAR GRAPH COMPARING CALCULATED VALUE OF VERTICAL ELECTROMAGNETIC LORENTZ FORCE ACTING ON SEVEN PF CONDUCTORS CALCULATED USING FIVE DIFFERENT MODELS. 2-21
FIGURE 2.14 — BAR GRAPH COMPARING CALCULATED VALUE OF ELECTROMAGNETIC HOOP LOADING. 2-22
FIGURE 3.1 — RADIAL ELECTROMAGNETIC FORCES ACTING ON PF COILS 1-7 DURING HC SCENARIO. 3-9
FIGURE 3.2 — VERTICAL ELECTROMAGNETIC FORCES ACTING ON PF COILS 1-7 DURING HC SCENARIO. 3-9
FIGURE 3.3 — FLUX LINES FROM ENERGIZATION OF COIL PF2U USED FOR DETERMINING INTERNAL FORCE COEFFICIENTS ASSOCIATED WITH PF2. 3-11
FIGURE 3.4 — RADIAL AND VERTICAL LORENTZ FORCE DISTRIBUTIONS INTERNAL TO PF1 FOR 1 MAT EXCITATION. 3-12
FIGURE 3.5 — RADIAL AND VERTICAL LORENTZ FORCE DISTRIBUTIONS INTERNAL TO PF2 FOR 1 MAT EXCITATION. 3-12
FIGURE 3.6 — RADIAL AND VERTICAL LORENTZ FORCE DISTRIBUTIONS INTERNAL TO PF3 FOR 1 MAT EXCITATION. 3-12
FIGURE 3.7 — RADIAL AND VERTICAL LORENTZ FORCE DISTRIBUTIONS INTERNAL TO PF5 FOR 1 MAT EXCITATION. 3-13
FIGURE 3.8 — RADIAL AND VERTICAL LORENTZ FORCE DISTRIBUTION INTERNAL TO PF6 FOR 1 MAT EXCITATION. 3-13
FIGURE 3.9 — RADIAL AND VERTICAL LORENTZ FORCE DISTRIBUTION INTERNAL TO PF7 FOR 1 MAT EXCITATION. 3-13
FIGURE 4.1 — MAXIMUM RADIAL AND VERTICAL COMPRESSIVE FORCES ACTING ON THE CS. THE RADIAL FORCES ARE OF ELECTROMAGNETIC ORIGIN. THE VERTICAL COMPRESSIVE FORCES INCLUDE PRESTRESS AND COOLDOWN EFFECTS IN ADDITION TO ELECTROMAGNETIC FORCES. 4-2
FIGURE 4.2 — MAXIMUM RADIAL AND VERTICAL LORENTZ FORCES ACTING ON COIL PF5 THROUGHOUT THE HC SCENARIO. THE STEADY LEVELS SUPERIMPOSED CORRESPOND TO EITHER AN INSTANT OF TIME DURING A DISRUPTION OR FAULT OR A STEADY-STATE OPERATING LEVEL IN THE EXTENDED Q-LI-β OPERATING SPACE 4-7

FIGURE 4.3 — MAXIMUM RADIAL AND VERTICAL LORENTZ FORCES ACTING ON COIL PF6 THROUGHOUT THE HC SCENARIO. THE STEADY LEVELS SUPERIMPOSED CORRESPOND TO EITHER AN INSTANT OF TIME DURING A DISIRUPTION OR FAULT OR A STEADY-STATE OPERATING LEVEL IN THE EXTENDED Q-LII-B OPERATING SPACE... 4-10
FIGURE 4.4 — MAXIMUM RADIAL AND VERTICAL LORENZ FORCES CTING ON COIL OF7 THROUGHOUT THE HC SCENARIO. THE STEADY LEVELS SUPERIMPOSED CORRESPOND TO EITHER AN INSTANT OF TIME DURING A DISRUPTION OR FAULT OR A STEADY-STATE OPERATING LEVEL IN THE EXTENDED Q-LI-B OPERATING SPACE..... 4-11
FIGURE 4.5 — CONTOURS OF MAGNETIC FLUX FOR EQUILIBRIA #1 (T=5 S OF HC SCENARIO) OBTAINED USING AN AXISYMMETRIC ANSYS MODEL OF THE PF CONDUCTORS. THE 60 INDIVIDUAL TURNS IN CONDUCTOR PF3U HAS BEEN MODELED IN DETAIL..... 4-14
FIGURE 4.6 — BLOWUP OF MAGNETIC FLUX LINES THROUGHOUT COIL PACK PF3 FOR EQUILIBRIA #1 (T=5 S OF HC SCENARIO). THE EFFECTS OF THE INCOLOY MAGNETIZATION HAVE BEEN NEGLECTED IN THE CASE SHOWN..... 4-14
FIGURE 4.7 — CONTOURS OF CONSTANT MAGNETIC FIELD MANITUDE THROUGHOUT COIL PACK PF3 FOR EQUILOIBRIA #1 (T=5 S OF HC SCENARIO)..... 4-15
FIGURE 4.8 — CONTOURS OF CONSTANT MAGNETIC FIELD THROUGHOUT LOWER INNERMOST TURN OF PF3 CONDUCTOR PACK FOR THE CASES OF INCLUDING AND IGNORING CONDUIT MAGNETIZATION..... 4-17
FIGURE 4.9 — CONTOURS OF CONSTANT MAGNETIC FIELD THROUGHOUT FOURTH LAYER, INNERMOST TURN OF PF3 CONDUCTOR PACK FOR THE CASES OF INCLUDING AND IGNORING CONDUIT MAGNETIZATION..... 4-18
FIGURE 4.10 — MAXWELL SURFACE STRESS FORCE DISTRIBUTION FOR EQUILIBRIA #1 (T=5 S OF HC SCENARIO). THE PRESSURE SURFACE WAS CHOSEN TO SURROUND THE CONDUIT FOR EACH TURN OF PF3. THE LOWER LEFT (TURN #1) IS SHOWN IN THIS FIGURE..... 4-19
FIGURE 4.11 — LORENTZ FORCE ACTING ON EACH OF THE PF3 TURNS FOR EQUILIBRIA #1. THE LENGTH OF THE VECTORS ARE PROPORTIONAL TO THE FORCE MAGNITUDE ACTING ON THE FINITE ELEMENT CONTAINING THE CURRENT. THE CONDUIT MAGNETIZATION IS NOT INCLUDED IN THIS RUN..... 4-19
FIGURE 4.12 — PORTION OF ANSYS FINITE ELEMENT MESH ILLUSTRATING THE REFINED PF3U MESH AND STITCHING WITH EXTERIOR MESH..... 4-26
FIGURE 4.13 — MAGNETIC FLUX LINES 2.7065 S AFTER SHORTING COIL PF3U. THIS TIME INSTANT CORRESPONDS TO THE HIGHEST RADIAL FORCE ON ANY OF THE PF COILS..... 4-27
FIGURE 4.14 — BLOWUP OF THE MAGNETIC FLUX LINES IN THE VICINITY OF CONDUCTOR PACK PF3U..... 4-28
FIGURE 4.15 — CONTOURS OF CONSTANT MAGNETIC FLUX DENSITY THROUGHOUT COIL PF3U 2.7 S AFTER A TERMINAL SHORT CIRCUIT. THE INITIAL CONDITIONS (PRE-FAULT STATE) WERE THOSE OF EQUILIBRIA #1 (I.E., PREBIAS)..... 4-29
FIGURE 4.16 — VECTOR LORENTZ FORCES ACTING ON INDIVIDUAL TURNS IN CONDUCTOR PACK PF3U DURING SUDDEN SHORT CIRCUIT FAULT..... 4-30
FIGURE 4.17 — PORTION OF THE ANSYS FINITE ELEMENT MESH ILLUSTRATING THE REFINED MESH IN PF1L AND STITCHING WITH EXTERIOR MESH..... 4-33
FIGURE 4.18 — MAGNETIC FLUX LINES FOR EQUILIBRIA #16. THIS LOAD CASE CORRESPONDS TO THE HIGHEST VERTICAL COMPRESSIVE FORCE ON ANY OF THE PF COILS..... 4-35
FIGURE 4.19 — BLOWUP OF THE MAGNETIC FLUX LINES IN THE VICINITY OF CONDUCTOR PACK PF1L..... 4-36
FIGURE 4.20 — VECTOR LORENTZ FORCES ACTING ON INDIVIDUAL TURNS IN CONDUCTOR PACK PF1L FOR EQUILIBRIA #16..... 4-37
FIGURE 4.21 — CONTOURS OF CONSTANT MAGNETIC FLUX DENSITY THROUGHOUT COIL PF1L FOR EQUILIBRIA #16. NINE FIELD CONTOURS ARE SHOWN UNIFORMLY SPACED BY 0.597 T..... 4-39
FIGURE 5.1 — ORTHOGONAL VIEWS ILLUSTRATING TWO LAYER SPIRAL WINDING CONFIGURATION WITH 6 TURNS PER LAYER..... 5-3
FIGURE 5.2 — ORTHOGONAL VIEWS ILLUSTRATING 10 LAYER, CONSTANT RADIUS/JOG WINDING CONFIGURATION WITH 15 DEGREE CROSSOVER INTERVAL AND 36 DEGREE RETARDED CLOCKING..... 5-5
FIGURE 5.3 — HELICAL RETURN PATH USED TO COMPENSATE FOR THE LAYER-TO-LAYER RAMPS..... 5-6
FIGURE 5.4 — COMPARISON BETWEEN RADIAL FIELD PERTURBATIONS FOR 60 TURN SPIRAL AND CONSTANT RADIUS COIL CONFIGURATIONS. THE RADIAL TRANSITION INTERVAL FOR THE CONSTANT RADIUS/JOG CONFIGURATION IS DEGREES..... 5-8

Page

FIGURE 5.5 — COMPARISON BETWEEN ANGULAR FIELD PERTURBATIONS FOR 60 TURN SPIRAL AND CONSTANT RADIUS COIL CONFIGURATIONS. THE RADIAL TRANSITION INTERVAL FOR THE CONSTANT RADIUS/JOG CONFIGURATION IS 30 DEGREES 5-8
FIGURE 5.6 — COMPARISON BETWEEN VERTICAL FIELD PERTURBATIONS FOR 60 TURN SPIRAL AND CONSTANT RADIUS COIL CONFIGURATIONS. THE RADIAL TRANSITION INTERVAL FOR THE CONSTANT RADIUS/JOG CONFIGURATION IS 30 DEGREES 5-9
FIGURE 5.7 — MAGNETIC FIELD ERRORS FOR A CONSTANT RADIUS/JOG CONFIGURATION WITH 15 DEGREE RADIAL TRANSITION INTERVAL AND VERTICAL RETURN LEAD. 5-9
FIGURE 5.8 — MAGNETIC FIELD ERRORS FOR A CO-LOCATED 60 TURN SPIRAL CONFIGURATION WITH A VERTICAL RETURN LEAD. 5-10
FIGURE 5.9 — MAGNETIC FIELD ERRORS FOR A CONSTANT RADIUS/JOG CONFIGURATION WITH 10 DEGREE RADIAL TRANSITION INTERVAL AND VERTICAL RETURN LEAD. 5-10
FIGURE 5.10 — MAGNETIC FIELD ERRORS FOR A CONSTANT RADIUS/JOG CONFIGURATION WITH 36 DEGREE CLOCKING AND 15 DEGREE RADIAL TRANSITIONS. 5-12
FIGURE 5.11 — BLOWUP OF VERTICAL MAGNETIC FIELD ERROR FOR A CONSTANT RADIUS/JOG CONFIGURATION WITH 36 DEGREE CLOCKING AND 15 DEGREE RADIAL TRANSITIONS. 5-12
FIGURE 5.12 — MAGNETIC FIELD ERRORS FOR A CONSTANT RADIUS/JOG CONFIGURATION WITH 36 DEGREE CLOCKING AND HELICAL RETURN COMPENSATION 5-14
FIGURE 5.13 — VERTICAL MAGNETIC FIELD ERROR FOR A PERFECT CIRCULAR COIL OFFSET 10 MM IN THE X-DIRECTION. 5-14
FIGURE 5.14 — LOCATION OF POINTS EQUALLY SPACED IN "LITTLE THETA" ON THE PLASMA SURFACE 5-17
FIGURE 5.15 — DEVELOPED PLOT OF THE NON-AXISYMMETRIC MAGNETIC FIELD ON THE "DEE-SHAPED" PLASMA SURFACE FOR COIL PF5U WITH A CO-LOCATED SPIRAL TYPE WINDING AND A VERTICAL RETURN LEAD. 5-20
FIGURE 5.16 — DEVELOPED PLOT OF THE NON-AXISYMMETRIC MAGNETIC FIELD ON THE "DEE-SHAPED" PLASMA SURFACE FOR COIL PF5U WITH A CO-LOCATED CONSTANT RADIUS/JOG TYPE WINDING WITH 10 DEGREE RADIAL TRANSITIONS AND A VERTICAL RETURN LEAD. 5-21
FIGURE 5.17 — DEVELOPED PLOT OF THE NON-AXISYMMETRIC MAGNETIC FIELD ON THE "DEE-SHAPED" PLASMA SURFACE FOR COIL PF5U WITH A UNIFORMLY CLOCKED (I.E., -36 DEGREE) CONSTANT RADIUS/JOG TYPE WINDING AND A VERTICAL RETURN LEAD. 5-21
FIGURE 5.18 — DEVELOPED PLOT OF THE NON-AXISYMMETRIC MAGNETIC FIELD ON THE "DEE-SHAPED" PLASMA SURFACE FOR COIL PF5U WITH A UNIFORMLY CLOCKED (I.E., -36 DEGREE) CONSTANT RADIUS/JOG TYPE WINDING AND A COMPENSATING HELICAL RETURN LEAD. 5-22

LIST OF TABLES

Page

TABLE 2.1 — COIL LOCATIONS, DIMENSIONS AND CURRENT LOADINGS AT T=9 S OF HC SCENARIO 2-2
TABLE 2.2 — TF COIL GEOMETRY PARAMETERS USED IN ANSYS MODEL. 2-3
TABLE 2.3 — PEAK MAGNETIC FIELD FOR EACH OF THE PF COILS AT T=9 S OF THE HC SCENARIO 2-6
TABLE 2.4 — COMPARISON OF CALCULATIONS FOR PEAK FIELD IN THE TF COILS 2-6
TABLE 2.5 — COMPARISON OF CALCULATED PF VERTICAL EM FORCES WITH AND WITHOUT TF CURRENTS 2-13
TABLE 2.6 — COMPARISON OF CALCULATED VERTICAL EM FORCES ACTING ON PF COILS AT T=9 SEC. OF HC SCENARIO. IN THE MIT/LLNL CASE, RESULTS ARE GIVEN FOR BOTH THE UPPER AND LOWER COILS SINCE THE TF INTERCONNECT RING IS INCLUDED IN THEIR CALCULATION. 2-15
TABLE 3.1 — FORCE COEFFICIENTS RELATING PF COIL CURRENT COMBINATIONS TO RADIAL BODY FORCES. THE COEFFICIENTS ARE EXPRESSED IN UNITS OF $N/MA^2/RAD$. 3-4
TABLE 3.2 — FORCE COEFFICIENTS RELATING PF COIL CURRENT COMBINATIONS TO VERTICAL BODY FORCES. THE COEFFICIENTS ARE EXPRESSED IN UNITS OF N/MA^2 3-5
TABLE 3.3 — PF AMPERE-TURNS LOADING (MA) VS TIME FOR THE TPX HC SCENARIO. 3-8
TABLE 3.4 — PF COIL COMPRESSIVE FORCE COEFFICIENTS. 3-14
TABLE 3.5 — PEAK INTERNAL RADIAL FORCES ($MN/(M^2$-RADIAN)) ACTING ON EACH PF COIL DURING 23 NORMAL OPERATING EQUILIBRIA. 3-15
TABLE 3.6 — PEAK INTERNAL VERTICAL FORCES ($MN/(M^2$-RADIAN)) ACTING ON EACH PF COIL DURING 23 NORMAL OPERATING EQUILIBRIA. 3-15
TABLE 3.7 – HARMONIC DECOMPOSITION OF ELECTROMAGNETIC FORCES ACTING ON PF5U, PF6U AND PF7U FOR START OF FLATTOP - HC SCENARIO. 3-17
TABLE 3.8 – MAGNITUDE OF RADIAL FORCE PERTURBATIONS ON PF5, 6 AND 7 FOR THE 23 STATIC CURRENT EQUILIBRIA 3-18
TABLE 3.9 – MAGNITUDE OF VERTICAL FORCE PERTURBATIONS ON PF5, 6 AND 7 FOR THE 23 STATIC CURRENT EQUILIBRIA 3-18
TABLE 3.10 – HORIZONTAL BODY FORCES (IN MN) DUE TO 1 CM HORIZONTAL OFFSET OF THE CENTRAL SOLENOID FOR EACH OF THE 23 EQUILIBRIA 3-21
TABLE 3.11 – HORIZONTAL BODY FORCES (IN MN) DUE TO 1 CM HORIZONTAL OFFSET OF PF5U, PF6U AND PF7U 3-22
TABLE 4.1 — SUMMARY OF WORST CASE CS COIL LOADINGS TO BE ANALYZED USING DETAILED CONDUCTOR PACK MODELS. 4-5
TABLE 4.2 — SUMMARY OF WORST CASE PF5, PF6 AND PF7 COIL ELECTROMAGNETIC LOADINGS 4-8
TABLE 4.3 — AMPERE-TURNS LOADING FOR EQUILIBRIA # 1 (I.E. HC SCENARIO AT T=5 SEC.). 4-12
TABLE 4.4 — PEAK MAGNETIC FIELD THROUGHOUT CONDUCTOR PACK PF3 FOR EQUILIBRIA #1. 4-16
TABLE 4.5 — HOOP AND VERTICAL FORCES ACTING ON 60 TURNS OF PF3U DURING EQUILIBRIA #1. 4-21
TABLE 4.6 — COMPARISON OF HOOP AND VERTICAL FORCES ACTING ON PF3U TURNS FOR CASES OF INCLUDING AND NEGLECTING EFFECTS OF CONDUIT MAGNETIZATION DURING EQUILIBRIA #1. 4-22
TABLE 4.7 — ELECTROMAGNETIC BODY FORCES ACTING ON CONDUCTOR PACK PF3 CALCULATED USING MAXWELL STRESS AND LORENTZ BODY FORCE METHODS. THE CASES OF INCLUDING AND NEGLECTING THE MAGNETIC PROPERTIES OF THE INCOLOY CONDUIT ARE SHOWN. 4-23
TABLE 4.8 — HOOP AND VERTICAL FORCES ACTING ON EACH TURN DURING PF3U SUDDEN SHORT CIRCUIT. 4-31
TABLE 4-9 : HOOP AND VERTICAL FORCES ACTING ON TOP 60 TURNS OF PF1L DURING EQUILIBRIA #16. 4-38
TABLE 4.10 — SUMMARY OF WORST CASE PF5, PF6 AND PF7 COIL ELECTROMAGNETIC LOADINGS INCLUDING STEADY AND SPATIALLY ALTERNATING FORCE COMPONENTS ALONG CONDUCTOR PATH LENGTH. 4-41
TABLE 5.1 — SUMMARY OF THE DIFFERENT MAFCO MODELS ESTABLISHED FOR ANALYSIS OF COIL NON-AXISYMMETRIC MODES. 5-2
TABLE 5.2 — MAGNITUDE OF THE CRITICAL RIGHT HELICAL FIELD MODES PRODUCED BY FOUR DIFFERENT PF5 COIL DESIGNS. THE COEFFICIENTS ARE EXPRESSED AS PARTS PER 10^4 RELATIVE TO 4T. 5-20

Page

TABLE C.1 – CALCULATED ELECTROMAGNETIC FORCES ACTING ON PF COILS 1-4 FOR EQUILIBRIA # 3. ..... C-1
TABLE C.2 – CALCULATED ELECTROMAGNETIC FORCES ACTING ON PF5 FOR EQUILIBRIA # 3. ..... C-1
TABLE C.3 – CALCULATED ELECTROMAGNETIC FORCES ACTING ON PF6 FOR EQUILIBRIA # 3. ..... C-1
TABLE C.4 – CALCULATED ELECTROMAGNETIC FORCES ACTING ON PF7U FOR EQUILIBRIA # 3. ..... C-2
TABLE M.1A – POSITIVE M AND N (I.E.,LEFT-HANDED, Nϕ+Mθ) HELICAL FOURIER COEFFICIENTS FOR CO-LOCATED PF3U SPIRAL DESIGN WITH VERTICAL RETURN. M-2
TABLE M.1B – NEGATIVE M AND POSITIVE N (I.E.,RIGHT-HANDED, Nϕ-Mθ) HELICAL FOURIER COEFFICIENTS FOR CO-LOCATED PF3U SPIRAL DESIGN WITH VERTICAL RETURN. M-2
TABLE M.2A–POSITIVE M AND N (I.E.,LEFT-HANDED, Nϕ+Mθ) HELICAL FOURIER COEFFICIENTS FOR CO-LOCATED PF3U CONSTANT RADIUS/JOG DESIGN WITH VERTICAL RETURN. M-3
TABLE M.2B – NEGATIVE M AND POSITIVE N (I.E.,RIGHT-HANDED, Nϕ-Mθ) HELICAL FOURIER COEFFICIENTS FOR CO-LOCATED PF3U CONSTANT RADIUS/JOG DESIGN WITH VERTICAL RETURN. M-3
TABLE M.3A –POSITIVE M AND N (I.E.,LEFT-HANDED, Nϕ+Mθ) HELICAL FOURIER COEFFICIENTS FOR UNIFORMLY CLOCKED (-36 DEGS.) PF3U CONSTANT RADIUS/JOG DESIGN WITH VERTICAL RETURN M-4
TABLE M.3B – NEGATIVE M AND POSITIVE N (I.E.,RIGHT-HANDED, Nϕ-Mθ) HELICAL FOURIER COEFFICIENTS FOR FOR UNIFORMLY CLOCKED (-36 DEGS.) PF3U CONSTANT RADIUS/JOG DESIGN WITH VERTICAL RETURN M-4
TABLE M.4A – POSITIVE M AND N (I.E.,LEFT-HANDED, Nϕ+Mθ) HELICAL FOURIER COEFFICIENTS FOR UNIFORMLY CLOCKED (-36 DEGS.) PF3U CONSTANT RADIUS/JOG DESIGN WITH HELICAL COMPENSATION RETURN. M-5
TABLE M.4B – NEGATIVE M AND POSITIVE N (I.E.,RIGHT-HANDED, Nϕ-Mθ) HELICAL FOURIER COEFFICIENTS FOR UNIFORMLY CLOCKED (-36 DEGS.) PF3U CONSTANT RADIUS/JOG DESIGN WITH HELICAL COMPENSATION RETURN. M-5

ABSTRACT

Several models have been formed for investigating the maximum electromagnetic loading and magnetic field levels associated with the Tokamak Physics eXperiment (TPX) superconducting Poloidal Field (PF) coils. The analyses have been performed to support the design of the individual fourteen hoop coils forming the PF system. The coils have been sub-divided into three coil systems consisting of the central solenoid (CS), PF5 coils, and the larger radius PF6 and PF7 coils. Various electromagnetic analyses have been performed to determine the electromagnetic loadings that the coils will experience during normal operating conditions, plasma disruptions, and fault conditions. The loadings are presented as net body forces acting on individual coils, spatial variations throughout the coil cross section, and force variations along the path of the conductor due to interactions with the Toroidal Field (TF) coils. Three refined electromagnetic models of the PF coil system that include a turn-by-turn description of the fields and forces during a worst case event are presented in this report. A global model including both the TF and PF system was formed to obtain the force variations along the path of the PF conductors resulting from interactions with the TF currents. In addition to spatial variations, the loadings are further subdivided into time-varying and steady components so that structural fatigue issues can be addressed by other designers and analysts.

Other electromagnetic design issues such as the impact of the detailed coil designs on field errors are addressed in this report. Coil design features that are analyzed include radial transitions via short jogs vs spiral type windings and the effects of layer-to-layer rotations (i.e., clocking) on the field errors. The field error has been analyzed on a circle passing through the center of the plasma and on a "dee-shaped" surface forming the plasma boundary. It is shown that either evaluation criteria can be used to identify good designs which produce a pure, highly axisymmetric field. The analysis is used as a guide for choosing a coil winding configuration that results in low field error.

This work was performed for Westinghouse Marine Division in Sunnyvale, California under contract No. B254501. It partially fulfills the deliverable requirements of the TPX Technical Scope of Work (TSOW), TPX Magnet System Rev. 5, Section 2.3.2.

1. INTRODUCTION

Westinghouse Science & Technology Center (WSTC) is providing electromagnetic field analysis of the Tokamak Physics eXperiment (TPX) superconducting Poloidal Field (PF) coils in partial fulfillment of Section 2.3.2 (PF magnet electromagnetic analysis) of the TPX Technical Scope of Work[1]. The analyses performed by WSTC are based on information received at the Design Information Technical Transfer Meeting (DIT-8/94) including the TPX conceptual design drawing package and the general documentation package for the superconducting magnet system[2]. In addition, several reports and/or memos have been generated since August 1994 and have been included into the documentation package.

The main focus of this report is to provide static electromagnetic field calculations in order to confirm University-supplied calculations, determine loads from sets of University-supplied currents[3] and misalignments, and calculate the level of field errors arising from detailed coil configurations. A global electromagnetic model of the complete current system has been formed to facilitate calculations of the electromagnetic loading of the PF coils. This model is described in Section 2.1 of this report. A single set of PF coil currents corresponding to Start-of-Flattop (SOF), High-Current (HC) scenario are used to verify the University-supplied calculations for Lorentz forces and peak magnetic fields throughout the PF and TF conductor packs. Here, periodic variations in the Lorentz force due to the interactions with the TF system are identified. The calculational accuracy associated with the ANSYS Biot-Savart algorithm is addressed in Section 2.2 along with the capability of the ANSYS calculation to resolve the force component resulting from the interaction of the PF coils with the TF intercoil hoop current.

Section 3 deals with establishing general algebraic expressions for calculating the PF coil Lorentz forces given any set of PF currents. Many different sets of currents must be processed in the analysis of the PF system, thus a set of general force expressions is convenient. For example, the body forces for the twenty-three equilibria are processed and compared with University published results[4]. Further, body forces for several time points throughout the HC scenario are evaluated so that the temporal behavior of the force can be determined and used in evaluating structural fatigue. In addition to radial and vertical body force components, approximate internal compressive forces and variations due to TF coil interactions are also expressed in terms of the system currents. The internal forces are important, particularly when concerned about the stress level internal to the conductor pack. The internal Lorentz forces are calculated for each of the twenty-three equilibria cases so they can be used in other structural models.

The most severe loadings of the PF coils are summarized in Section 4. Several different types of events (i.e., normal operating, plasma disruptions and faults) are examined and worst-case conductor pack loadings are defined. In the case of the central solenoid, four worst case loadings are identified as particularly severe and are examined in greater detail using refined electromagnetic and structural models. These include 1) worst-case vertical compressive, and 2) worst-case radial forces, and 3) worst-case radial including mechanically transmitted shear (i.e., traction forces) at the conductor pack interface, during normal operating conditions and 4) worst-case radial forces during a sudden short circuit fault. Cases 2) and 3) correspond to the same electromagnetic event so only three unique electromagnetic analyses are actually required. The effects of preload and thermal contraction due to cooldown are also accounted for in defining the worst-case vertical compressive loading (i.e., case 1) by incorporating results from a companion structural analysis performed on the central solenoid coils and prestress member[16].

Section 4.2 describes each of the three refined electromagnetic models and gives the forces acting on each of the individual turns throughout the conductor pack

of concern. The effect of the conduit magnetization on the fields and forces is also considered in this section by modeling the actual magnetization characteristics of the incoloy material. Force calculations are shown to be consistent using both the Lorentz force law (i.e., JxB) and the Maxwell stress tensor methods.

Worst case vertical and radial forces for PF5, PF6 and PF7 are identified by examining many University-supplied load cases [3-6,9-14] and incorporating mutually agreed upon screening rules [15] to obtain a few severe loading events. The electromagnetic forces are defined in Section 4.1 so that further detailed mechanical analyses can be performed to verify structural integrity. The force fluctuations due to the interaction with the TF system become significant in these coils, particularly PF6 and PF7.

Lastly, Section 5 addresses the impact of the PF coil design details (i.e., design of radial and vertical jogs, layer-to-layer clocking and current return path) on the magnetic field errors in the plasma region. The approach taken here is that of a coil designer, rather than an analyst. That is, not only is the error field analysis of a PF coil design presented, but the current components which drive significant non-axisymmetric field content are identified, and coil designs are proposed that minimize these current components. This results in a recommended hoop coil design that generates low field errors when evaluated on a circle surrounding the coil and also when evaluated as complex helical field coefficients on the plasma "dee-shaped" surface. The "designed-in" field errors from the recommended hoop coil design are shown to be a factor of 10 less than those due to expected coil horizontal offsets.

2. ANSYS THREE-DIMENSIONAL GLOBAL EM MODEL

A global three-dimensional electromagnetic model of the TPX coils has been established using the computer program ANSYS. The model has been constructed so that magnetic fields and Lorentz forces acting on the PF and TF conductors can be obtained for any set of current loadings. The model is described in this section and results for Start-of-Flattop of the TPX HC scenario are presented. This operating point was chosen since the PF5 and PF6 currents and fields are largest and the vertical compressive forces acting on the central solenoid are maximum at this time. The model is verified and its accuracy investigated by comparing with published results from Pillsbury[5,6].

2.1 MODEL DESCRIPTION

The operating coil dimensions for PF1-7 were taken from TPX drawing F-9414002B (in millimeters) from the section of the table entitled "nominal winding pack geometry (at operating temperature)". The dimensions were converted to a mean radial and vertical location and a coil radial and vertical thickness for input to ANSYS as shown in Table 2.1. The dimensions for the internal control coil (IC) were taken from reference 4. The TF interconnect ring was modeled using the dimensions of the TF cable and its location was first approximated near the top of the TF case chimney. A document was later published by Pillsbury[3] which summarized the dimensions appropriate for electromagnetic modeling of all the TPX PF coils. These dimensions were consistent with those used in the current ANSYS model, except for the precise location of the TF intercoil current ring. Unfortunately, the modeling of this coil was completed before the Pillsbury document was available. As a result, a different location than that defined by Pillsbury was used to model the TF interconnect ring. A comparison with the data in the PF System Specification (B-level) indicates that all values except for the TF intercoil ring are within a couple of millimeters of what was modeled. Subsequent to approval of the PF System

Table 2.1 — Coil locations, dimensions and current loadings at t=9 s of HC scenario.

COIL	MEAN RADIUS (m)	MEAN AXIAL LOCATION (m)	RADIAL THICKNESS (m)	AXIAL THICKNESS (m)	AMPERE-TURNS (AT)
PF1U/PF1L	0.81	0.251	0.144	0.478	-2,953,000.
PF2U/PF2L	0.81	0.7065	0.144	0.383	-679,000.
PF3U/PF3L	0.81	1.0415	0.144	0.239	115,000.
PF4U/PF4L	0.81	1.3055	0.144	0.239	319,000.
PF5U/PF5L	1.213	2.35	0.192	0.382	3,348,000.
PF6U/PF6L	3.7585	2.144	0.143	0.478	-1,699,000.
PF7U/PF7L	4.297	1.1135	0.144	0.335	-202,000.
ICU/ICL	2.9405	0.6845	0.045	0.045	0.
PLASMA	2.25	0.0	1.0	1.0	2,000,000.
TF INTERCONNECT	3.1915	2.6924	0.023	0.027	33,500.

Specification and the higher level Tokamak Specification (A-level), all analysis will be performed with the data contained in those specifications. The discrepancies in the calculated fields and forces are expected to be minor, since the mismatch in the coil location are relatively small. The plasma has been modeled as a solid ring with rectangular section (1m by 1m) and uniform current density. The PF system ampere-turns were taken from reference 4 at t=9 s (i.e., SOF HC scenario) and the TF current was taken to be 33.5 kA. A plot of the ampere-turns vs time for the HC scenario is given in Fig. 2.1.

The TF coil geometry is described with 5 arcs and 1 straight bar of current in TPX drawing E-941301. The top two arcs are symmetric below the coil centerline. Thus, dimensions for only 3 arcs are specified and in Table 2.2. Arcs 1 and 2 form the top sections of the coil. Arc 3 forms the outer leg of the coil and the straight bar forms the inner leg of the coil. The TF coil cross section is .2138 (radial) by .3037 (axial) meters with an ampere-turn loading of 2.814 MAT's.

The overall model of the TPX current system and the global coordinate directions are shown in Fig. 2.2. A right-handed coordinate system is used with the positive x-axis to the right, the positive y-axis into the plane of the paper and the positive z-axis upward. TF #1 lies in the x-z plane and is axially centered about the

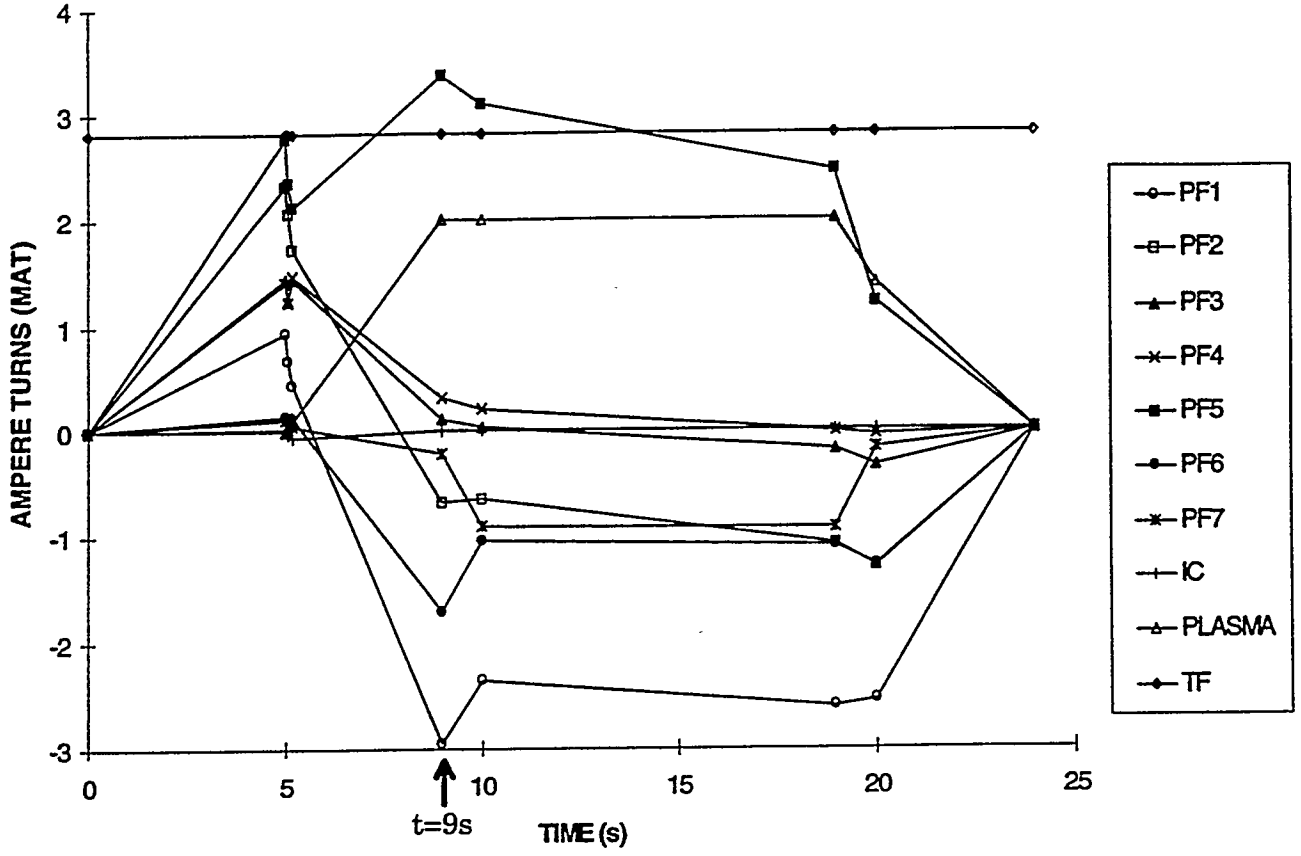


Figure 2.1 — PF system ampere-turns vs time for HC scenario.

Table 2.2 — TF coil geometry parameters used in ANSYS model.

COIL	RADIAL CENTER (m)	AXIAL CENTER (m)	ARC INNER RADIUS (m)	ARC START ANGLE (DEG)	ARC END ANGLE (DEG)
ARC1	2.29108	1.16586	1.05156	90	180
ARC2	2.29108	0.67564	1.5418	9.11	90
ARC3	-1.9223	0.0	5.809	-9.11	9.11

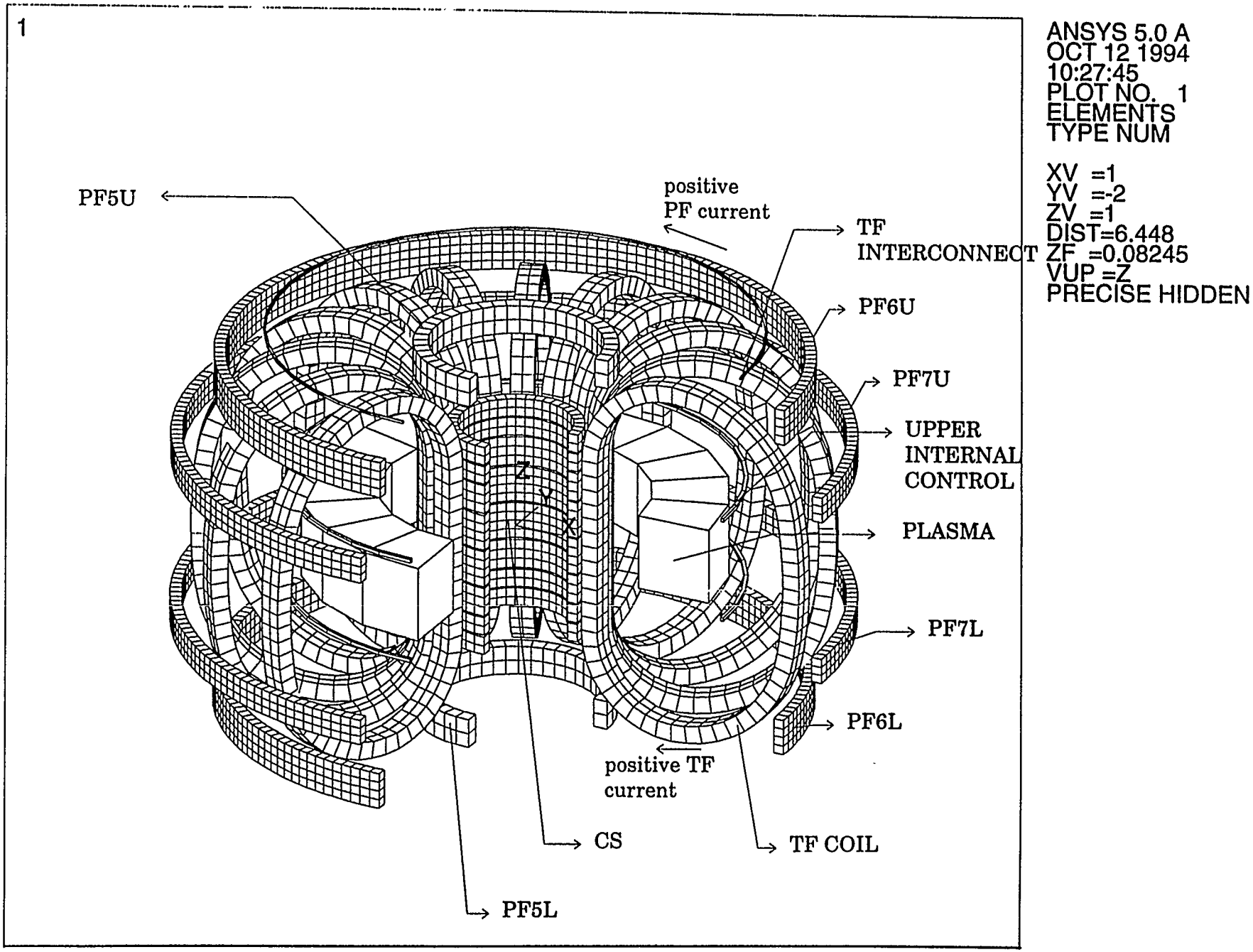


Figure 2.3 Three-dimensional view illustrating current sources, global coordinate system and current flow conventions in the TPX global EM model

positive x-axis. A positive PF current is counterclockwise looking down (i.e. viewed from positive z values) on the x-y plane. The positive TF current is clockwise when viewing TF coil #1 in the x-z plane from in front of the paper (i.e. viewed from negative y values).

The ANSYS commands used to construct the model are given in Appendix A. Several of the geometric parameters are set as parameter assignments at the beginning of this command file so they can easily be changed in future runs. For example, the location of the TF interconnect ring is defined by the parameters r10 and z10 that can be changed once upfront, and the program re-run to re-establish the model database based on the new dimensions. The dimensions are specified in units of meters and the currents are given as Ampere-turns.

The source currents are modeled using ANSYS element type SOURC36. These elements define the current geometry throughout which the Biot-Savart integration takes place. All of the PF ring coils are modeled with four 90 degree solid arc sections that contain uniform current throughout their section. The TF coils are modeled with both solid arc and straight lengths or bars throughout which the current is assumed to be uniform. The observation points are defined using ANSYS STIF5 elements. The magnetic field is actually evaluated at the nodes of these brick elements and the finite elements are used to facilitate interpolation between the nodes. The observation elements are uniformly located throughout each of the current regions. Although the source current elements are defined for an entire 360 degrees of the machine, the observation points are only placed throughout a one-sixteenth angular span (i.e. 22.5 degrees) because the fields and forces are periodic over this interval.

2.2 RESULTS FOR START OF FLATTOP - HC SCENARIO

2.2.1 Peak Magnetic Fields

A set of field observation points throughout a 22.5 (i.e., 360/16) degree angular span was established for each of the PF conductors. The magnitude of the magnetic field was obtained with PF currents set for start of flattop during the HC

Table 2.3 — Peak Magnetic Field for Each of the PF Coils at t=9 s of the HC Scenario

COIL	MIT/LLNL CALCULATION*	ANSYS 3-D EM MODEL WITH I_{tf}=0	ANSYS 3-D EM MODEL WITH I_{tf}=33.5 KA
PF1U/PF1L (T)	5.071/5.071	4.982/4.982	4.969/4.969
PF2U/PF2L (T)	3.658/3.659	3.618/3.618	3.612/3.612
PF3U/PF3L (T)	2.107/2.116	2.073/2.073	2.086/2.085
PF4U/PF4L (T)	1.325/1.311	1.287/1.287	1.311/1.310
PF5U/PF5L (T)	4.738/4.734	4.634/4.634	4.643/4.637
PF6U/PF6L (T)	2.156/2.156	2.023/2.023	2.412/2.418
PF7U/PF7L (T)	0.457/0.457	0.444/0.444	1.038/1.040

Table 2.4 — Comparison of Calculations for Peak Field in the TF Coils

COIL	MIT/LLNL CALCULATION†	WESTINGHOUSE EM MODEL
$TF_{I_{tf}=0}$ (T)	8.39	8.00
$TF_{I_{tf}=0}$ (T)	8.42	8.085

scenario (i.e., Pillsbury's equilibria[3] #3) for the cases of zero and full TF currents. The peak fields observed in each of the conductors are given in Tables 2.3 and 2.4. Also given in Tables 2.3 and 2.4 are published results from previous works (i.e. MIT/LLNL reference 5). The Westinghouse results with zero TF current should be compared with the MIT/LLNL calculations which also do not account for TF currents. The Westinghouse results are generally lower than the MIT/LLNL calculations. This was originally thought to be due to the coarseness of the grid used in the Westinghouse ANSYS analysis. However, adding more observation points did not significantly change the peak fields. It was later concluded that the ANSYS Biot-Savart algorithm is slightly inaccurate when evaluating field on the outer surface of a current element[7]. As a result, the inaccuracy is in the Westinghouse ANSYS calculation. This inaccuracy is discussed in more detail in Section 2.2.6 of this report.

---

* TPX Document No. 14-940803-MIT/RPILLSBURY-01, "Evaluation of the HC Scenario for TPX - Magnets and Power Supplies"

† TPX Document No. 13-940314-MIT/RPILLSBURY-01, "TF Peak field calculations for TPX (Model 021194)"

The peak TF coil field without the PF coils energized is 8.00 T and located at the top of the inside leg. This value is somewhat lower than that obtained by MIT/LLNL (i.e. 8.39 T, reference 6). The discrepancy is attributed to the fact that the MIT/LLNL model uses a refined model of the current distribution in the conductor pack (i.e. 4 filaments in each of the 84 turns). In this case the ANSYS results are believed to be very accurate since the location of the peak field is on the surface of a solid bar element, rather than a solid arc element as in the case of the PF coils. The fields in the vicinity of the bar element do not contain the same accuracy problems as do the solid arc elements. This has been verified by comparing with a second Biot-Savart computer code*. The peak TF field increases to 8.083 T when the PF coils are energized. The location of the peak field changes from the top of the inner leg to the center (i.e. midplane) of the inner leg. The field distribution is illustrated for this case by the contour plot in Figure 2.3.

The effects of the TF currents on the peak PF fields is substantial in the cases of PF6 and PF7. The peak field on PF6 was increased from 2.02 to 2.41 T as a result of TF currents. Figure 2.4 shows contours of constant magnetic field regions on the upper outside surface of PF7L. The variations along the path of the conductor are attributed to the presence of the TF currents. This analysis corresponds to a time (i.e. t=9 s) in the HC scenario when the PF6 field is maximum. Therefore, the relative PF6 field increase is significant when compared to the field created by PF6 alone. In the case of PF7, the total field is relatively low at t=9 s. Even a larger increase in field from the TF current was observed on PF7, but a more appropriate case of interest is at t=19 s when the steady field from the PF coils will be three times larger.

The effect of the TF interconnect ring current on the PF fields is believed to be minor. There are small differences in the peak fields recorded in the upper and lower coils. These differences are attributed to the TF interconnect, since it is the only top-bottom asymmetry that exists in the model†. The maximum difference occurs in PF5 or PF6 and is only 0.006 T.

---

* The Westinghouse Biot-Savart computer program MAFCO produced a peak field of 8.028T.
† At the time this calculation was performed compensation for the TF intercoil current using PF6 coils was not yet included in the modeling.

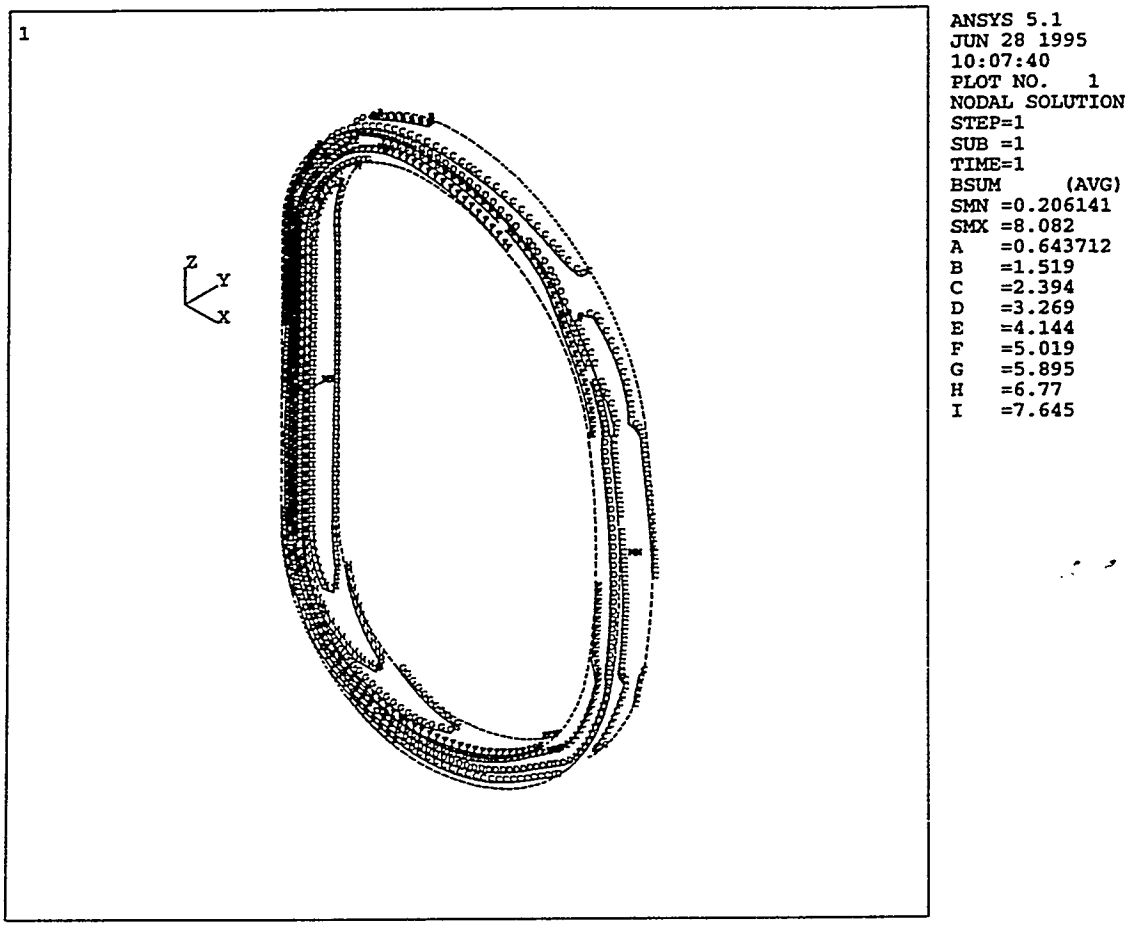


Figure 2.3 — Contours of constant magnetic field throughout a TF coil for equilibria #3 (t=9 s of the HC scenario).

2.2.2 Lorentz forces acting on CS coils

The Lorentz forces acting on the current elements are calculated in the ANSYS post-processor by evaluating the cross product of the current density and magnetic flux density (i.e., JxB). A series of ANSYS commands are used to perform this operation. The file containing these commands is given in Appendix B. The first part of the algorithm forms an array containing the force components associated with each finite element, and the second part sums the force for small angular slices, then normalizes by the mean arc length to produce the force per unit length. The algorithms are exercised for each of the PF conductors to obtain the force distribution along the path length.

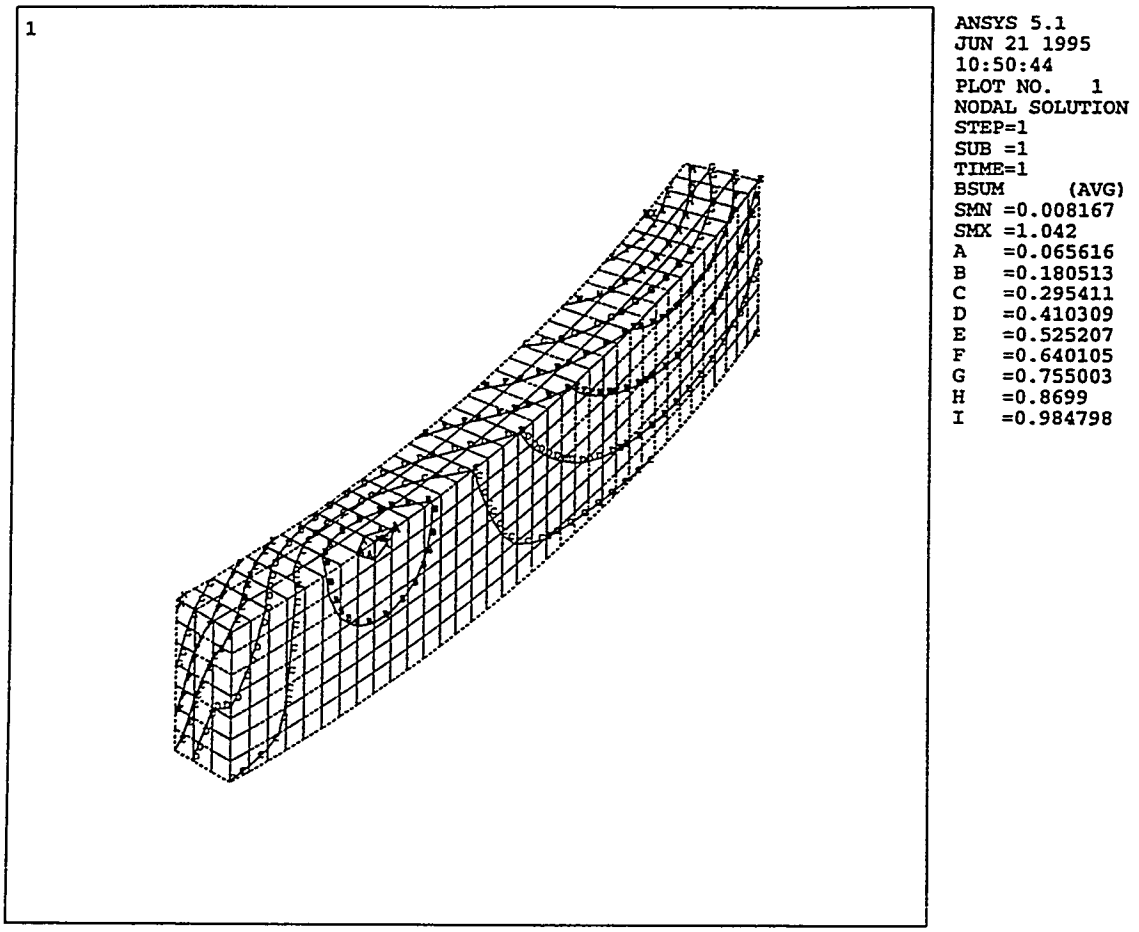


Figure 2.4 — Contours of constant magnetic field throughout PF7L at t=9 s of the HC scenario.

The resulting vertical and radial Lorentz forces acting on each of the central solenoid coils (i.e. PF1-4) along their length are plotted in Fig. 2.5. In this case the vertical force is primarily negative on the top half of the stack and positive on the bottom half of the stack acting to compress the coils. Therefore, the negative vertical force is presented as a positive compressive force (per unit length) in Fig. 2.5. The fields from the TF coil appear to have little impact on the force distribution. A slight angular variation in the vertical compressive force on PF1 can be detected, however it is significantly smaller than that observed on the larger radius PF coils. The net force acting on the entire coil length (i.e., 360 degrees)

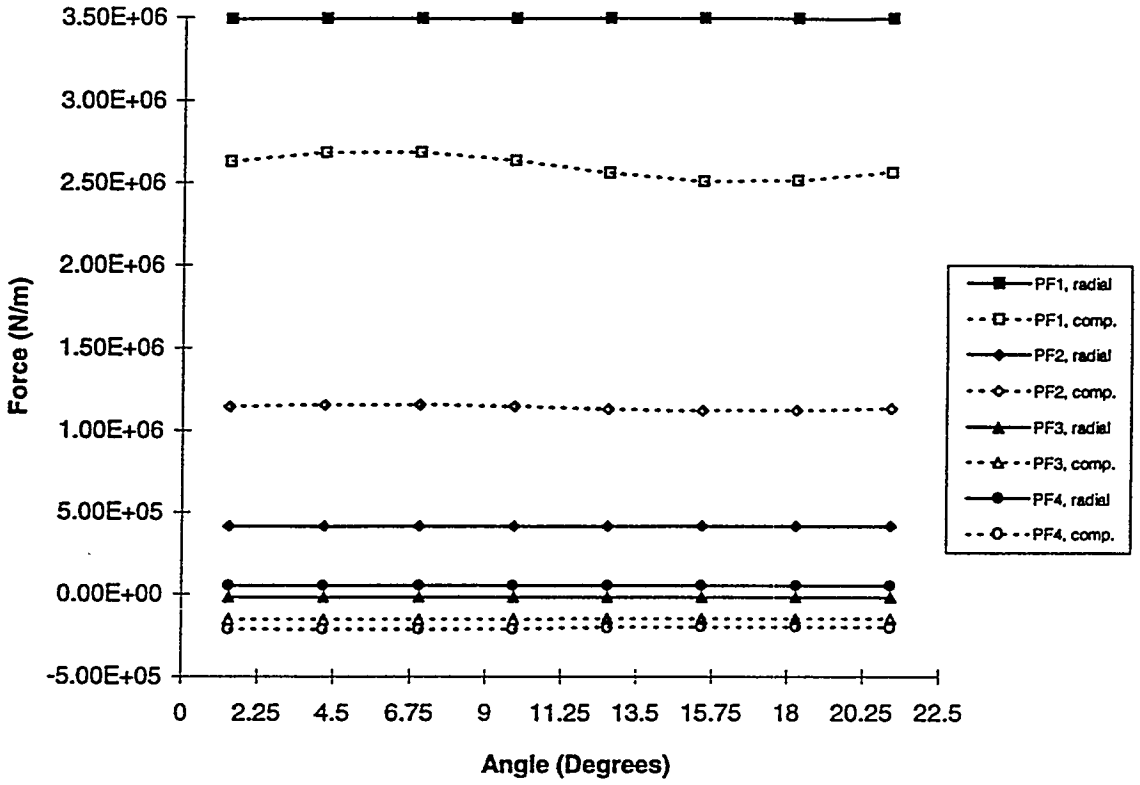


Figure 2.5 — Radial and compressive forces acting on PF1-4 upper coils plotted as a function of angular location. The case of full TF excitation is shown.

for PF1 through PF4 upper is 21.69 MN radial and 18.70 MN vertical compressive. The PF1 coil contributes the greatest amount to the net force at this particular time instant since its current and field are largest. Tables containing the force data are given in Appendix C.

2.2.3 Lorentz Forces Acting on PF5, PF6 and PF7

The Lorentz forces have been calculated for coils PF5U/L and PF6U/L for the cases of zero and full TF coil energization. Figure 2.6 shows the radial and axial force on PF5U and PF5L as a function of coil angular location. An angle of 0 degrees corresponds to the axial center of TF1. An angle 22.5 degrees (i.e. 360/16) corresponds to the center of TF2. Angular variations in both radial and axial force are evident. This variation is attributed to TF coil interaction, since when a run was made with the TF coils deenergized, no angular force variation existed. The angular force variations are relatively small for PF5 when compared with PF6.

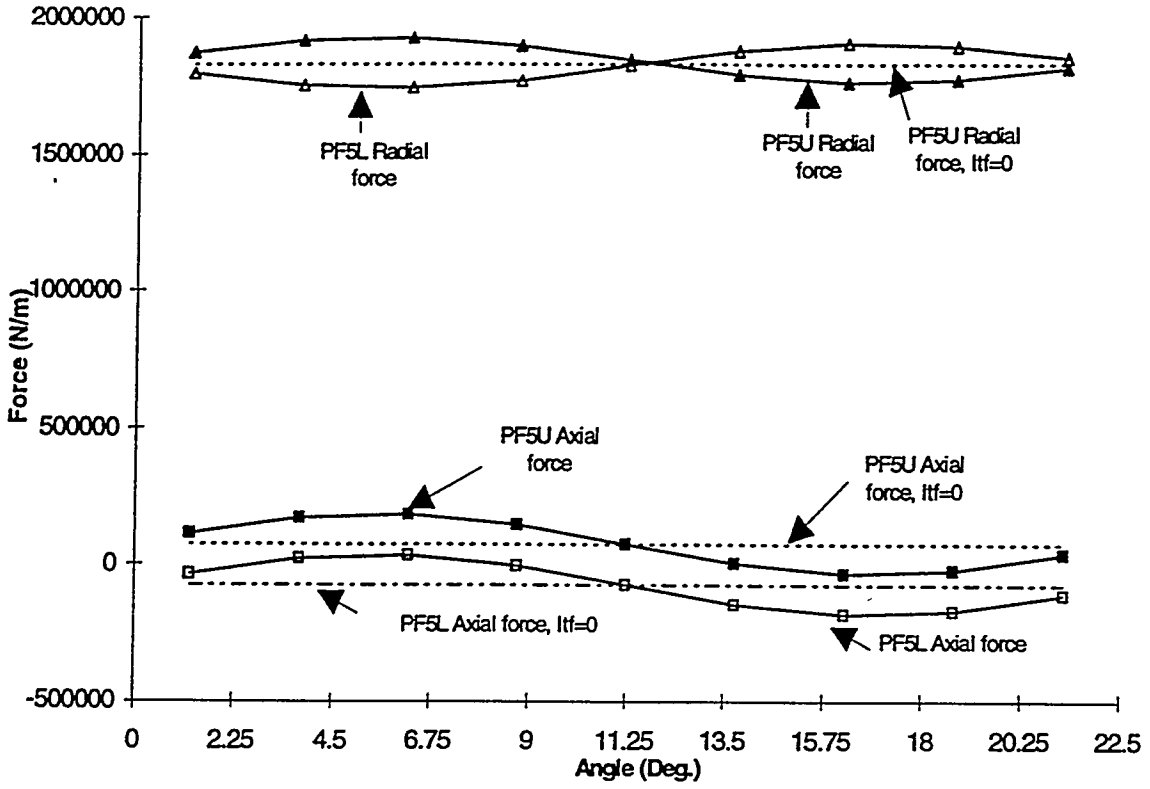


Figure 2.6 — Radial and axial forces acting on PF5 upper and lower coils plotted as a function of angular location. The cases of full TF excitation and zero TF excitation are shown.

The results for PF6U and PF6L are given in Fig. 2.7 and PF7U in Fig. 2.8. In these cases the angular variations are as large as the steady space-invariant component.

Symmetry can be observed in the results for the upper and lower coils. In the case of the radial forces, the upper and lower coil forces are 180 degrees out of phase. That is, a peak positive force component in the upper coil corresponds to a peak negative component in the lower coil. This is because the radial force is generated by the axial component of field from the TF coils. In an upper PF coil, a positive z-directed field is established by the TF coils, while in a lower PF coil (at the same angular location) a negative z-directed field is established. As a result, the radial force perturbations are also oppositely directed. In the case of the axial forces, the upper and lower coil forces are in phase. Here, the radial field from the TF coils generates the force. The radial field is directed the same on both the top

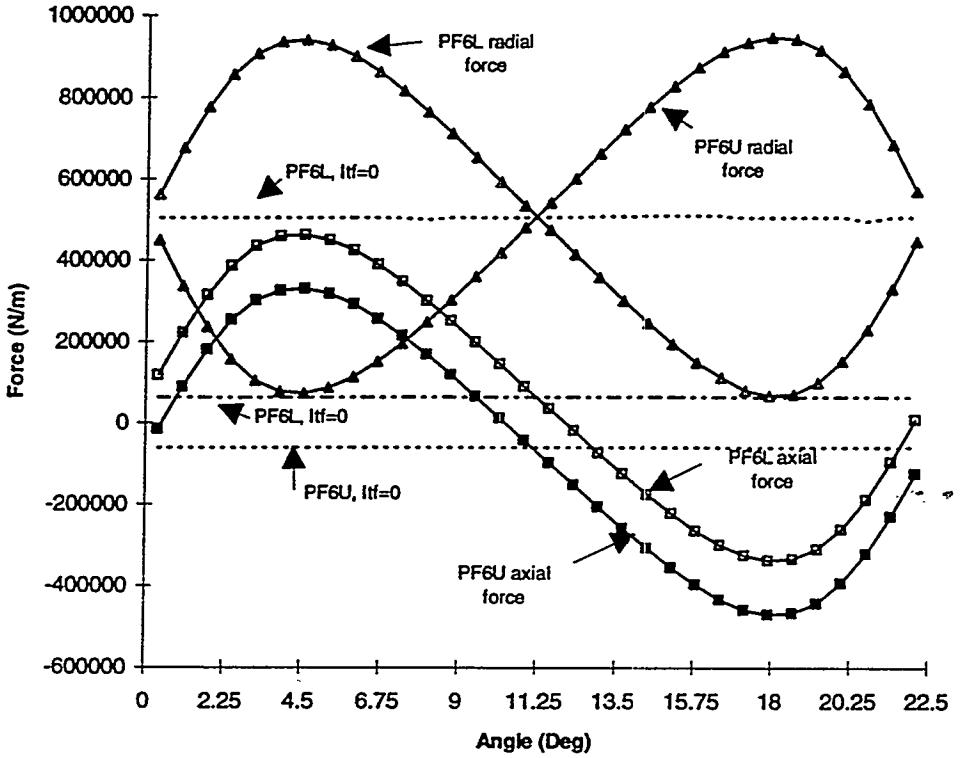


Figure 2.7 — Radial and axial forces acting on PF6 upper and lower coils plotted as a function of angular location. The cases of full TF excitation and zero TF excitation are shown.

and bottom of the TF coil, therefore, the force perturbations are in the same direction.

2.2.4 Effects of the TF Interconnect on the PF Conductor Forces

Some results are presented for the forces acting on the PF conductors due to the presence of the poloidal current ring representing the TF coil interconnects. The main concern here is that the TF interconnect ampere-turns are relatively small and their effects may be masked by the inaccuracies associated with the calculation, especially in PF6 and PF7 where large force variations exist due to interaction with the main TF coils. However close examination of the force results indicates that this is not the case. That is, the three-dimensional model is able to resolve the steady forces on the PF conductors produced by the TF interconnect loop. Table 2.5 gives net vertical PF conductor forces with and without TF current. PF6 upper shows a

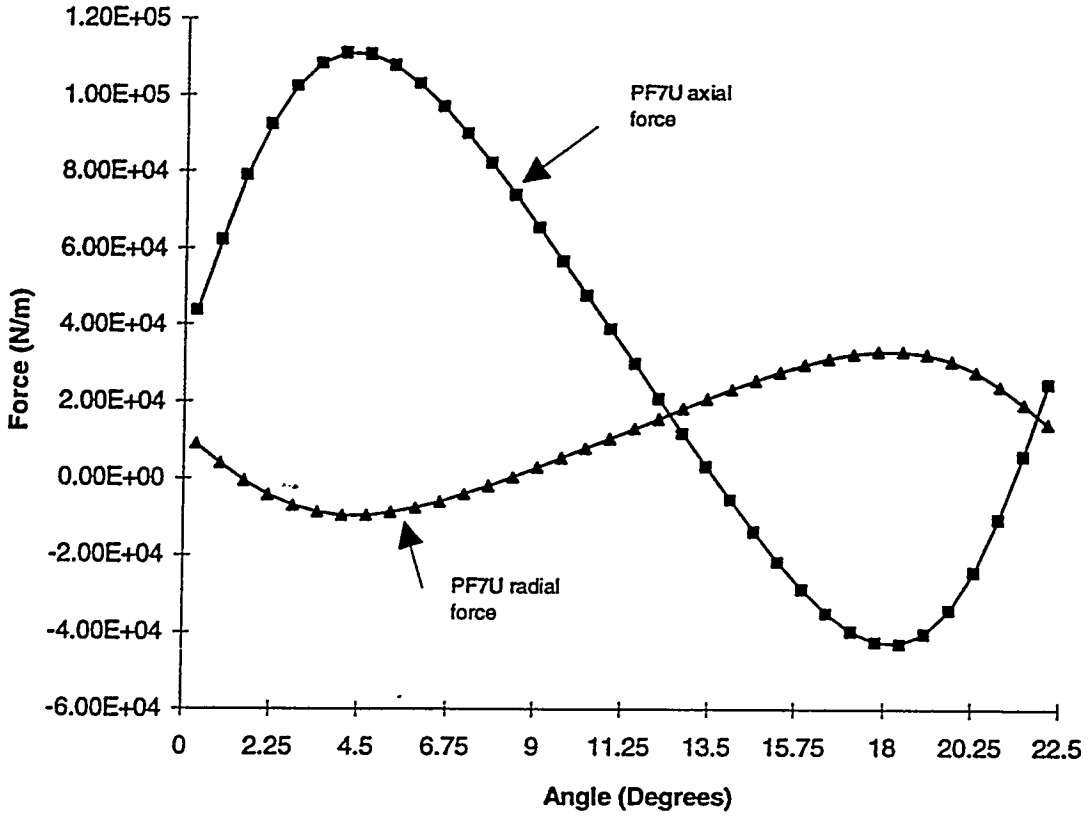


Figure 2.8 — Radial and axial forces acting on PF7 upper coil plotted as a function of angular location. The case of full TF excitation is shown.

Table 2.5 — Comparison of calculated PF vertical EM forces with and without TF currents

VERTICAL FORCE (MN)		
Coil	I_{tf}=0	I_{tf}=33.5 KA
PF1U/L	-14.405/14.405	-14.414/14.398
PF2U/L	-6.303/6.303	-6.306/6.302
PF3U/L	0.834/-0.834	0.8346/-.8339
PF4U/L	1.147/-1.147	1.148/-1.1465
PF5U/L	0.611/-0.611	0.624/-.6047
PF6U/L	-1.407/1.407	-1.607/1.386
PF7U/L	0.955/-0.955	0.9445/-.9595

substantial decrease in vertical force (i.e., from -1.407 to -1.607 MN) when the TF is energized. This decrease is reasoned to result from the interaction of the positive TF interconnect loop current and the negative PF6 current (recall unlike currents

repel). The force change is largest since the interconnect loop is located close to PF6U. In the case of PF6L, the force change is also negative but much smaller in magnitude due to its distant location from the TF interconnect loop. This type of effect is observed for each of the PF conductors. Specifically, positive PF currents show an increase in vertical force and negative currents show a decrease in vertical force. This evidence indicates that the ANSYS 3-D model is capable of resolving these relatively small forces.

2.2.5 Comparisons with other force calculations

Lorentz forces acting on the PF conductors have also been calculated by MIT/LLNL in reference 4. These calculations have been compared with those from two different Westinghouse generated ANSYS models in Table 2.6. The two ANSYS models are: 1) the full three-dimensional Biot-Savart model with TF currents set to zero, and 2) an axisymmetric (i.e., plane 53) finite element model of the PF conductors and plasma. The TF interconnect current ring was ignored in the axisymmetric model since the TF current was set zero. Appendix D contains a list of the ANSYS input commands used in forming the axisymmetric model. In principle, the force results for the two ANSYS calculations and the MIT/LLNL should be identical, with the minor exception being the MIT/LLNL calculation includes the TF interconnect ring current. If the MIT/LLNL results for the lower PF coils are used, the agreement between the three calculations is remarkably good. The data for the lower coil is assumed to be a better comparison with the Westinghouse results because the force interactions from the TF interconnect are smaller due to the substantial separation distance between the hoop coils. Close examination of Table 2.6 indicates that the only force component of concern may be the hoop force on PF5 for the MIT/LLNL calculation. Further examination of the results for all of the 23 equilibria showed that this force is slightly higher in every case. The problem was finally tracked to an input error in the radial build dimension of PF5 for the MIT/LLNL calculation.

Table 2.6 — Comparison of calculated vertical EM forces acting on PF coils at t=9 sec. of HC scenario. In the MIT/LLNL case, results are given for both the upper and lower coils since the TF interconnect ring is included in their calculation.

	VERTICAL FORCE (MN)			HOOP TENSION (MN)		
Coil	3-D ANSYS B-S	Axisymmetric FE	MIT/LLNL	3-D ANSYS B-S	Axisymmetric FE	MIT/LLNL
PF1U	-14.40	-14.41	-14.3/14.3	3.03	3.08	3.07/3.07
PF2U	-6.30	6.308	-6.31/6.31	0.370	0.369	0.368/0.368
PF3U	0.834	0.835	0.834/-0.834	-0.015	-0.015	-0.015/-0.015
PF4U	1.15	1.147	1.15/-1.15	0.045	0.045	0.046/0.046
PF5U	0.61	0.616	0.624/-0.613	2.37	2.353	2.45/2.45
PF6U	-1.406	-1.407	-1.75/1.44	1.88	1.871	1.96/1.87
PF7U	0.955	0.955	0.960/-0.948	0.051	0.051	0.050/0.051

* Radial build dimension input incorrectly

2.2.6 ANSYS Calculational Errors

It was observed that the peak magnetic field values calculated using the three-dimensional ANSYS electromagnetic model appear to be slightly lower than those results obtained using other analysis programs. In particular, it was pointed out that the ANSYS calculated peak magnetic field in conductor PF6 appeared to be low by 6.5 percent when compared with MIT/LLNL calculations. This discrepancy is rather significant when concerned with evaluating whether or not a superconducting magnet will quench. For this reason, the discrepancy between ANSYS 3-D and other field calculations has been pursued further.

Four different models of the TPX PF coil system were established in order to compare the electromagnetic fields throughout the upper seven PF coils. Two of the four models were constructed using ANSYS 5.0a. The first of these is a two-dimensional axisymmetric finite element model (i.e. ANSYS element stif53). The second is the full, three-dimensional ANSYS Biot-Savart calculation (i.e. ANSYS element sourc36) which utilizes the new ANSYS integration algorithms for arc primitives with rectangular section. The other two models (i.e., the third and fourth) were constructed using WSTC internal programs. The third model was made in HOTMAP which is a two-dimensional, axisymmetric finite element

program. The fourth model was constructed using MAFCO which is based on Biot-Savart integration technique in three-dimensions. The input command files for the ANSYS axisymmetric model is given in Appendix D, the ANSYS Biot-Savart in Appendix A, the Westinghouse HOTMAP model in Appendix E and the Westinghouse MAFCO model in Appendix F.

The magnetic field distribution was obtained throughout the r-z plane using each of the four models. Contour plots of the field magnitude throughout the r-z plane of the PF coil system is shown in Fig. 2.9 for currents corresponding to t=9 s of the TPX HC scenario. A blow-up of the region containing the central solenoid is shown in Fig. 2.10. The plots are very similar for each of the models[7] as one would expect and were primarily used a debugging tool when preparing the input files for the four models. Any one of them can be used with reasonable accuracy to get the field variation throughout a region of the r-z plane.

In order to precisely compare the results from the four models, the peak field in each of the seven coils are plotted in Fig. 2.11. Also shown on the bar plot of Fig. 2.11 are results from a separate analysis performed by MIT[5]. The results of the 2-D ANSYS, the 2-D HOTMAP, the MIT/LLNL and the 3-D MAFCO model are nearly identical and are believed to be converging on the correct solution to the problem. The ANSYS 3-D results, however, are generally lower than the results of the other models. The relative error is greatest in the case of coil PF6 where the 6.5 percent error is apparent.

Another comparison of ANSYS 3-D with Westinghouse MAFCO results for the case of PF6 only is shown in Fig. 2.12. Here the vertical component of the field is plotted along a radial line from inside to far outside of the PF6 conductor. The point on the outside edge of PF6 is higher using the MAFCO program when compared with the ANSYS 3-D program. Since the other analysis programs agree with the MAFCO result, it is believed the ANSYS 3D program is locally in error. The ANSYS error is confined to the boundary of the conductor. That is, points internal and external to the current region appear to be accurate. It is only points on the surface of the conductor where the fields appear to be inaccurate.

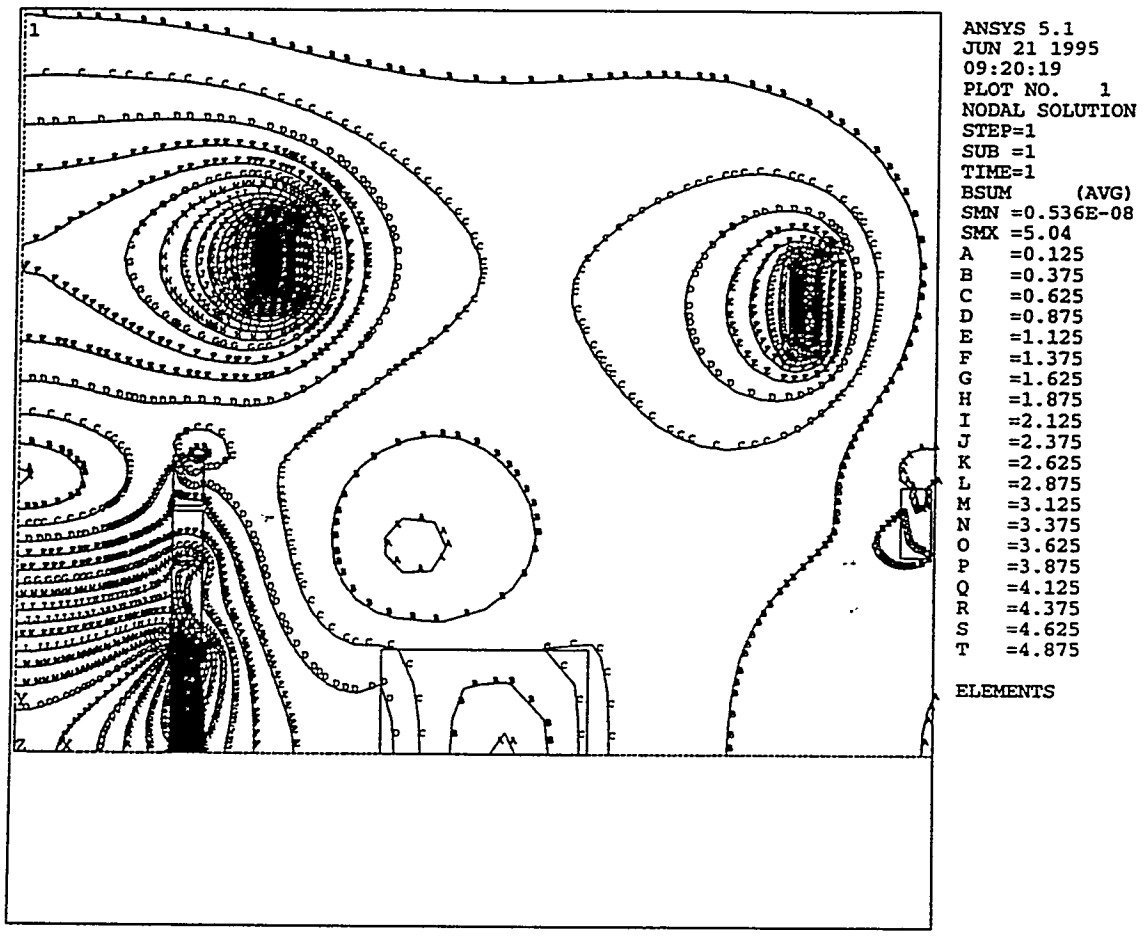


Figure 2.9 — Contours of constant magnetic field throughout the top half of the PF system calculated using ANSYS STIF53 axisymmetric finite elements.

In addition to the peak fields, the calculated vertical and radial electromagnetic forces acting on the coils are plotted in Figs. 2.13 and 2.14. In the case of the vertical forces all the calculations produce results in close agreement. The radial forces are expressed as coil hoop forces and compared in Fig. 2.12. Again the agreement is good with only minor discrepancies associated with the MIT calculations on coil PF5 which can be explained by a dimensional error. The main point is that the errors observed in the peak field calculations using the ANSYS 3-D Biot-Savart solution are not apparent in the calculated electromagnetic forces.

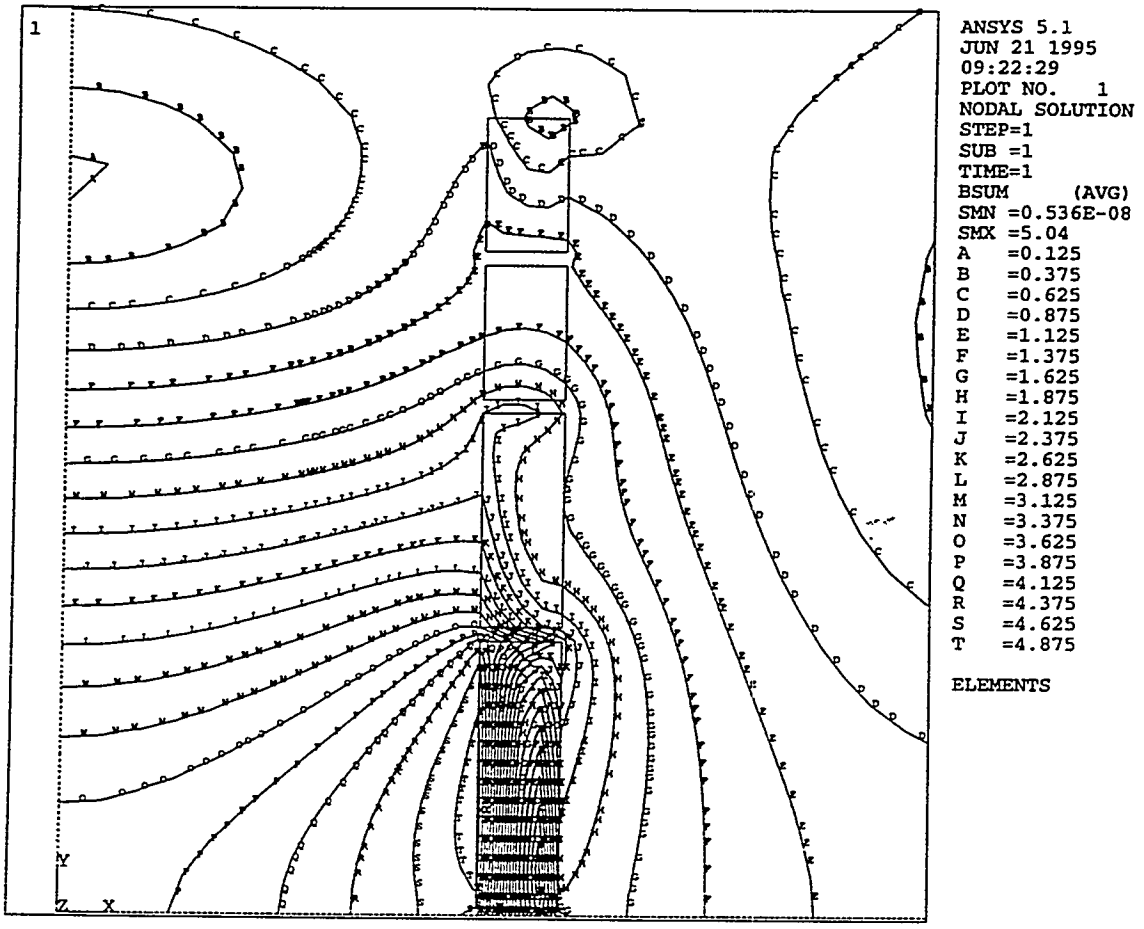


Figure 2.10 — Blowup of contours of constant magnetic field magnitude in the central solenoid region calculated using ANSYS STIF53 axisymmetric finite elements.

In summary, it is suggested that the ANSYS 3-D peak field results for solid arc sections be used with some caution. The peak magnetic fields appear to be slightly low, which may cause a problem when designing a superconducting magnet with very tight margin to quench. This problem appears to persist even if the ANSYS field error tolerance* is set very low. A value of .000005 was used in the calculations shown. The ANSYS default value is 0.001. Although the ANSYS field results are locally in error, the force results appear to be very accurate.

* According to ANSYS, Inc., the field error tolerance, ΔH, is the change in magnetic field at a point in units of A/m between consequtive iterations.

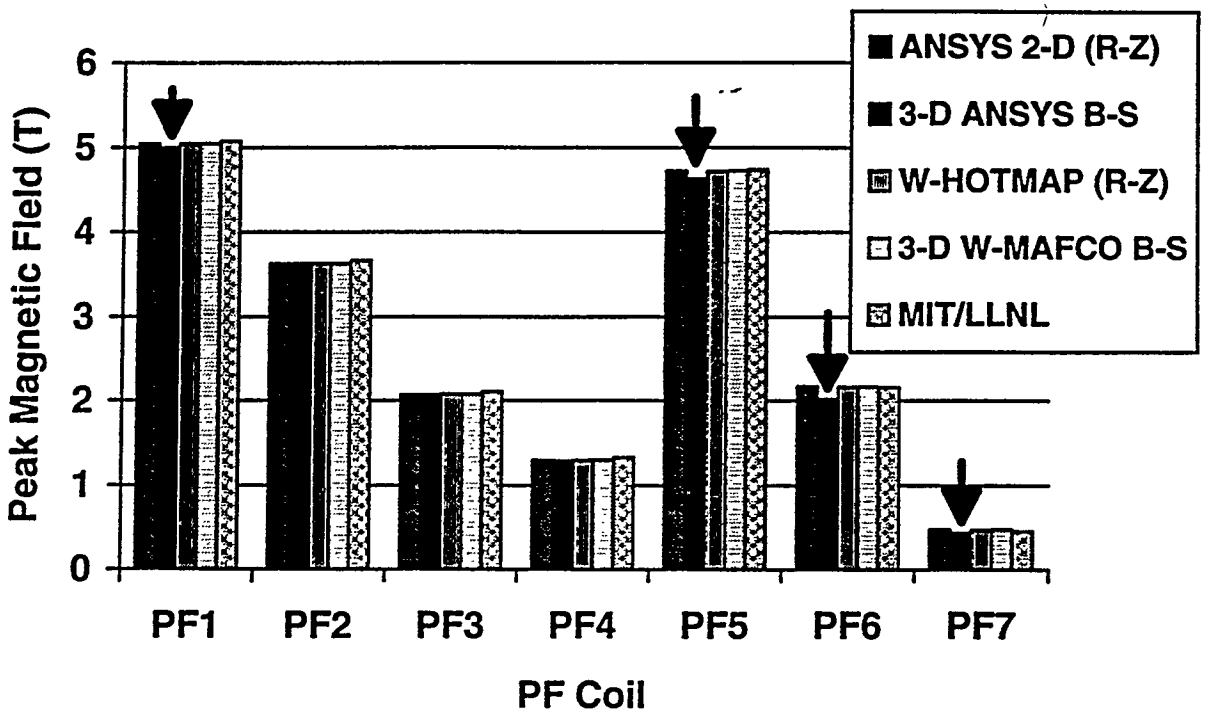


Figure 2.11 — Bar graph comparing value of peak magnetic field obtained in seven PF coils calculated using five different solution methods.

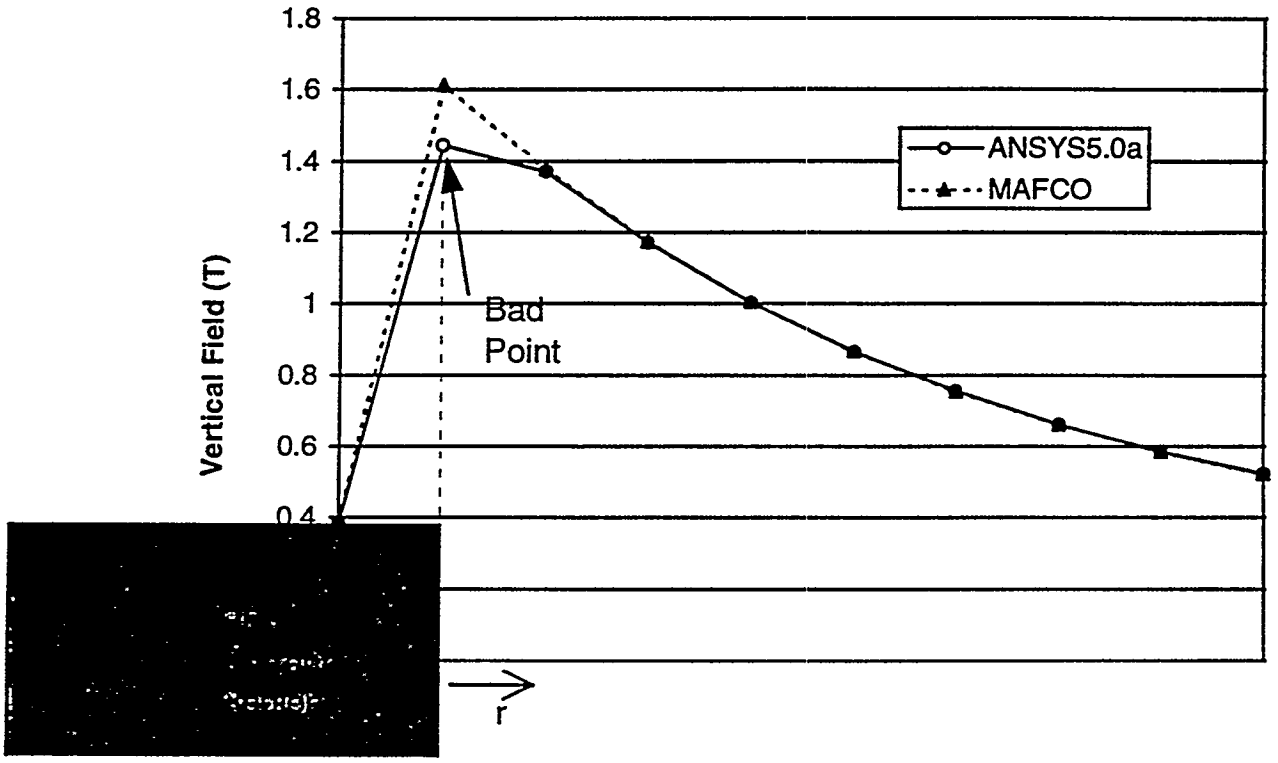


Figure 2.12 — Plot of vertical component of magnetic field obtained using ANSYS 3-D and Westinghouse MAFCO programs for analysis of PF6. The plot illustrates the field error at the outer surface of PF6.

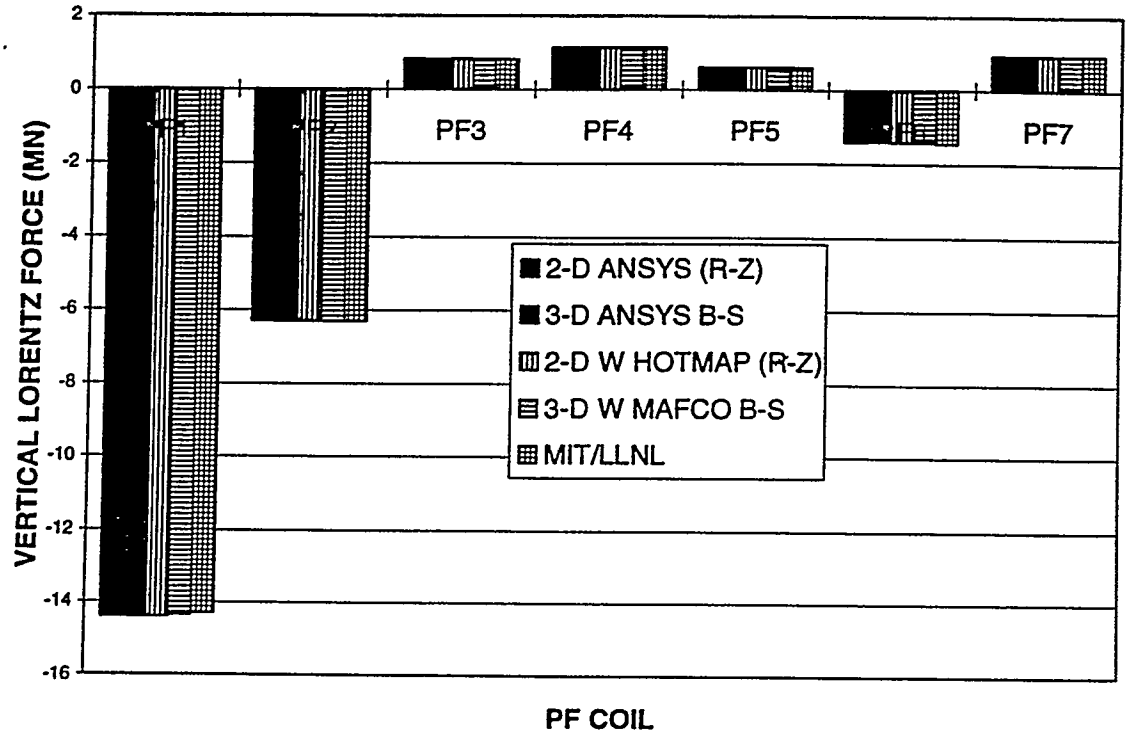


Figure 2.13 — Bar graph comparing calculated value of vertical electromagnetic Lorentz force acting on seven PF conductors calculated using five different models.

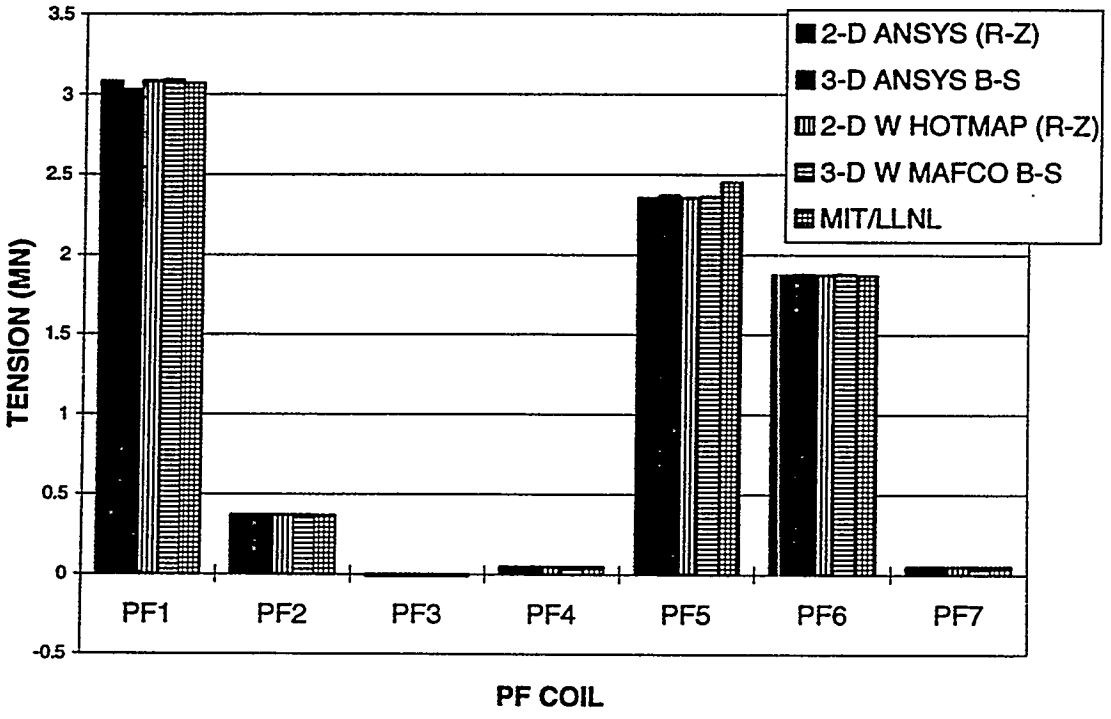


Figure 2.14 — Bar graph comparing calculated value of electromagnetic hoop loading.

3. GENERAL ALGEBRAIC EXPRESSIONS FOR FORCES ACTING ON THE PF COILS

General expressions for the forces acting on the conductors in terms of the PF currents are useful for evaluating worst case loading conditions and force behavior as a general function of time. Actually performing a Biot-Savart or finite element calculation at each operating point is too computationally intensive and not required as long as the current paths are well defined. The alternate approach described in this section is to establish algebraic expressions that relate the system currents to the conductor body forces. The effects of internal compressive forces and TF interactions can also be included and are described in this section.

3.1 EXPRESSIONS FOR BODY FORCES

The relationship between the electromagnetic body forces and applied currents can be written in terms of the sum of the products of any two currents in the system since the system is linear. Specifically, the radial and vertical force acting on coil PF1U can be expressed as:

$$f^r_{PF1U} = k^r_{1,1} i^2_{PF1U} + k^r_{1,2} i_{PF1U} i_{PF1L} + k^r_{1,3} i_{PF1U} i_{PF2U} + k^r_{1,4} i_{PF1U} i_{PF2L} + \ldots + k^r_{1,14} i_{PF1U} i_{PF7L} + k^r_{1,15} i_{PF1U} i_{plas} + k^r_{1,16} i_{PF1U} i_{ICU} + k^r_{1,17} i_{PF1U} i_{ICL} + k^r_{1,18} i_{PF1U} i_{TFIC} \quad (3\text{-}1a)$$

$$f^z_{PF1U} = k^z_{1,2} i_{PF1U} i_{PF1L} + k^z_{1,3} i_{PF1U} i_{PF2U} + k^z_{1,4} i_{PF1U} i_{PF2L} + \ldots + k^z_{1,14} i_{PF1U} i_{PF7L} + k^z_{1,15} i_{PF1U} i_{plas} + k^z_{1,16} i_{PF1U} i_{ICU} + k^z_{1,17} i_{PF1U} i_{ICL} + k^z_{1,18} i_{PF1U} i_{TFIC} \quad (3\text{-}1b)$$

Here the convention used is that the coefficient superscript identifies the force component (i.e., "r" or "z") and the subscript identifies the combination of two coils interacting. It can be observed that the radial force expression includes self terms

(i.e. $k^r_{1,1} i^2_{PF1U}$), while the vertical force expression only contains terms involving two different currents in the system. This occurs because a single hoop coil exerts a radial force on itself, but no vertical force. This self force complicates the problem somewhat because it destroys the symmetry in the radial force coefficient matrix. To see this, we must consider the entire set of 18 coils in the PF system. If an expression similar to (1) is written for each coil the following matrix equation results:

$$\begin{bmatrix} f^r_{PF1U} \\ f^r_{PF1L} \\ f^r_{PF2U} \\ f^r_{PF2L} \\ \vdots \\ f^r_{PF7L} \\ f^r_{PLAS} \\ f^r_{ICU} \\ f^r_{ICL} \\ f^r_{TFIC} \end{bmatrix} = I_{diag} \begin{bmatrix} k^r_{1,1} & k^r_{1,2} & k^r_{1,3} & k^r_{1,4} & \cdots & k^r_{1,14} & k^r_{1,15} & k^r_{1,16} & k^r_{1,17} & k^r_{1,18} \\ k^r_{2,1} & k^r_{2,2} & k^r_{2,3} & k^r_{2,4} & & k^r_{2,14} & k^r_{2,15} & k^r_{2,16} & k^r_{2,17} & k^r_{2,18} \\ k^r_{3,1} & k^r_{3,2} & k^r_{3,3} & k^r_{3,4} & & k^r_{3,14} & k^r_{3,15} & k^r_{3,16} & k^r_{3,17} & k^r_{3,18} \\ k^r_{4,1} & k^r_{4,2} & k^r_{4,3} & k^r_{4,4} & & k^r_{4,14} & k^r_{4,15} & k^r_{4,16} & k^r_{4,17} & k^r_{4,18} \\ & & & & \ddots & & & & & \\ k^r_{14,1} & k^r_{14,2} & k^r_{14,3} & k^r_{14,4} & & k^r_{14,14} & k^r_{14,15} & k^r_{14,16} & k^r_{14,17} & k^r_{14,18} \\ k^r_{15,1} & k^r_{15,2} & k^r_{15,3} & k^r_{15,4} & & k^r_{15,14} & k^r_{15,15} & k^r_{15,16} & k^r_{15,17} & k^r_{15,18} \\ k^r_{16,1} & k^r_{16,2} & k^r_{16,3} & k^r_{16,4} & \cdots & k^r_{16,14} & k^r_{16,15} & k^r_{16,16} & k^r_{16,17} & k^r_{16,18} \\ k^r_{17,1} & k^r_{17,2} & k^r_{17,3} & k^r_{17,4} & & k^r_{17,14} & k^r_{17,15} & k^r_{17,16} & k^r_{17,17} & k^r_{17,18} \\ k^r_{18,1} & k^r_{18,2} & k^r_{18,3} & k^r_{18,4} & & k^r_{18,14} & k^r_{18,15} & k^r_{18,16} & k^r_{18,17} & k^r_{18,18} \end{bmatrix} \begin{bmatrix} i_{PF1U} \\ i_{PF1L} \\ i_{PF2U} \\ i_{PF2L} \\ \vdots \\ i_{PF7L} \\ i_{PLAS} \\ i_{ICU} \\ i_{ICL} \\ i_{TFIC} \end{bmatrix} \tag{3-2a}$$

and

$$\begin{bmatrix} f^z_{PF1U} \\ f^z_{PF1L} \\ f^z_{PF2U} \\ f^z_{PF2L} \\ \vdots \\ f^z_{PF7L} \\ f^z_{PLAS} \\ f^z_{ICU} \\ f^z_{ICL} \\ f^z_{TFIC} \end{bmatrix} = I_{diag} \begin{bmatrix} 0 & k^z_{1,2} & k^z_{1,3} & k^z_{1,4} & \cdots & k^z_{1,14} & k^r_{1,15} & k^z_{1,16} & k^z_{1,17} & k^z_{1,18} \\ -k^z_{1,2} & 0 & k^z_{2,3} & k^z_{2,4} & & k^z_{2,14} & k^z_{2,15} & k^z_{2,16} & k^z_{2,17} & k^z_{2,18} \\ -k^z_{1,3} & -k^z_{2,3} & 0 & k^z_{3,4} & & k^z_{3,14} & k^z_{3,15} & k^z_{3,16} & k^z_{3,17} & k^z_{3,18} \\ -k^z_{1,4} & -k^z_{2,4} & -k^z_{3,4} & 0 & & k^z_{4,14} & k^z_{4,15} & k^z_{4,16} & k^z_{4,17} & k^z_{4,18} \\ & & & & \ddots & & & & & \\ -k^z_{1,14} & -k^z_{2,14} & -k^z_{3,14} & -k^z_{4,14} & & 0 & k^z_{14,15} & k^z_{14,16} & k^z_{14,17} & k^z_{14,18} \\ -k^z_{1,15} & -k^z_{2,15} & -k^z_{3,15} & -k^z_{4,15} & & -k^z_{14,15} & 0 & k^z_{15,16} & k^z_{15,17} & k^z_{15,18} \\ -k^z_{1,16} & -k^z_{2,16} & -k^z_{3,16} & -k^z_{4,16} & \cdots & -k^z_{14,16} & -k^z_{15,16} & 0 & k^z_{16,17} & k^z_{16,18} \\ -k^z_{1,17} & -k^z_{2,17} & -k^z_{3,17} & -k^z_{4,17} & & -k^z_{14,17} & -k^z_{15,17} & -k^z_{16,17} & 0 & k^z_{17,18} \\ -k^z_{1,18} & -k^z_{2,18} & -k^z_{3,18} & -k^z_{4,18} & & -k^z_{14,18} & -k^z_{15,18} & -k^z_{16,18} & -k^z_{17,18} & 0 \end{bmatrix} \begin{bmatrix} i_{PF1U} \\ i_{PF1L} \\ i_{PF2U} \\ i_{PF2L} \\ \vdots \\ i_{PF7L} \\ i_{PLAS} \\ i_{ICU} \\ i_{ICL} \\ i_{TFIC} \end{bmatrix} \tag{3-2b}$$

where

$$I_{diag} = \begin{bmatrix} i_{PF1U} & & & & & & & & \\ & i_{PF1L} & & & & & & & \\ & & i_{PF2U} & & & & 0 & & \\ & & & i_{PF2L} & & & & & \\ & & & & \ddots & & & & \\ & & & & & i_{PF7L} & & & \\ & & 0 & & & & i_{PLAS} & & \\ & & & & & & & i_{ICU} & \\ & & & & & & & & i_{ICL} \\ & & & & & & & & & I_{TFIC} \end{bmatrix}$$

The vertical coefficient matrix is skew symmetric because the vertical force on any one coil must be reacted by an equal and opposite vertical force on the other coil. This symmetry is not evident in the radial force matrix, since all the force is not fully reacted by another coil in the system, but is in part reacted by itself.

The actual values of the coefficients for the PF system are given in Tables 3.1 and 3.2. The coefficients were calculated from successive finite element runs by applying 1 MA to each of two coils and recording the resulting Lorentz forces. The Westinghouse electromagnetic finite element code HOTMAP was used for the coefficient calculation. Second-order elements were employed in an attempt to achieve high accuracy. A short FORTRAN computer program was written to evaluate the coefficients from the set of calculated forces. The program listing is given in Appendix G.

We can gauge the accuracy of the matrix terms by examining the diagonal terms of the vertical force matrix. In theory these terms should be identically zero, but in the actual numerical solution a small residual force is obtained due to finite element truncation error. The size of these diagonal terms, relative to the off-diagonal terms, gives an indication of the calculation accuracy associated with that particular conductor. For example, coils PF1-4 produce very small diagonal terms since their finite element mesh is relatively fine. On the other hand, the internal control and TF interconnect coils are geometrically small and are only meshed with

Table 3.1 — Force coefficients relating PF coil current combinations to radial body forces. The coefficients are expressed in units of $N/MA^2/rad$.

	PF1U	PF1L	PF2U	PF2L	PF3U	PF3L	PF4U	PF4L	PF5U	PF5L	PF6U	PF6L	PF7U	PF7L	PLASM	ICU	ICL	TFIC
PF1U	281987	156388	166403	81725	101133	53266	71637	38934	42209	26651	96380	80366	113789	103781	240190	175887	153688	82105
PF1L	156388	281986	81725	166404	53266	101133	38934	71637	26651	42209	80366	96380	103781	113789	240190	153688	175887	65517
PF2U	166403	81725	299106	46098	197867	31183	130726	23469	67163	18277	111404	67308	119723	92911	204471	183272	128062	99790
PF2L	81725	166404	46098	299104	31183	197867	23469	130726	18277	67163	67308	111404	92911	119723	204471	128062	183272	53212
PF3U	101133	53266	197867	31183	331773	21700	220773	16687	98138	14156	121814	58839	121533	84542	169187	178612	109400	113941
PF3L	53266	101133	31183	197867	21700	331765	16687	220782	14156	98138	58839	121814	84542	121533	169187	109400	178612	45695
PF4U	71637	38934	130726	23469	220773	16687	331720	13035	137691	11737	128935	52894	121187	78016	142526	169267	95893	125247
PF4L	38934	71637	23469	130726	16687	220782	13035	331702	11737	137692	52894	128935	78016	121187	142526	95893	169267	40611
PF5U	21668	14958	29623	10757	35006	8532	34945	7174	331579	8310	218187	50320	162672	80676	93634	164833	78710	249913
PF5L	14958	21668	10757	29623	8532	35006	7174	34945	8310	331615	50320	218187	80676	162672	93634	78710	164834	37251
PF6U	-3900	-933	-7308	931	-10000	1848	-11996	2338	-36117	6936.8	437097	83203	553644	151867	4139	-11464	57074	-335705
PF6L	-932.8	-3900	931	-7308	1848	-10000	2338	-11996	6936	-36117	83203	437027	151867	553644	4139	57074	-11464	58289
PF7U	-9541	-7078	-11112	-4678	-11608	-3039	-11513	-1900	-17652	2849	-93819	83378	477057	167163	-72264	-253691	-23705	-39470
PF7L	-7078	-9541	-4678	-11113	-3039	-11609	-1900	-11513	2849	-17653	83378	-93819	167164	477056	-72264	-23705	-253692	56413
PLASM	-4209.7	-4209.7	-26331	-26331	-12701	-12701	-4267	-4267	20885	20885	217561	217560	339226	339226	267262	570193	570194	156108
ICU	-23101	-15199	-25947	-7394	-24130	-2760	-20614	24	-5187	11514	354697	163225	649755	319539	-165134	640176	178540	208473
ICL	-15199	-23101	-7394	-25947	-2726	-24130	24.3	-20615	11513	-5188	163225	354696	319538	649755	-156134	178541	563752	110240
TFIC	265	2415.6	-2951.5	3408	-6155	3736	-9105	3826	-46724	7808	1105861	77260.6	400640	136406	35368	86939	72672	1335629

Table 3.2 — Force coefficients relating PF coil current combinations to vertical body forces. The coefficients are expressed in units of N/MA^2.

	PF1U	PF1L	PF2U	PF2L	PF3U	PF3L	PF4U	PF4L	PF5U	PF5L	PF6U	PF6L	PF7U	PF7L	PLASM	ICU	ICL	TFIC
PF1U	1.77	-316476	353979	-89839	127919	-45087	71815	-28095	19963	-10857	12925	-12116	6416	-8731	-15661	11303	-19641	14511
PF1L	316476	-2.45	89839	-353979	45087	-127919	28095	-71815	10856	-19963	12116	-12925	8731	-6416	15661	19640	-11303	12097
PF2U	-353979	-89839	3.42	-36196	494735	-20207	201728	-13414	36425	-6555	12470	-10756	3296	-9723	-34876	-615	-21773	16177
PF2L	89839	353979	36196	-3.5	20207	-494735	13414	-201729	6555	-36425	10756	-12470	9723	-3296	34876	21773	615	9915
PF3U	-127919	-45087	-494735	-20207	-2.13	-11965	615963	-8255	58312	-4653	11092	-9616	598	-9865	-38403	-9633	-20897	16595
PF3L	45087	127919	20207	494735	11965	0.15	8256	-615964	4653	-58312	9616	-11092	9865	-598	38402	20897	9632	8463
PF4U	-71815	-28095	-201728	-13414	-615963	-8256	-52.45	-5845	86208	-3622	9254	-8715	-1589	-9693	-36411	-15367	-19356	16085
PF4L	28095	71815	13414	201729	8255	615964	5845	63.1	3621.8	-86208	8715	-9254	9693	1590	36411	19356	15367	7445
PF5U	-19963	-10856	-36425	-6555	-58312	-4653	-86208	-3621.8	41.9	-3136	-6450	-12414	-19812	-17442	-42161	-49825	-26084	11327
PF5L	10857	19963	6555	36425	4653	58312	3622	86208	3136	-29	12414	6450	17442	19812	42161	26084	49825	9701
PF6U	-12925	-12116	-12470	-10756	-11092	-9616	-9254	-8715	6450	-12414	-229	-89598	-566875	-158651	-114321	-285073	-136233	795850
PF6L	12116	12925	10756	12470	9616	11092	8715	9254	12414	-6450	89598	114.7	158651	566875	114321	136233	285073	64019
PF7U	-6416	-8731	-3296	-9723	-598	-9865	1589	-9693	19812	-17442	566875	-158651	334.4	-315440	-90267	-130013	-190011	305911
PF7L	8731	6416	9723	3296	9865	598	9693	-1590	17442	-19812	158651	-566875	315440	-276.22	90267	190011	130014	109214
PLASM	15661	-15661	34876	-34876	38403	-38402	36411	-36411	42161	-42161	114321	-114321	90267	-90267	0.06	348256	-348255	102107
ICU	-11303	-19640	615	-21773	9633	-20897	15367	-19356	49825	-26084	285073	-136233	130013	-190011	-348256	30266	-361145	239536
ICL	19641	11303	21773	-615	20897	-9632	19356	-15367	26084	-49825	136233	-285073	190011	-130014	348255	361145	-79437	103360
TFIC	-14511	-12097	-16177	-9915	-16595	-8463	-16085	-7445	-11327	-9701	-795850	-64019	-64019	-109214	-102107	-239536	-103360	0

a couple of finite elements. The force coefficients for these coils are expected to be rough as indicated by the size of their diagonal terms relative to the off-diagonal terms. Another indication of the low accuracy associated with these coils is the difference in the radial coefficient matrix diagonal terms for the IC coils. Since the upper and lower coils are identical in shape they must have the same radial force when their own current is applied. Yet, these two diagonal terms vary by 12 % indicating an accuracy problem. This does not appear to be an issue with PF coils 1 through 7 where the diagonal terms (upper vs lower coils) are identical to 1 part in 10^4. Additional symmetries can be observed in the coefficient matrices as a result of the top-to-bottom symmetry in the coil system. If 2 by 2 subblocks corresponding to symmetric coil pairs (i.e., PF1U, PF1L) are examined in either the radial or vertical coefficient matrices a symmetry is apparent in the coefficients.

3.1.1 Verification via the twenty-three equilibria cases

The force coefficients have been verified by comparing with the 23 equilibria cases examined by Pillsbury[4]. An EXCEL spreadsheet which contains the algebraic force relationships was used for the calculation and is available for any calculations required in the future. The resulting forces were compared by superimposing the algebraic calculations on the bar plots presented by Pillsbury. The comparison for each component of the 18 coils is given in reference 7. The comparison is very good with the following four exceptions:

1. The Pillsbury results and the proposed force coefficient method show a higher level of mismatch for equilibria cases #17 and #18. This problem has been resolved and was due to a data error in the plasma current for the original Pillsbury calculation.

2. The Pillsbury results are consistently higher (only a couple of percent) for radial forces on coils PF5U and PF5L. The problem was tracked to a dimension error (i.e., the radial build) in the original Pillsbury calculation.

3. The Pillsbury results for the radial force on the plasma are significantly different than the proposed force coefficient method. This difference has been tracked to the use of different plasma current dimensions. Pillsbury used a build of 0.5 m by 0.5 m, while the force coefficient matrix was formed using a build of 1 m by 1 m. Although the radial forces differ, the vertical forces are in good agreement even though the assumed dimensions differ.

4. The force agreement for the case of the IC and TF interconnect coils are not as good as in the cases of other PF coils. The error (roughly 10 percent) is most likely due to inaccuracies in the force coefficient matrix for these coils. The focus of our work is on coils PF1 through PF7 where the results are very accurate. The inaccuracy in the IC and TFIC coils is judged as acceptable for our purposes.

3.1.2 HC scenario data

The immediate need for the force expressions was to establish the temporal behavior of the forces acting on the PF coils throughout the HC scenario. The 18 PF currents were first calculated at 36 time points (see Table 3.3) and then the radial and vertical forces calculated from these currents. The resulting force profiles are plotted vs time for PF1 through PF7 in Figs. 3.1 and 3.2. Since the forces are, for the most part, top-bottom symmetric (strictly speaking this is not true due to the asymmetric TF interconnect and PF6 compensation currents) only the lower coils are shown. The radial forces are expressed as force per turn per radian so that it is equivalent to the coil average hoop force. The vertical forces are given as total body forces acting on the entire hoop.

3.2 EXPRESSIONS FOR INTERNAL COMPRESSIVE FORCES

One of the difficulties with using only body forces in analyzing the coil loading is that the compressive component of the Lorentz force is neglected. This force component can be very large and always acts to reduce the coil size. Accounting for the compressive force is particularly important when evaluating the

Table 3.3 — PF Ampere-turns loading (MA) vs time for the TPX HC scenario.

time (s)	0	1	2	3	4	5	5.037	5.074	5.111	5.148	5.185	5.948	6.711	7.474	8.237
PF1U	0	0.1868	0.3736	0.5604	0.7472	0.934	0.8354	0.7368	0.6382	0.5396	0.441	-0.2378	-0.9166	-1.5954	-2.2742
PF1L	0	0.1868	0.3736	0.5604	0.7472	0.934	0.8354	0.7368	0.6382	0.5396	0.441	-0.2378	-0.9166	-1.5954	-2.2742
PF2U	0	0.4636	0.9272	1.3908	1.8544	2.318	2.197	2.076	1.955	1.834	1.713	1.2346	0.7562	0.2778	-0.2006
PF2L	0	0.4636	0.9272	1.3908	1.8544	2.318	2.197	2.076	1.955	1.834	1.713	1.2346	0.7562	0.2778	-0.2006
PF3U	0	0.2896	0.5792	0.8688	1.1584	1.448	1.445	1.442	1.439	1.436	1.433	1.1694	0.9058	0.6422	0.3786
PF3L	0	0.2896	0.5792	0.8688	1.1584	1.448	1.445	1.442	1.439	1.436	1.433	1.1694	0.9058	0.6422	0.3786
PF4U	0	0.2812	0.5624	0.8436	1.1248	1.406	1.4176	1.4292	1.4408	1.4524	1.464	1.235	1.006	0.777	0.548
PF4L	0	0.2812	0.5624	0.8436	1.1248	1.406	1.4176	1.4292	1.4408	1.4524	1.464	1.235	1.006	0.777	0.548
PF5U	0	0.554	1.108	1.662	2.216	2.77	2.64	2.51	2.38	2.25	2.12	2.3656	2.6112	2.8568	3.1024
PF5L	0	0.554	1.108	1.662	2.216	2.77	2.64	2.51	2.38	2.25	2.12	2.3656	2.6112	2.8568	3.1024
PF6U	0	0.023	0.046	0.069	0.092	0.115	0.111	0.107	0.103	0.099	0.095	-0.2696	-0.6342	-0.9988	-1.3634
PF6L	0	0.02936	0.05872	0.08808	0.11744	0.1468	0.1428	0.1388	0.1348	0.1308	0.1268	-0.2378	-0.6024	-0.967	-1.3316
PF7U	0	0.024	0.048	0.072	0.096	0.12	0.1054	0.0908	0.0762	0.0616	0.047	-0.0028	-0.0526	-0.1024	-0.1522
PF7L	0	0.024	0.048	0.072	0.096	0.12	0.1054	0.0908	0.0762	0.0616	0.047	-0.0028	-0.0526	-0.1024	-0.1522
PLAS	0	0	0	0	0	0	0.02	0.04	0.06	0.08	0.1	0.48	0.86	1.24	1.62
ICU	0	0.0044	0.0088	0.0132	0.0176	0.022	0.0076	-0.0068	-0.0212	-0.0356	-0.05	-0.04	-0.03	-0.02	-0.01
ICL	0	0.0044	0.0088	0.0132	0.0176	0.022	0.0076	-0.0068	-0.0212	-0.0356	-0.05	-0.04	-0.03	-0.02	-0.01
TFIC	0	0.0068	0.0136	0.0204	0.0272	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034

time (s)	9	9.2	9.4	9.6	9.8	10	11.8	13.6	15.4	17.2	19	19.2	19.4	19.6	19.8	20	20.8	21.6	22.4	23.2	24
PF1U	-2.953	-2.8314	-2.7098	-2.5882	-2.4666	-2.345	-2.3954	-2.4458	-2.4962	-2.5466	-2.597	-2.5836	-2.5702	-2.5568	-2.5434	-2.53	-2.024	-1.518	-1.012	-0.506	0
PF1L	-2.953	-2.8314	-2.7098	-2.5882	-2.4666	-2.345	-2.3954	-2.4458	-2.4962	-2.5466	-2.597	-2.5836	-2.5702	-2.5568	-2.5434	-2.53	-2.024	-1.518	-1.012	-0.506	0
PF2U	-0.679	-0.6702	-0.6614	-0.6526	-0.6438	-0.635	-0.7238	-0.8126	-0.9014	-0.9902	-1.079	-1.1198	-1.1606	-1.2014	-1.2422	-1.283	-1.0264	-0.7698	-0.5132	-0.2566	0
PF2L	-0.679	-0.6702	-0.6614	-0.6526	-0.6438	-0.635	-0.7238	-0.8126	-0.9014	-0.9902	-1.079	-1.1198	-1.1606	-1.2014	-1.2422	-1.283	-1.0264	-0.7698	-0.5132	-0.2566	0
PF3U	0.115	0.1	0.085	0.07	0.055	0.04	-0.0052	-0.0504	-0.0956	-0.1408	-0.186	-0.2158	-0.2456	-0.2754	-0.3052	-0.335	-0.268	-0.201	-0.134	-0.067	0
PF3L	0.115	0.1	0.085	0.07	0.055	0.04	-0.0052	-0.0504	-0.0956	-0.1408	-0.186	-0.2158	-0.2456	-0.2754	-0.3052	-0.335	-0.268	-0.201	-0.134	-0.067	0
PF4U	0.319	0.298	0.277	0.256	0.235	0.214	0.1696	0.1252	0.0808	0.0364	-0.008	-0.0128	-0.0176	-0.0224	-0.0272	-0.032	-0.0256	-0.0192	-0.0128	-0.0064	0
PF4L	0.319	0.298	0.277	0.256	0.235	0.214	0.1696	0.1252	0.0808	0.0364	-0.008	-0.0128	-0.0176	-0.0224	-0.0272	-0.032	-0.0256	-0.0192	-0.0128	-0.0064	0
PF5U	3.348	3.2954	3.2428	3.1902	3.1376	3.085	2.961	2.837	2.713	2.589	2.465	2.2138	1.9626	1.7114	1.4602	1.209	0.9672	0.7254	0.4836	0.2418	0
PF5L	3.348	3.2954	3.2428	3.1902	3.1376	3.085	2.961	2.837	2.713	2.589	2.465	2.2138	1.9626	1.7114	1.4602	1.209	0.9672	0.7254	0.4836	0.2418	0
PF6U	-1.728	-1.5964	-1.4648	-1.3332	-1.2016	-1.07	-1.079	-1.088	-1.097	-1.106	-1.115	-1.1516	-1.1882	-1.2248	-1.2614	-1.298	-1.0384	-0.7788	-0.5192	-0.2596	0
PF6L	-1.6962	-1.5646	-1.433	-1.3014	-1.1698	-1.0382	-1.0472	-1.0562	-1.0652	-1.0742	-1.0832	-1.1198	-1.1564	-1.193	-1.2296	-1.2662	-1.013	-0.7597	-0.5065	-0.2532	0
PF7U	-0.202	-0.3426	-0.4832	-0.6238	-0.7644	-0.905	-0.9068	-0.9086	-0.9104	-0.9122	-0.914	-0.7632	-0.6124	-0.4616	-0.3108	-0.16	-0.128	-0.096	-0.064	-0.032	0
PF7L	-0.202	-0.3426	-0.4832	-0.6238	-0.7644	-0.905	-0.9068	-0.9086	-0.9104	-0.9122	-0.914	-0.7632	-0.6124	-0.4616	-0.3108	-0.16	-0.128	-0.096	-0.064	-0.032	0
PLAS	2	2	2	2	2	2	2	2	2	2	2	1.88	1.76	1.64	1.52	1.4	1.12	0.84	0.56	0.28	0
ICU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ICL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TFIC	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.0272	0.0204	0.0136	0.0068	0

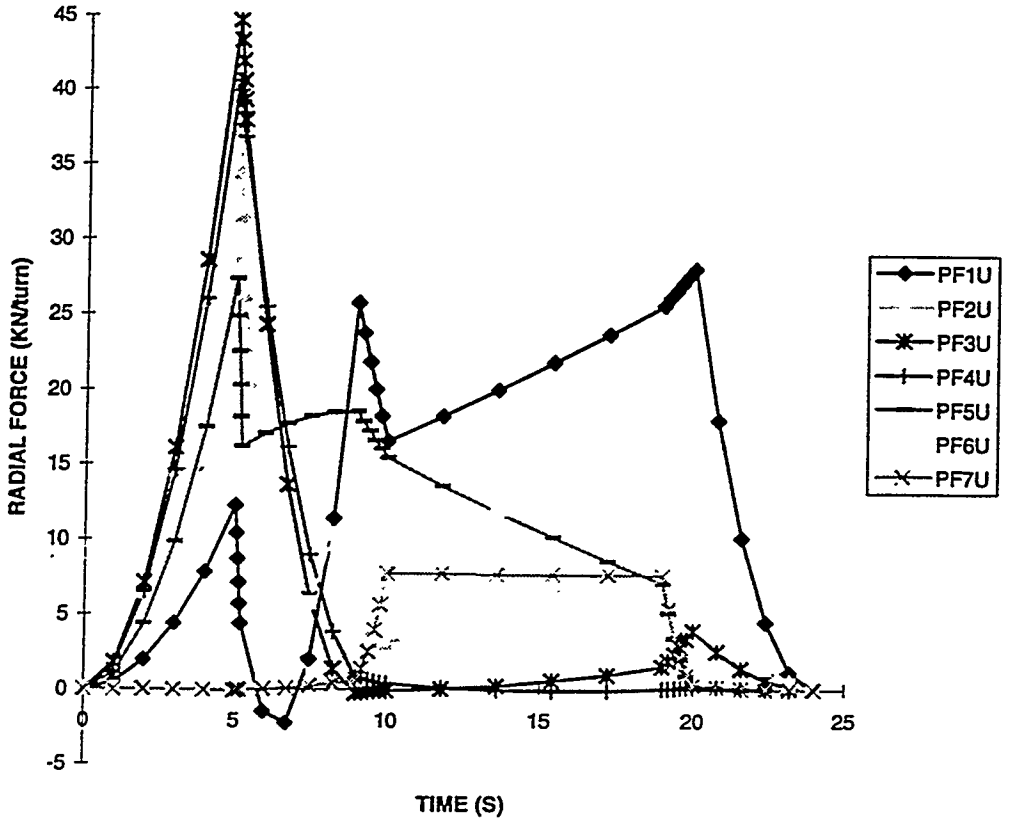


Figure 3.1 — Radial electromagnetic forces acting on PF coils 1-7 during HC scenario.

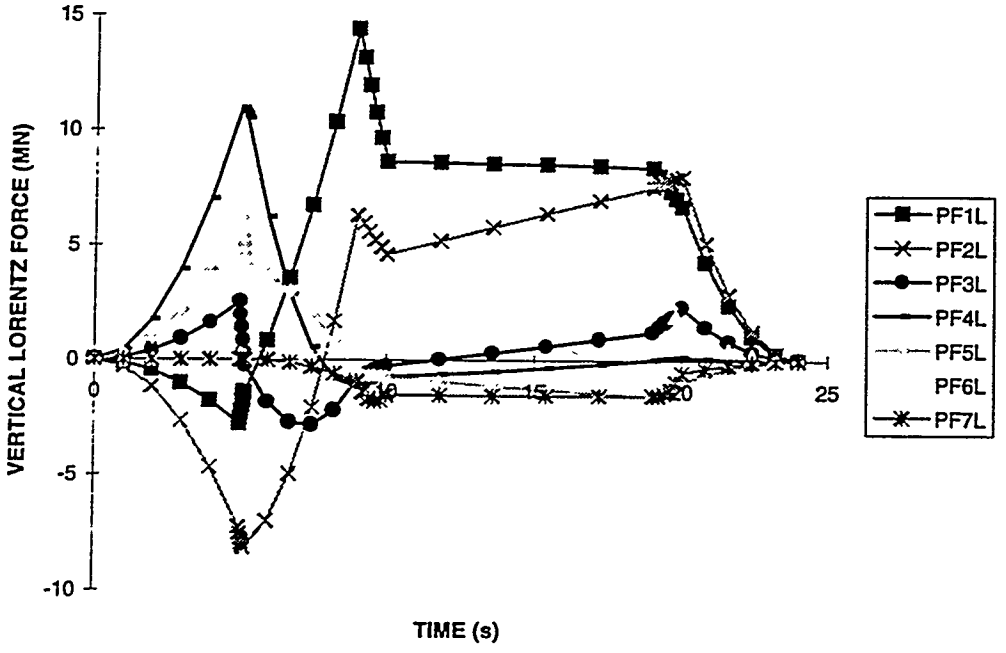


Figure 3.2 — Vertical electromagnetic forces acting on PF coils 1-7 during HC scenario.

stresses internal to the conductor pack. The compressive force component is primarily a result of the interaction of the current in a given coil with its own field. That is, the compressive force is proportional to the square of its current. In order to obtain expressions for the magnitude of the internal force, the following approximate form is assumed for variations throughout the coil cross section.

$$\Delta f_{PFi}^{r} = c_{PFi}^{r} \frac{2(r_c - r)}{r\Delta r} i_{PFi}^{2} \tag{3-3a}$$

$$\Delta f_{PFi}^{z} = c_{PFi}^{z} \frac{2(z_c - z)}{r\Delta z} i_{PFi}^{2} \tag{3-3b}$$

It is noted that if the force density is integrated throughout the cross section a net body force of zero is obtained. Thus, the additional component is purely an internal force distribution.

3.2.1 Internal force coefficients

The force coefficients can be obtained from a finite element solution for each of the PF coils. However, since some of the coils are identical, only six different runs are actually needed for the 14 PF coils. Specifically, the coefficients are determined by applying 1 MA to a given coil, then plotting the resulting Lorentz force on lines through the center of the coil cross section. For example, the field solution for the case of PF2U is shown in Fig. 3.3. The Lorentz force density is plotted on vertical and radial lines passing through the center of the coil cross section in Figs. 3.5a and 3.5b. In the case of the radial component, the force is plotted throughout the vertical center of the coil on a line starting at the inner radius and ending at the outer radius. In the case of the vertical component, the force is plotted throughout the radial center of the coil section on a line starting at the bottom of the coil and ending at the top of the coil. From these plots the radial and vertical force coefficients in (3.4a) and (3.4b) are obtained. The vertical coefficients can be read

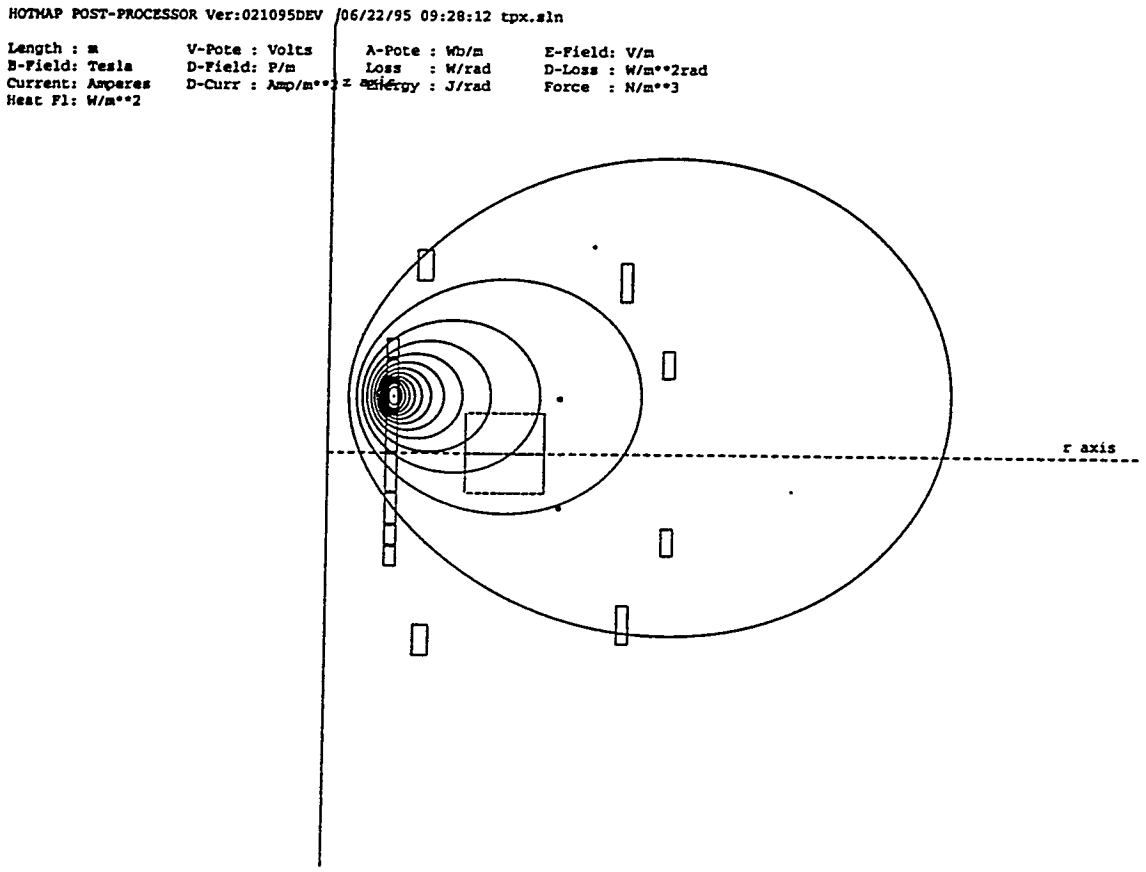


Figure 3.3 — Flux lines from energization of coil PF2U used for determining internal force coefficients associated with PF2.

directly from the plots since the mean value of the vertical force is zero. In the case of PF2 this coefficient is 19.7 MN/(MA^2-m^2). Extracting the radial force coefficient requires slightly more work because of the mean radially outward force component which is superimposed on the results. Here the coefficient is taken as the excursion about the dc force value. For PF2 the radial coefficient is 18.05 MN/(MA^2-m^2). The coefficients are summarized for all seven PF coils in Table 3.4.

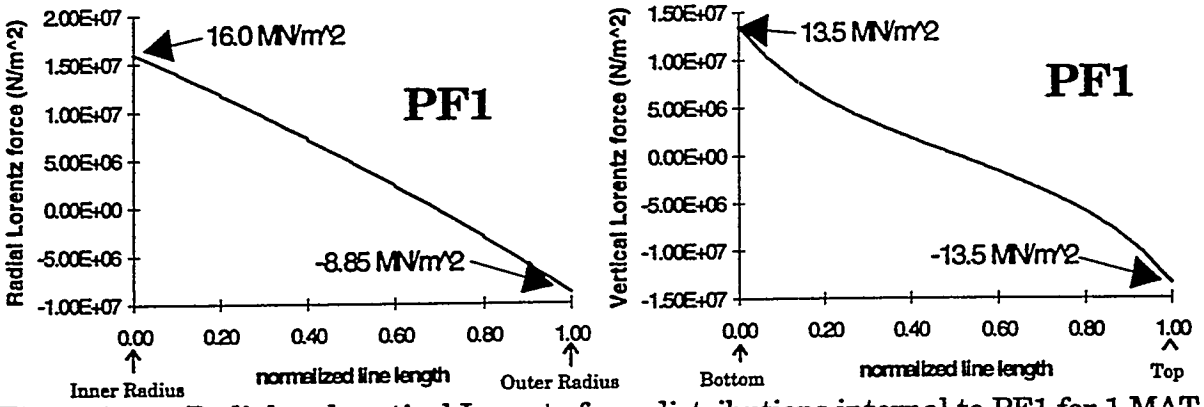


Figure 3.4 — Radial and vertical Lorentz force distributions internal to PF1 for 1 MAT excitation.

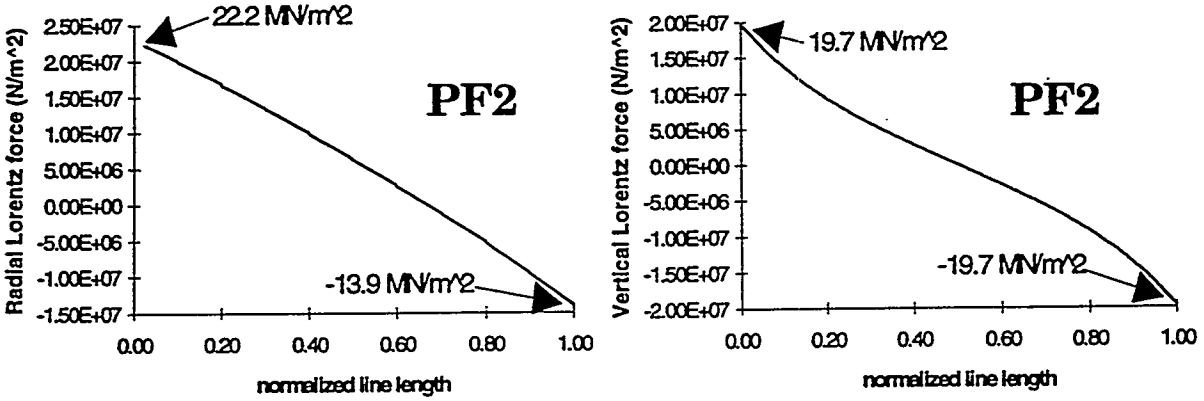


Figure 3.5 — Radial and vertical Lorentz force distributions internal to PF2 for 1 MAT excitation.

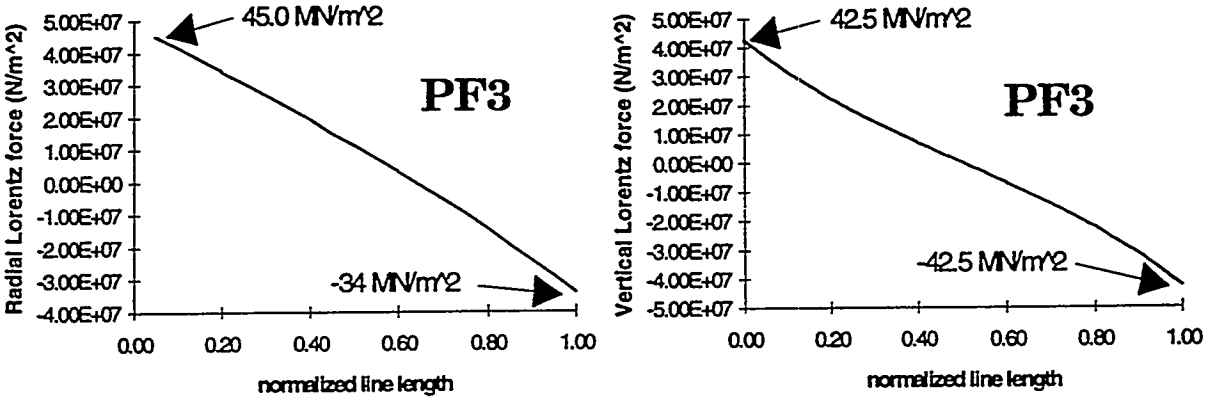


Figure 3.6 — Radial and vertical Lorentz force distributions internal to PF3 for 1 MAT excitation.

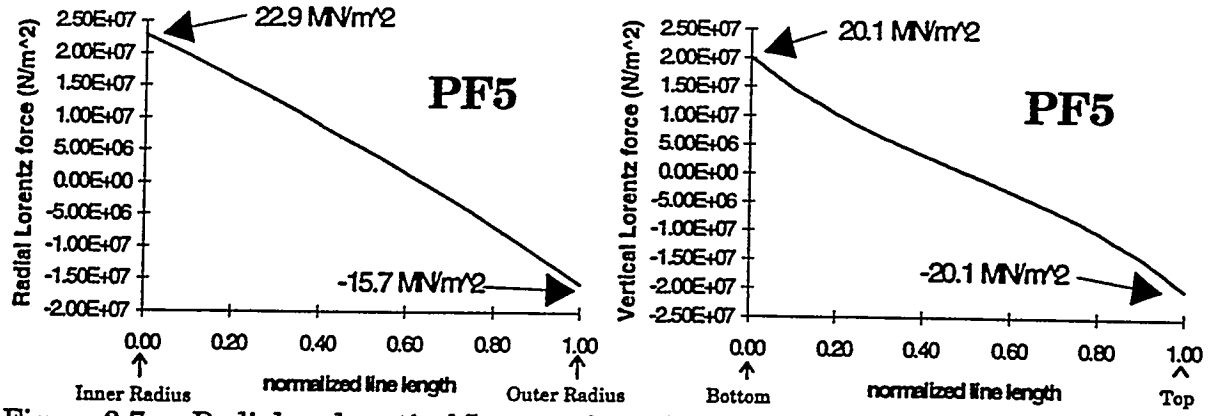


Figure 3.7 — Radial and vertical Lorentz force distributions internal to PF5 for 1 MAT excitation.

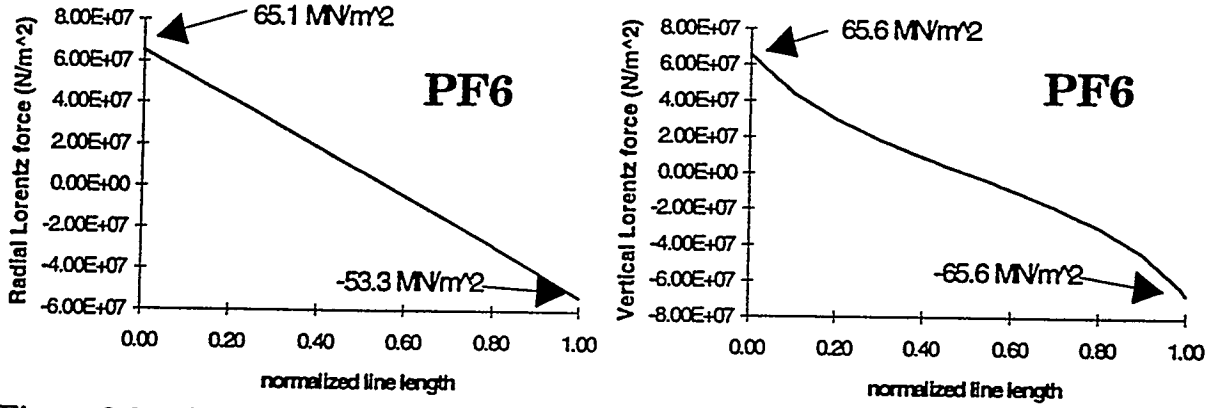


Figure 3.8 — Radial and vertical Lorentz force distribution internal to PF6 for 1 MAT excitation.

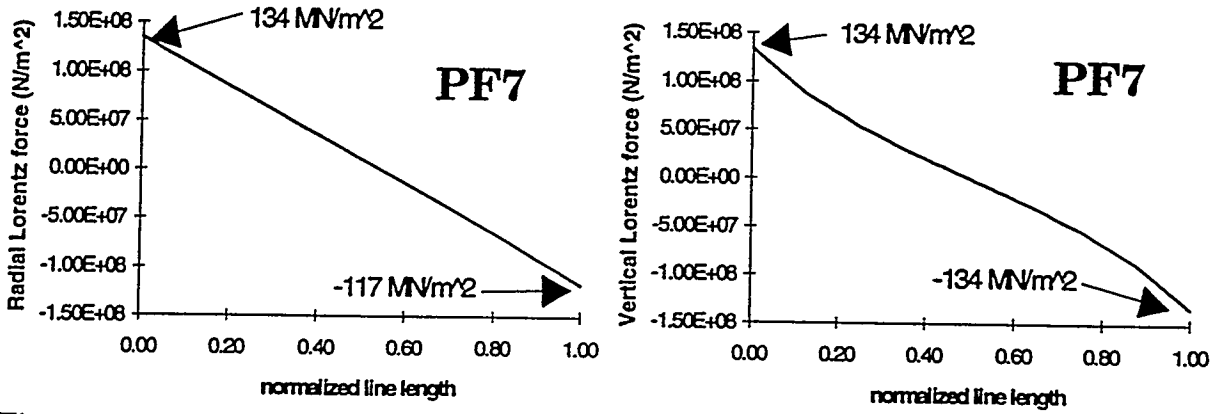


Figure 3.9 — Radial and vertical Lorentz force distribution internal to PF7 for 1 MAT excitation.

Table 3.4 — PF coil compressive force coefficients.

Force Coefficient	PF1	PF2	PF3, PF4	PF5	PF6	PF7
c^r [MN/(MA^2-m^2)]	12.4	18.0	44.0	19.3	59.2	125.5
c^z [MN/(MA^2-m^2)]	13.5	19.7	42.5	20.1	65.6	134.0

3.2.2 Internal forces for 23 equilibria

The radial and vertical internal force components are given in Tables 3.5 and 3.6 for each of the 23 normal operating equilibria established by Pillsbury. The tabulated forces have been obtained by simply considering self field effects assuming the form of equation (3-4). The factor of 2π has not been included in the tabulated forces, so the values should be interpreted as per radian quantities. All the results are positive indicating a compressive force acts internally to reduce the size of each coil. Also shown in the far right column are the maximum internal forces normalized by the conductor length. This basis is used to compare the internal forces for establishing an overall worst case. PF5L possesses the largest internal EM compressive force densities during equilibria #14. This load case also corresponds to largest vertical launch forces on PF5 and will be analyzed in greater detail using a detailed structural model.

In the case of the central solenoid PF1 possesses the largest internal forces during equilibria #11. However, equilibria #16 which produces the largest overall vertical compressive forces, results in nearly the same internal compressive forces as equilibria #11. Equilibria #16 is being analyzed in greater detail using a refined structural model of the PF1L conductor pack. Conductor pack PF3U is also being analyzed in greater detail for the case of equilibria #1. The peak internal compressive forces acting on PF3 occur during this load case, along with the greatest radial per-turn body force.

Table 3.5 — Peak internal radial forces (MN/(m²-radian)) acting on each PF coil during 23 normal operating equilibria.

	PREBLIP	BLIP	SOF	SOB	EOB	EOF	SOF	SOB	0.4, 5.0	0.5, 2.2	0.7, 0.0	1.2, 0.0	1.2, 5.0	0.4, 5.0	0.5, 2.2	0.7,0.0	1.2, 0.0	1.2, 5.0	0.4, 7.0	0.4, 5.0	0.7, 0.0	1.5, 0.0	1.5, 7.0	MAX	MAX DENSITY
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	MN/(m²-radian)	MN/m³
PF1U	10.82	2.41	108.13	68.19	83.63	79.37	0.04	1.76	25.71	66.63	113.62	112.72	65.48	27.64	76.94	111.38	79.06	40.44	9.95	13.62	50.95	38.02	2.26	113.62	140.27
PF1L	10.82	2.41	108.13	68.19	83.63	79.37	0.04	1.76	25.71	66.63	113.62	112.72	65.48	27.64	76.94	111.38	79.06	40.44	9.95	13.62	50.95	38.02	2.26	113.62	140.27
PF2U	96.72	52.82	8.30	7.26	20.96	29.63	10.92	2.49	97.30	70.92	7.86	3.94	1.46	102.65	61.61	10.15	1.05	0.87	79.08	70.50	4.54	8.03	4.10	102.65	126.72
PF2L	96.72	52.82	8.30	7.26	20.96	29.63	10.92	2.49	97.30	70.92	7.86	3.94	1.46	102.65	61.61	10.15	1.05	0.87	79.08	70.50	4.54	8.03	4.10	102.65	126.72
PF3U	92.25	90.35	0.58	0.07	1.52	4.94	29.30	21.50	44.71	21.99	0.81	22.94	4.79	18.82	3.38	4.23	0.89	1.69	40.38	34.38	0.13	17.46	5.67	92.25	113.90
PF3L	92.25	90.35	0.58	0.07	1.52	4.94	29.30	21.50	44.71	21.99	0.81	22.94	4.79	43.04	23.19	1.39	6.19	0.65	40.38	34.38	0.13	17.46	5.67	92.25	113.90
PF4U	86.98	94.31	4.48	2.02	0.00	0.05	46.59	45.24	26.63	10.10	5.15	32.32	5.21	1.38	0.05	8.40	3.70	3.23	25.28	21.25	1.59	20.77	7.69	94.31	116.43
PF4L	86.98	94.31	4.48	2.02	0.00	0.05	46.59	45.24	26.63	10.10	5.15	32.32	5.21	29.95	11.27	0.21	11.09	2.93	25.28	21.25	1.59	20.77	7.69	94.31	116.43
PF5U	148.09	86.74	216.34	183.68	117.27	28.21	52.35	58.84	222.71	178.72	218.93	184.16	163.88	65.27	43.89	69.09	89.46	37.50	152.07	135.53	86.17	60.06	151.10	222.71	183.61
PF5L	148.09	86.74	216.34	183.68	117.27	28.21	52.35	58.84	222.71	178.72	218.93	184.16	163.88	237.37	201.85	224.82	131.98	152.39	152.07	135.53	86.17	60.06	151.10	237.37	195.69
PF6U	0.78	0.53	176.77	67.78	73.60	99.74	3.21	1.52	334.49	318.09	189.05	17.71	30.69	221.66	217.78	133.20	0.84	1.06	196.31	210.13	83.83	0.31	0.01	334.49	88.99
PF6L	1.28	0.95	170.32	63.81	69.46	94.91	4.15	2.18	325.60	309.42	182.38	15.71	28.04	323.93	323.38	207.28	20.97	20.48	189.51	203.09	79.41	0.64	0.02	325.60	86.63
PF7U	1.81	0.28	5.12	102.79	104.84	3.21	14.94	17.37	9.15	0.41	2.71	107.38	201.78	16.17	1.93	3.58	109.95	200.83	46.39	14.17	1.21	75.96	196.09	201.78	46.96
PF7L	1.81	0.28	5.12	102.79	104.84	3.21	14.94	17.37	9.15	0.41	2.71	107.38	201.78	16.17	1.93	3.58	109.95	200.83	46.39	14.17	1.21	75.96	196.09	201.78	46.96

Table 3.6 — Peak internal vertical forces (MN/(m²-radian)) acting on each PF coil during 23 normal operating equilibria.

	PREBLIP	BLIP	SOF	SOB	EOB	EOF	SOF	SOB	04, 5.0	0.5, 2.2	0.7, 0.0	1.2, 0.0	1.2, 5.0	0.4, 5.0	0.5, 2.2	0.7,0.0	1.2, 0.0	1.2, 5.0	0.4, 7.0	0.4, 5.0	0.7, 0.0	1.5, 0.0	1.5, 7.0	MAX	MAX DENSITY
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	MN/(m²-radian)	MN/m³
PF1U	11.78	2.63	117.72	74.24	91.05	86.41	0.05	1.92	27.99	72.54	123.70	122.72	71.29	30.09	83.77	121.26	86.07	44.03	10.84	14.83	55.47	41.39	2.46	123.70	152.71
PF1L	11.78	2.63	117.72	74.24	91.05	86.41	0.05	1.92	27.99	72.54	123.70	122.72	71.29	30.09	83.77	121.26	86.07	44.03	10.84	14.83	55.47	41.39	2.46	123.70	152.71
PF2U	105.85	57.81	9.08	7.94	22.94	32.43	11.95	2.73	106.49	77.62	8.61	4.31	1.60	112.34	67.42	11.11	1.15	0.95	86.55	77.15	4.96	8.79	4.48	112.34	138.69
PF2L	105.85	57.81	9.08	7.94	22.94	32.43	11.95	2.73	106.49	77.62	8.61	4.31	1.60	112.34	67.42	11.11	1.15	0.95	86.55	77.15	4.96	8.79	4.48	112.34	138.69
PF3U	89.11	87.27	0.56	0.07	1.47	4.77	28.30	20.77	43.18	21.24	0.79	22.15	4.63	18.18	3.26	4.08	0.86	1.63	39.00	33.21	0.12	16.87	5.48	89.11	110.01
PF3L	89.11	87.27	0.56	0.07	1.47	4.77	28.30	20.77	43.18	21.24	0.79	22.15	4.63	41.57	22.40	1.35	5.98	0.63	39.00	33.21	0.12	16.87	5.48	89.11	110.01
PF4U	84.02	91.09	4.32	1.95	0.00	0.04	45.00	43.70	25.72	9.75	4.97	31.21	5.03	1.33	0.05	8.12	3.57	3.12	24.42	20.53	1.53	20.06	7.43	91.09	112.46
PF4L	84.02	91.09	4.32	1.95	0.00	0.04	45.00	43.70	25.72	9.75	4.97	31.21	5.03	28.93	10.88	0.20	10.71	2.83	24.42	20.53	1.53	20.06	7.43	91.09	112.46
PF5U	154.23	90.34	225.30	191.30	122.13	29.38	54.52	61.28	231.95	186.12	228.00	191.79	170.68	67.98	45.71	71.95	93.17	39.06	158.37	141.15	89.74	62.55	157.36	231.95	191.22
PF5L	154.23	90.34	225.30	191.30	122.13	29.38	54.52	61.28	231.95	186.12	228.00	191.79	170.68	247.21	210.22	234.14	137.45	158.71	158.37	141.15	89.74	62.55	157.36	247.21	203.80
PF6U	0.87	0.59	195.88	75.11	81.56	110.52	3.56	1.68	370.65	352.48	209.49	19.63	34.01	245.62	241.32	147.60	0.93	1.18	217.53	232.84	92.90	0.34	0.01	370.65	98.62
PF6L	1.41	1.05	188.74	70.71	76.97	105.17	4.60	2.41	360.80	342.87	202.10	17.41	31.07	358.95	358.34	229.69	23.24	22.70	210.00	225.05	88.00	0.71	0.02	360.80	96.00
PF7U	1.93	0.30	5.47	109.75	111.94	3.43	15.95	18.54	9.77	0.44	2.90	114.65	215.45	17.27	2.06	3.83	117.40	214.43	49.53	15.13	1.29	81.11	209.38	215.45	50.14
PF7L	1.93	0.30	5.47	109.75	111.94	3.43	15.95	18.54	9.77	0.44	2.90	114.65	215.45	17.27	2.06	3.83	117.40	214.43	49.53	15.13	1.29	81.11	209.38	215.45	50.14

3-15

3.3 FORCE VARIATIONS DUE TO TF COIL INTERACTION

The force variations acting on the PF coils due to the interaction with the 16 discrete TF coils can be expressed in terms of the product of the individual currents and a spatial function which describes the angular variation. Mathematically, this can be expressed as:

$$\Delta f^{r}_{PFi} = f(16\phi) i_{PFi} i_{tf} \approx c^{r}_{PFi} i_{PFi} i_{tf} \sin(16\phi) \tag{3.4a}$$

$$\Delta f^{z}_{PFi} = g(16\phi) i_{PFi} i_{tf} \approx c^{z}_{PFi} i_{PFi} i_{tf} \sin(16\phi) \tag{3.4b}$$

where ϕ is the toroidal angle referenced to zero down the positive x-axis and positive for counterclockwise rotations looking down from the top of the machine. The spatial functions are periodic in the number of TF coils and can be approximated with a single term from the Fourier expansion. Since the TF current is set at 33.5 kA, the alternating component of force is simply proportional to the level of current in the individual PF coils. The proportionality constants are obtained by Fourier analyzing the results obtained in Section 2.2.3 for start of flattop - HC scenario. The dc terms and first four harmonics of the Fourier decomposition of the forces are given in Table 3-7 for PF coils 5U, 6U, and 7U. General expressions for the alternating component of force can be obtained in from this decomposition. The expressions which follow are written as general functions of current (actually megaampere-turns) in the i'th coil by simply normalizing by the current used in Section 2.2.3. Harmonics greater than 1 have been truncated.

$$\Delta f^{r}_{PF5U} = 24.25 i_{PF5U} \sin(16\phi) \qquad kN/m$$

$$\Delta f^{z}_{PF5U} = 32.83 i_{PF5U} \sin(16\phi) \qquad kN/m$$

$$\Delta f^{r}_{PF6U} = 250.3 i_{PF6U} \sin(16\phi) \qquad kN/m$$

$$\Delta f^{z}_{PF6U} = -228.2 i_{PF6U} \sin(16\phi) \qquad kN/m$$

$$\Delta f^{r}_{PF7U} = 102.2 i_{PF7U} \sin(16\phi) \qquad kN/m$$

$$\Delta f^{r}_{PF7U} = -366.1 i_{PF7U} \sin(16\phi) \qquad kN/m$$

It is assumed that the current is input in units of MA-Turns and the force perturbation is in units of kN per meter of conductor length. The cases of the lower coils are handled by a changing the sign of the force perturbation in the case of the radial component, but keeping it the same in the case of the vertical force component. Given these force relationships, the variations for the 23 static equilibria are calculated and shown in Tables 3-8 and 3-9.

Table 3.7 – Harmonic decomposition of electromagnetic forces acting on PF5U, PF6U and PF7U for start of flattop - HC scenario.

Harmonic	PF5U-RADIAL (N/m)	PF5U-VERTICAL (N/m)	PF6U-RADIAL (N/m)	PF6U-VERTICAL (N/m)	PF7U-RADIAL (N/m)	PF7U-VERTICAL (N/m)
dc	1,841,267.0	75,720.4	1,019,305.0	141,953.4	11,585.7	34,017.7
sin(16ϕ)	81,193.9	109,944.0	-425,231.3	387,771.0	-20,652.1	73,961.5
sin(2*16ϕ)	-243.6	-136.1	-71,772.2	68,512.8	-3,658.1	14,208.3
sin(3*16ϕ)	-43.3	-52.1	-12,075.6	11,306.8	-610.4	2,452.5
sin(4*16ϕ)	1.2	0.7	-1,706.7	1,123.6	-79.9	323.4

Table 3.8 – Magnitude of radial force perturbations on PF5, 6 and 7 for the 23 static current equilibria.

RADIAL Force perturbation (kN/(m-turn))	1	2	3	4	5	6	7	8	9	10	11
PF5U	0.524785	0.401641	0.634289	0.584463	0.467002	0.229049	0.312029	0.330785	0.643572	0.576506	0.638078
PF5L	-0.524785	-0.401641	-0.634289	-0.584463	-0.467002	-0.229049	-0.312029	-0.330785	-0.643572	-0.576506	-0.638078
PF6U	0.239871	0.198154	-3.60432	-2.231842	-2.325704	-2.707412	0.485999	0.333733	-4.958026	-4.834962	-3.727384
PF6L	-0.3062	-0.264484	3.537991	2.165512	2.259375	2.641082	-0.552329	-0.400063	4.891696	4.768632	3.661055
PF7U	0.146	0.057183	-0.245767	-1.101083	-1.112033	-0.194667	-0.41975	-0.4526	-0.3285	-0.06935	-0.17885
PF7L	-0.146	-0.057183	0.245767	1.101083	1.112033	0.194667	0.41975	0.4526	0.3285	0.06935	0.17885

RADIAL Force perturbation (kN/(m-turn))	12	13	14	15	16	17	18	19	20	21	22	23
PF5U	0.585221	0.552066	0.348404	0.285695	0.358445	0.407893	0.264098	0.531795	0.502051	0.400314	0.334195	0.53009
PF5L	-0.585221	-0.552066	-0.664412	-0.612691	-0.646604	-0.49542	-0.532363	-0.531795	-0.502051	-0.400314	-0.334195	-0.53009
PF6U	-1.140951	-1.5018	-4.036088	-4.000628	-3.12875	-0.248214	-0.279502	-3.798303	-3.92971	-2.482142	0.15018	-0.029202
PF6L	1.074621	1.435471	4.879181	4.87501	3.903011	1.241488	1.226887	3.731973	3.863381	2.415812	-0.21651	-0.037128
PF7U	-1.125417	-1.542733	-0.436783	-0.150867	-0.205617	-1.1388	-1.539083	-0.739733	-0.4088	-0.119233	-0.946567	-1.520833
PF7L	1.125417	1.542733	0.436783	0.150867	0.205617	1.1388	1.539083	0.739733	0.4088	0.119233	0.946567	1.520833

Table 3.9 – Magnitude of vertical force perturbations on PF5, 6 and 7 for the 23 static current equilibria.

VERTICAL Force perturbation (kN/m)	1	2	3	4	5	6	7	8	9	10	11
PF5U	90.9391	69.5996	109.9148	101.2806	80.92595	39.69147	54.07101	57.32118	111.5235	99.90169	110.5714
PF5L	90.9391	69.5996	109.9148	101.2806	80.92595	39.69147	54.07101	57.32118	111.5235	99.90169	110.5714
PF6U	-26.243	-21.679	394.3296	244.174	254.443	296.2036	-53.1706	-36.512	542.4314	528.9676	407.7934
PF6L	-33.49976	-28.93576	387.0728	236.9172	247.1862	288.9468	-60.42736	-43.76876	535.1746	521.7108	400.5366
PF7U	-43.932	-17.2067	73.9522	331.3205	334.6154	58.576	126.3045	136.1892	98.847	20.8677	53.8167
PF7L	-43.932	-17.2067	73.9522	331.3205	334.6154	58.576	126.3045	136.1892	98.847	20.8677	53.8167

VERTICAL Force perturbation (kN/(m)	12	13	14	15	16	17	18	19	20	21	22	23
PF5U	101.4119	95.66662	60.37437	49.50764	62.11436	70.68299	45.76502	92.15381	86.9995	69.36979	57.91212	91.85834
PF5L	101.4119	95.66662	115.1348	106.1722	112.0488	85.85045	92.2523	92.15381	86.9995	69.36979	57.91212	91.85834
PF6U	124.8254	164.304	441.567	437.6876	342.3	27.1558	30.5788	415.5522	429.9288	271.558	-16.4304	3.1948
PF6L	117.5686	157.0472	533.8054	533.349	427.01	135.8246	134.2272	408.2954	422.672	264.3012	-23.68716	-4.06196
PF7U	338.6425	464.2148	131.4299	45.3964	61.8709	342.6696	463.1165	222.5888	123.0096	35.8778	284.8258	457.625
PF7L	338.6425	464.2148	131.4299	45.3964	61.8709	342.6696	463.1165	222.5888	123.0096	35.8778	284.8258	457.625

3.4 FORCE VARIATIONS DUE TO PF COIL MISALIGNMENTS

The force variations acting on the PF coils due to slight horizontal and vertical misalignments can be expressed in terms of the system currents and magnitude of the offset. For example, the horizontal force on PF1U due to a slight horizontal offset can be expressed as:

$$\Delta f^{x}_{PF1U} = i_{PF1U}\delta x_{PF1U}\left(\sum_{i=2}^{7} a_i i_{PF1U} + \sum_{i=1}^{7} b_i i_{PF1L}\right) \tag{3-5a}$$

where δx is the magnitude of the offset in the horizontal direction, i_{PFUi} and i_{PFLi} are currents in the i'th upper and lower PF coils, and the coefficients, a_i and b_i, relate the horizontal body force component acting on PF1U from another PF coil. The resulting force perturbation is positive if the body force is in the direction of the offset and negative the body force opposes the offset. Similar expressions can be obtained for the horizontal force acting on any of the PF coils. The case of a vertical misalignment can be treated in the same way. That is, the force on a coil due to a vertical offset is expressed as:

$$\Delta f^{z}_{PF1U} = i_{PF1U}\delta z_{PF1U}\left(\sum_{i=2}^{7} c_i i_{PF1U} + \sum_{i=1}^{7} d_i i_{PF1L}\right) \tag{3-5b}$$

where δz is the magnitude of the offset in the vertical direction, i_{PFUi} and i_{PFLi} are currents in the i'th upper and lower PF coils, and the coefficients, c_i and d_i, relate the change vertical body force component acting on PF1U from a single other PF coil.

3.4.1 Forces resulting from vertical and horizontal coil misalignments

In general the force perturbations due to coil vertical misalignments on the order of 1 cm are expected to be small relative to the nominal vertical forces acting on the individual coil. For example, the maximum vertical force acting on PF5U for any of the 23 equilibria is 6.31 MN downward for equilibria #1. If the coil is vertically misaligned (moved downward) by 1 cm, then the force increases by 0.08 MN to 6.39 MN. This small perturbation in force will have no impact on the design

of the PF5 supports. As a result of this argument, the effects of vertical misalignments are not considered further.

Perhaps of greater importance is the horizontal force which is normally zero for perfectly aligned coils, but is nonzero due to a horizontal misalignment. Knowledge of this loading is important, since the overall structure must be designed to react the load. The case where the central solenoid is misaligned by 1 cm has been analyzed in detail and the results are summarized in Table 3-10. Given in the table are the forces on each of the individual coils in the PF system along with the net force acting on the PF1-4 coils forming the central solenoid. Also given is the sum of the forces for the entire PF system of coils. This quantity is known to be identically zero, but is slightly inaccurate due to numerical errors in the calculation. It can be observed that the residual is indeed small relative to the individual coil forces so that the calculation is indeed capable of resolving the small offset forces. Examination of the net CS forces indicates that for some cases the force tends to try to center the CS and in other cases the force is in the same direction as that of the offset. The maximum occurs for equilibria #1 where the force is 83.6 kN restoring. The maximum force in the direction of the offset is 40.7 kN for equilibria #10.

The cases of a 1 cm horizontal offset in PF5U, PF6U and PF7U have also been analyzed. The current loadings analyzed for these cases are PF5U: EQ #1, PF6U: EQ #19, and PF7U: EQ #19. These load cases were chosen since the vertical forces were largest; therefore, the horizontal forces are also expected to be large. The results are summarized in Table 3-11. The restoring force on PF5U, PF6U and PF7U is 42.3 kN, 19.0 kN and 17.7 kN, respectively. The trend that appears is the larger the coil diameter, the smaller the horizontal restoring force for a 1 cm offset.

Table 3.10 – Horizontal body forces (in MN) due to 1 cm horizontal offset of the central solenoid for each of the 23 equilibria.

Coil	EQ-1	EQ-2	EQ-3,	EQ-4	EQ-5	EQ-6	EQ-7	EQ-8	EQ-9	EQ-10	EQ-11
PF1U	-0.003044	-0.001057	0.000727	0.000464	-0.001408	-0.002984	8.17E-05	-0.000558	-0.000228	-0.000496	0.000753
PF1L	-0.003046	-0.001056	0.000723	0.00046	-0.001412	-0.002988	8.16E-05	-0.000557	-0.00023	-0.0005	0.000748
PF2U	-0.011488	-0.006498	0.003155	0.00278	0.003518	0.001552	-0.002176	-0.001108	0.00954	0.008031	0.003085
PF2L	-0.011478	-0.006492	0.003153	0.002777	0.003514	0.001547	-0.002173	-0.001106	0.009531	0.008023	0.003082
PF3U	-0.011249	-0.008603	-0.001119	-0.000365	0.001372	0.001213	-0.00387	-0.003519	0.009004	0.006274	-1.33E-03
PF3L	-0.011242	-0.008597	-0.001118	-0.000365	0.001371	0.001211	-0.003866	-0.003516	0.009000	0.006271	-0.001329
PF4U	-0.016036	-0.012884	-0.004762	-0.002974	9.07E-05	0.000185	-0.007213	-0.00754	1.07E-02	0.006573	-0.005132
PF4L	-0.01603	-0.01288	-0.00476	-0.002973	9.07E-05	0.000185	-0.007208	-0.007536	0.010717	0.006571	-0.005131
PF5U	0.0421	0.02908	-0.010389	-0.009084	-0.013811	-0.007751	0.013002	0.012725	-0.036448	-0.031418	-0.010118
PF5L	0.0421	0.029082	-0.010389	-0.009084	-0.013811	-0.007751	0.013002	0.012725	-0.036448	-0.031418	-0.010118
PF6U	-2.15E-05	-2.39E-05	0.000597	0.000285	0.000277	0.000301	-4.79E-05	-2.59E-05	-3.05E-05	0.000302	0.000639
PF6L	-2.75E-05	-3.2E-05	0.000586	0.000277	0.000269	0.000293	-5.45E-05	-3.1E-05	-3.01E-05	0.000298	0.000627
PF7U	-0.000191	-6.07E-05	-0.00019	-0.000718	-0.001002	-0.000188	0.000219	0.000229	-0.000402	-8.57E-05	-0.000139
PF7L	-0.000191	-6.07E-05	-0.00019	-0.000718	-0.001002	-0.000188	0.000219	0.000229	-0.000402	-8.57E-05	-0.000139
ICU	-9.69E-05	0.000169	0	0	0	0	0	0	0	0	0
ICL	-9.69E-05	0.000169	0	0	0	0	0	0	0	0	0
TF INTER	3.2E-05	2.26E-05	-3.37E-05	-2.77E-05	-3.43E-05	-3.58E-05	8.36E-06	9.22E-06	-3.53E-05	-4.03E-05	-3.42E-05
PLASMA	0	-0.000277	0.023994	0.019256	0.02197	0.015397	-3.73E-06	-0.000418	0.015724	0.021684	2.45E-02
Sum F	-5.89E-06	1.32E-06	-1.39E-05	-9.71E-06	-8.57E-06	-1.51E-06	1.96E-06	3.15E-06	-1.57E-05	-1.75E-05	-1.47E-05
CS sum	-0.083613	-0.058067	-0.004002	-0.000196	0.007134	-7.85E-05	-0.026342	-0.02544	0.058055	0.040747	-0.005254

Coil	EQ-12	EQ-13	EQ-14	EQ-15	EQ-16	EQ-17	EQ-18	EQ-19	EQ-20	EQ-21	EQ-22	EQ-23
PF1U	0.000776	0.000587	-0.001353	-0.00335	-2.73E-03	-0.000781	-0.001051	0.000219	0.000199	0.00027	0.000599	0.000695
PF1L	0.000771	0.000583	-0.000298	-0.001529	-8.02E-04	-0.000225	4.58E-05	0.000218	0.000197	0.000267	0.000596	0.000694
PF2U	-0.002059	0.001204	0.005434	0.003005	1.73E-03	0.000704	0.000418	0.008362	0.007352	0.001467	-0.001753	-0.002189
PF2L	-0.002057	0.001203	0.011101	0.007549	3.35E-03	0.000881	0.000866	0.008354	0.007344	0.001465	-0.00175	-0.002188
PF3U	-0.0066	-0.0029	0.0037	0.0013	-1.79E-03	-0.0009	-0.0009	0.0079	0.0069	-0.0003	-0.0033	-0.0030
PF3L	-0.006565	-0.002869	0.009959	0.006703	1.73E-03	-0.002903	-0.001004	0.007945	0.006877	-0.000331	-0.003292	-0.00297
PF4U	-0.011861	-0.004538	0.001572	-0.000254	-3.92E-03	-0.002849	-0.001851	0.009613	0.008294	-0.001792	-0.005416	-0.005138
PF4L	-0.011857	-0.004537	0.012857	0.007285	-1.04E-03	-0.005932	-0.003241	0:00961	0.008292	-0.001791	-0.005413	-0.005139
PF5U	0.00875	-0.002624	-0.016157	-0.010665	-4.46E-03	-0.003858	-0.001238	-0.030012	-0.02701	-0.005039	0.006594	0.008658
PF5L	0.00875	-0.002624	-0.042714	-0.033412	-1.72E-02	-0.000963	-0.003167	-0.030012	-0.02701	-0.005039	0.006594	0.008658
PF6U	0.000249	0.000213	0.000415	0.000687	7.12E-04	2.95E-05	3.19E-05	-0.000112	-6.48E-05	0.000276	-2.17E-05	-2.64E-09
PF6L	0.000235	0.000204	-0.000274	7.67E-05	3.75E-04	0.000233	0.000125	-0.00011	-6.37E-05	0.000268	-3.13E-05	-2.17E-06
PF7U	-0.000338	-0.000736	-0.000456	-0.000158	-1.49E-04	-0.000658	-0.000595	-0.00076	-0.000413	-6.54E-05	-5.45E-06	0.000242
PF7L	-0.000338	-0.000736	-0.000556	-0.000192	-1.89E-04	-0.000542	-0.000625	-0.00076	-0.000413	-6.54E-05	-5.45E-06	0.000242
ICU	0	0	0	0	0	0	0	0	0	0	0	0
ICL	0	0	0	0	0	0	0	0	0	0	0	0
TF INTER	-0.000035	-2.35E-05	-3.88E-05	-4.33E-05	-3.74E-05	-2.44E-05	-1.91E-05	-2.81E-06	-2.84E-05	-2.35E-05	-9.9E-06	7.12E-07
PLASMA	2.21E-02	1.76E-02	1.68E-02	2.30E-02	2.44E-02	1.78E-02	1.22E-02	9.51E-03	9.55E-03	1.05E-02	6.61E-03	1.41E-03
Sum F	-1.62E-05	-7.08E-06	-1.16E-05	-8.8E-06	-7.62E-06	-4.1E-06	-2.16E-06	1.22E-05	-1.22E-05	-5.95E-06	-3.16E-07	7.62E-07
CS sum	-0.039421	-0.011238	0.04301	0.020718	-0.003477	-0.012018	-0.006699	0.052269	0.045437	-0.000776	-0.019723	-0.019204

Table 3.11 – Horizontal body forces (in MN) due to 1 cm horizontal offset of PF5U, PF6U and PF7U.

Coil	1 cm horizontal offset in PF5U for equilibria 1	1 cm horizontal offset in PF6U for equilibria 19	1 cm horizontal offset in PF5U for equilibria 19
PF1U	2.07E-03	2.30E-05	-1.01E-04
PF1L	1.01E-03	1.30E-04	-5.63E-05
PF2U	1.02E-02	-3.29E-04	3.09E-04
PF2L	1.38E-03	3.98E-04	-4.24E-05
PF3U	1.07E-02	-3.14E-04	-1.52E-04
PF3L	5.71E-04	1.89E-04	4.49E-06
PF4U	1.57E-02	-3.54E-04	-1.19E-04
PF4L	4.10E-04	1.46E-04	1.47E-05
PF5U	-4.23E-02	4.93E-03	4.74E-04
PF5L	5.58E-04	-8.82E-04	-2.89E-04
PF6U	-3.08E-04	-1.90E-02	1.25E-02
PF6L	7.03E-05	4.19E-03	2.60E-03
PF7U	-9.24E-05	1.24E-02	-1.77E-02
PF7L	5.62E-05	2.64E-03	2.19E-03
ICU	2.74E-05	0.00E+00	0.00E+00
ICL	2.74E-05	0.00E+00	0.00E+00
TF INTER	-1.32E-04	1.11E-04	-8.00E-05
PLASMA	0.00E+00	-4.23E-03	1.11E-03
Sum F	-6.51E-06	4.96E-05	0.00064
CS sum	0.042102	-0.000112	-0.000142

4. SUMMARY OF WORST CASE EM LOADING ON PF COILS

Several contributions to evaluating the worst case forces for different electromagnetic events (i.e., normal operating conditions[4,8] various disruption[9] and fault scenarios[10-14,24]) have been made to date. These go into great detail analyzing transient events and specifying points in time and PF coil force components that appear to be particularly severe. The results have been further filtered by Schultz[15] to reduce the number of "interesting events" from a few thousand to roughly 20 affecting the PF coils. However, in addition to identifying the load cases of concern, a more complete definition of all the forces acting on the coil packs is required. This includes defining the force components (radial and vertical) simultaneously, defining the temporal behavior of the force components, defining the compressive stress components due to externally applied prestress and thermal contraction particularly in the case of the central solenoid, and including the internal forces and spatial variations due to the TF coils. This section goes a step further in defining the forces acting on the PF coil packs and summarizes the most severe electromagnetic forces to be used in more detailed structural analyses of the PF coil systems.

4.1 MAXIMUM RADIAL AND VERTICAL LOADS

4.1.1 Body EM Loads on the Central Solenoid

The PF coils have been broken down into four different coil systems: the central solenoid, PF5, PF6 and PF7. The worst case electromagnetic forces acting on the coils in the central solenoid are summarized in Fig. 4.1. Shown in Fig. 4.1 are both the radial and vertical compressive components of force throughout the HC

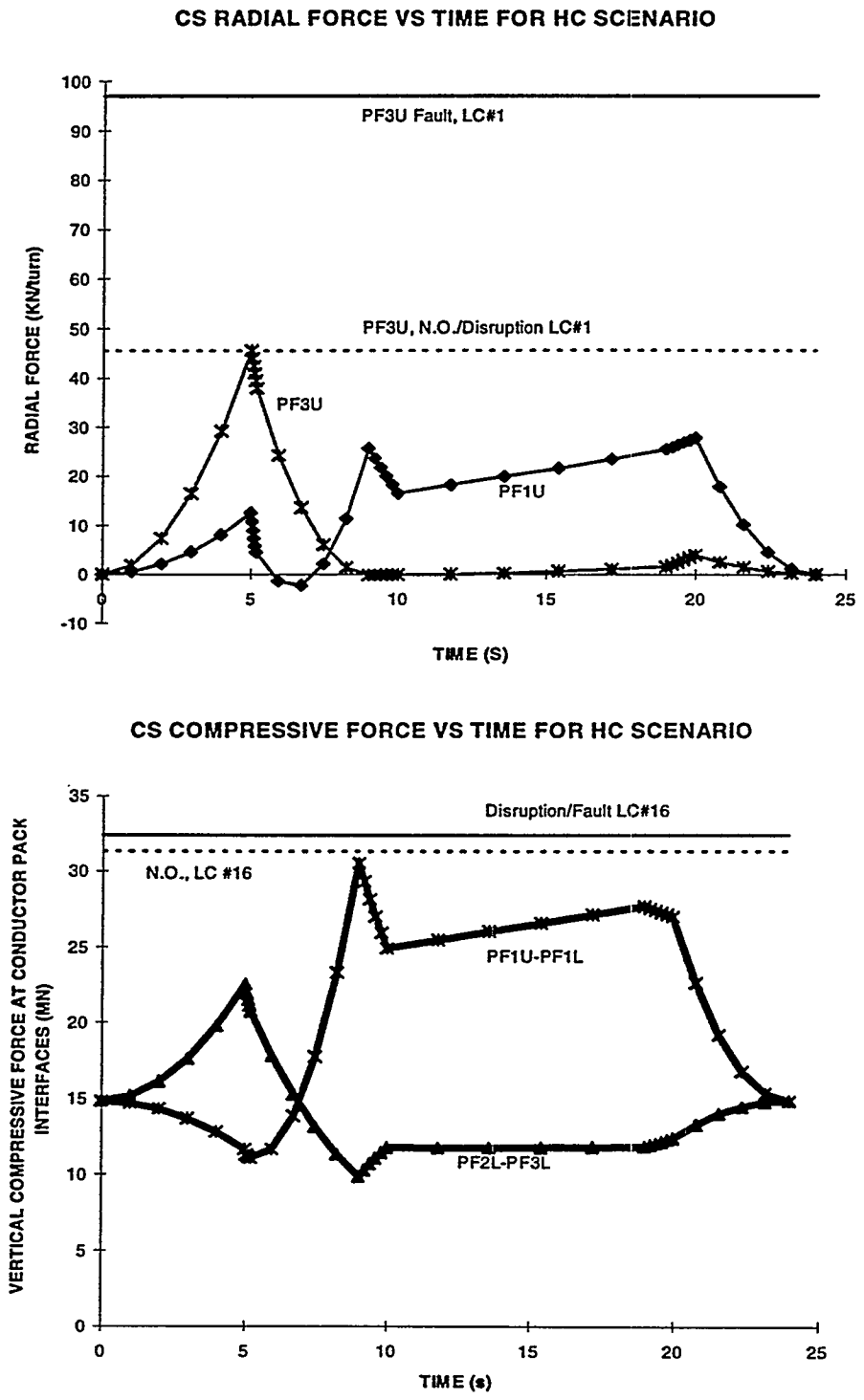


Figure 4.1 — Maximum Radial and vertical compressive forces acting on the CS. The radial forces are of electromagnetic origin. The vertical compressive forces include prestress and cooldown effects in addition to electromagnetic forces.

scenario. The radial force case represents the radial Lorentz force acting on coils PF3U and PF1U presented on an averaged per turn (per radian) basis so that it is equivalent to the average hoop load per turn. These two coils are of primary interest since the maximum compressive force occurs on PF1 and the maximum radial force occurs on PF3. The vertical compressive component of force is more involved because it contains contributions from prestress and cooldown, in addition to the vertical Lorentz forces acting on each of the coils in the CS. A structural analysis[16] was performed in order to determine the prestress required to maintain vertical compressive loading (currently set to 15 MN cold). Then, a second set of runs were made to determine the coil interface force profiles throughout the HC scenario. The forces are presented in Fig. 4.1b as acting through the PF1U-PF1L and PF2L-PF3L coil-to-coil interfaces where analysis shows the compression is largest.

It is recognized that the maximum force or force component does not necessarily occur during the HC scenario, but may occur during steady-state operation in the extended li-β-q space. Consequently, in addition to the HC scenario, the maximum forces from the 23 normal operating equilibria points[3] are also superimposed on Fig. 4.1 as a dashed line. In the case of the radial force, the t=5 point coincides with the maximum equilibria #1. However, in the case of the compressive force, equilibria #16 is slightly larger than maximum predicted throughout the HC scenario. Nevertheless, the HC scenario is considered to be characteristic of the general temporal force data since the peak force levels are similar.

It is also pointed out that reference 15 identified equilibria #15 as the maximum compressive force acting on the PF1U/PF1L interface. However, a more detailed structural analysis[16] which accounts for the individual conductor pack stiffnesses indicated that equilibria #16 is actually more severe than #15. As a result, equilibria #16 has been adopted to examine the worst case conductor pack compression.

In addition to the normal operating conditions described by the twenty-three equilibria points, the worst case disruption and fault loadings are also superimposed on Fig. 4.1a. In the case of the radial forces the worst case disruption is less than the normal operating force. This occurs because the normal operating case corresponds to Pillsbury's equilibria #1 (i.e., prebias) where there is no plasma current. As a result, no disruptions can occur for this case. Further, in the other load cases where plasma disruptions can occur, the resulting forces are smaller than in equilibria #1. The fault case corresponds to a sudden short circuit of PF3U and results in a significantly higher force as indicated by the solid line in Fig. 4.1a.

In the case of the compressive forces, the disruption was approximated based on the force amplification associated with a disruption from equilibria #15. Specific data was not requested for equilibria #16 disruption, since it was originally thought that equilibria #15 was the most severe. The fault case is no greater than that of the disruption. That is, the maximum vertical compressive forces only decrease throughout the transient fault interval.

The three CS cases of prime concern from the perspective of worst case conductor pack loading are peak radial loading during normal operating and fault conditions and peak compressive loading during normal operating conditions. These cases were chosen for more detailed study using coupled EM-structural finite element analysis with refined models of the pertinent CS conductor packs. The EM and externally applied loads are summarized in Table 4.1. The vertical and radial Lorentz forces acting on the single coil pack of interest are given in the first two columns of this table. The sign convention is that a positive radial force produces hoop tension and a positive vertical force is upward. The mechanical loads transmitted through the conductor stack are included as forces normal and tangential to the top and bottom of the coil pack. These loadings are based on results from the structural modeling of the CS stack[16]. A positive normal force on the top of the coil is upward and a positive normal force on the bottom of the coil is downward directed. A positive tangential force is directed radially outward, while a negative tangential force is radially inward.

Table 4.1 — Summary of worst case CS coil loadings to be analyzed using detailed conductor pack models.

Case Description		Radial EM Body Force[a] (kN/turn)	Vertical EM Body Force[a] (MN)	Upper/Lower Coil End Normal Force[b] (MN)	Upper/Lower Coil End Tangential Force[b] (MN)
PF3U Radial	Fault following Equilibria #1	97.0	-0.073	-14.29/14.40	-4.36/-4.25
PF3U Radial	Normal Operating Equilibria #1	45.6	-3.37	-19.18/22.5	0.19/-0.01
PF3U with PF2 Shear	Normal Operating Equilibria#1	45.6	-3.37	-19.18/22.5	0.01/-1.39
PF1L Compres-sive	Normal Operating Equilibria#16	28.5	13.5	-31.33/17.95	-0.02/-0.95

[a] Lorentz force acting on single conductor pack only
[b] Based on structural analysis of entire central solenoid

A fourth case was later added to account for the worst case conductor pack shear during normal operating conditions. Originally it was thought that the worst case shear would occur in PF3 during the case of maximum radial differential loading. However, upon close examination of results from the CS structural model[16] it was

revealed that a larger shear actually existed on PF2, rather than PF3 during worst case radial loading. In order to accommodate this shear in our modeling, an additional run will be performed with the higher boundary tangential forces acting on PF2L applied to our PF3U conductor pack structural model.

4.1.2 Body EM Loads on PF5

The EM forces acting on the PF5 coils are summarized in Fig. 4.2. Here the radial and vertical forces represent the mean EM hoop load per turn and the vertical body force acting on the entire coil pack, respectively. The maximum radial force during normal operation occurs for equilibria #1 which corresponds to HC scenario at t=5 s. Plasma disruptions produce no increase in the maximum hoop load. This again is due to the fact that equilibria #1 corresponds to prebias during which there is no plasma current and the other cases where plasma currents do exist result in lower forces. The increase in the peak force level due to shorting coil PF5 is relatively minor (10% increase). In the case of the vertical forces both maximum launch (away from machine center) and centering type forces are shown. The centering force is greater during normal operating conditions, but larger launching forces occur during disruption for equilibria #14. The level of the launching force is 7.23 MN as taken from reference 13. However, a slightly smaller number (6.63 MN) was reported in reference 15 for this case. It is believed the difference is due to the assumption of constant PF coil flux linkages (the 6.63 MN case) or constant coil currents (the 7.23 MN case) during the disruption. The higher value of 7.23 MN is being used for design purposes.

Since the average hoop loads in PF5 are lower than those in the CS by nearly a factor of 2 and the vertical forces are several times lower than in the CS it was anticipated that conductor pack stresses would be lower than in the CS. However, there remains a concern that the bending stresses in PF5 due to its 8 discrete support points can be large. Consequently, a more detailed structural model will be created to examine the local PF5 stress levels. Table 4.2 contains the average

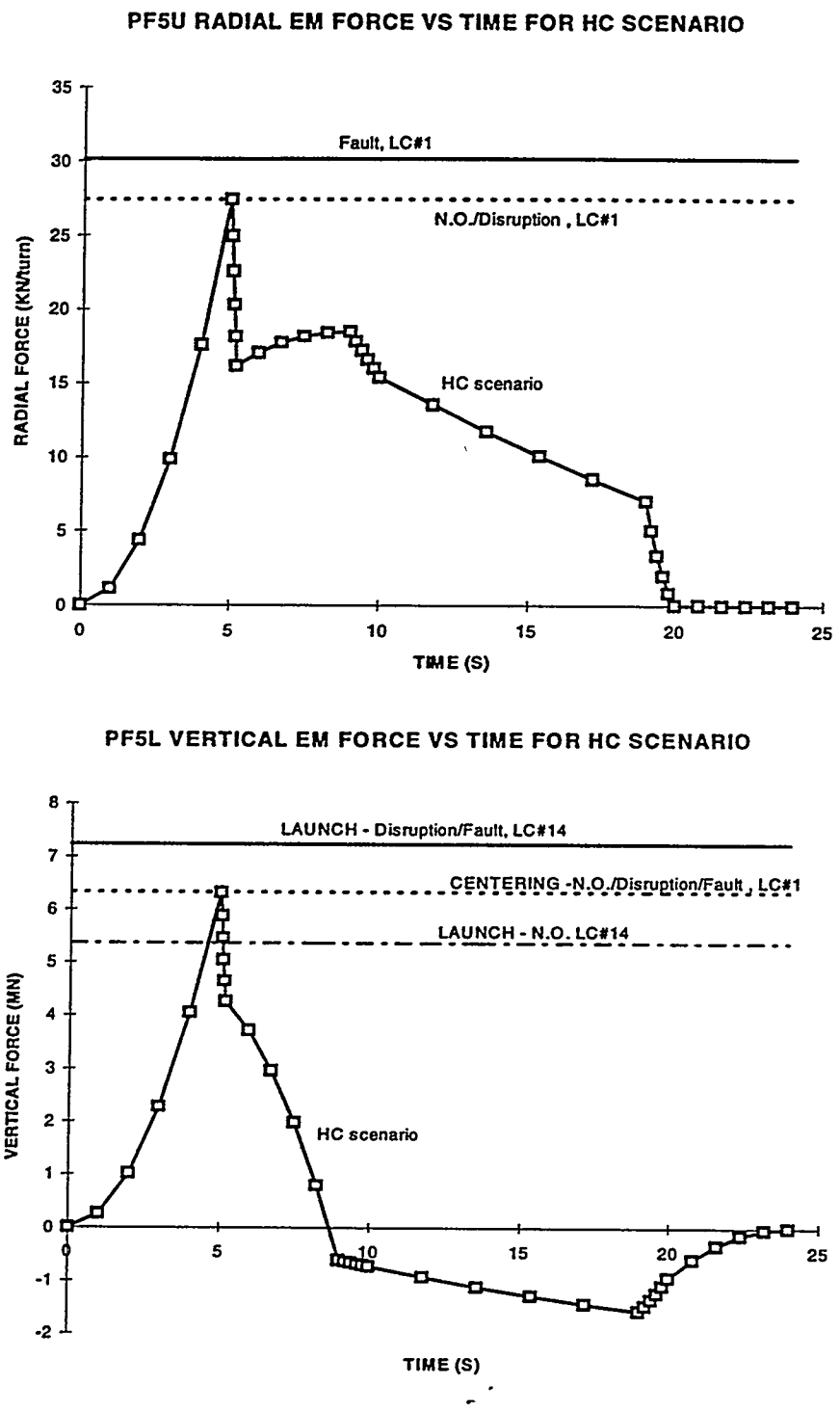


Figure 4.2 — Maximum radial and vertical Lorentz forces acting on coil PF5 throughout the HC scenario. The steady levels superimposed correspond to either an instant of time during a disruption or fault or a steady-state operating level in the extended q-li-β operating space.

worst-case electromagnetic loadings that will be applied. These loads, along with a superimposed variation based on Fig. 2.6, will be applied in a 3-D structural model.

4.1.3 Body EM loads on PF6 and PF7

Also shown in Table 4.2 are the worst case EM forces acting on PF6 and PF7. These loadings are generally consistent with those identified in reference 15, except for the case of PF6 vertical centering force. Here, the more conservative 8.21 MN value obtained from reference 13 is being used, rather than the 6.98 MN given in reference 15. The difference is again attributed to the constant current (8.21 MN

Table 4.2 — Summary of worst case PF5, PF6 and PF7 coil electromagnetic loadings.

Case Description		Average Radial EM Load (kN/turn)	Vertical EM Load (MN)
PF5 Radial/ Centering	Normal Operating Equilibria #1	27.4	6.32
PF5L Launch	Disruption following Equilibria#14	7.34	7.23
PF6U Radial	Normal Operating Equilibria #9	29.5	4.62
PF6L Centering	Disruption following Equilibria #19	21.7	8.21
PF7U Radial	Disruption following Equilibria #13	14.9	0.10
PF7U Centering	Disruption following Equilibria #18	12.6	3.58

case) vs. constant flux assumption (6.98 MN case) throughout the plasma disruption. A slightly larger PF7 hoop load (1.25 MN, equilibria #13 disruption) was also identified in reference 13 and is being used for PF7 worst case conductor loading.

Figures 4.3 and 4.4 contain the temporal data for PF6 and PF7 throughout the HC scenario. In these cases the HC loadings are somewhat below the maximum levels occurring at corner points in the extended flexibility space. However, since the HC scenario is taken as the reference scenario it has been assumed to be representative of the force pulse shape for design purposes.

4.2 SPATIAL VARIATION OF LOADS

In addition to the temporal variations, spatial variations also exist in the EM force distributions. The spatial variations include the local turn-to-turn internal force distribution throughout the cross section of the coil and the force fluctuations along the path of the conductor (i.e., toroidal variations for PF coils). A complete definition of the turn-by-turn EM forces for each of the three critical CS load cases summarized in Table 4-1* is rather involved and is described in the next three sections (4.2.1-4.2.3) of this document. Section 4.2.4 summarizes the worst case EM force variations along the conductor path due to interactions with the TF conductors.

4.2.1 Refined Model of PF3U for Analysis of Maximum Normal-Operating Radial EM Loading

An electromagnetic model of the PF system including a very detailed representation of conductor pack PF3U has been formed so that the internal Lorentz

* Although four load case are shown in Table 4.1, only three cases have unique EM loadings. Cases #2 and #3 contain the same EM loading pattern and only differ in that case #3 contains additional mechanically transmitted traction forces on the coil upper and lower boundaries.

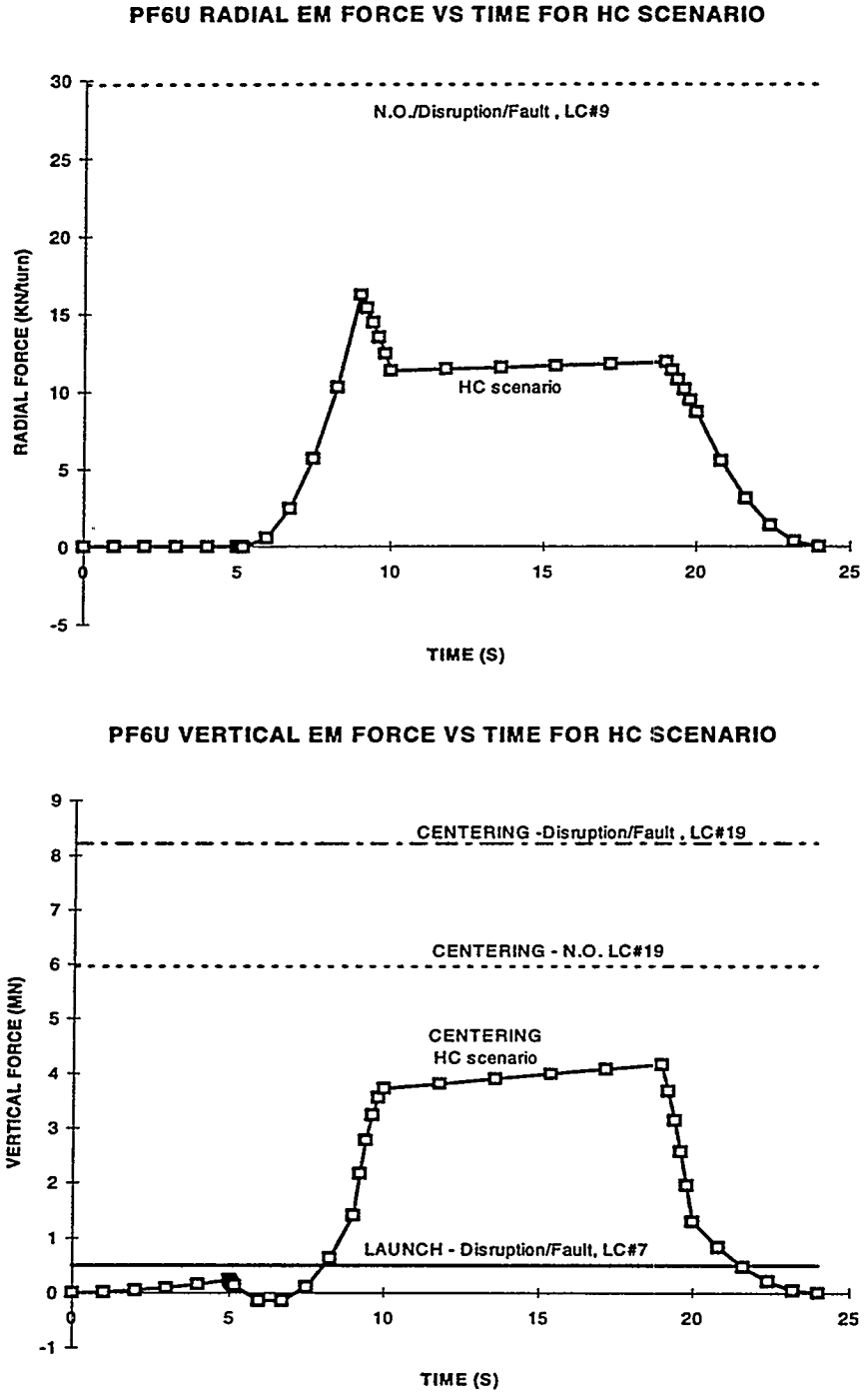


Figure 4.3 — Maximum radial and vertical Lorentz forces acting on coil PF6 throughout the HC scenario. The steady levels superimposed correspond to either an instant of time during a disruption or fault or a steady-state operating level in the extended q-li-β operating space.

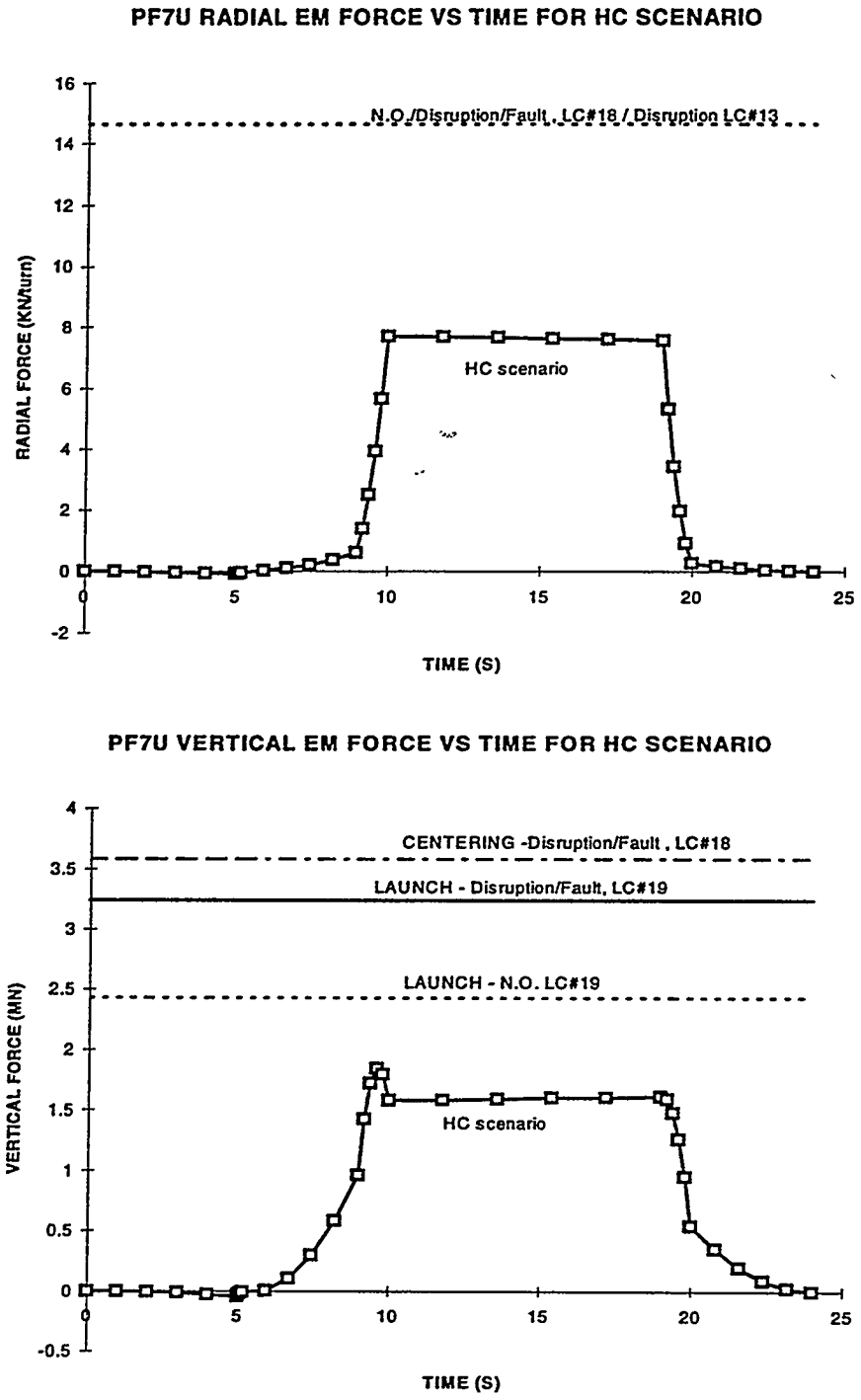


Figure 4.4 — Maximum radial and vertical Lorentz forces acting on coil PF7 throughout the HC scenario. The steady levels superimposed correspond to either an instant of time during a disruption or fault or a steady-state operating level in the extended q-li-β operating space.

forces acting throughout the conductor pack during worst case, normal operating radial EM loading can be determined. The electromagnetic model has been created using ANSYS 5.0a and shares the same finite element mesh as the detailed structural model of the conductor pack*. The approach taken in this analysis is to use the automated features in the ANSYS program to directly couple the electromagnetic and structural analyses. The first step of this process is to solve the electromagnetic field problem and write a file containing the electromagnetic forces acting on the individual finite elements. Next, the finite element types are changed to contain structural degrees of freedom and the electromagnetic forces are automatically applied as loads to the structural model.

The PF3 conductor was chosen for the analysis based on examination of the radial forces for the twenty-three equilibrium cases as indicated in Section 4.1.1. The ampere-turn loadings for this case are summarized in Table 4.3. Only the top portion of the PF system was modeled and top-to-bottom symmetry was assumed. The TF interconnect ring and PF6 compensation currents were ignored, since it was known that their effects on PF3 forces are minor and the additional computational costs of including the bottom portion of the mesh are substantial.

Table 4.3 — Ampere-turns loading for equilibria # 1 (i.e. HC scenario at t=5 sec.).

Coil	Ampere-Turns (MAT)
PF1	0.934
PF2	2.318
PF3	1.448
PF4	1.406
PF5	2.770
PF6	0.144
PF7	0.120
PLASMA	0.000

* The detailed structural model already existed and the electromagnetics model was built around the pre-existing structural model. Contact Bill Hannan of WSTC for more details concerning the structural model.

The overall model is illustrated by the flux plot shown in Fig. 4.5. The region of primary interest is conductor pack PF3 where the outline of the 60 individual turns can be observed. Fig. 4.6 shows a blowup of this region. The location of the individual turns throughout the coil pack was pre-established by the structural model. The relative offset of the individual rows of conductors is due to the assumed spiral winding of the individual central solenoid coils. The ANSYS command files used to form this model are given in Appendix H.

4.2.1.1 Effects of conduit magnetization on peak field

Two different situations were examined. The first neglects the magnetic effects of the ferromagnetic incoloy conduit, while the second accounts for the conduit by including a nonlinear source magnetization throughout the conduit regions. The magnetization characteristics for the conduit were taken from reference 17 for incoloy 908 at 4K with the error in field strength accounted for*. The magnetic field obtained for the two cases is illustrated by the contour plots in Fig 4.7 and the peak field for each case is listed in Table 4.4. The peak field is only slightly different with or without the conduit magnetization modeled. However, the location of the peak field changes from the lower, inner-most turn (i.e., turn 1) when the conduit magnetization is neglected to the inner-most turn of the fourth layer (i.e. turn 19) when the conduit is included. A plot of the magnetic field magnitude throughout the entire conductor pack is shown in Fig. 4.7. Contour plots of the magnetic field for the cases of ignoring and including the magnetization is shown in Fig. 4.8 for turn #1. The inclusion of the conduit magnetization results in a 0.011 T decrease in the peak field. The situation is different for turn #19 as shown in Fig. 4.9. Here, the inclusion of the conduit magnetization increases the magnetic field by 0.084 T. In both cases the field perturbation is quite small and it appears the additional field from the conduit magnetization is in general less than 0.1 T.

* In reference 17 the applied field strength was in error by a factor of 1000.

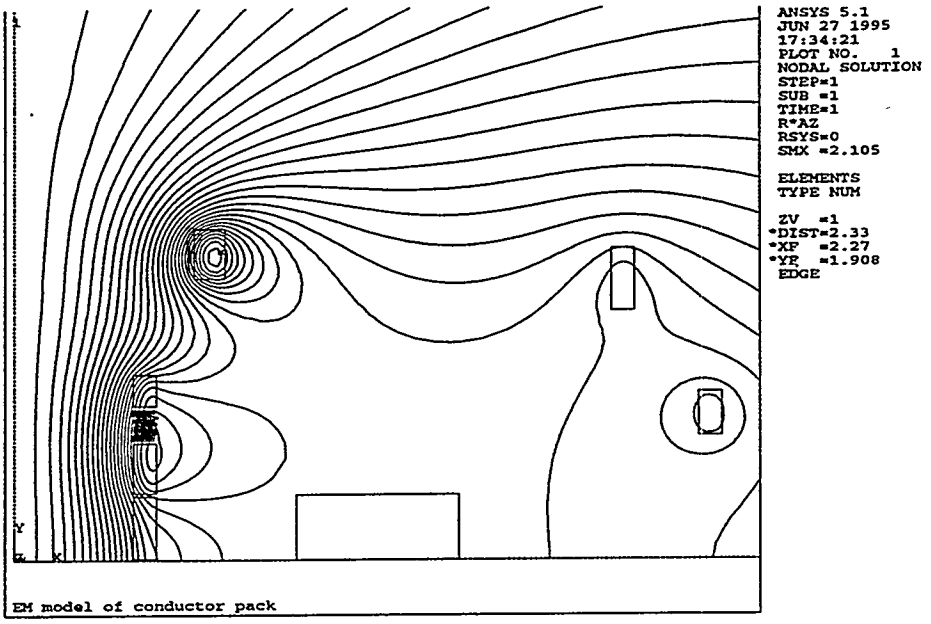


Figure 4.5 — Contours of magnetic flux for equilibria #1 (t=5 s of HC scenario) obtained using an axisymmetric ANSYS model of the PF conductors. The 60 individual turns in conductor PF3U has been modeled in detail.

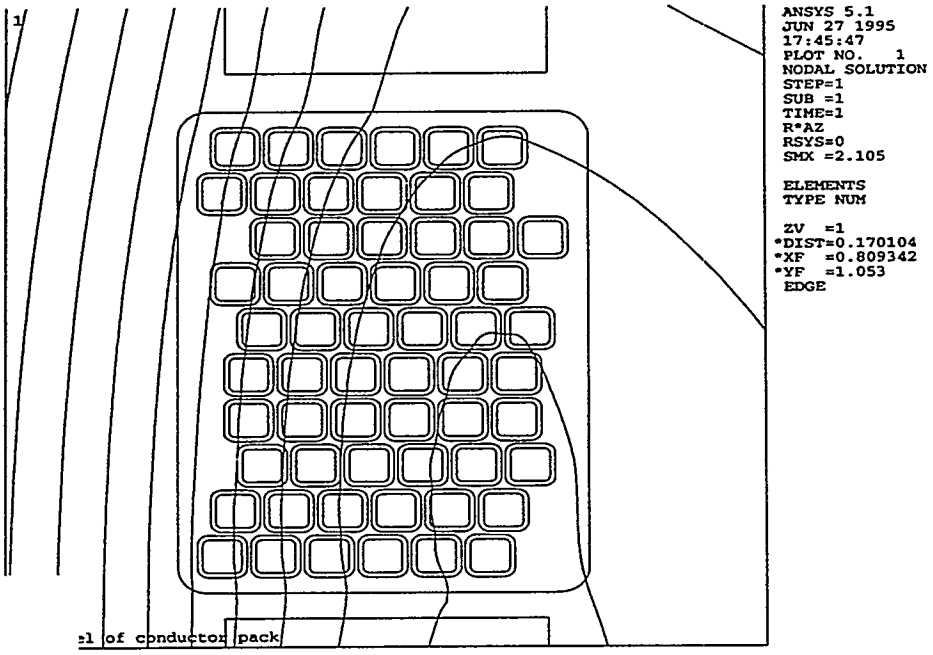
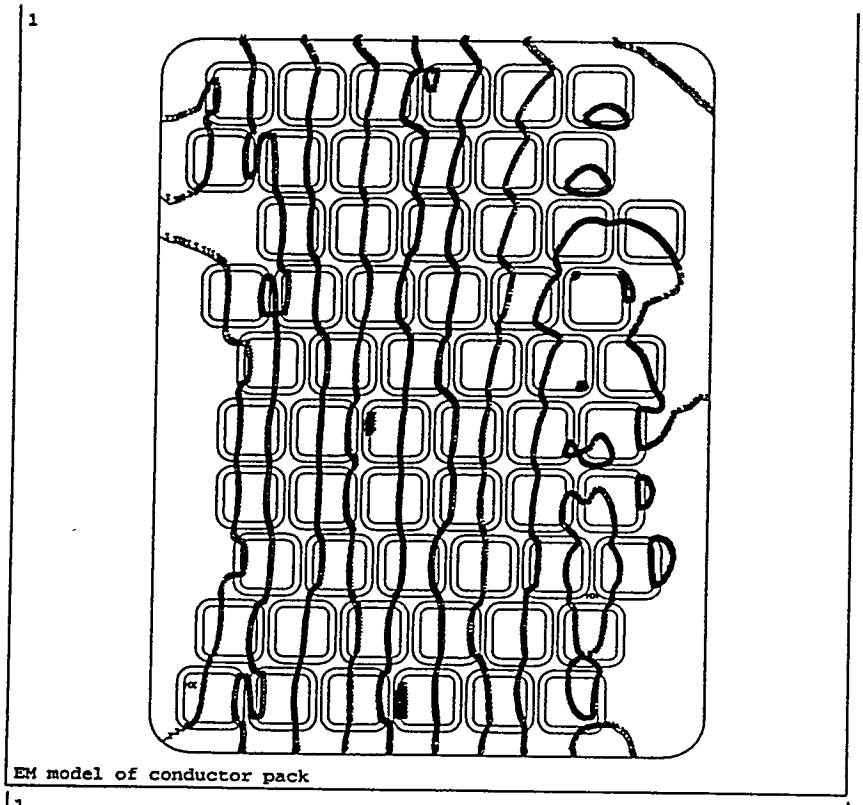


Figure 4.6 — Blowup of magnetic flux lines throughout coil pack PF3 for equilibria #1 (t=5 s of HC scenario). The effects of the incoloy magnetization have been neglected in the case shown.



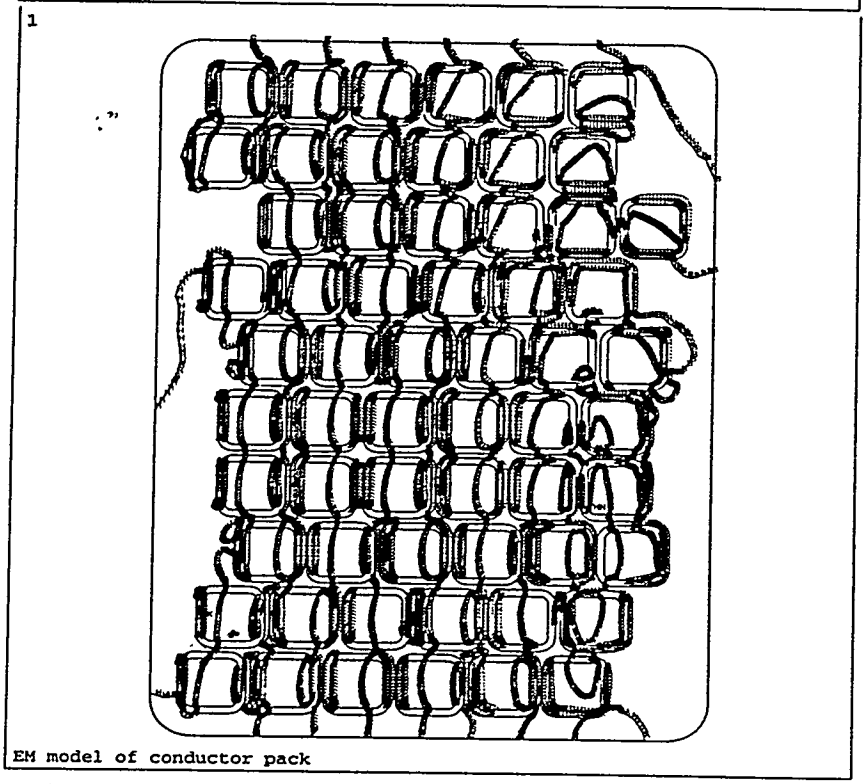


Figure 4.7 — Contours of constant magnetic field magnitude throughout coil pack PF3 for equilibria #1 (t=5 s of HC scenario).

Table 4.4 — Peak magnetic field throughout conductor pack PF3 for equilibria #1.

ANALYSIS	PEAK MAGNETIC FIELD
MIT/LLNL	5.82
Refined without conduit	5.929
Refined with conduit Magnetization	5.948

Also shown in Table 4.4 are results from an analysis performed by MIT/LLNL[5] where the current was distributed uniformly throughout a rectangular window. The slightly higher peak field (i.e. 0.11 T) obtained using the detailed model is attributed to the locally higher density of current in the detailed model. Specifically, the PF3 current area in the MIT/LLNL analysis was 0.0342 m^2, while a total current area of 0.01795 m^2 was used in the detailed model. The smaller area in the detailed model is due to the allocation of space for the precise modeling of the insulation and epoxy regions throughout the interior of the coil pack.

4.2.1.2 Maxwell stress tensor and Lorentz force calculations

The forces on the individual turns were calculated using two different force calculation methods. Method 1 uses the Lorentz force law (JxB) at each point to determine the force. Method 2 uses the Maxwell stress tensor method to obtain the force transmitted through an artificial surface which surrounds the conductor. Method 1, while generally more numerically precise, does not account for forces due to the net magnetic moment associated with the incoloy conduit. Method 2 is more general and accounts for ferromagnetic materials, but does not guarantee the proper force distribution; only the net integrated body force. Figures 4.10 and 4.11 illustrate the force distributions via vector plots using the two methods for the case where the conduit magnetization is neglected. Clearly, the Maxwell stress method gives a nonphysical distribution of force even though the net integrated body force is correct.

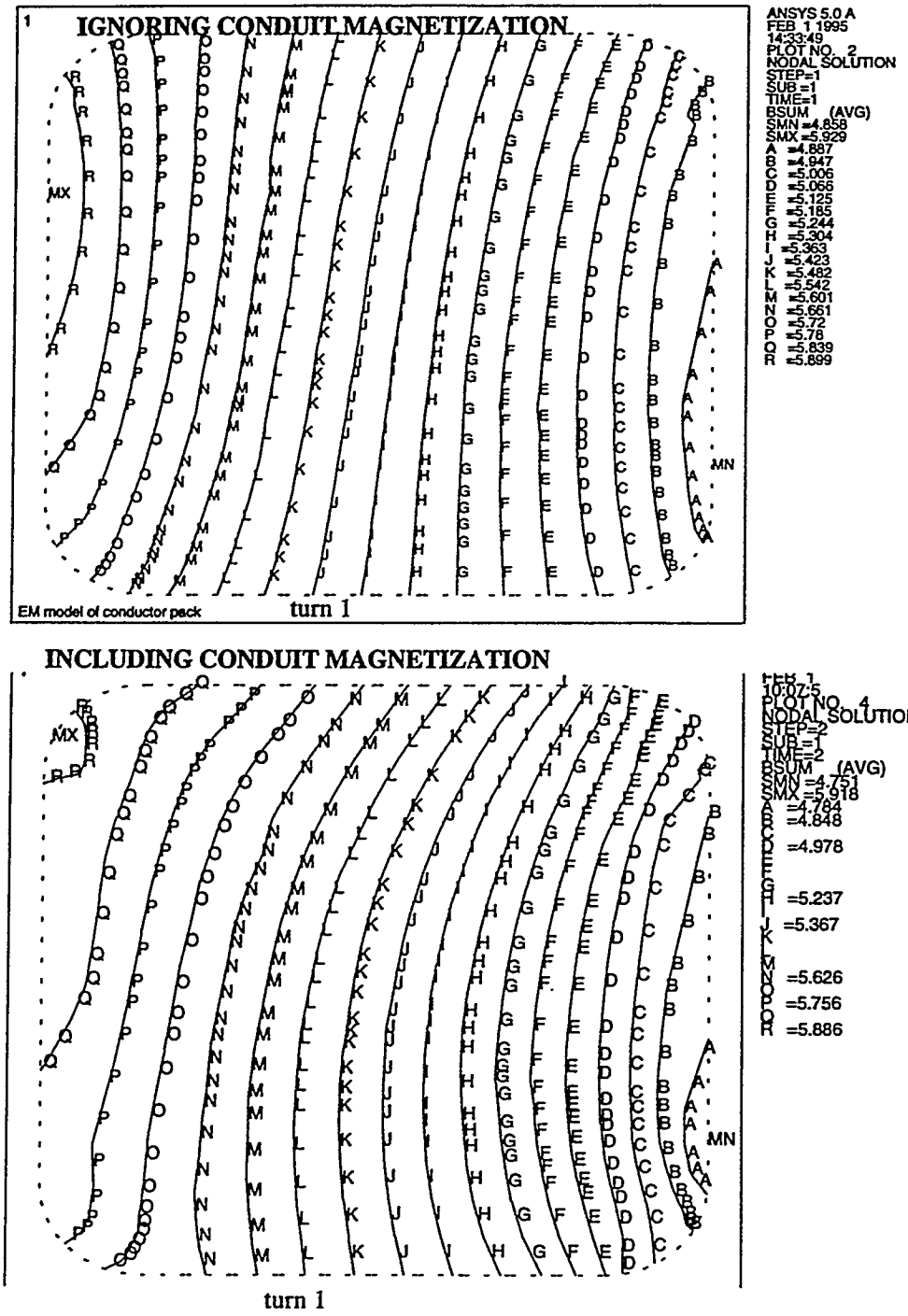


Figure 4.8 — Contours of constant magnetic field throughout lower innermost turn of PF3 conductor pack for the cases of including and ignoring conduit magnetization.

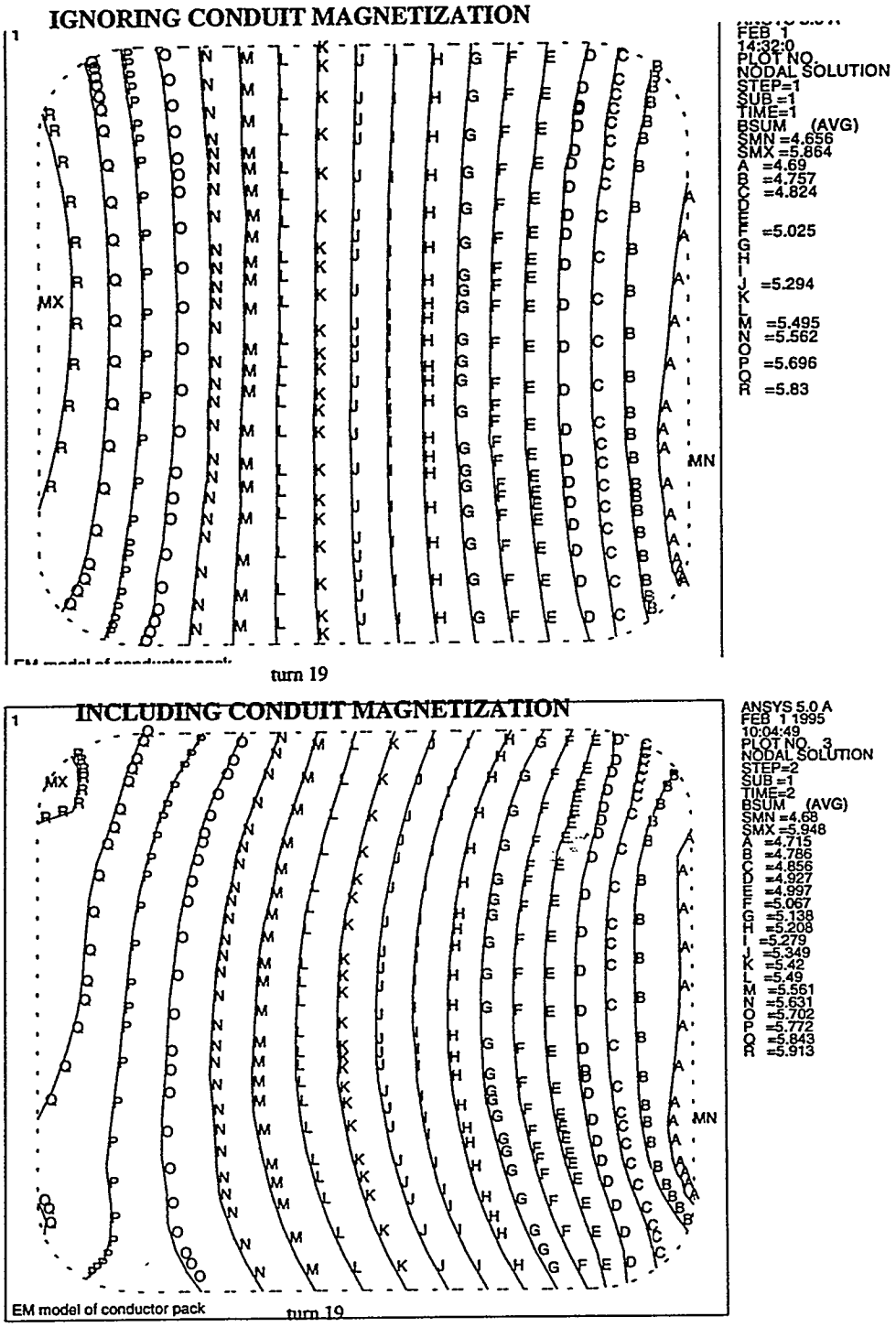


Figure 4.9 — Contours of constant magnetic field throughout fourth layer, innermost turn of PF3 conductor pack for the cases of including and ignoring conduit magnetization.

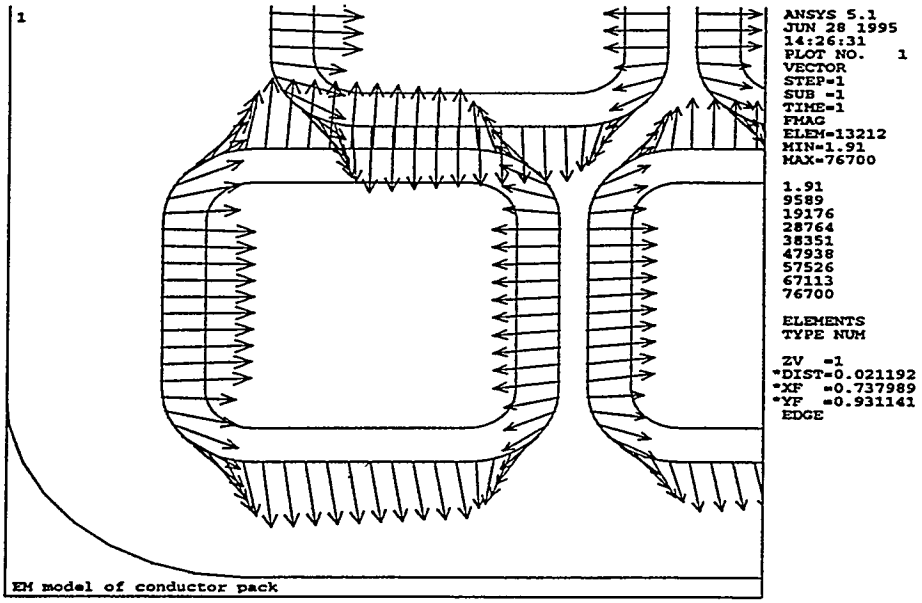


Figure 4.10 — Maxwell surface stress force distribution for equilibria #1 (t=5 s of HC scenario). The pressure surface was chosen to surround the conduit for each turn of PF3. The lower left (turn #1) is shown in this figure.

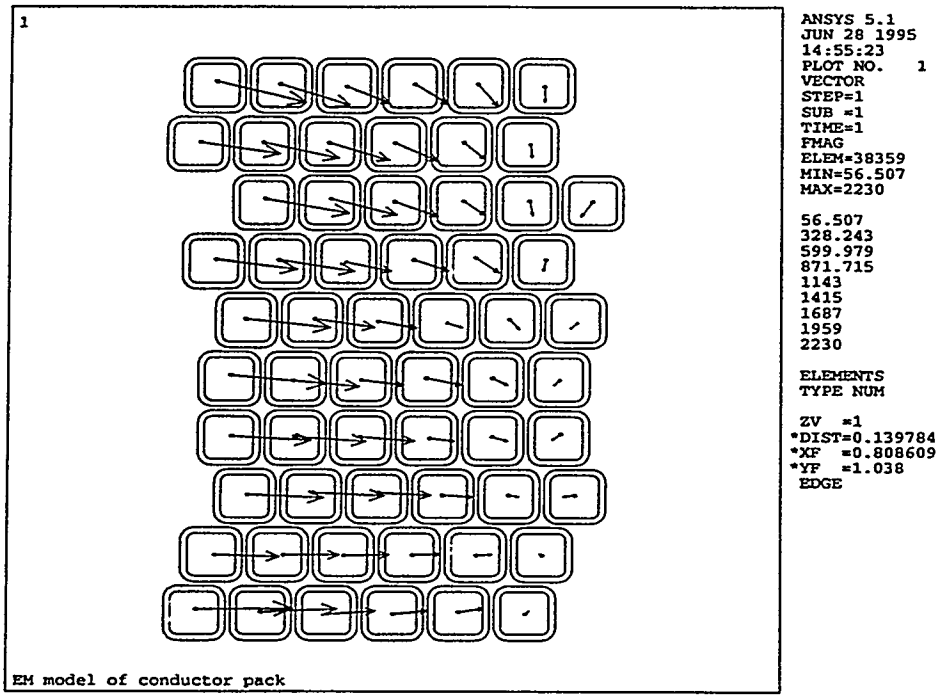


Figure 4.11 — Lorentz force acting on each of the PF3 turns for equilibria #1. The length of the vectors are proportional to the force magnitude acting on the finite element containing the current. The conduit magnetization is not included in this run.

The forces acting on each of the individual turns was calculated using each of the calculation methods. The results are summarized in Table 4.5 for the case where the conduit magnetization is neglected. Theoretically, either method should give the same answer, but differences occur due to the finite element approximations and numerical truncation. The level of calculation certainty can be judged from this data. Examination of the data indicates that the calculated vertical force components are in much better agreement than the radial force components. The vertical force components obtained using the Maxwell stress method are consistently (for all 60 turns) slightly lower in magnitude (~0.7 percent) than the Lorentz force calculations. However, the comparison of the radial forces is not nearly as good. Here the calculations differ by up to 6 percent. The Maxwell stress again gives a lower force result, but in this case the percentage error is usually greater for the inner radius turns and becomes smaller for the outer radius turns. A few of the outermost coils actually give force results which are slightly greater in magnitude than the Lorentz force results. The reason for this behavior is not known. It is suspected, although not specifically shown here, that the Lorentz force calculation is the more accurate of the two sets of calculations.

4.2.1.3 Effects of conduit magnetization on electromagnetic forces

The effects of the conduit magnetization was considered by including the magnetization in a separate nonlinear run and recalculating the forces using the Maxwell stress method. The same surface was used (i.e., just external to the conduits) as was used when conduit magnetization was neglected. Since the finite element mesh, boundary conditions and force evaluation surfaces are the same in the two cases, the net change in the body forces can only be attributed to the conduit magnetization. Table 4.7 shows that the cumulative effects of the incoloy magnetization is relatively small, producing a net 1.9 percent decrease in the hoop tension and a 3.6 percent increase in the downward vertical force. The decrease in hoop tension indicates the conduit magnetization experiences a radially inward force towards the center of the hoop. This is reasoned to be due to the fact that the

Table 4.5 — Hoop and vertical forces acting on 60 turns of PF3U during equilibria #1.

Turn	Hoop Tension (kN)		Vertical Force (kN)		Row
	Lorentz	Maxwel	Lorentz	Maxwell	
1	95.77	89.67	11.45	11.38	
2	81.94	77.61	24.42	24.26	
3	63.38	62.65	29.03	28.84	1
4	46.75	45.31	30.62	30.41	
5	26.41	25.87	29.80	29.60	
6	3.98	3.90	23.31	23.15	
7	95.52	89.55	-18.36	-18.25	
8	79.39	75.37	-1.98	-1.97	
9	61.40	59.01	5.25	5.21	2
10	41.91	40.74	8.15	8.09	
11	20.83	20.45	9.39	9.33	
12	-2.17	-2.20	12.64	12.55	
13	90.42	85.18	-23.71	-23.57	
14	71.62	68.37	-16.97	-16.86	
15	52.28	50.55	-13.26	-13.17	3
16	31.83	31.11	-11.24	-11.16	
17	10.16	10.02	-9.54	-9.47	
18	-11.51	-11.51	-7.60	-7.54	
19	94.90	89.03	-33.65	-33.44	
20	76.85	73.08	-33.84	-33.61	
21	57.64	55.50	-32.42	-32.21	4
22	37.33	36.35	-31.35	-31.14	
23	15.80	15.54	-30.97	-30.76	
24	-7.20	-7.22	-33.07	-32.84	
25	94.91	89.02	-51.39	-51.07	
26	76.94	73.14	-50.36	-50.03	
27	57.72	55.56	-50.60	-50.26	5
28	37.38	36.38	-50.85	-50.50	
29	15.81	15.52	-50.84	-50.48	
30	-7.29	-7.32	-49.14	-48.80	
31	90.68	85.36	-62.65	-62.27	
32	71.97	68.64	-66.74	-66.31	
33	52.52	50.70	-69.03	-68.58	6
34	31.96	31.17	-70.45	-69.98	
35	10.20	10.00	-71.36	-70.88	
36	11.86	-11.93	-73.07	-72.59	
37	96.13	90.02	-77.17	-76.71	
38	80.51	76.29	-81.85	-81.32	
39	61.87	59.35	-86.15	-85.59	7
40	42.08	40.80	-89.44	-88.85	
41	21.08	20.60	-91.02	-90.41	
42	-1.70	-1.82	-89.81	-89.23	
43	84.58	79.88	-94.55	-93.96	
44	65.78	62.89	-104.36	-103.66	
45	46.62	45.04	-110.18	-109.44	8
46	26.29	25.60	-113.02	-112.25	
47	4.95	4.73	-114.74	-113.93	
48	-13.09	-13.23	-111.35	-110.64	
49	94.26	88.23	-91.58	-91.03	
50	81.09	76.65	-113.29	-112.54	
51	64.30	61.44	-128.28	-127.42	9
52	45.93	44.32	-135.14	-134.22	
53	26.06	25.31	-137.17	-136.23	
54	3.84	3.56	-136.08	-135.16	
55	88.84	83.35	-136.34	-135.51	
56	74.74	70.81	-152.49	-151.51	
57	58.63	56.09	-160.63	-159.58	10
58	40.63	39.18	-164.92	-163.81	
59	21.41	20.71	-163.61	-162.50	
60	0.692	0.408	-148.81	-147.81	

Table 4.6 — Comparison of hoop and vertical forces acting on PF3U turns for cases of including and neglecting effects of conduit magnetization during equilibria #1.

Turn	Hoop Tension (kN)		Vertical Force (kN)		Row
	with M	No M	With M	no M	
1	89.13	89.67	8.71	11.38	1
2	76.54	77.61	24.79	24.26	
3	61.21	62.65	33.97	28.84	
4	43.68	45.31	41.28	30.41	
5	24.22	25.87	47.35	29.60	
6	2.81	3.90	46.43	23.15	
7	89.12	89.55	-20.10	-18.25	2
8	74.67	75.37	0.088	-1.97	
9	58.19	59.01	10.51	5.21	
10	39.93	40.74	17.35	8.09	
11	19.38	20.45	22.77	9.33	
12	-4.33	-2.20	24.43	12.55	
13	84.58	85.18	-24.33	-23.57	3
14	67.93	68.37	-15.86	-16.86	
15	50.17	50.55	-10.22	-13.17	
16	30.88	31.11	-6.27	-11.16	
17	9.69	10.02	-2.65	-9.47	
18	-13.44	-11.51	0.198	-7.54	
19	88.91	89.03	-33.66	-33.44	4
20	72.82	73.08	-33.41	-33.61	
21	55.25	55.50	-31.15	-32.21	
22	36.08	36.35	-29.71	-31.14	
23	14.67	15.54	-30.89	-30.76	
24	-9.44	-7.22	-28.95	-32.84	
25	88.89	89.02	-53.50	-51.07	5
26	72.98	73.14	-52.15	-50.03	
27	55.39	55.56	-52.39	-50.26	
28	36.13	36.38	-52.70	-50.50	
29	14.93	15.52	-52.65	-50.48	
30	-9.20	-7.32	-51.93	-48.80	
31	84.97	85.36	-64.72	-62.27	6
32	68.39	68.64	-68.85	-66.31	
33	50.41	50.70	-71.62	-68.58	
34	30.72	31.17	-73.87	-69.98	
35	9.47	10.00	-75.07	-70.88	
36	-13.74	-11.93	-80.34	-72.59	
37	90.16	90.02	-79.91	-76.71	7
38	76.04	76.29	-85.39	-81.32	
39	59.04	59.35	-90.96	-85.59	
40	40.43	40.80	-95.37	-88.85	
41	19.92	20.60	-99.20	-90.41	
42	-3.54	-1.82	-94.35	-89.23	
43	79.12	79.88	-98.40	-93.96	8
44	62.28	62.89	-109.61	-103.66	
45	44.35	45.04	-117.40	-109.44	
46	24.77	25.60	-122.57	-112.25	
47	4.02	4.73	-123.98	-113.93	
48	-15.00	-13.23	-120.95	-110.64	
49	87.82	88.23	-91.90	-91.03	9
50	76.09	76.65	-118.35	-112.54	
51	60.62	61.44	-136.17	-127.42	
52	43.45	44.32	-146.01	-134.22	
53	24.43	25.31	-150.42	-136.23	
54	2.36	3.56	-150.90	-135.16	
55	82.35	83.35	-139.01	-135.51	10
56	69.57	70.81	-157.95	-151.51	
57	54.56	56.09	-171.11	-159.58	
58	37.75	39.18	-180.74	-163.81	
59	19.60	20.71	-182.32	-162.50	
60	-0.921	0.408	-166.98	-147.81	

Table 4.7 — Electromagnetic body forces acting on conductor pack PF3 calculated using Maxwell stress and Lorentz body force methods. The cases of including and neglecting the magnetic properties of the incoloy conduit are shown.

	Without Incoloy Magnetization		With Incoloy Magnetization	
	Radial Force (MN)	Vertical Force (MN)	Radial Force (MN)	Vertical Force (MN)
Lorentz (JxB)	2.774	-3.662	2.791	-3.561
Maxwell Stress	2.640	-3.638	2.591	-3.769
MIT/LLNL	2.74	-3.34	-	-

magnetic field is significantly higher near the inner radius of the coil, thereby pulling the magnetic incoloy inward toward the high field region. The increase in the downward vertical force is explained by the interaction of the vertical magnetization and the ampere-turns in PF1 and PF2. The magnetic material is attracted to the large ampere-turn source below it similar to a soft magnetic washer on top of a solenoid.

Table 4.6 contains the forces acting on the individual turns for the cases of including and neglecting the conduit magnetization. In the case of the radial force the effect is rather benign.

Here the individual turns experience a uniform decrease in the radial force. Each of the turns are affected in the same way. However, in the case of the vertical force the effect of the magnetization is not as uniform. The turns with the highest force receive the greatest degree of amplification. The turns near the bottom of the coil pack experience an upward vertical force which is increased substantially (~10-40%) when the incoloy magnetization is included. Similarly, the turns near the top

of the stack experience a downward force which is also increased (~10 %) when the magnetization is accounted for. A substantial increase in the vertical compressive force results from this distribution.

Since the absolute values of the vertical forces calculated via the Maxwell stress method are known with a great deal of certainty (i.e., < 0.7 % error), the accuracy in the calculation for vertical forces due to the conduit is believed to be high. The absolute value of the radial forces calculated using the Maxwell stress method are not known as precisely. However, since both calculations use the same method with the same evaluation surface, the relative change in radial force is believed to be attributable to the conduit magnetization, rather than calculation error.

The effect of the conduit magnetization is judged to be relatively minor when considering the overall stress levels internal to the conductor pack. For this reason, and the fact that the force distribution predicted using the Maxwell stress method is nonphysical, it has been suggested that the Lorentz force method be used to transfer forces to the structural mesh and the forces due to the conduit magnetization be neglected in the initial structural modeling.

4.2.2. Refined model of PF3U for analysis of maximum fault radial EM loading

Another model of the TPX PF coil system was constructed in support of an effort to examine the stress state internal to conductor pack PF3U during a worst case radial fault event. The current loading analyzed corresponds to a time instant during a sudden short circuit of PF3U occurring at t=5 s of the HC scenario (i.e., prebias, equilibria #1 as defined by MIT[3]). It was originally thought that since the event being modeled is a transient, eddy current paths should be represented; therefore, they are included in the model. An ANSYS axisymmetric model which includes PF coils 1-7U/L, upper and lower internal control coils, the toroidal TF interconnect ring, inner and outer passive structure, cryostat, and vacuum vessel was constructed and analyzed. The eventual focus of this modeling effort is a

detailed analysis of the stress state of the PF3 conductor pack during fault conditions. Consequently, a very refined turn-by-turn representation of the PF3U coil is used in this model.

ANSYS 5.1 was used to construct an axisymmetric model of the PF system. The overall geometry was specified in an earlier memo by MIT[13] Specifically, Table A2.1 of reference 13 was used in constructing the PF system geometry. Coil pack PF3U was modeled in greater detail on a turn-by-turn basis. A structural model including the 10 by 6 array of individual turns, the conduit, turn insulation, filler material, and groundwrap insulation was earlier constructed by B. Hannan[1] and the model was used as a magnetics mesh by converting to a magnetics element (i.e., PLANE13). The conductor pack was treated as if it contained free space magnetic characteristics including the conduit material. This detailed region was embedded into the entire PF system by stitching the PF3U region to the much coarser surrounding regions. The mesh of the conductor pack and interfacing regions is shown in Fig. 4.12. The current loading was identified as case #3 in reference 13 and the individual currents are specified in Table A2.2.3 of reference 13. Table A2.2.3 of reference 13 indicates that the peak force occurs 2.7065 s after the short circuit is applied. It is at this time the detailed analysis takes place. A file containing the ANSYS commands used to construct the geometry and specify the current loadings is given in Appendix I.

4.2.2.1 Magnetic field distribution throughout PF3U

The magnetic field distribution at t=2.7065 s is shown in the flux plot given in Fig. 4.13. The flux lines are concentrated about PF3U indicating that the field and currents are largest there. The flux lines also circulate about PF6 and PF7

[1] Hannan, B., ANSYS 5.1 input file "sl12d1.str" used to construct structural model of 10 layer CS conductor pack.

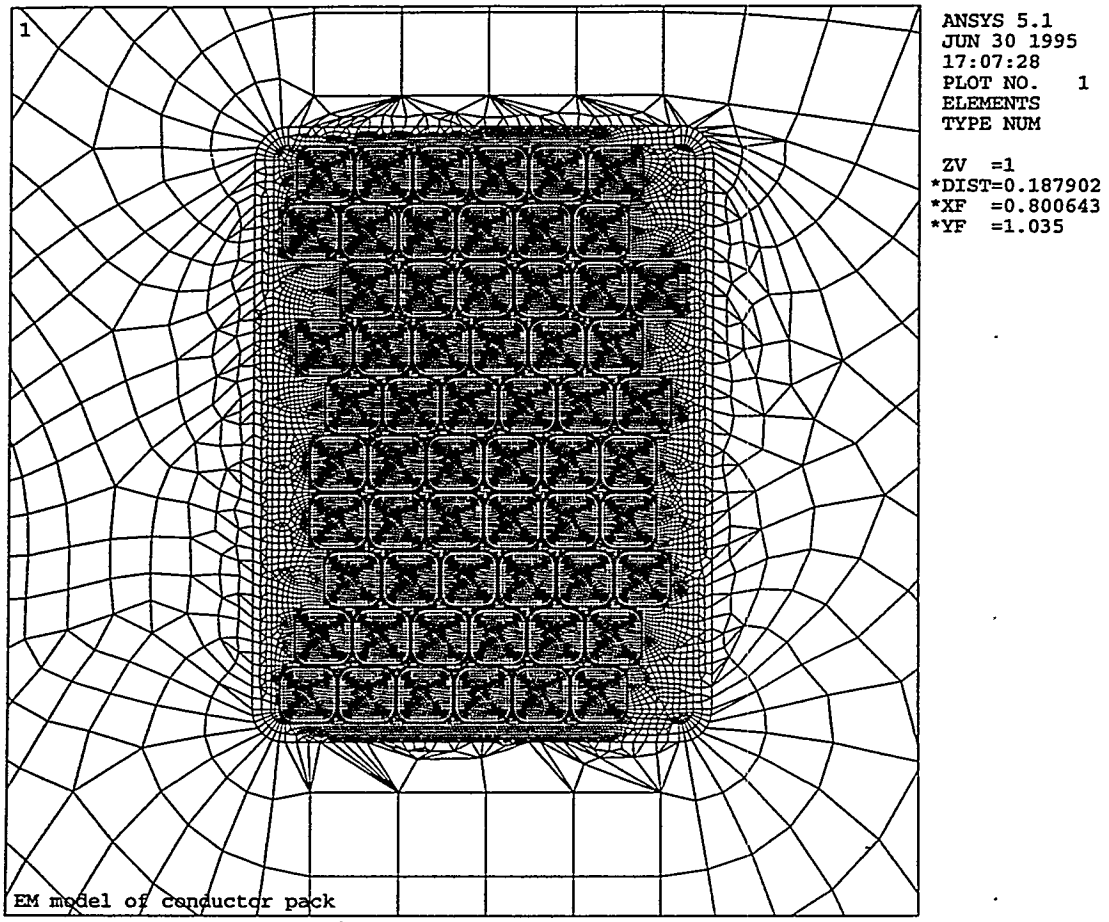


Figure 4.12 — Portion of ANSYS finite element mesh illustrating the refined PF3U mesh and stitching with exterior mesh.

indicating that these currents are still somewhat significant at this time during the transient. The flux lines do not appear to be altered by the presence of the eddy current paths indicating the eddy currents are small. Figure 4.14 shows a blowup of the flux lines in the vicinity of PF3U. These flux plots indicate that the event can be characterized simply as the self fields from the very large PF3U currents which tend to burst the coil radially. This characterization is further reinforced by evaluating the net radial and vertical body forces acting on the coil. The net vertical force

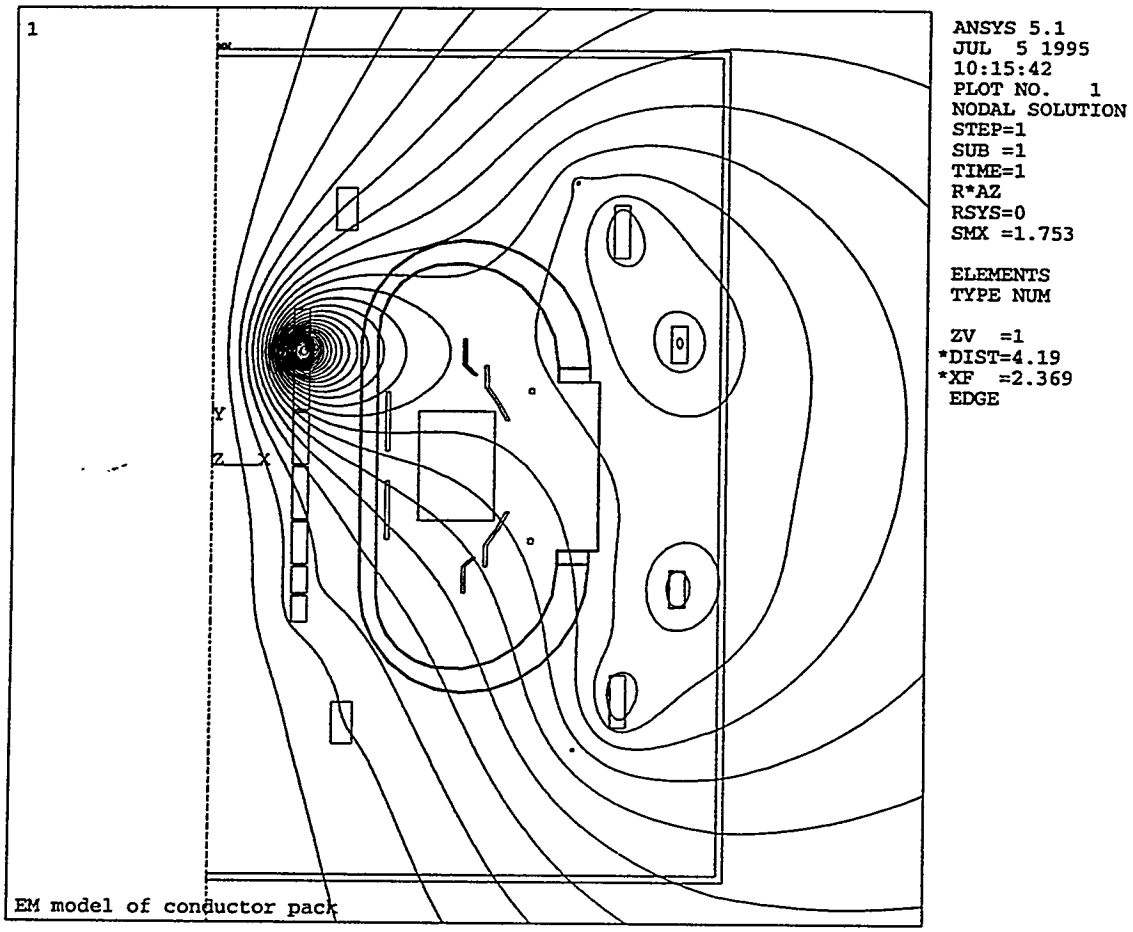


Figure 4.13 — Magnetic flux lines 2.7065 s after shorting coil PF3U. This time instant corresponds to the highest radial force on any of the PF coils.

acting on PF3U is -0.0732 MN and the net radial force is 36.41 MN for the entire hoop (i.e., for 2π radians). On a per-turn basis this gives an average radial force of 96.6 kN/turn. This is very close to the value of 97.0 kN/turn published by Radovinsky.[13]

Figure 4.15 shows contours of the magnetic fields. The main point here is that the peak field is 9.6 T on the inside edge of the conductor. This combined with the PF3U current of 68.3 kA will likely result in a quench, so that such a large electromagnetic load may never actually exist. However, a conservative design

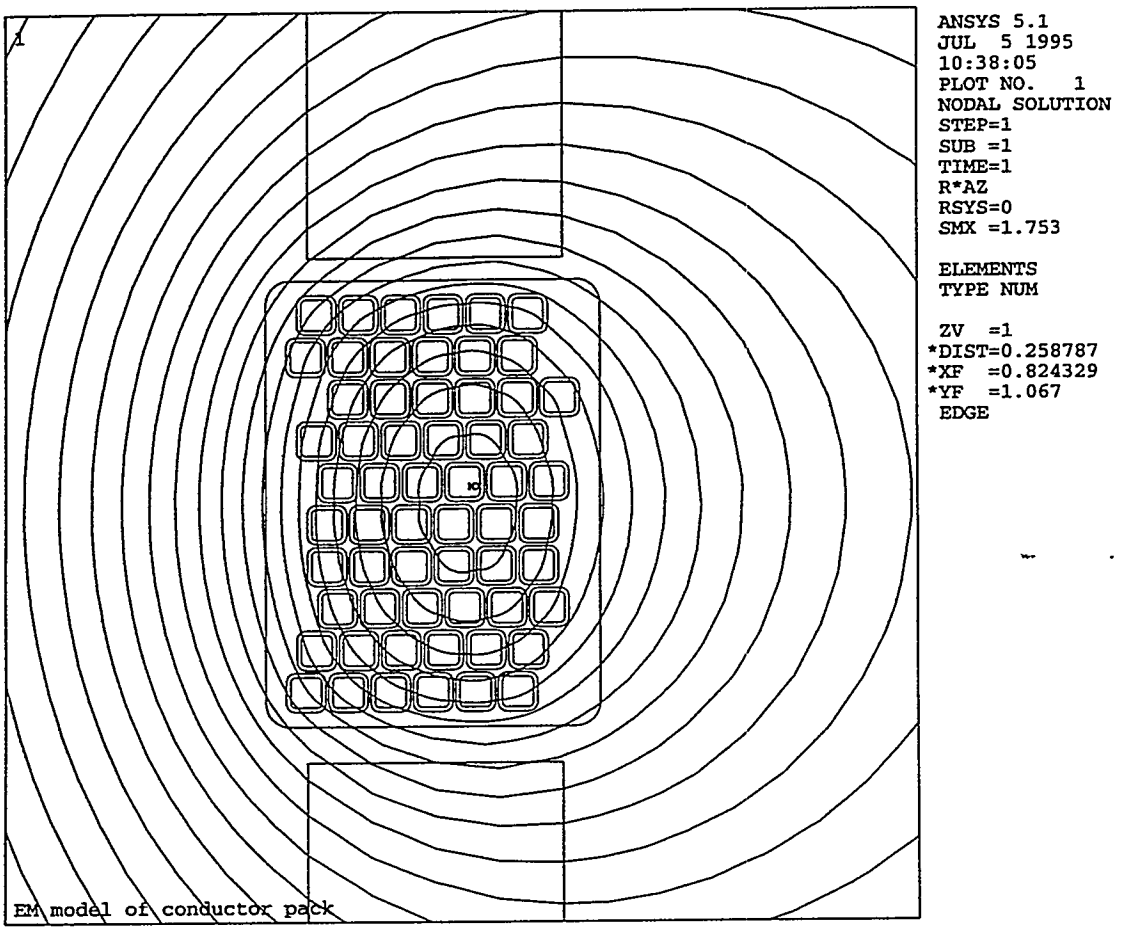


Figure 4.14 — Blowup of the magnetic flux lines in the vicinity of conductor pack PF3U.

approach is being taken, whereby the conductor pack is being designed to withstand these high forces.

4.2.2.2 Electromagnetic forces acting throughout PF3U

The forces acting on each turn in PF3U are shown in Fig. 4.16. It can be observed that the force is large and radially outward on the innermost turns and actually changes direction to radially inward for the outermost turns. There is also a large vertical compressive force component which tends to squeeze the coil from

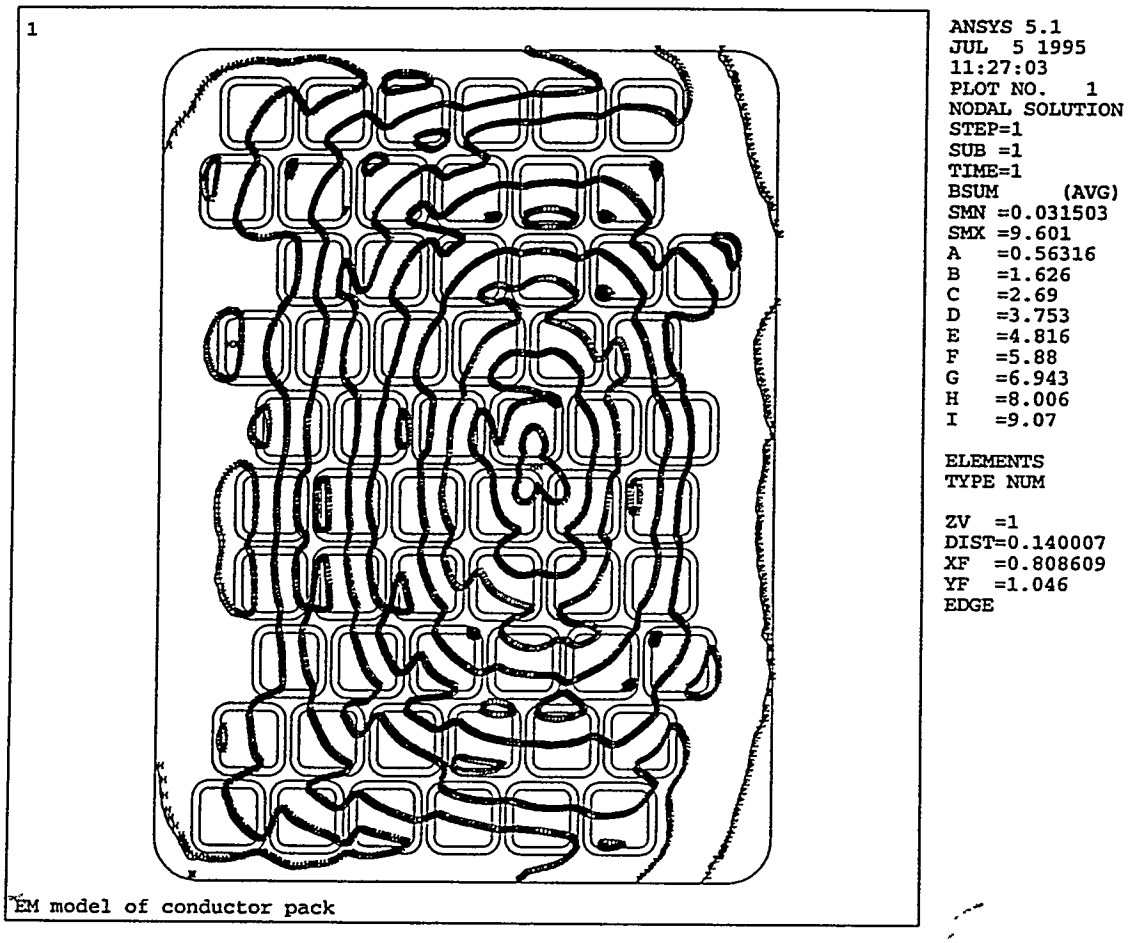


Figure 4.15 — Contours of constant magnetic flux density throughout coil PF3U 2.7 s after a terminal short circuit. The initial conditions (pre-fault state) were those of equilibria #1 (i.e., prebias).

the top and bottom. The forces acting on each of the individual turns are given in Table 4.8. The peak hoop force of 414 kN/turn is much larger than the average radial hoop force (97 kN/turn) that is usually reported for this load case. The electromagnetic forces are being transferred automatically via the ANSYS "*.rmg" file so that the detailed structural model of PF3U can be run during worst case fault conditions.

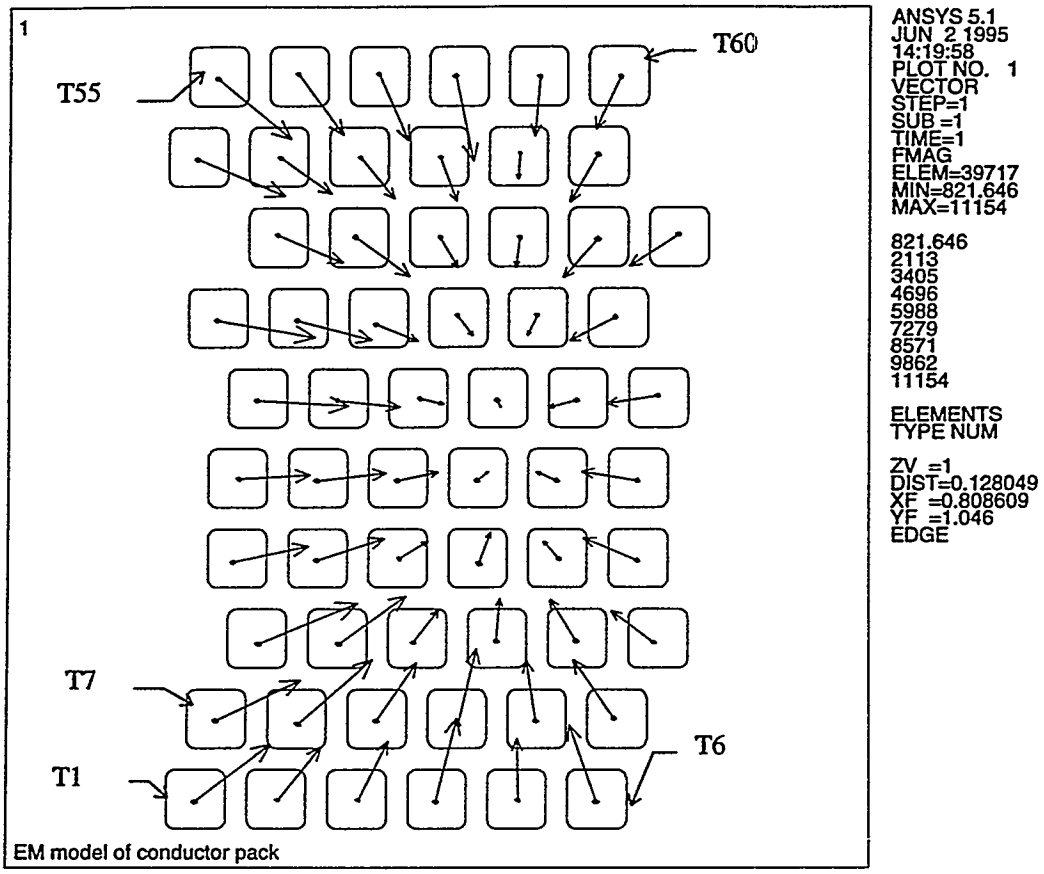


Figure 4.16 — Vector Lorentz forces acting on individual turns in conductor pack PF3U during sudden short circuit fault.

4.2.2. Refined model of PF1L for analysis of maximum normal-operating vertical compressive EM loading

A refined electromagnetic model of TPX CS coil PF1L has been constructed to analyze the case of maximum compressive force in the conductor pack during normal operating conditions for the TPX machine. The current loading corresponding to the maximum compression was identified as equilibria #16 in Table 4.1. An ANSYS axisymmetric model which includes PF 1-7 upper and lower coils, upper and lower internal control coils, the plasma current, and the toriodal TF interconnect ring was

Table 4.8 — Hoop and vertical forces acting on each turn during PF3U sudden short circuit.

Turn	Hoop Tension (kN)	Vertical Force (MN)	Row
1	325.3	1.522	
2	250.4	1.832	
3	174.3	2.125	1
4	88.2	2.230	
5	-6.1	2.218	
6	-119.4	2.047	
7	366.5	1.087	
8	271.9	1.384	
9	173.2	1.556	2
10	69.1	1.629	
11	-45.5	1.617	
12	-178.5	1.552	
13	362.8	0.853	
14	246.4	1.001	
15	132.6	1.087	3
16	13.0	1.116	
17	-116.1	1.097	
18	-248.6	1.040	
19	405.7	0.506	
20	290.0	0.566	
21	170.6	0.620	4
22	46.2	0.645	
23	-87.0	0.639	
24	-233.6	0.588	
25	414.0	0.137	
26	297.0	0.176	
27	175.1	0.197	5
28	47.3	0.207	
29	-89.1	0.206	
30	-239.1	0.208	
31	-389.4	-.172	
32	267.2	-.200	
33	143.6	-.214	6
34	13.68	-.219	
35	-125.3	-.219	
36	-268.3	-.225	
37	419.4	-.501	
38	319.6	-.565	
39	201.5	-.616	7
40	77.9	-.646	
41	-53.7	-.647	
42	-200.4	-.611	
43	338.8	-.903	
44	220.7	-1.031	
45	104.9	-1.099	8
46	-17.8	-1.111	
47	-149.3	-1.084	
48	-257.6	-.991	
49	376.0	-1.025	
50	297.9	-1.316	
51	200.8	-1.523	9
52	97.9	-1.618	
53	-14.3	-1.619	
54	-146.8	-1.544	
55	312.8	-1.657	
56	235.7	-1.968	
57	154.9	-2.159	10
58	67.4	-2.234	
59	-28.8	-2.180	
60	-141.0	-1.939	

constructed and analyzed. A very detailed turn-by-turn representation of the top half of PF1L is used so that the electromagnetic loadings can be directly transferred to a structural model sharing the same finite element mesh.

A structural finite element model including a 10 by 6 array of individual turns, the conduit, turn insulation, filler material, and groundwrap insulation was earlier constructed by B. Hannan (of WSTC) and the model was used as a magnetics mesh by converting to a magnetics element (i.e., PLANE13). Since the model was originally intended for coil PF3U, the mesh is first translated to the PF1U location and then mirrored about the horizontal axis so that it is correctly located and representative of the top 60 turns of PF1L. The lower half of PF1L is modeled in much less detail with the current smeared uniformly throughout a rectangular region. The ampere-turns are divided evenly between the upper and lower portions of the PF1L conductor pack. The detailed portion of the conductor pack model is treated as if it contained free space magnetic characteristics (including the conduit material). The coil pack is embedded into the entire PF system by stitching the region with the much coarser surrounding regions. The mesh of the conductor pack and interfacing regions is shown in Fig. 4.17. The current loading was identified as equilibria #16 and the individual currents are specified by Pillsbury[3]. This loading corresponds to a single null case so that the electromagnetic loading is not top-bottom symmetric requiring both top and bottom halves to be modeled. A file containing the ANSYS commands used to construct the geometry and specify the current loadings is given in Appendix J.

4.2.2.1 Magnetic field and force distribution throughout PF1L

The magnetic field distribution is shown in the flux plot given in Fig. 4.18. The flux lines are radial throughout PF2, PF3 and PF4 which results in the large compressive component of electromagnetic force acting on PF1. Figure 4.18 shows a blowup of the flux lines in the vicinity of the upper half of PF1L. Here, the flux lines

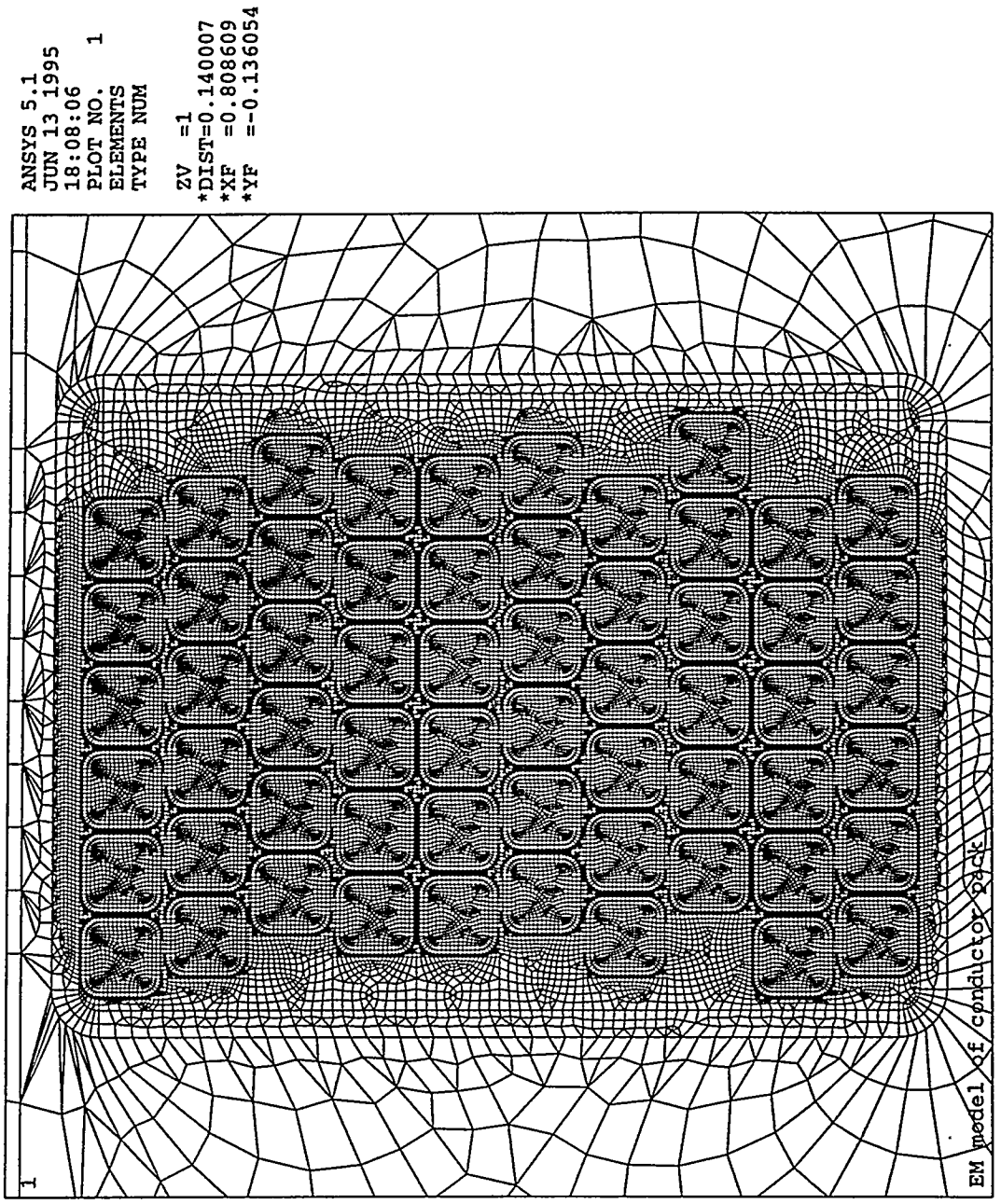


Figure 4.17 — Portion of the ANSYS finite element mesh illustrating the refined mesh in PF1L and stitching with exterior mesh.

are primarily vertical throughout the coil pack, thus, the electromagnetic forces are primarily radial. The net vertical force acting on the top half of PF1L is 1.27 MN and the net vertical force on the bottom half of PF1L is 11.81 MN for the entire hoop (i.e., for 2π radians). This results in a total body force of 13.1 MN for the entire coil pack which compares well with the value of 13.4 MN predicted by Pillsbury[1] based on a smeared current distribution. The calculated hoop force (3.44 MN) also compares well with that of Pillsbury (3.40 MN).

The forces acting on each turn in PF1L are shown in Fig. 4.20. It can be observed that the force is large and radially outward on the innermost turns and changes direction to radially inward on the outermost turns as is the usual case. There is also a vertical compressive force component which tends to squeeze the coil from the top and bottom. The forces acting on each of the individual turns are given in Table 4.9. The electromagnetic forces are transferred automatically via the ANSYS "file.rmg" file so that the detailed structural model of PF1L can be run during worst case compressive conditions.

Figure 4.21 shows contours of the magnetic fields. The peak magnetic field is 5.37 T on the inside edge of turn #49. This is also where the largest electromagnetic loading exists.

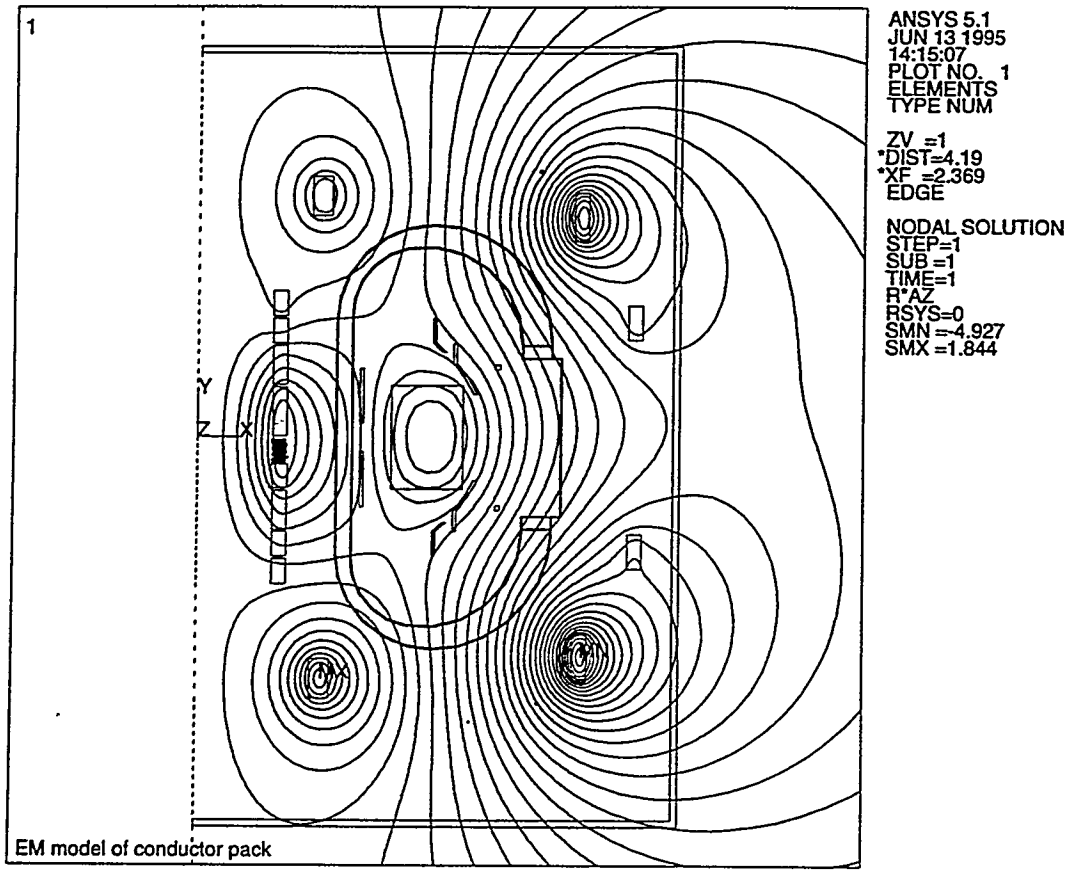


Figure 4.18 — Magnetic flux lines for equilibria #16. This load case corresponds to the highest vertical compressive force on any of the PF coils.

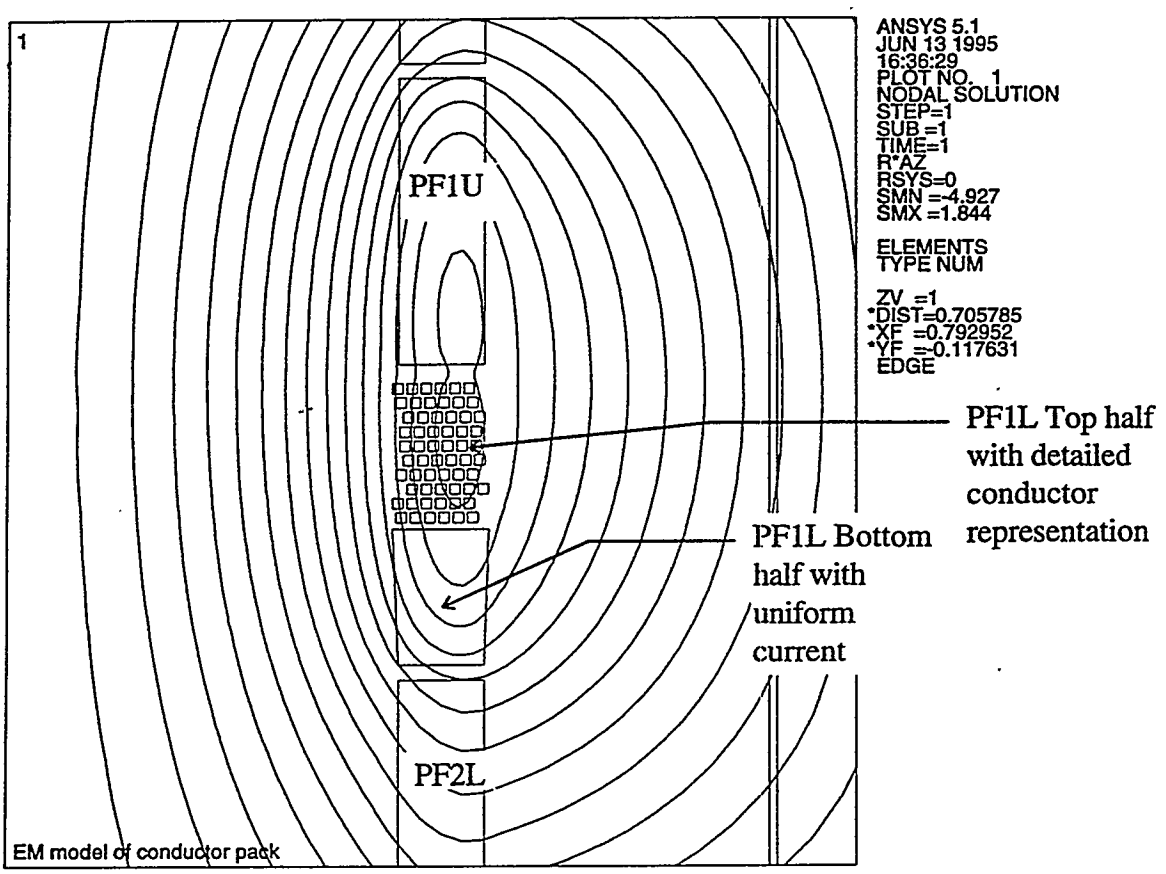


Figure 4.19 — Blowup of the magnetic flux lines in the vicinity of conductor pack PF1L.

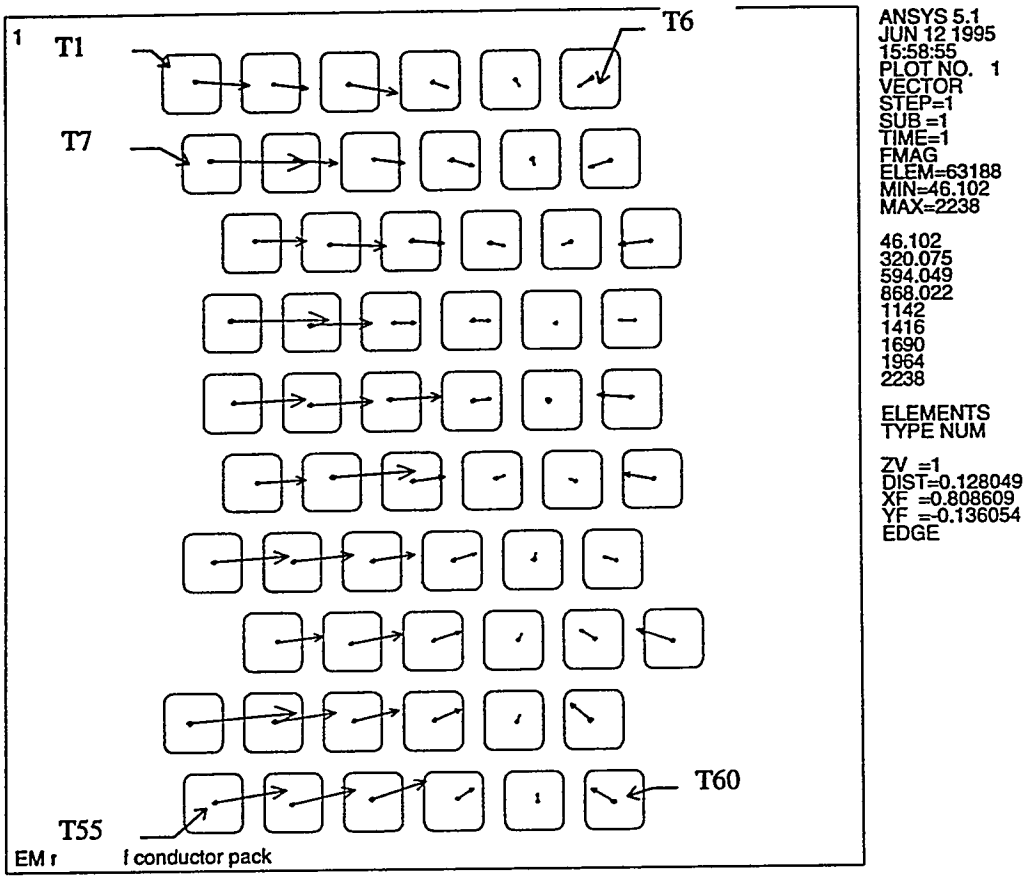


Figure 4.20 — Vector Lorentz forces acting on individual turns in conductor pack PF1L for equilibria #16.

Table 4.9 — Hoop and vertical forces acting on top 60 turns of PF1L during equilibria #16.

Turn	Hoop Tension (kN)	Vertical Force (kN)	Row
1	84.64	-40.18	
2	69.12	-58.63	
3	51.07	-67.34	1
4	30.91	-70.82	
5	8.97	-70.15	
6	-15.21	-61.53	
7	84.75	-10.01	
8	66.85	-30.82	
9	47.08	-41.01	2
10	25.76	-45.27	
11	2.77	-46.32	
12	-22.3	-48.05	
13	79.44	-6.60	
14	58.61	-16.25	
15	37.28	-21.75	3
16	14.72	-24.28	
17	-9.11	-25.24	
18	-32.99	-25.37	
19	84.87	3.45	
20	64.73	1.17	
21	43.34	-1.99	4
22	20.77	-3.72	
23	-3.09	-3.58	
24	-28.54	0.274	
25	85.34	20.53	
26	65.16	16.78	
27	43.61	15.32	5
28	20.82	15.02	
29	-3.27	15.66	
30	-28.98	15.64	
31	81.07	29.04	
32	59.94	30.58	
33	37.94	31.42	6
34	14.71	32.72	
35	-9.79	34.92	
36	-34.56	39.27	
37	88.08	42.99	
38	70.15	43.83	
39	48.83	45.67	7
40	26.18	48.12	
41	2.22	50.55	
42	-23.59	51.81	
43	75.53	52.84	
44	53.79	59.35	
45	31.52	63.75	8
46	7.94	67.19	
47	-16.68	71.93	
48	-37.56	73.56	
49	88.55	50.26	
50	72.72	65.11	
51	52.70	76.35	9
52	30.92	81.56	
53	7.43	84.01	
54	-18.66	86.51	
55	84.24	85.71	
56	66.31	93.48	
57	46.51	99.25	10
58	24.87	101.91	
59	1.48	100.31	
60	-23.88	89.18	

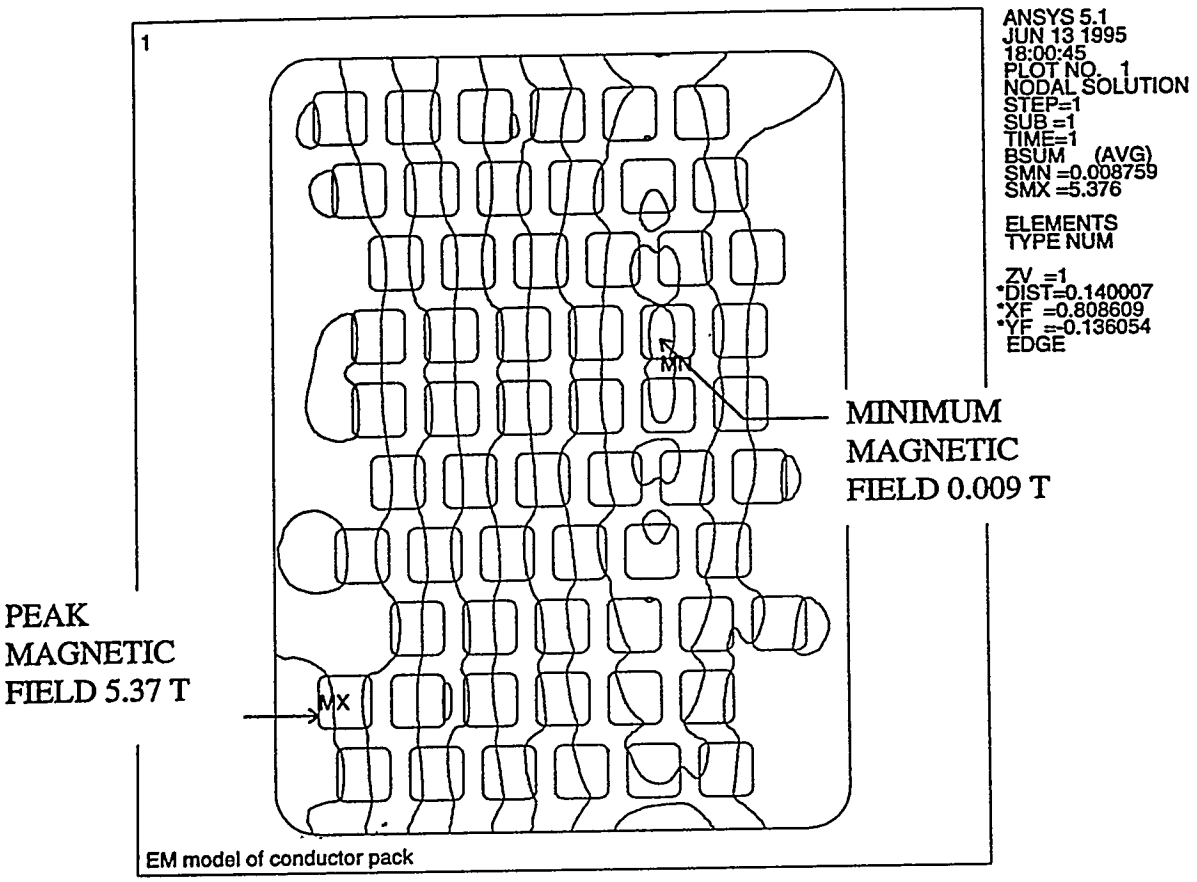


Figure 4.21 — Contours of constant magnetic flux density throughout coil PF1L for equilibria #16. Nine field contours are shown uniformly spaced by 0.597 T.

4.2.4. Force variations during worst case loading due to interactions with the TF coils

The force variations along the path of the conductor are significant in the case of PF6 and PF7 and, to a lesser extent, PF5. The angular force variations are due to the presence of the 16 discrete TF coils. The larger radius PF coils are subject to substantial variations in forces and fields around the TF coils. For example, Fig. 2.7 illustrates the force variation along a small portion (1/16'th) of PF6 at t=9 s of the HC scenario. The radial and vertical Lorentz force can be decomposed into steady and alternating components. The steady component has already been summarized in Figs. 4.2 through 4.4 and Table 4.2. The alternating component is proportional to the level of the TF coil current and the current in the PF coil of interest. Since the TF current, and correspondingly magnetic field, are constant in time, the alternating component of force is simply proportional to the magnitude of the PF coil current. The proportionality constants for PF5, PF6 and PF7 have been obtained from a single calculation for equilibria #3 (i.e., t=9 s of the HC scenario). Using the proportional constants, the zero-to-peak alternating component of force can be determined for each of the worst case loadings. Table 4.10 contains both the steady and alternating force components for PF5, PF6 and PF7 worst case EM loadings. In all three coils the vertical force component possesses a greater degree of spatial variation. In the case of PF5, the zero-to-peak alternating component is less than 12.2 percent of the steady force. However, in the cases of PF6 and PF7 the alternating force is as large as 119 and 365 percent of the steady force, respectively.

Table 4.10 — Summary of worst case PF5, PF6 and PF7 coil electromagnetic loadings including steady and spatially alternating force components along conductor path length.

Case Description		Radial EM Load (kN/(m-turn))		Vertical EM Load (MN/m)	
		Steady Force	Alternating Force	Steady Force	Alternating Force
PF5 Radial/ Centering	Normal Operating LC #1	22.6	0.52	0.829	0.091
PF5L Launch	Disruption following LC#14	6.05	0.66	0.949	0.116
PF6U Radial	Normal Operating LC#9	7.85	4.97	0.196	0.551
PF6L Centering	Disruption following LC #19	5.77	3.74	0.348	0.415
PF7U Radial	Disruption following LC#13	3.47	1.59	0.004	0.483
PF7U Centering	Disruption following LC#18	2.93	1.59	0.132	0.482

5. IMPACT OF COIL WINDING CONFIGURATIONS ON MAGNETIC FIELD ERRORS

In this section detailed filament models of the actual coil winding configurations are used to evaluate the level of magnetic field errors in the plasma region. A single 60 turn coil is modeled and the non-axisymmetric field components are calculated on a circle surrounding the coil possessing a radius equal to that of the center of the plasma. The effects on the field harmonics from design specific features such as spiral vs. constant radius/jogged and co-located vs. uniformly clocked layer-to-layer vertical transitions are evaluated. It is shown that different components of the non-axisymmetric magnetic field are directly driven by poor symmetry of the "in-plane" (i.e., in the plane of the ring coil) current and lack of cancellation of the "out-of-plane" (i.e., normal to the plane of the ring coil) current components. These current components which are contained in the different coil designs are first identified, and then a coil design is established which results in low field error in the plasma region. Lastly, the harmonic components of field error are evaluated on a more complex "dee-shaped" toroidal surface by decomposing the normal field in terms of its Fourier components for different PF3U coil designs.

5.1 MAFCO MODELS OF A CS CONDUCTOR PACK

The MAFCO computer program[18-20] along with the Westinghouse pre- and post-processor WECAN/Plus has been used to perform the magnetic analysis. The MAFCO program solves the Biot Savart integral for several different elementary current elements. The current elements used in this analysis were restricted to filament straight, filament arc, and filament helix. The filament representation for current is adequate since the fields are being evaluated at a substantial distance

away from the coils. Specifically, the initial set of observation points were placed on a radius of 225 cm and the coil mean radius is 81 cm. Later, a set of observation points slightly closer to the source currents on the "dee-shaped" plasma surface are used to extract the Fourier components of the error field.

Several different models were formed as the analysis evolved. Originally, a very simple 4 turn coil (i.e., 2 layers of 2 turns) was examined, but it was later suggested that a 12 turn coil (2 layers of 6 turns) will behave somewhat differently. The next iteration included 10 vertical layers, rather than 2, in an effort to more precisely represent a real PF coil (PF3). It was finally concluded that analysis of a 60 turn coil (10 layers of 6 turns) would be adequate to investigate the field effects of design details such as spiral vs. constant radius/jog windings and the effects of vertical transitions and the return lead. The different models that have been formed are summarized in Table 5.1.

The windings are constrained to have a mean radius of 81 cm and a turn-to-turn spacing of 2.54 cm (1 inch). Figure 5.1 shows orthogonal views of model #1 which is representative of a spiral winding. This model contains ten layers of 6 spiraled turns. The lowermost layer of the coil spirals outward radially until six complete turns are made. The current is then routed directly upward to the second

Table 5.1 — Summary of the different MAFCO models established for analysis of coil non-axisymmetric modes.

MODEL	WINDING TYPE	DESCRIPTION
1	spiral	6 spiral turns per layer, 10 layers with adjustable clocking and vertical return
2	constant radius	6 constant radius/jog turns per layer, 10 layers with adjustable clocking and vertical return
3	constant radius	6 constant radius/jog turns per layer, 10 layers with adjustable clocking and helical return

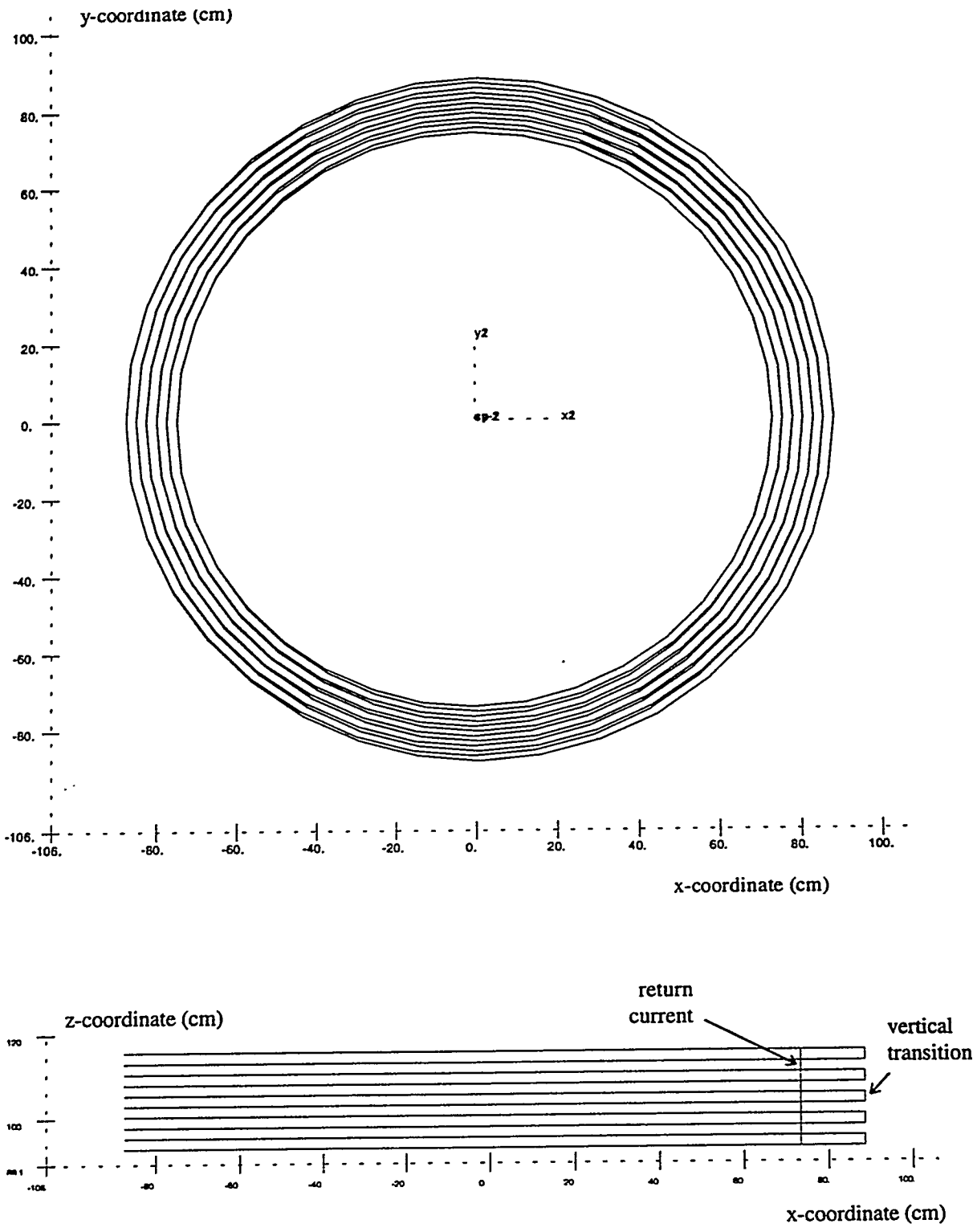


Figure 5.1 — Orthogonal views illustrating two layer spiral winding configuration with 6 turns per layer.

layer. The second layer spirals radially inward for six more complete turns. When the six turns are completed the current is again routed directly upward (i.e., a second vertical transition) and a second double layer (i.e., pancake) is started. Five complete pancakes form the ten layer coil. A final vertical transition serves to return the current from the 10'th layer to the 1st, thereby forming a completely closed path for the current to circulate The xy plane in Fig. 5.1 illustrates the radial and angular flow of current. The xz plane is useful in visualizing the vertical component of current.

Figure 5.2 illustrates the case of a 10 layer constant radius/jog winding configuration identified as model 2. The individual turns consist of a constant radius 345 degree arc and a 15 degree radial transition section wherein the arc radius is increased by the width of a single turn (i.e., 2.54 cm). In general, the angular span of the radial transition interval is specified in the input file with a parameter called JOG which is taken to be in the range of 10 - 30 degrees. The model also includes a layer-to-layer clocking. That is, the last turn of a given layer is either extended or reduced by a fraction of a turn so that the radial transitions in the next layer are slightly rotated. The clocking is specified with a parameter called ADV which is generally taken to be -36, 0, or +36 degrees in the analyses performed so that the start of the 1st layer and end of the 10'th layer occur at the same angular location. That is, in order to obtain symmetry in the x-y plane, the clocking should be set to an integer multiple of 360 divided by the number of layers ($\pm 360k/10$). The case of k=1 is termed "perfect clocking" and is the case generally considered in this report. A +36 degree clocking scheme will result in an extra turn when the entire coil is wound, while a -36 degree clocking scheme will result in the loss of a turn. The case of ADV=+36 will actually produce a physical interference in model 2 or 3, whereby a small section (36 degree) of the current lies on top of another piece. However, no attempt is made to re-route the turns since the analysis is only preliminary and of an exploratory nature. The xy plane illustrates the flow of radial and angular current and locations of the transitions around the periphery of the coil for the case ADV=-36 degrees. The xz plane shows the flow of vertical

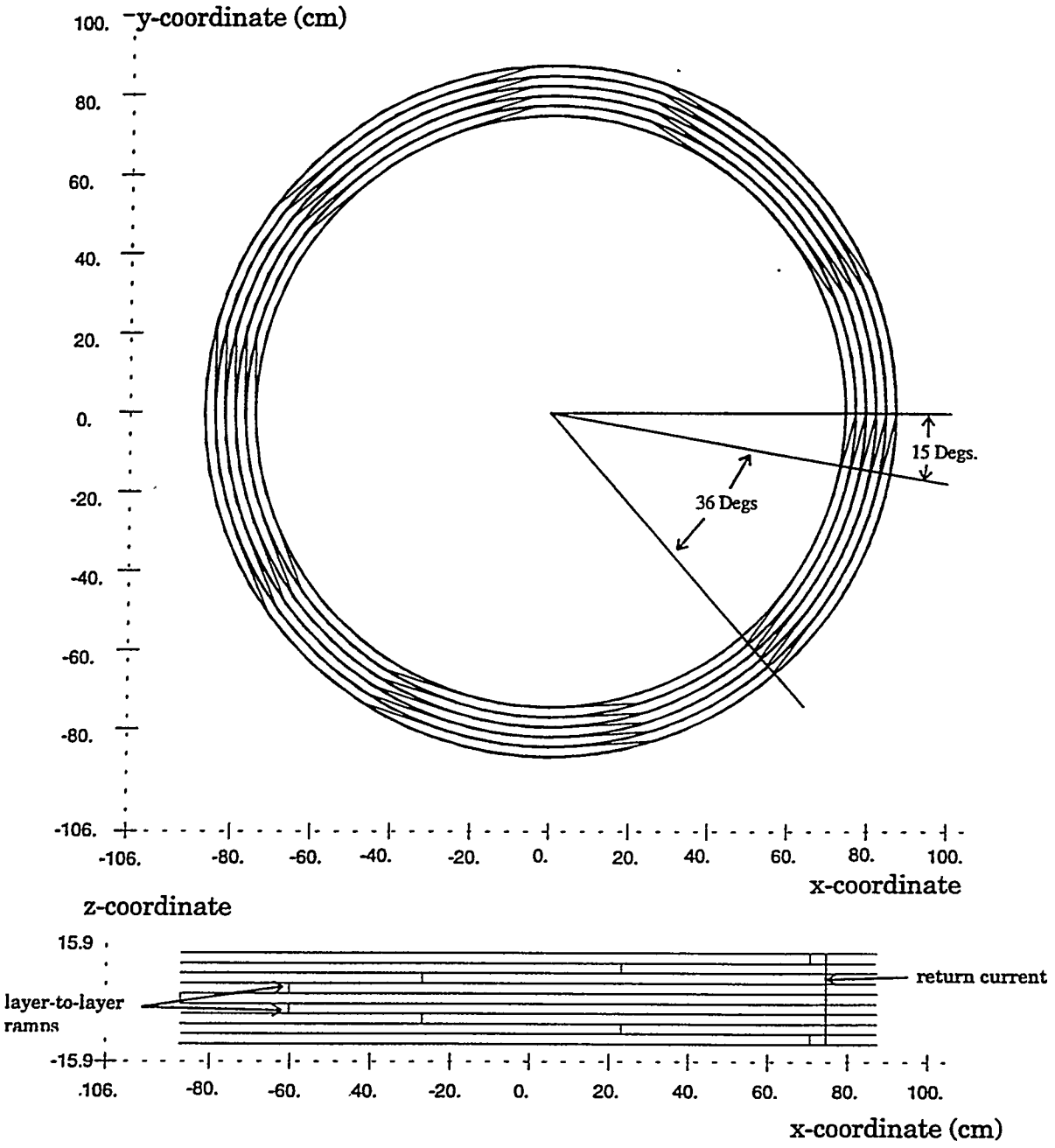


Figure 5.2 — Orthogonal views illustrating 10 layer, constant radius/jog winding configuration with 15 degree crossover interval and 36 degree retarded clocking.

current through the coil. The xz plane is particularly interesting since it clearly illustrates the large spatial separation (i.e., lack of cancellation) in the layer-to-layer vertical ramp elements and the coil end return lead.

Model 3 is the same as model 2 with the exception that the return current is helically routed from the top of the coil to the bottom as illustrated in Fig. 5.3. The helical return is used to provide better cancellation in the vertical component of current when the individual layers are clocked. It will be shown that the lack of vertical current cancellation produces substantial radial and angular non-axisymmetric field components. The helical return also serves to offset the gain or loss of a turn due to layer-to-layer clocking.

A listing of the three WECAN/PLUS command files used to establish the three MAFCO models is given in Appendix J. The procedure followed to form the MAFCO models was to use the finite element program WECAN/PLUS as a pre-processor to set up the coil geometry and the locations of field observation points. The individual elements defining the coil geometry were then converted to a MAFCO type input file using a translator program[21]. Lastly, the MAFCO program was used to calculate the magnetic fields from the filaments at each of the observation points.

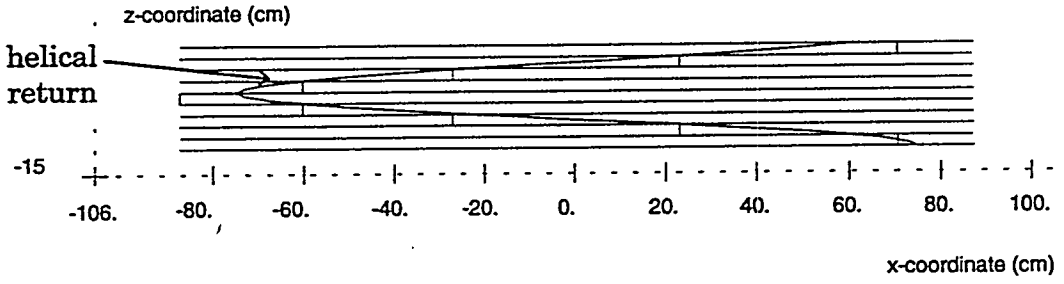


Figure 5.3 — Helical return path used to compensate for the layer-to-layer ramps.

5.2 SPIRAL VS CONSTANT RADIUS WINDING CONFIGURATIONS

The coil designs are evaluated by calculating the radial, angular and axial field components on an arc of a circle with its center located at the center of the coil and possessing a radius of 225 cm. The field errors can be directly observed in the case of the radial and angular fields since an ideal circular coil (60 pure hoops) will only produce a uniform z-directed field. The z-directed error field is obtained by subtracting the steady, space-invariant component from the signal. The error fields are expressed in parts per 10000 of the fundamental poloidal field where the fundamental poloidal field is the steady average z-directed field.

Plots of the magnetic field arising for the cases of the 60 turn spiral and constant radius/jog coils are shown in Figs. 5.4 through 5.6. Figure 5.4 compares the radial component of field for the spiral and constant radius designs. A 100 A current was used so that the coils produced 6000 A-T. No clocking exists between the individual layers of the coils so that the current pattern in the x-y plane is the same for each pancake. Figure 5.5 compares the angular components and Fig. 5.6 compares the vertical component. The radial and angular error fields are similar, but the vertical error field is much greater for the case the constant radius/jog coil. The large vertical error field in the constant radius/jog coil is attributed to the relatively large (i.e., 30 degrees) radial transition interval used in this design. Smaller radial transition intervals considerably reduce the z-directed error field as shown in the next section.

5.2.1 Effect of radial transition interval on z-directed field errors

A smaller crossover interval of 15 degrees for the case of the constant radius/jog configuration was also analyzed. This significantly reduces the vertical field variation so that it is of the same order as that of the spiral winding. In order to directly compare each of the 3 components of error field on the same scale, the field errors are normalized by the nominal field magnitude. Figures 5.7 through 5.9

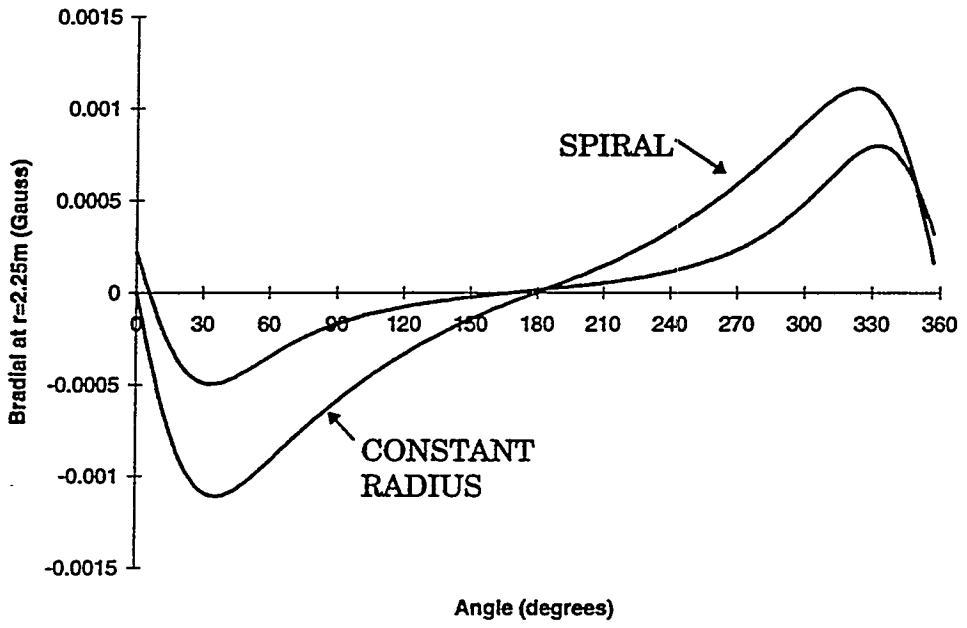


Figure 5.4 — Comparison between radial field perturbations for 60 turn spiral and constant radius coil configurations. The radial transition interval for the constant radius/jog configuration is degrees.

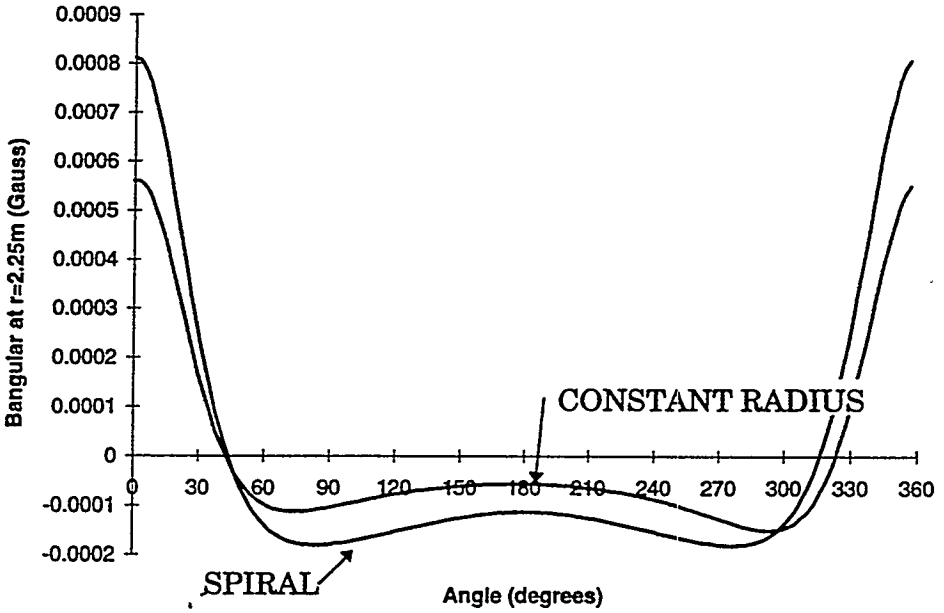


Figure 5.5 — Comparison between angular field perturbations for 60 turn spiral and constant radius coil configurations. The radial transition interval for the constant radius/jog configuration is 30 degrees.

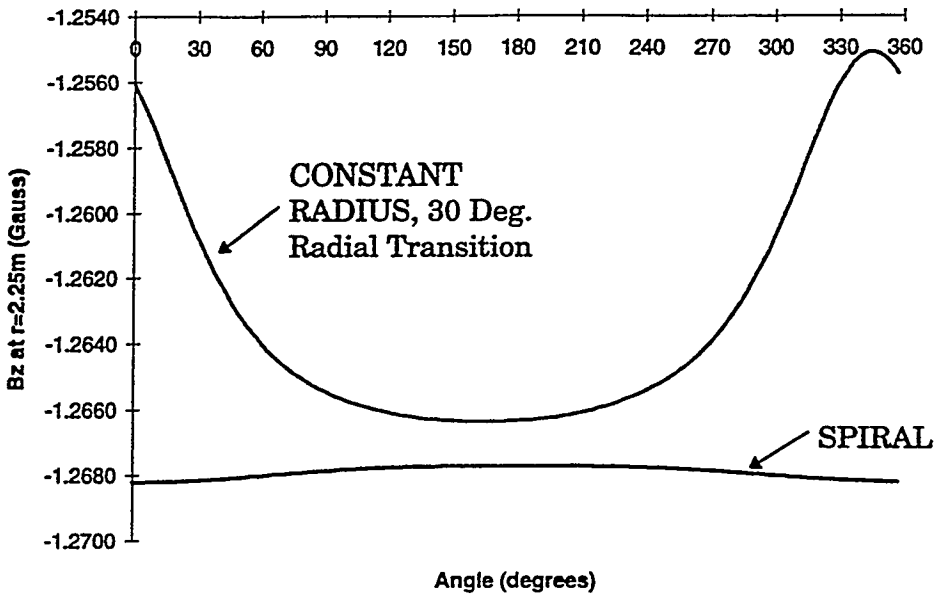


Figure 5.6 — Comparison between vertical field perturbations for 60 turn spiral and constant radius coil configurations. The radial transition interval for the constant radius/jog configuration is 30 degrees.

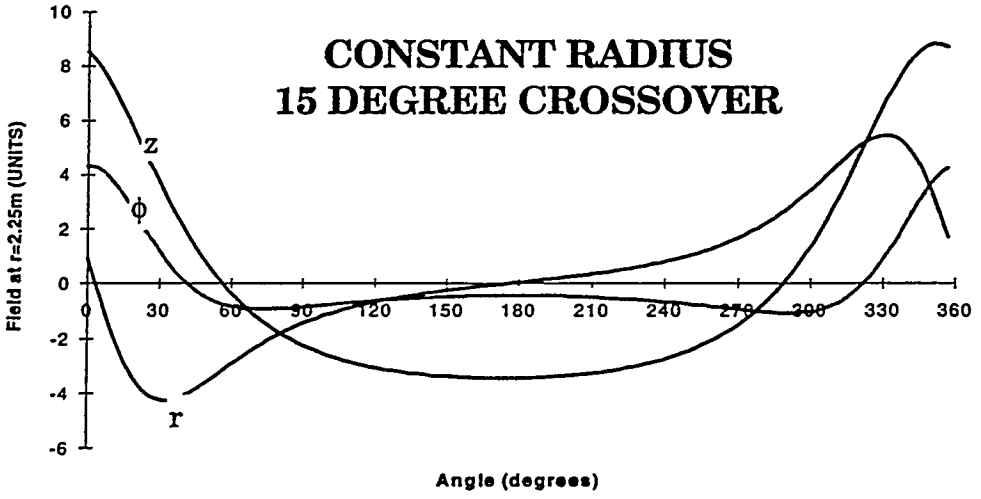


Figure 5.7 — Magnetic field errors for a constant radius/jog configuration with 15 degree radial transition interval and vertical return lead.

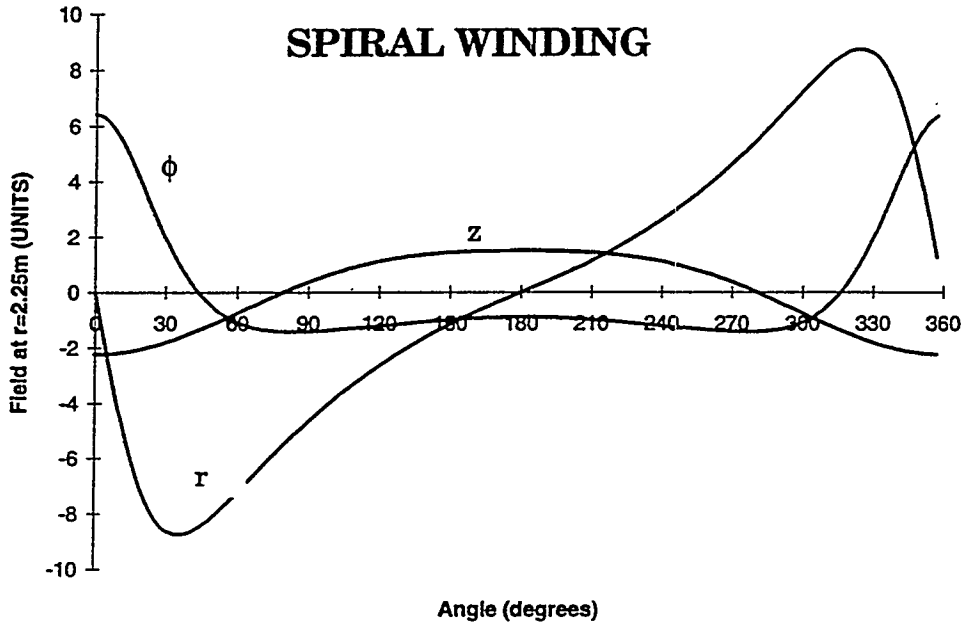


Figure 5.8 — Magnetic field errors for a co-located 60 turn spiral configuration with a vertical return lead.

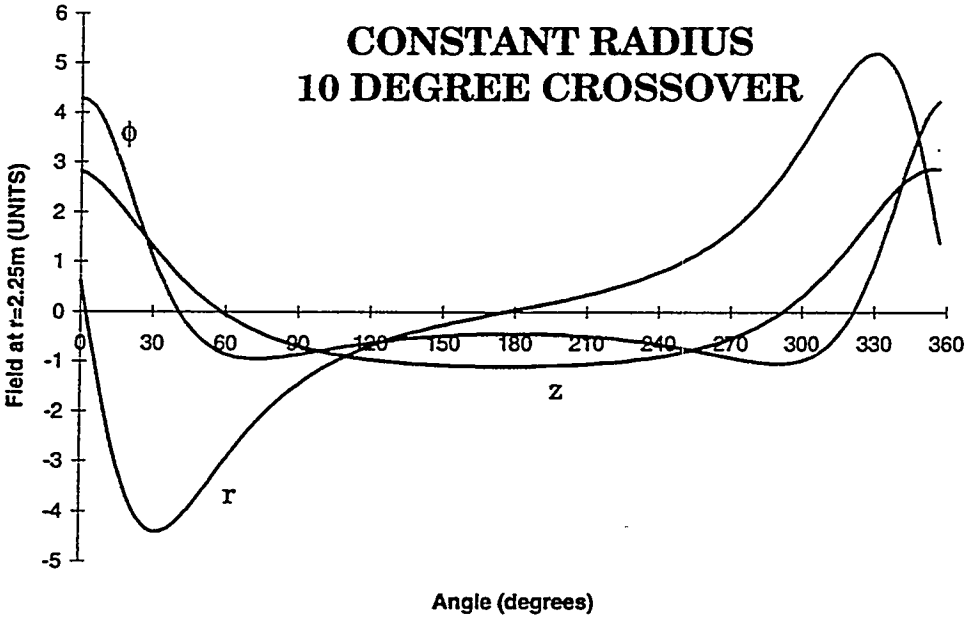


Figure 5.9 — Magnetic field errors for a constant radius/jog configuration with 10 degree radial transition interval and vertical return lead.

show the field errors expressed as parts per 10000 of the nominal field for constant radius/jog and spiral cases.

Although the vertical field error is still larger for the constant radius/jog case, it has been considerably reduced by halving the angular transition interval from 30 to 15 degrees. The vertical error can be further reduced for the constant radius/jog by reducing the crossover angle to less than 15 degrees. To illustrate this a third case of a 10 degree radial transition interval is shown in Fig. 5.9. This results in even a smaller z-directed error field, with practically no change in the radial and angular field components. It is clear that the vertical-field variations are driven by the current components in the plane of the coil (i.e., x-y plane), while the radial and angular field variations are relatively independent of these current components. The 10 degree radially transition interval produces field harmonics for the constant radius/jog design which are as low as or slightly lower than that of the spiral configuration.

5.3 CO-LOCATED VS UNIFORMLY ANGULAR SPACED LAYER-TO-LAYER JOGGLES

The effects of layer-to-layer clocking was evaluated by uniformly rotating each of the 10 coil layers relative to each other and appropriately extending or trimming the end turn so that the coil layers properly interconnect. Figure 5.2 illustrates the geometry and Fig. 5.10 shows the corresponding field errors. Clearly the radial and angular errors have grown considerably. The peak radial error is about 8 times larger as a result of the layer-to-layer clocking. The angular field error has increased by a factor of about 6. On the other hand, the vertical field component has been reduced to below 2 parts in 10000. Figure 5.11 shows a blowup of the vertical component. Unfortunately, this reduction has been accomplished at the expense of the radial and angular field errors.

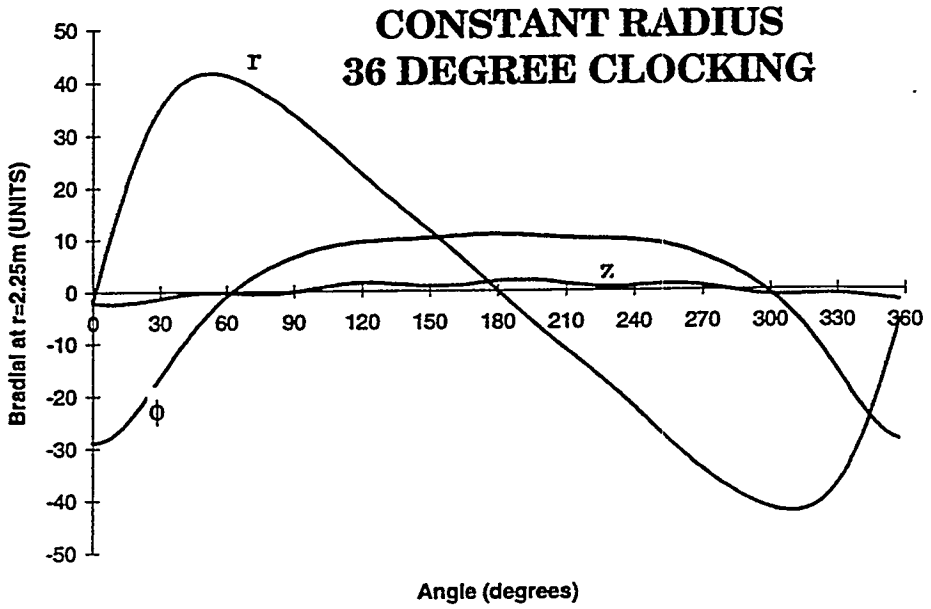


Figure 5.10 — Magnetic field errors for a constant radius/jog configuration with 36 degree clocking and 15 degree radial transitions.

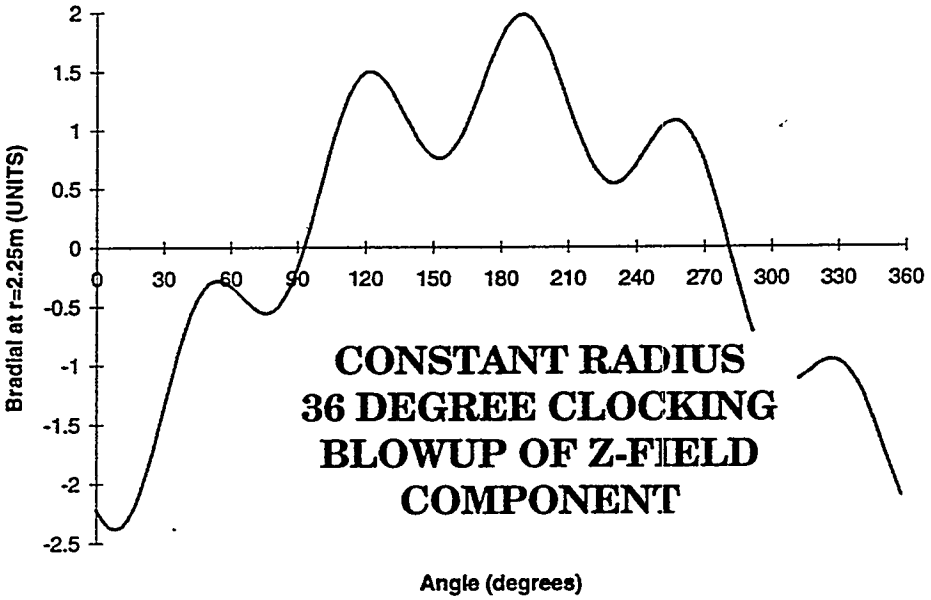


Figure 5.11 — Blowup of vertical magnetic field error for a constant radius/jog configuration with 36 degree clocking and 15 degree radial transitions.

5.3.1 Compensation of the vertical current with a helical return

The major problem with the layer-to-layer clocking is that the cancellation in the vertical components of current is poor. That is, the return lead is located at a single angular location while the vertical ramps are distributed about the coil periphery. As a result of this, the vertical currents are no longer locally compensated by a portion of the return lead. One way to fix the problem is to track the return lead back along the same angular pattern that the ramps form. This path turns out to be a helix for the uniform clocking schemes as illustrated in Fig. 5.3. A helical return was added to the 60 turn, constant radius coil model with -36 degree clocking to illustrate the cancellation concept. The field errors for this case are plotted in Fig. 5.12. The errors have been significantly reduced from those of the straight vertical lead as was anticipated.

5.4 ERROR FIELDS FROM GROSS COIL HORIZONTAL MISALIGNMENT

It is believed that the radial perturbations shown in Fig. 5.11 could be further reduced by more carefully designing the helical return so that the vertical current component precisely aligns with the layer-to-layer transitions. However, other effects such as coil centering may contribute to field errors which are much larger in magnitude, thereby masking the contribution from the winding design. In order to determine the expected level of field error due to coil offset an analysis has been performed with a perfect circular coil translated 10 mm in the x-direction. The field variation is again plotted on an circle of radius 2.25 m as shown in Fig. 5.12. In this case only a z-directed component of field exists because the field is exactly normal to the coil midplane. The peak variation is 150 parts of the nominal vertical field which is much larger than those errors attributed to coil design. If the alignment is held to within 5 mm the field error is 75 parts which is still larger than the worst case design induced field error of 40 parts. Based on this argument it is suggested that the CS coils be designed with field errors less than 10 parts per

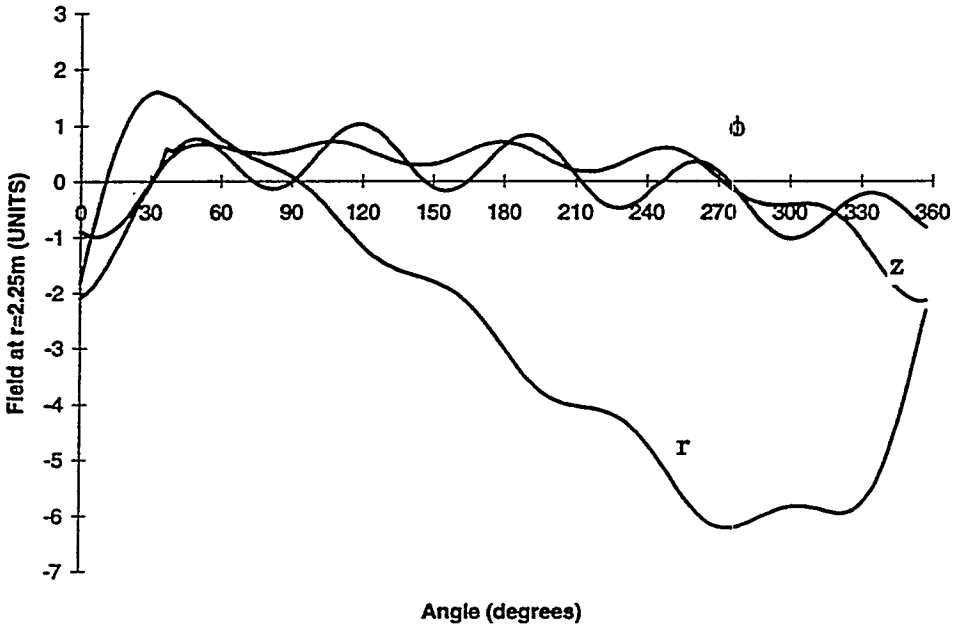


Figure 5.12 — Magnetic field errors for a constant radius/jog configuration with 36 degree clocking and helical return compensation.

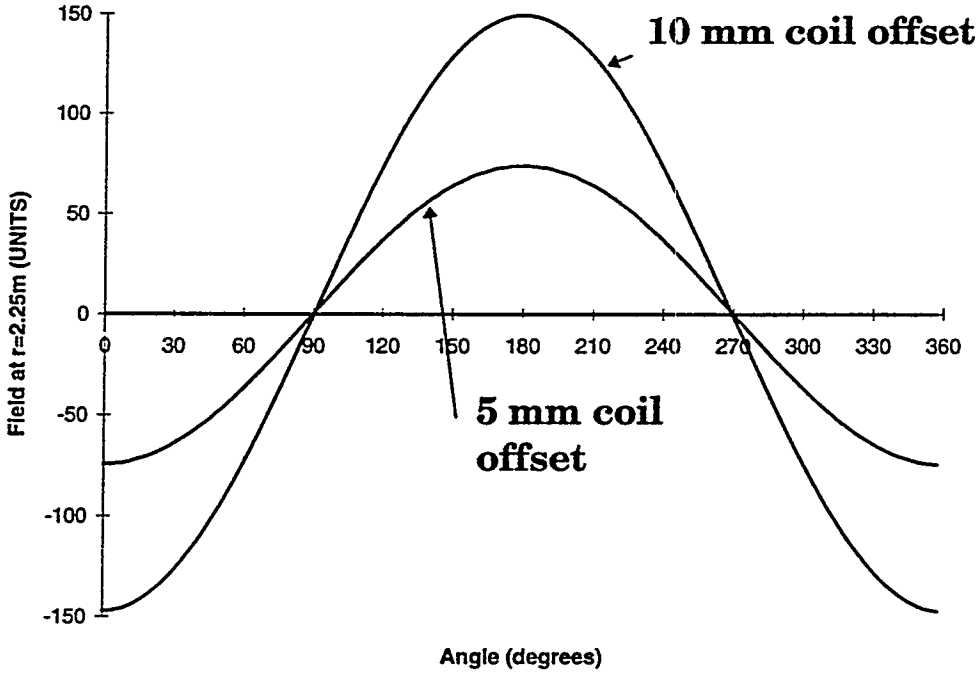


Figure 5.13 — Vertical magnetic field error for a perfect circular coil offset 10 mm in the x-direction.

10000 relative to the nominal vertical field so the design contribution to field error is insignificantly relative to alignment error.

5.5 FIELD ERROR EXPRESSED AS FOURIER COMPONENTS ON "DEE-SHAPED" SURFACE

The convention used for the TPX program is to express field errors in terms of complex resonant field components associated with the Fourier decomposition of the magnetic field normal to a "dee-shaped" toroidal surface[21]. Thus far in this report, the error field has been described in terms of variations in the radial, angular, and vertical field components. In order to be consistent with the definition and requirements adopted by the TPX program, the aim of this section is to express the field errors from the different coil designs in terms of the Fourier components on the plasma surface.

5.5.1 Calculation of the complex resonant, helical field component

The field error modes are defined by Jardin[22] to be

$$\delta B^{r}_{m,n} = \frac{1}{2\pi^2}\int_0^{2\pi}\int_0^{2\pi} \nabla r \cdot \bar{B} e^{i(n\phi - m\theta)} d\phi d\theta \tag{5-1}$$

where ϕ is the toriodal angle, θ is the poloidal angle, ∇r is the unit vector normal to the "dee-shaped" surface and $\bar{B}$ is the magnetic flux density. The "dee-shaped" surface is define parametrically by

$$R(\Theta) = R + a\cos(\Theta + \delta\sin\Theta) \tag{5-2a}$$

$$Z(\Theta) = -\kappa a\sin(\Theta) \tag{5-2b}$$

where the parameters are: R=2.25 m, a=0.5 m, κ=1.8, δ=0.5 and Θ is varied from 0 to 2π. The angle θ of the expansion given in (5-1) is related to the parameter Θ by

$$\theta = \frac{2\pi \int_0^{\Theta} f(\Theta')\,d\Theta'}{\int_0^{2\pi} f(\Theta')\,d\Theta'} \qquad (5\text{-}3)$$

where

$$f(\Theta) = \frac{\cos(\delta \sin\Theta) + \frac{\delta}{2}\sin(2\Theta)\sin(\Theta + \delta\sin\Theta)}{R(\Theta)}.$$

Unfortunately, the physical meaning of "little theta", θ, is not given by Jardin[22]. Although it is not needed to proceed since the mathematical definition is given, it would be complete to have an understanding of the physical significance of the angle θ.

An EXCEL spread sheet was used to define 512 points equally spaced in "little theta" along the "dee-shaped" path. In order to do this, equation (5-3) is solved for "big theta" as "little theta" is stepped from 0 to π. Since the equation is expressed in terms of an integral, an iterative technique is required to determine "big theta". The location of every 16'th point is plotted in Fig. 5.14 so that the point spacing can be observed. The upper half points are obtained by symmetry. The same set of 32 poloidal points are used at 32 different toroidal locations to define the surface at which the field is to be evaluated. Locating the array of points in this way has the advantage that a two-dimensional Fast Fourier Transform (FFT) can be applied to the data to quickly and accurately determine the harmonic coefficients. A listing of the entire 1024 points defining the "dee-shaped" surface is given in Appendix K.

The Fourier integration in (5-1) is performed using the computer program MATLAB[23]. A two-dimensional complex FFT is applied to transform the 32 by 32 array of magnetic field components. This transform is defined for N_1 points in the poloidal direction and N_2 points in the toroidal direction as

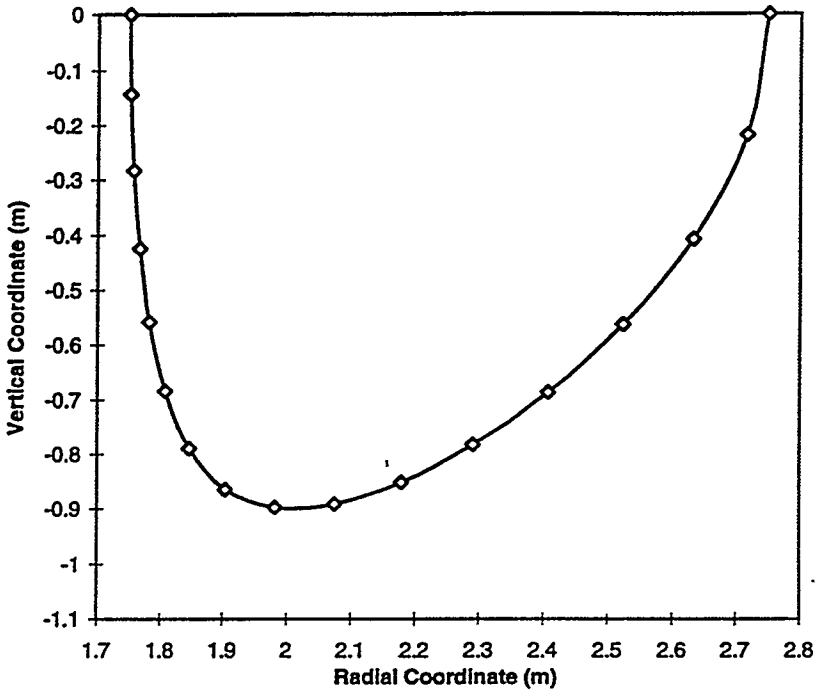


Figure 5.14— Location of points equally spaced in "little theta" on the plasma surface.

$$X(m,n) = \sum_{k=0}^{N_2-1} \sum_{j=0}^{N_1-1} x(j,k) W_1^{mj} W_2^{nk} \tag{5-4}$$

$$W_1 = e^{-\frac{2\pi i}{N_1}} \qquad \text{and} \qquad W_2 = e^{-\frac{2\pi i}{N_2}}$$

Equation (5-4) can be interpreted as a discrete version of (5-1) if positive values of n and negative values of m are considered. Further some scaling must be applied to (5-4) so that it can be used as an approximation of (5-1). The relationship between the transform given by (5-4) and the actual field error modes is given below.

$$\delta B^r_{m,n} = \frac{2}{N_1 N_2} X(m,n) \tag{5-5}$$

Since the number of points in both the toroidal and poloidal directions have been taken to be 32, the scale factor is 1/512. Also, the range on m and n is from -15 to 16. Again, we are only interested in negative m's (primarily m=-1,-2,-3 and -4) and

positive n's (primarily n=1 and 2). These terms represent the right-handed modes of the magnetic field. That is, the peak of the magnetic field rotates in the positive (clockwise) poloidal direction as one moves in a positive (counterclockwise) toriodal direction. The other left-handed modes (positive n's and positive m's*) correspond to a field component that rotates in the negative (counterclockwise) poloidal direction as one moves in a positive (counterclockwise) toroidal direction. According to Jardin[22] the left-handed modes are not of interest.

Lastly, the transform can be expressed in terms of sine and cosine components to allow comparison with results presented by others[24]. Equation (5-4) is expanded in terms of sine and cosine components as:

$$\delta B^{r}_{m,n} = \frac{2}{N_1 N_2} \sum_{k=0}^{N_2-1} \sum_{j=0}^{N_1-1} x(j,k) \left[\cos\left(\frac{2\pi mj}{N_1} + \frac{2\pi nk}{N_2} \right) - \sin\left(\frac{2\pi mj}{N_1} + \frac{2\pi nk}{N_2} \right) \right]$$

Therefore, the real part of the coefficient can be interpreted as the cosine transform component and the negative of the imaginary part is the sine transform component. One final complication that exists in the Wang[24] implementation of the sine and cosine transformation is that the argument (i.e. $m\theta$-$n\phi$) is the negative of that of Jardin[22]. This has no effect on the cosine transformation, but alters the sign of the sine transformation. As a result of this, it is believed that Wang's cosine transformation produces the real part of the complex Fourier coefficient and the sine transformation produces the imaginary part of the complex coefficient.

5.5.2 Results for the PF5U coil designs

The complex helical field components have been calculated for the PF3 coil designs described in Section 5.1. These designs are:

---

* negative n's and negative m's are also left handed. They are simply the complex conjugate of the positive m,n modes since the signal is purely real.

1) the spiral winding configuration with the vertical transitions co-located at 0 degrees and a vertical return at zero degrees;
2) the constant radius/jog configuration (10 deg. radial transitions) with vertical transitions co-located at 0 degrees and a vertical return at 0 degrees;
3) the constant radius/jog configuration (10 deg. radial transitions) with vertical transitions clocked by -36 degrees and a vertical return at 0 degrees;
4) the constant radius/jog configuration (10 deg. radial transitions) with vertical transitions clocked by 36 degrees and a helical return which compensates for the clocking

A current level of 24 kA was used in the calculation since it is the largest PF5 current of the 23 equilibria. The magnitude of the complex coefficients for the right helical modes of interest are summarized in Table 5.2. Also shown in the table are the required levels from ECP #0037. The complex coefficients are normalized to 4T to be consistent with the requirements in ECP #0037. It is noted that the requirement includes all of the coils and leads in the machine, while the coil design calculations are only for the contribution from PF5U. The complete set of complex coefficients for the four designs are given in Appendix L.

In addition to the numerical coefficients, the field error from the four coil designs can be illustrated by plotting the non-axisymmetric portion of the magnetic field on the developed "dee-shaped" surface. The non-axisymmetric portion of the magnetic field from PF5U is obtained by subtracting, at any point, the n=0 field component. That is, the toroidally averaged field is subtracted from every point to obtain the distributions shown in Figs. 5.15 through 5.18. Each of the plots correspond to one of the four different designs.

Both the tabulated helical coefficients and the surface plots appear to be consistent with the results obtained with the magnetic field evaluation on a circle surrounding the coil. Specifically, Figs. 5.8 through 5.12 correspond to the same

Table 5.2 — Magnitude of the critical right helical field modes produced by four different PF5 coil designs. The coefficients are expressed as parts per 10^4 relative to 4T.

	n=1				n=2		
	m=1	m=2	m=3	m=4	m=3	m=4	m=5
System Requirement	< 2.000	< 1.000	< 1.000	< 1.000	< 4.000	< 4.000	< 4.000
PF5U Spiral, co-located	0.0197	0.0194	0.0139	0.0094	0.0068	0.0041	0.0027
PF5U constant radius/jog co-located	0.0077	0.0039	0.0019	0.0011	0.0020	0.0010	0.0004
PF5U constant radius with -36 deg. clocking	0.0962	0.0639	0.0436	0.0269	0.0177	0.0109	0.0059
PF5U constant radius, -36 deg. clocking, helical return	0.0079	0.0092	0.0062	0.0044	0.0029	0.0019	0.0011

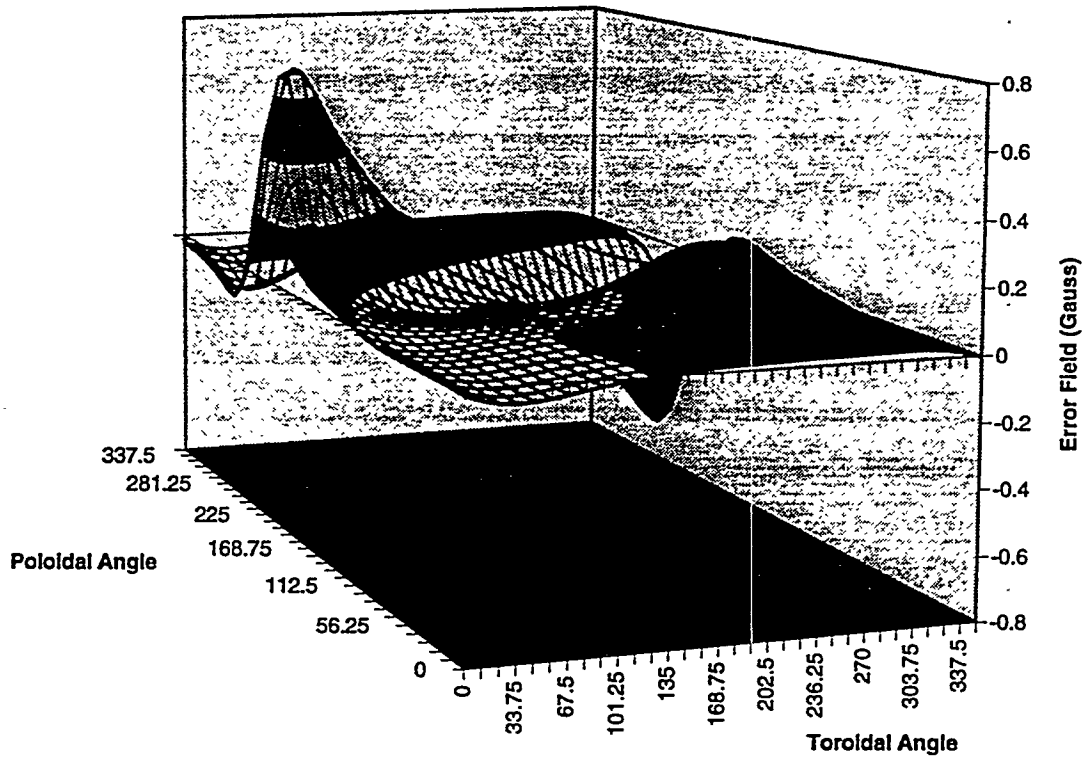


Figure 5.15 — Developed plot of the non-axisymmetric magnetic field on the "dee-shaped" plasma surface for coil PF5U with a co-located spiral type winding and a vertical return lead.

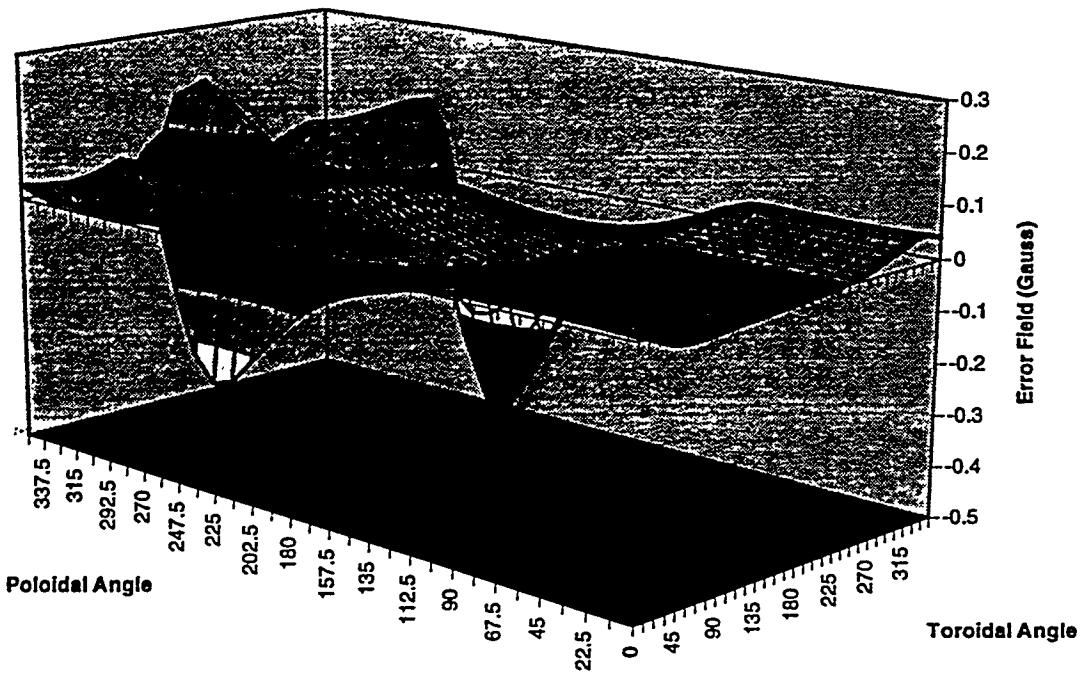


Figure 5.16 — Developed plot of the non-axisymmetric magnetic field on the "dee-shaped" plasma surface for coil PF5U with a co-located constant radius/jog type winding with 10 degree radial transitions and a vertical return lead.

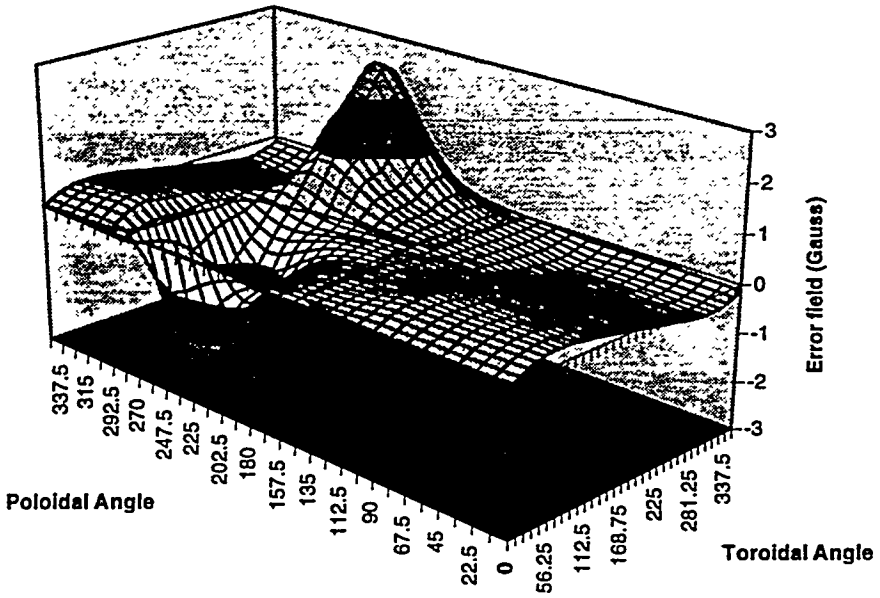


Figure 5.17 — Developed plot of the non-axisymmetric magnetic field on the "dee-shaped" plasma surface for coil PF5U with a uniformly clocked (i.e., -36 degree) constant radius/jog type winding and a vertical return lead.

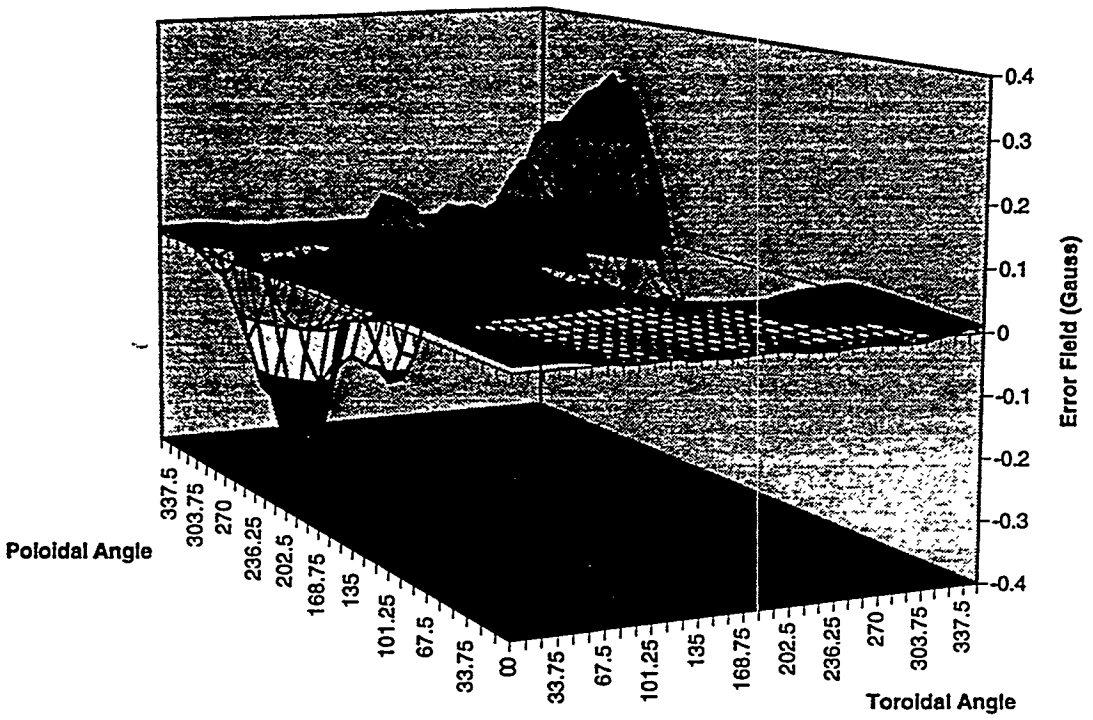


Figure 5.18 — Developed plot of the non-axisymmetric magnetic field on the "dee-shaped" plasma surface for coil PF5U with a uniformly clocked (i.e., -36 degree) constant radius/jog type winding and a compensating helical return lead.

four coil designs, but with the magnetic field component (i.e., r,ϕ, z) being evaluated on a 2.25 m circle. The radial, r, and vertical, z, components are of primary interest since the angular component does not contribute to the normal field on the "dee-shaped" surface (i.e., it is always tangential). Figure 5.10 illustrates the case of the uncompensated uniformly clocked design which contains very high radial field harmonic content relative to the other designs. The peak radial field is about ten times higher than that of the co-located constant radius/jog design (Fig. 5.9). Similarly, the harmonics in Table 5.2 for these two designs differ by about an order of magnitude. The spiral design appears slightly worse in harmonic content than the co-located constant radius/jog design (10 deg. radial transitions) regardless of

the method of evaluation. Likewise, the helically compensated, uniformly clocked designed performed well using both methods of field error evaluation. The ranking of the four coil designs, based on either the peak radial field excursion in the case of the circle, or the magnitude of the helical coefficients in the case of the surface expansion, is given below ordered from best to worst design:

1. The co-located constant radius/jog design (10 deg. radial transitions) with a vertical return.
2. The uniformly clocked (-36 deg.) constant radius/jog (10 deg. radial transitions) with a helical return to compensate for the vertical current component.
3. The co-located spiral design with a vertical return.
4. The uncompensated uniformly clocked (-36 deg.) constant radius/jog (10 deg. radial transitions) with a vertical return.

The design with the helical return for compensation (ranked #2) is very similar in field error content to the co-located constant radius/jog design (ranked #1). It is anticipated that this design would actually be the best with more precise sizing and locating of the compensating helical return.

5.5.3 Discussion and recommendation

The answer to the question of which method of layer winding is superior "spiral or constant radius/jog" is dependent upon the length of the angular span of the radial transition section used in the constant radius/jog coil. If an angular span greater than 15 degrees is chosen, then the spiral coil is superior. If an angular span less than 15 degrees is realized, then the constant radius/jog coil will produces less field error. In the case of the larger transition angles (i.e., >30 degrees) the present modeling becomes inaccurate since a straight line element is assumed throughout the transition region. In actual coil designs with large transition angles a gentle spiral section would most likely be used to make the transition. The

straight line current element is a poor approximation to this current geometry since it begins to invade the interior of the coil.

The compensation in the vertical components of current is more important from a field error perspective than the "in-plane effects" (i.e., current flow in the plane of the coil). If the individual layers of the coils are rotated around or "clocked" and no attempt is made to compensate the vertical component of current with an equal and opposite current element, then the effect on the field error is substantial. This is the situation which occurs with the "perfect clocking scheme" (i.e., -36 degree rotation for each of 10 layers) that was analyzed in this report. The helical coefficients resulting from this type design are an order of magnitude larger than those from other designs.

The question of whether or not these "designed-in" field errors are important depends on their amplitudes relative to manufacturing errors such as coil shape (i.e., ovality) and alignment (i.e., offsets and tilts). This issue was only briefly addressed in this work by horizontally offsetting the PF5U coil by 5 mm and evaluating the relative size of the field error. About 66 percent more error than the worst case coil design was observed. This means that a 3 mm horizontal offset (if we assume a linear scaling rule) will produce field errors comparable to a poorly designed coil. Based on the understanding that this (i.e., 3 mm) is roughly the level of alignment which is presently achieved, the detailed design of the coil can significantly contribute to the field error. The "designed-in" errors will become more important as better alignment and manufacturing is achieved. My suggested criteria for acceptable coil designs is that the "designed-in" field errors are less than 10 percent of those due to a 5 mm offset (comparable to that of a 0.5 mm horizontal offset).

As for the question of whether or not the co-located spiral design is judged as acceptable, my answer is a "guarded yes". The field errors from this design are very nearly at the 10 percent criteria according to the analysis presented. However, some of the details of the actual coil design such as small levels of layer-to-layer clocking to avoid physical interferences or the precise angular span of the vertical transition elements could produce substantial field error. These design modifications should

not incorporated without considering their impact on field errors. Also, the present analysis was focused on central solenoid coils, in particular PF3U, and the extension of the conclusions to bigger radius coils (PF6 and PF7) should not be made without further analysis.

6. SUMMARY AND CONCLUSIONS

6.1 THE GLOBAL ELECTROMAGNETIC MODEL

A global model including the TF coils, PF coils, internal control coils, plasma current and TF interconnect hoop current has been formed using the ANSYS computer program. The SOURC36 stranded bar and arc primitives are used to construct the current geometry and the magnetic fields have been calculated using the Biot-Savart integration algorithm internal to the ANSYS code. The Lorentz forces are then evaluated in the post-processor using a small set of ANSYS commands tailored for this purpose. The forces results were in very good agreement (i.e. 2 percent or better) with University results with the exception of the radial force on PF5 which showed slightly lower radial forces. The discrepancy was tracked to a slight error in the radial build of PF5 in the University model.

In the case of the magnetic field, local errors (up to -7 percent) were observed in the ANSYS model. These occurred on the surfaces of the hoop coils where the Biot-Savart integration becomes particularly difficult due to singularities. ANSYS, Inc. has been notified of the errors and indicated they were working on refining their calculation at those locations. Since the peak field generally occurs on the inner surface of the hoop coils, the ANSYS generated results (for PF peak field only) should be treated with caution. The error is very localized; thus, it has very little effect on the body Lorentz forces.

6.2 ALGEBRAIC FORCE EXPRESSIONS

Algebraic expressions have been established to obtain the body forces in terms of the system currents for the present PF coil system. This allows for quick

evaluation of the forces on a spread sheet by simply substituting the PF current levels. The force coefficients have been verified by comparing with the University supplied body forces for the twenty-three static equilibria. The concept has applied to the alternating force component from interactions with the TF system and the internal compressive forces due to a turn interacting with its self field.

6.3 WORST CASE ELECTROMAGNETIC LOADING

Worst case electromagnetic loadings of the PF coils have been defined by examining University-supplied force results for several different events including normal operating modes, plasma disruptions and terminal faults. The events have been screened in cooperation with the University to identify a small number of particularly severe events that are examined in greater detail using refined electromagnetic and structural models. The refined electromagnetic models have been used to obtained a turn-by-turn description of the forces acting throughout the conductor pack. These electromagnetic loadings, in turn, are incorporated into other structural models to evaluate structural integrity. Temporal data is supplied in addition to the spatial force data so that structural fatigue issues can be investigated.

Some comments are appropriate as to the level of uncertainty in the calculations so that adequate design margins can be established. In general, the University-supplied Lorentz force calculations have been found to be of high accuracy and in close agreement with our own; usually to within two percent or less[7]. The primary contributor to uncertainties in the electromagnetic forces deals with specifying the system currents. This includes currents in the PF coils themselves and, to a lesser degree, currents induced in other conducting members. For example, some rather large changes in the force values were observed during disruption cases when the current conservation rule was replaced by a flux conservation rule. Other changes in the force results were reported when the short circuit delay time (after plasma quench) was varied.

Additional factors that have not been thoroughly analyzed in the studies performed to date includes the effects of the conduit magnetization, coil misalignments, and radial and vertical control functions. The modeling work described in Section 4.2 indicates the impact of the conduit magnetization will be beneficial in the case of the maximum radial force since the force is reduced by the presence of the incoloy conduit. However, in the case of the vertical force component the effect is detrimental since the compressive force is enhanced by the conduit magnetization. The amount of the enhancement is a few percent for the single case studied in Section 4.2, but other load cases may result in even larger force enhancements. The maximum coil Lorentz forces will certainly be increased due to radial and vertical control functions of PF5 and PF6, since the magnetic fields and PF5 and/or PF6 currents will be slightly higher. This variation has not yet been accounted for in the calculations performed to date. It is *estimated* that all the electromagnetic variations can enhance the coil loading by 5 to 10 percent. Further, if these variations are combined with those of structural origin[16] it is *estimated* that a ±15 percent window would cover the uncertainties. Based on this assessment a 15 percent design margin is recommended.

6.4 FIELD ERRORS DUE TO HOOP COIL DESIGN

Detailed hoop coil design features such as radial transitions via short jogs and the effects of layer-to-layer clocking have been shown to possess current components which drive the undesirable error field modes. In particular, it has been shown that constant radius/jog designs with a radial transition interval greater than 15 degrees produces more field error than a spiral type design. Additionally, layer-to-layer clocking arrangements without vertical current compensation produce a significant level of field error. It is demonstrated that a helical return lead can be configured to to compensate for the layer-to-layer clocking so that the resulting field errors are reduce by an order of magnitude. The level of field error from a poorly designed (as judged from the viewpoint of field errors) coil are of the same magnitude as that from a gross 3 mm horizontal coil misalignment which implies

that field errors inherent to the coil design can be a significant contributor to the total field error. A co-located vertical transition, spiral type coil design is being proposed for the PF coils. This design has been analyzed for the case of PF3 and shown to produce acceptable levels of field error on the plasma surface. A more complete summary of the field error analysis is given in Section 5.5.3.

7. REFERENCES

1. Pedrotti, L., Jackson, M.C., and Deis, G.A., "Tokamak Physics Experiment Technical Scope of Work - TPX Magnet System," Revision 5, Lawrence Livermore National Laboratory TPX SOW document, 7/6/95.

2. Zbasnik, J. and Lang, D., "Tokamak Physics Experiment Superconducting Magnet System Design Documentation List," TPX #91-940815-LLNL-DLang, Aug. 15, 1994.

3. Pillsbury, R.D., "Poloidal Field Coil System Current Requirements for TPX," TPX #14-941007-MIT-RPillsbury-01, Oct. 7, 1994

4. Pillsbury, R. D., Jr., "Poloidal Field Coil System Static Forces for the Twenty-three Equilibria in TPX," 11/17/94, TPX Document #14-941117-MIT-RPillsbury-01.

5. Pillsbury, R. D., Jr., "Evaluation of the HC Scenario for TPX - Magnets and Power Supplies," TPX Document #14-940803-MIT-RPILLSBURY-01.

6. Pillsbury, R. D., Jr., "TF Peak Field Calculations for TPX (Model 021194)," TPX Document No. 13-940314-MIT-RPILLSBURY-01.

7. Krefta, M. P., "TPX Electromagnetic Modelling Accuracy," 1/11/95, Westinghouse TPX Document # TPX.STC.MPK.STC.SKS.M004.01.11.95.

8. Krefta, M. P., "Simple Algebreic Expressions for TPX EM Force Calculations," 5/2/95, Westinghouse TPX Document # TPX.STC.MPK.STC.PS.M009.05.02.95.

9. Radovinsky, A. L., "Forces on the PF Coils due to a Vertical Plasma Disruption at the Twenty-Three Equilibria in TPX," 12/28/94, TPX Report #14-941228-MIT-ARadovinsky-01.

10. Radovinsky, A. L., "Forces on the PF Coils due to a Vertical Plasma Disruption Followed by a System Dump with Shorted PF Coils Terminals at the Twenty-Three Equilibria in TPX, Revision 1," 2/17/95, TPX Report #14-950217-MIT-ARadovinsky-01.

11. Radovinsky, A. L., "Compressive and Separation Forces on the Interfaces between the Coils of the Central Solenoid due to a Vertical Plasma Disruption Followed by a System Dump with Shorted PF Coils Terminals at the Twenty-Three Equilibria in TPX," 3/8/95, TPX Report #14-950308-MIT-ARadovinsky-01.

12. Radovinsky, A. L., "Forces on the Interface between the Coils of the Central Solenoid due to a Vertical Plasma Disruption Followed by a System Dump with Shorted PF Coils Terminals at the Twenty-Three Equilibria in TPX," 3/21/95, TPX Report #14-950321-MIT-ARadovinsky-01.

13. Radovinsky, A. L., "The Worst Fault Load Cases on the Coils of the TPX PF Set due to a Vertical Plasma Disruption Followed by a System Dump with Shorted PF Coils Terminals at the Twenty-Three Equilibria," 3/27/95, TPX Report #14-950327-MIT-ARadovinsky-01.

14. Radovinsky, A. L., "The Worst Loads on the Coils of the TPX, Revision 1," 4/27/95, TPX Report #1314-950427-MIT-ARadovinsky-01.

15. Schultz, J., "Selection of Scenario Points for FEA Analysis," 4/20/95, TPX Report #1314-950420-MIT-JSchultz-01.

16. Corpuz, A, "CS Preload and Worst Case Loads," TPX Report #14-950717-WEC-ACorpuz-01, 7/14/95.

17 Toma, L.S., Steeves, M.M., and Reed, R. P., "Incoloy 908 Data Handbook," March 1994, MIT #PFC/RR-94-2.

18 Hoecker, D. A., "User's Manual for the Revised Computer Code MAFCO-W-FORCES (Magnetic Fields and Forces for 3-D Conductor Models)," Westinghouse STC Report #89-1E8-EMSYB-R1, Nov. 30, 1989.

19 Perkins, W. A., and Brown, J. C.,"MAFCO - A Magnetic Field Code for Handling General Current Elements in Three Dimensions," Journal of Applied Physics, Vol. 35, No. 11,pp 3337-3343, Nov. 1964.

20 Yang, T.F., "A Magnetic Field Code for Handling General Current Carrying Conductors in Three Dimensions - MAFCO-W," Presented at Fifth International Conference on Magnet Technology (Roma 1975), MT-5, pp. 203-209, Frascati, Italy, 1975.

21 Hoecker, D. A., "The MAFIG Package: Interactive Graphical Pre- and Post-Processing of MAFCO Magnetic Field Calculations Using FIGURES II," Westinghouse STC Report #90-1TM3-INMAG-R1, Jan. 18, 1991.

22 Jardin, S. C., "Updated TPX Field Error Criterion," TPX #93-950405-PPPL-SJardin-01, Princeton University Plasma Physics Laboratory, April 5, 1995.

23 The Mathworks, Inc., Computer program PC-MATLAB version 3.5k for MS-DOS personal computers, March, 1991.

24 Wang, P.W., "Field Errors due to Nominal Coil Winding and Lead Geometry," TPX #94-950523-MIT/PWANG-01, May 23,1995.

25. Radovinsky, A., "Fault Loads on the PF Coils due to Shorted Terminals during System Dump," TPX Document 14-940919-MIT-ARadovinsky-01.

Appendix A - ANSYS 3-D command file

The following are ANSYS commands used to establish the three-dimensional electromagnetic model of the TPX coils.

```
/com kan,-1      !analysis type
et,1,5,10  !Observation grid
et,2,sourc36 !Source currents
/com  define permeabilities
mp,murx,1,1.0  *primatives, cs coil
mp,murx,2,1.0  * tf coil
mp,murx,5,1.0  *pf5
mp,murx,6,1.0  *pf6
mp,murx,7,1.0  *pf7
mp,murx,8,1.0  *IC coil
mp,murx,9,1.0  *Plasma
mp,murx,10,1.0 *TF interconnect
/com
/com  DEFINE PF CURRENT SOURCE GEOMETRY
pr1=.81   $pz1=.251   $pdr1=.144   $pdz1=.478  !PF1U/L
pr2=.81   $pz2=.7065  $pdr2=.144   $pdz2=.383  !PF2U/L
pr3=.81   $pz3=1.0415 $pdr3=.144   $pdz3=.239  !PF3U/L
pr4=.81   $pz4=1.3055 $pdr4=.144   $pdz4=.239  !PF4U/L
pr5=1.213 $pz5=2.35   $pdr5=.192   $pdz5=.382  !PF5U/L
pr6=3.7585 $pz6=2.144  $pdr6=.143   $pdz6=.478  !PF6U/L
pr7=4.297 $pz7=1.1135 $pdr7=.144   $pdz7=.335  !PF7U/L
/com
/com  PF CURRENTS for HC Scenario
ni1=-2953000.  $ni2= -679000.  $ni3=  115000.  $ni4=  319000.
ni5= 3348000.  $ni6=-1699000.  $ni7= -202000.  $ni8=    000.
ni9= 2000000.0
/com itf= 2814000.0      ! tf current level
itf=0
ntrn=84  $icon=itf/ntrn  !tf interconnect current level
/com
/com  IC COIL GEOMETRY AND CURRENTS
pr8=2.9405  $pz8=0.6845 $pdr8=.045 $pdz8=.045
/com  PLASMA GEOMETRY AND CURRENTS
pr9=2.25 $pz9=0.0 $pdr9=1.0 $pdz9=1.0
/com  TF INTERCONNECT COIL
r10=3.1915 $z10=2.6924 $dr10=.023 $dz10=.027
/com
/com  TF CURRENT SOURCE GEOMETRY
tdr1=.2138 $tdz1=.3037 $tr1=2.29108 $tz1=1.16586
tdr2=.2138 $tdz2=.3037 $tr2=2.29108 $tz2=0.67564
tdr3=.2138 $tdz3=.3037 $tr3=-1.9223 $tz3=0.0
tdr4=.2138 $tdz4=.3037          $tz4=0.0
tsa1=90.0 $tea1=180.0 $tin1=1.05156
tsa2=9.11 $tea2=90.0  $tin2=1.5418
tsa3=-9.11 $tea3=9.11 $tin3=5.809
tlen=2.3317 $thl=tlen/2
trm1=tin1+tdr1/2
tr4=tr1-trm1
trm2=tin2+tdr2/2
trm3=tin3+tdr3/2
ang=22.5      !meshed angular span of pf coils
acc=.0005    !Biot-savart integration accuracy
/com
/com
/com  START PF GEOMETRY  PRIMATIVES
/com PF1 upper
r,1,3,ni1,pdr1,pdz1,,  $rmore,,,acc
csys,1  $type,2  $real,1  $mat,1
nmx=0
n,nmx+1,pr1,  0,pz1  $n,nmx+2,pr1, 90,pz1  $n,nmx+3,0,0,pz1
n,nmx+4,pr1,  90,pz1  $n,nmx+5,pr1,180,pz1  $n,nmx+6,0,0,pz1
n,nmx+7,pr1,-180,pz1  $n,nmx+8,pr1,-90,pz1  $n,nmx+9,0,0,pz1
n,nmx+10,pr1,-90,pz1  $n,nmx+11,pr1, 0,pz1  $n,nmx+12,0,0,pz1
e,nmx+1,nmx+2,nmx+3
e,nmx+4,nmx+5,nmx+6
e,nmx+7,nmx+8,nmx+9
e,nmx+10,nmx+11,nmx+12
/com PF1 lower
n,nmx+13,pr1,  0,-pz1  $n,nmx+14,pr1, 90,-pz1  $n,nmx+15,0,0,-pz1
n,nmx+16,pr1,  90,-pz1  $n,nmx+17,pr1,180,-pz1  $n,nmx+18,0,0,-pz1
n,nmx+19,pr1,-180,-pz1  $n,nmx+20,pr1,-90,-pz1  $n,nmx+21,0,0,-pz1
n,nmx+22,pr1,  -90,-pz1  $n,nmx+23,pr1,  0,-pz1  $n,nmx+24,0,0,-pz1
e,nmx+13,nmx+14,nmx+15
e,nmx+16,nmx+17,nmx+18
e,nmx+19,nmx+20,nmx+21
e,nmx+22,nmx+23,nmx+24
/com
/com  PF2 upper
r,2,3,ni2,pdr2,pdz2,,  $rmore,,,acc
type,2  $real,2  $mat,1
*get,nmx,node,,num,max
n,nmx+1,pr2,  0,pz2  $n,nmx+2,pr2, 90,pz2  $n,nmx+3,0,0,pz2
n,nmx+4,pr2,  90,pz2  $n,nmx+5,pr2,180,pz2  $n,nmx+6,0,0,pz2
n,nmx+7,pr2,-180,pz2  $n,nmx+8,pr2,-90,pz2  $n,nmx+9,0,0,pz2
n,nmx+10,pr2,-90,pz2  $n,nmx+11,pr2, 0,pz2  $n,nmx+12,0,0,pz2
e,nmx+1,nmx+2,nmx+3
e,nmx+4,nmx+5,nmx+6
e,nmx+7,nmx+8,nmx+9
e,nmx+10,nmx+11,nmx+12
/com  PF2 lower
n,nmx+13,pr2,  0,-pz2  $n,nmx+14,pr2, 90,-pz2  $n,nmx+15,0,0,-pz2
n,nmx+16,pr2,  90,-pz2  $n,nmx+17,pr2,180,-pz2  $n,nmx+18,0,0,-pz2
n,nmx+19,pr2,-180,-pz2  $n,nmx+20,pr2,-90,-pz2  $n,nmx+21,0,0,-pz2
n,nmx+22,pr2,  -90,-pz2  $n,nmx+23,pr2,  0,-pz2  $n,nmx+24,0,0,-pz2
e,nmx+13,nmx+14,nmx+15
e,nmx+16,nmx+17,nmx+18
e,nmx+19,nmx+20,nmx+21
e,nmx+22,nmx+23,nmx+24
/com
/com
/com  PF3 upper
r,3,3,ni3,pdr3,pdz3,,  $rmore,,,acc
type,2  $real,3  $mat,1
*get,nmx,node,,num,max
n,nmx+1,pr3,  0,pz3  $n,nmx+2,pr3, 90,pz3  $n,nmx+3,0,0,pz3
n,nmx+4,pr3,  90,pz3  $n,nmx+5,pr3,180,pz3  $n,nmx+6,0,0,pz3
n,nmx+7,pr3,-180,pz3  $n,nmx+8,pr3,-90,pz3  $n,nmx+9,0,0,pz3
n,nmx+10,pr3,-90,pz3  $n,nmx+11,pr3, 0,pz3  $n,nmx+12,0,0,pz3
e,nmx+1,nmx+2,nmx+3
e,nmx+4,nmx+5,nmx+6
e,nmx+7,nmx+8,nmx+9
e,nmx+10,nmx+11,nmx+12
/com  PF3 lower
n,nmx+13,pr3,  0,-pz3  $n,nmx+14,pr3, 90,-pz3  $n,nmx+15,0,0,-pz3
n,nmx+16,pr3,  90,-pz3  $n,nmx+17,pr3,180,-pz3  $n,nmx+18,0,0,-pz3
n,nmx+19,pr3,-180,-pz3  $n,nmx+20,pr3,-90,-pz3  $n,nmx+21,0,0,-pz3
n,nmx+22,pr3,  -90,-pz3  $n,nmx+23,pr3,  0,-pz3  $n,nmx+24,0,0,-pz3
e,nmx+13,nmx+14,nmx+15
e,nmx+16,nmx+17,nmx+18
e,nmx+19,nmx+20,nmx+21
e,nmx+22,nmx+23,nmx+24
/com
/com
/com  PF4 upper
r,4,3,ni4,pdr4,pdz4,,  $rmore,,,acc
type,2  $real,4  $mat,1
*get,nmx,node,,num,max
n,nmx+1,pr4,  0,pz4  $n,nmx+2,pr4, 90,pz4  $n,nmx+3,0,0,pz4
n,nmx+4,pr4,  90,pz4  $n,nmx+5,pr4,180,pz4  $n,nmx+6,0,0,pz4
n,nmx+7,pr4,-180,pz4  $n,nmx+8,pr4,-90,pz4  $n,nmx+9,0,0,pz4
n,nmx+10,pr4,-90,pz4  $n,nmx+11,pr4, 0,pz4  $n,nmx+12,0,0,pz4
e,nmx+1,nmx+2,nmx+3
e,nmx+4,nmx+5,nmx+6
e,nmx+7,nmx+8,nmx+9
e,nmx+10,nmx+11,nmx+12
/com  PF4 lower
n,nmx+13,pr4,  0,-pz4  $n,nmx+14,pr4, 90,-pz4  $n,nmx+15,0,0,-pz4
n,nmx+16,pr4,  90,-pz4  $n,nmx+17,pr4,180,-pz4  $n,nmx+18,0,0,-pz4
n,nmx+19,pr4,-180,-pz4  $n,nmx+20,pr4,-90,-pz4  $n,nmx+21,0,0,-pz4
n,nmx+22,pr4,  -90,-pz4  $n,nmx+23,pr4,  0,-pz4  $n,nmx+24,0,0,-pz4
e,nmx+13,nmx+14,nmx+15
e,nmx+16,nmx+17,nmx+18
e,nmx+19,nmx+20,nmx+21
e,nmx+22,nmx+23,nmx+24
/com
/com
/com  PF5 upper
r,5,3,ni5,pdr5,pdz5,,  $rmore,,,acc
type,2  $real,5  $mat,1
*get,nmx,node,,num,max
n,nmx+1,pr5,  0,pz5  $n,nmx+2,pr5, 90,pz5  $n,nmx+3,0,0,pz5
n,nmx+4,pr5,  90,pz5  $n,nmx+5,pr5,180,pz5  $n,nmx+6,0,0,pz5
n,nmx+7,pr5,-180,pz5  $n,nmx+8,pr5,-90,pz5  $n,nmx+9,0,0,pz5
n,nmx+10,pr5,-90,pz5  $n,nmx+11,pr5, 0,pz5  $n,nmx+12,0,0,pz5
e,nmx+1,nmx+2,nmx+3
e,nmx+4,nmx+5,nmx+6
e,nmx+7,nmx+8,nmx+9
e,nmx+10,nmx+11,nmx+12
```

```
/com PF5 lower
n,nmx+13,pr5, 0,-pz5 $n,nmx+14,pr5, 90,-pz5 $n,nmx+15,0.0,-pz5
n,nmx+16,pr5, 90,-pz5 $n,nmx+17,pr5,180,-pz5 $n,nmx+18,0.0,-pz5
n,nmx+19,pr5,-180,-pz5 $n,nmx+20,pr5,-90,-pz5 $n,nmx+21,0.0,-pz5
n,nmx+22,pr5,-90,-pz5 $n,nmx+23,pr5, 0,-pz5 $n,nmx+24,0.0,-pz5
e,nmx+13,nmx+14,nmx+15
e,nmx+16,nmx+17,nmx+18
e,nmx+19,nmx+20,nmx+21
e,nmx+22,nmx+23,nmx+24
/com
/com
/com PF6 upper
r,6,3,ni6,pdr6,pdz6,,, $rmore,,,acc
type,2 $real,6 $mat,1
*get,nmx,node,,num,max
n,nmx+1,pr6, 0,pz6 $n,nmx+2,pr6, 90,pz6 $n,nmx+3,0.0,pz6
n,nmx+4,pr6, 90,pz6 $n,nmx+5,pr6,180,pz6 $n,nmx+6,0.0,pz6
n,nmx+7,pr6,-180,pz6 $n,nmx+8,pr6,-90,pz6 $n,nmx+9,0.0,pz6
n,nmx+10,pr6,-90,pz6 $n,nmx+11,pr6, 0,pz6 $n,nmx+12,0.0,pz6
e,nmx+1,nmx+2,nmx+3
e,nmx+4,nmx+5,nmx+6
e,nmx+7,nmx+8,nmx+9
e,nmx+10,nmx+11,nmx+12
/com PF6 lower
n,nmx+13,pr6, 0,-pz6 $n,nmx+14,pr6, 90,-pz6 $n,nmx+15,0.0,-pz6
n,nmx+16,pr6, 90,-pz6 $n,nmx+17,pr6,180,-pz6 $n,nmx+18,0.0,-pz6
n,nmx+19,pr6,-180,-pz6 $n,nmx+20,pr6,-90,-pz6 $n,nmx+21,0.0,-pz6
n,nmx+22,pr6,-90,-pz6 $n,nmx+23,pr6, 0,-pz6 $n,nmx+24,0.0,-pz6
e,nmx+13,nmx+14,nmx+15
e,nmx+16,nmx+17,nmx+18
e,nmx+19,nmx+20,nmx+21
e,nmx+22,nmx+23,nmx+24
/com
/com
/com PF7 upper
r,7,3,ni7,pdr7,pdz7,,, $rmore,,,acc
type,2 $real,7 $mat,1
*get,nmx,node,,num,max
n,nmx+1,pr7, 0,pz7 $n,nmx+2,pr7, 90,pz7 $n,nmx+3,0.0,pz7
n,nmx+4,pr7, 90,pz7 $n,nmx+5,pr7,180,pz7 $n,nmx+6,0.0,pz7
n,nmx+7,pr7,-180,pz7 $n,nmx+8,pr7,-90,pz7 $n,nmx+9,0.0,pz7
n,nmx+10,pr7,-90,pz7 $n,nmx+11,pr7, 0,pz7 $n,nmx+12,0.0,pz7
e,nmx+1,nmx+2,nmx+3
e,nmx+4,nmx+5,nmx+6
e,nmx+7,nmx+8,nmx+9
e,nmx+10,nmx+11,nmx+12
/com PF7 lower
n,nmx+13,pr7, 0,-pz7 $n,nmx+14,pr7, 90,-pz7 $n,nmx+15,0.0,-pz7
n,nmx+16,pr7, 90,-pz7 $n,nmx+17,pr7,180,-pz7 $n,nmx+18,0.0,-pz7
n,nmx+19,pr7,-180,-pz7 $n,nmx+20,pr7,-90,-pz7 $n,nmx+21,0.0,-pz7
n,nmx+22,pr7,-90,-pz7 $n,nmx+23,pr7, 0,-pz7 $n,nmx+24,0.0,-pz7
e,nmx+13,nmx+14,nmx+15
e,nmx+16,nmx+17,nmx+18
e,nmx+19,nmx+20,nmx+21
e,nmx+22,nmx+23,nmx+24
/com
/com
/com IC upper
r,8,3,ni8,pdr8,pdz8,,, $rmore,,,acc
type,2 $real,8 $mat,1
*get,nmx,node,,num,max
n,nmx+1,pr8, 0,pz8 $n,nmx+2,pr8, 90,pz8 $n,nmx+3,0.0,pz8
n,nmx+4,pr8, 90,pz8 $n,nmx+5,pr8,180,pz8 $n,nmx+6,0.0,pz8
n,nmx+7,pr8,-180,pz8 $n,nmx+8,pr8,-90,pz8 $n,nmx+9,0.0,pz8
n,nmx+10,pr8,-90,pz8 $n,nmx+11,pr8, 0,pz8 $n,nmx+12,0.0,pz8
e,nmx+1,nmx+2,nmx+3
e,nmx+4,nmx+5,nmx+6
e,nmx+7,nmx+8,nmx+9
e,nmx+10,nmx+11,nmx+12
/com IC lower
n,nmx+13,pr8, 0,-pz8 $n,nmx+14,pr8, 90,-pz8 $n,nmx+15,0.0,-pz8
n,nmx+16,pr8, 90,-pz8 $n,nmx+17,pr8,180,-pz8 $n,nmx+18,0.0,-pz8
n,nmx+19,pr8,-180,-pz8 $n,nmx+20,pr8,-90,-pz8 $n,nmx+21,0.0,-pz8
n,nmx+22,pr8,-90,-pz8 $n,nmx+23,pr8, 0,-pz8 $n,nmx+24,0.0,-pz8
e,nmx+13,nmx+14,nmx+15
e,nmx+16,nmx+17,nmx+18
e,nmx+19,nmx+20,nmx+21
e,nmx+22,nmx+23,nmx+24
/com
/com PLASMA  (note that 5 is for SOLID acr  1/r in current)
r,9,3,ni9,pdr9,pdz9,,, $rmore,,,acc
type,2 $real,9 $mat,1
*get,nmx,node,,num,max
n,nmx+1,pr9, 0,pz9 $n,nmx+2,pr9, 90,pz9 $n,nmx+3,0.0,pz9
n,nmx+4,pr9, 90,pz9 $n,nmx+5,pr9,180,pz9 $n,nmx+6,0.0,pz9
n,nmx+7,pr9,-180,pz9 $n,nmx+8,pr9,-90,pz9 $n,nmx+9,0.0,pz9
n,nmx+10,pr9,-90,pz9 $n,nmx+11,pr9, 0,pz9 $n,nmx+12,0.0,pz9
e,nmx+1,nmx+2,nmx+3
e,nmx+4,nmx+5,nmx+6
e,nmx+7,nmx+8,nmx+9
e,nmx+10,nmx+11,nmx+12
/com
/com TF interconnect
r,20,3,icon,dr10,dz10,,, $rmore,,,acc
type,2 $real,20 $mat,1
*get,nmx,node,,num,max
n,nmx+1,r10, 0,z10 $n,nmx+2,r10, 90,z10 $n,nmx+3,0.0,z10
n,nmx+4,r10, 90,z10 $n,nmx+5,r10,180,z10 $n,nmx+6,0.0,z10
n,nmx+7,r10,-180,z10 $n,nmx+8,r10,-90,z10 $n,nmx+9,0.0,z10
n,nmx+10,r10,-90,z10 $n,nmx+11,r10, 0,z10 $n,nmx+12,0.0,z10
e,nmx+1,nmx+2,nmx+3
e,nmx+4,nmx+5,nmx+6
e,nmx+7,nmx+8,nmx+9
e,nmx+10,nmx+11,nmx+12
/com
/com
/com  define local coordinate system needed for TF coil's esys
local,26,0,tr4,0,tz4,0,90,0
/com
/com
/com START of TF GEOMETRY PRIMATIVES
/com TF1 arc1
/com for high accuracy use nig=40
/com  nig=10  ! nig only used in version 5.0
r,10,3,-itf,tdr1,tdz1,,, $rmore,,,acc
local,11,1,tr1,0,tz1,0,90,0
*get,nmx,node,,num,max
*get,etf,elem,,num,max
n1=nmx+1
csys,11
n,nmx+1,trm1,tsa1,0 $n,nmx+2,trm1,tea1,0  $n,nmx+3,0.0,0
type,2 $real,10 $mat,1
e,nmx+1,nmx+2,nmx+3
local,12,1,tr1,0,-tz1,0,90,0
csys,12
*get,nmx,node,,num,max
n,nmx+1,trm1,-tea1,0 $n,nmx+2,trm1,-tsa1,0  $n,nmx+3,0.0,0
e,nmx+1,nmx+2,nmx+3
/com
/com TF1 arc2
r,11,3,-itf,tdr2,tdz2,,, $rmore,,,acc
local,13,1,tr2,0,tz2,0,90,0
csys,13
*get,nmx,node,,num,max
n,nmx+1,trm2,tsa2,0 $n,nmx+2,trm2,tea2,0 $n,nmx+3,0.0,0
real,11
e,nmx+1,nmx+2,nmx+3
local,14,1,tr2,0,-tz2,0,90,0
csys,14
*get,nmx,node,,num,max
n,nmx+1,trm2,-tea2,0 $n,nmx+2,trm2,-tsa2,0 $n,nmx+3,0.0,0
e,nmx+1,nmx+2,nmx+3
/com
/com TF1 arc3
r,12,3,-itf,tdr3,tdz3,,, $rmore,,,acc
local,15,1,tr3,0,tz3,0,90,0
real,12
*get,nmx,node,,num,max
n,nmx+1,trm3,tsa3,0 $n,nmx+2,trm3,tea3,0 $n,nmx+3,0.0,0
e,nmx+1,nmx+2,nmx+3
/com
/com TF1 arc4  (actually straight length)
r,13,2,-itf,tdr4,tdz4,,, $rmore,,,acc
local,16,0,tr4,0,tz4
real,13
*get,nmx,node,,num,max
n,nmx+1,0.0,thl $n,nmx+2,0.0,-thl $n,nmx+3,0,thl,0
e,nmx+1,nmx+2,nmx+3
n2=nmx+3
/com
/com copy to make other 15 TF coils
csys,1
noff=n2-n1+1
ngen,16,noff,n1,n2,1,0,22.5,0,
egen,16,noff,etf+1,etf+6,1,
/com  edel,etf+1,etf+6,1  !delete TF1
/com
/com  BEGIN PF OBSERVATION MESH
/com CS MESH
csys,1
! recall variable ang is meshed angular span for pf coils
/com pf1
ndr=2  !radial divisions
ndz=3  !z (axial) divisions
nda=3  !angular divisions
r1=pr1-pdr1/2  $r2=pr1+pdr1/2
z1=pz1-pdz1/2  $z2=pz1+pdz1/2
kmx=0
k,kmx+1,r1,,z1  $k,kmx+2,r2,,z1  $k,kmx+3,r2,ang,z1 $k,kmx+4,r1,,z2
k,kmx+5,r1,ang,z1 $k,kmx+6,r1,ang,z2 $k,kmx+7,r2,,z2 $k,kmx+8,r2,ang,z2
```

```
l,1,2 $l,4,7 $l,6,8 $l,5,3 !radial
l,2,3 $l,1,5 $l,7,8 $l,4,6 !angular
l,1,4 $l,2,7 $l,5,6 $l,3,8 !axial
v,1,2,3,5,4,7,8,6
/com pf2
*get,kmx,kp,,num,max
r1=pr2-pdr2/2   $r2=pr2+pdr2/2
z1=pz2-pdz2/2   $z2=pz2+pdz2/2
k,kmx+1,r1,  ,z1 $k,kmx+2,r2,,z1  $k,kmx+3,r2,ang,z1 $k,kmx+4,r1,,z2
k,kmx+5,r1,ang,z1 $k,kmx+6,r1,ang,z2 $k,kmx+7,r2,,z2 $k,kmx+8,r2,ang,z2
l,kmx+1,kmx+2 $l,kmx+4,kmx+7 $l,kmx+6,kmx+8 $l,kmx+5,kmx+3 !radial
l,kmx+2,kmx+3 $l,kmx+1,kmx+5 $l,kmx+7,kmx+8 $l,kmx+4,kmx+6 !angular
l,kmx+1,kmx+4 $l,kmx+2,kmx+7 $l,kmx+5,kmx+6 $l,kmx+3,kmx+8 !axial
v,kmx+1,kmx+2,kmx+3,kmx+5,kmx+4,kmx+7,kmx+8,kmx+6
/com pf3
*get,kmx,kp,,num,max
r1=pr3-pdr3/2   $r2=pr3+pdr3/2
z1=pz3-pdz3/2   $z2=pz3+pdz3/2
k,kmx+1,r1,  ,z1 $k,kmx+2,r2,,z1  $k,kmx+3,r2,ang,z1 $k,kmx+4,r1,,z2
k,kmx+5,r1,ang,z1 $k,kmx+6,r1,ang,z2 $k,kmx+7,r2,,z2 $k,kmx+8,r2,ang,z2
l,kmx+1,kmx+2 $l,kmx+4,kmx+7 $l,kmx+6,kmx+8 $l,kmx+5,kmx+3 !radial
l,kmx+2,kmx+3 $l,kmx+1,kmx+5 $l,kmx+7,kmx+8 $l,kmx+4,kmx+6 !angular
l,kmx+1,kmx+4 $l,kmx+2,kmx+7 $l,kmx+5,kmx+6 $l,kmx+3,kmx+8 !axial
v,kmx+1,kmx+2,kmx+3,kmx+5,kmx+4,kmx+7,kmx+8,kmx+6
/com pf4
*get,kmx,kp,,num,max
r1=pr4-pdr4/2   $r2=pr4+pdr4/2
z1=pz4-pdz4/2   $z2=pz4+pdz4/2
k,kmx+1,r1,  ,z1 $k,kmx+2,r2,,z1  $k,kmx+3,r2,ang,z1 $k,kmx+4,r1,,z2
k,kmx+5,r1,ang,z1 $k,kmx+6,r1,ang,z2 $k,kmx+7,r2,,z2 $k,kmx+8,r2,ang,z2
l,kmx+1,kmx+2 $l,kmx+4,kmx+7 $l,kmx+6,kmx+8 $l,kmx+5,kmx+3 !radial
l,kmx+2,kmx+3 $l,kmx+1,kmx+5 $l,kmx+7,kmx+8 $l,kmx+4,kmx+6 !angular
l,kmx+1,kmx+4 $l,kmx+2,kmx+7 $l,kmx+5,kmx+6 $l,kmx+3,kmx+8 !axial
v,kmx+1,kmx+2,kmx+3,kmx+5,kmx+4,kmx+7,kmx+8,kmx+6
/com
/com PF5
ndr=2  $ndz=3  $nda=4
r1=pr5-pdr5/2  $r2=pr5+pdr5/2
z1=pz5-pdz5/2  $z2=pz5+pdz5/2
k,501,r1,  ,z1 $k,502,r2,,z1   $k,503,r2,ang,z1 $k,504,r1,,z2
k,505,r1,ang,z1 $k,506,r1,ang,z2 $k,507,r2,0,z2 $k,508,r2,ang,z2
l,501,502 $l,504,507 $l,506,508 $l,505,503  !radial
l,502,503 $l,501,505 $l,507,508 $l,504,506  !angular
l,501,504 $l,502,507 $l,505,506 $l,503,508  !axial
v,501,502,503,505,504,507,508,506
/com
/com Volume pf6
ndr=2 $ndz=3 $nda=5
r1=pr6-pdr6/2  $r2=pr6+pdr6/2
z1=pz6-pdz6/2  $z2=pz6+pdz6/2
k,601,r1,  ,z1 $k,602,r2,,z1   $k,603,r2,ang,z1 $k,604,r1,,z2
k,605,r1,ang,z1 $k,606,r1,ang,z2 $k,607,r2,0,z2 $k,608,r2,ang,z2
l,601,602 $l,604,607 $l,606,608 $l,605,603  !radial
l,602,603 $l,601,605 $l,607,608 $l,604,606  !angular
l,601,604 $l,602,607 $l,605,606 $l,603,608  !axial
v,601,602,603,605,604,607,608,606
/com
/com pf7
ndr=2  $ndz=3  $nda=6
r1=pr7-pdr7/2  $r2=pr7+pdr7/2
z1=pz7-pdz7/2  $z2=pz7+pdz7/2
k,701,r1,  ,z1 $k,702,r2,,z1   $k,703,r2,ang,z1 $k,704,r1,,z2
k,705,r1,ang,z1 $k,706,r1,ang,z2 $k,707,r2,0,z2 $k,708,r2,ang,z2
l,701,702 $l,704,707 $l,706,708 $l,705,703  !radial
l,702,703 $l,701,705 $l,707,708 $l,704,706  !angular
l,701,704 $l,702,707 $l,705,706 $l,703,708  !axial
v,701,702,703,705,704,707,708,706
/com
/com apply symmetry mirror to obtain lower-half coils
csys,0
/pnum,node,0
/vup,,z
/view,,1,-1,1
/type,,2
vsymm,z,1,7,1,0,0,0
/com  vsymm,x,1,14,1,0,0,0
/com  vsymm,y,1,28,1,0,0,0
/com
/com
/com  MESH VOLUMES 1 through vmax
type,1  $local,29,1,0,0,0 $esys,29
esize,pdr1/3 $mat,1  $vmesh,1,4  $vmesh,8,11  !cs coils
esize,pdr5/3 $mat,5  $vmesh,5   $vmesh,12   !pf 5
esize,pdr6/3 $mat,6  $vmesh,6   $vmesh,13   !pf6
esize,pdr7/3 $mat,7  $vmesh,7   $vmesh,14   !pf7
/com
/com
/com  BEGIN TF MESH TO DEFINE OBSERVATION POINTS
/com
csys,11
/com only half thickness is mesh due to symmetry
/com  top-inner arc
z1=tdz1/2   $tou1=tin1+tdr1
*get,vtf,volu,,num,max
/com  fine mesh for TF analysis
/com  ndr=5   $ndz=7
/com t1=32 $t2=28 $t3=12  $t4=28
ndr=2 $ndz=3
t1=12 $t2=10  $t3=5  $t4=10
k,1001,tin1,tsa1,-z1  $k,1002,tou1,tsa1,-z1  $k,1003,tou1,tea1,-z1
k,1004,tin1,tsa1,z1   $k,1005,tin1,tea1,-z1  $k,1006,tin1,tea1,z1
k,1007,tou1,tsa1,z1   $k,1008,tou1,tea1,z1
l,1001,1002 $l,1004,1007  $l,1006,1008  $l,1005,1003 !radial
l,1002,1003 $l,1001,1005  $l,1007,1008  $l,1004,1006 !angular
l,1001,1004 $l,1002,1007  $l,1005,1006  $l,1003,1008 !axial
v,1001,1002,1003,1005,1004,1007,1008,1006
/com
/com  top-outer arc
csys,13
z2=tdz2/2
tou2=tin2+tdr2
k,1009,tin2,tsa2,z2  $k,1010,tou2,tsa2,z2  $k,1011,tin2,tsa2,-z2
k,1012,tou2,tsa2,-z2
l,1001,1011  $l,1002,1012  $l,1007,1010  $l,1004,1009 !angular
l,1012,1011  $l,1010,1009                !radial
l,1011,1009  $l,1010,1012                !axial
v,1011,1012,1010,1009,1001,1002,1007,1004
/com
/com  outside-most half-arc (top half only)
csys,15
z3=tdz3/2
tou3=tin3+tdr3
k,1013,tin3,0,z3  $k,1014,tou3,0,z3  $k,1015,tou3,0,-z3 $k,1016,tin3,0,-z3
l,1015,1012 $l,1016,1011  $l,1014,1010  $l,1013,1009 !angular
l,1015,1016 $l,1014,1013                 !radial
l,1014,1015 $l,1013,1016                 !axial
v,1016,1015,1014,1013,1011,1012,1010,1009
/com
/com  inboard leg (straight segment, top half only)
csys,16
z4=tdz4/2   $r4=tdr4/2
k,1017,r4,-z4,0  $k,1018,r4,z4,0  $k,1019,-r4,-z4,0  $k,1020,-r4,z4,0
l,1018,1005 $l,1020,1003  $l,1017,1006  $l,1019,1008 !angular
l,1018,1020 $l,1017,1019                 !radial
l,1017,1018 $l,1019,1020                 !axial
v,1020,1018,1017,1019,1003,1005,1006,1008
/com
/com
/com  MIRROR volumes about z=0 plane
csys,0
vsymm,z,vtf+1,vtf+4,1,,0,0
/com
/com  MIRROR about 11.25 degrees
/com local,17,0,0,0,0,11.25
/com  vsymm,y,vtf+1,vtf+8,1,,0,0
/com  local,18,0,0,0,0,33.75
/com  vsymm,y,vtf+1,vtf+16,1,,0,0
/com  local,19,0,0,0,0,78.75
/com  vsymm,y,vtf+1,vtf+32,1,,0,0
/com  local,20,0,0,0,0,168.75
/com  vsymm,y,vtf+1,vtf+64,1,,0,0
/com
esize,tdz1/4
type,1 $mat,2
vmesh,vtf+1,vtf+8       !mesh top and bottom tf coils
vlsel,s,,vtf+1          !1st arc, top
evolu
emodif,all,esys,11
vlsel,s,,vtf+2          !2nd arc, top
evolu
emodif,all,esys,13
vlsel,s,,vtf+3          !3rd arc, outerleg, top
evolu
emodif,all,esys,15
vlsel,s,,vtf+4          !straight seg., inner leg, top
evolu
emodif,all,esys,26
vlsel,s,,vtf+5          !1st arc bottom
evolu
emodif,all,esys,12
vlsel,s,,vtf+6          !2nd arc bottom
evolu
emodif,all,esys,14
vlsel,s,,vtf+7          !3rd arc, outerleg, bottom
evolu
emodif,all,esys,15
vlsel,s,,vtf+8          !straight seg., inner leg, bottom
evolu
emodif,all,esys,26
/com
```

```
/com  mesh IC coil to get observation points
csys,1
ndr=1  $ndz=1  $nda=5
*get,vic,volu,,num,max
*get,kmx,kp,,num,max
r1=pr8-pdr8/2  $r2=pr8+pdr8/2
z1=pz8-pdz8/2  $z2=pz8+pdz8/2
k,kmx+1,r1,  ,z1  $k,kmx+2,r2,,z1  $k,kmx+3,r2,ang,z1  $k,kmx+4,r1,,z2
k,kmx+5,r1,ang,z1  $k,kmx+6,r1,ang,z2  $k,kmx+7,r2,,z2  $k,kmx+8,r2,ang,z2
l,kmx+1,kmx+2,ndr  $l,kmx+4,kmx+7,ndr  $l,kmx+6,kmx+8,ndr
l,kmx+5,kmx+3,ndr  $l,kmx+2,kmx+3,nda  $l,kmx+1,kmx+5,nda
l,kmx+7,kmx+8,nda  $l,kmx+4,kmx+6,nda  $l,kmx+1,kmx+4,ndz
l,kmx+2,kmx+7,ndz  $l,kmx+5,kmx+6,ndz  $l,kmx+3,kmx+8,ndz
v,kmx+1,kmx+2,kmx+3,kmx+5,kmx+4,kmx+7,kmx+8,kmx+6
/com
/com  apply symmetry mirror
csys,0
/com
vsymm,z,vic+1,vic+1,1,0,0,0
/com  vsymm,x,vic+1,vic+2,1,0,0,0
/com  vsymm,y,vic+1,vic+4,1,0,0,0
type,1  $mat,8  $esys,29
vmesh,vic+1,vic+2
/com
/com  INCLUDE PLASMA
/com  Mesh Plasma
csys,1
ndr=5  $ndz=5  $nda=4
*get,vpl,volu,,num,max
*get,kmx,kp,,num,max
r1=pr9-pdr9/2  $r2=pr9+pdr9/2
z1=pz9-pdz9/2  $z2=pz9+pdz9/2
k,kmx+1,r1,  ,z1  $k,kmx+2,r2,,z1  $k,kmx+3,r2,ang,z1  $k,kmx+4,r1,,z2
k,kmx+5,r1,ang,z1  $k,kmx+6,r1,ang,z2  $k,kmx+7,r2,,z2  $k,kmx+8,r2,ang,z2
l,kmx+1,kmx+2  $l,kmx+4,kmx+7  $l,kmx+6,kmx+8  $l,kmx+5,kmx+3  !radial
l,kmx+2,kmx+3  $l,kmx+1,kmx+5  $l,kmx+7,kmx+8  $l,kmx+4,kmx+6  !angular
l,kmx+1,kmx+4  $l,kmx+2,kmx+7  $l,kmx+5,kmx+6  $l,kmx+3,kmx+8  !axial
v,kmx+1,kmx+2,kmx+3,kmx+5,kmx+4,kmx+7,kmx+8,kmx+6
/com  apply symmetry mirror
csys,0
/com  vsymm,x,vpl+1,vpl+1,1,0,0,0
/com  vsymm,y,vpl+1,vpl+2,1,0,0,0
esize,pdr9/5  $type,1  $mat,9  $esys,29
vmesh,vpl+1
/com
/com
/com
/com  boundary conditions (fix mag. scalar potential to zero)
esel,type,1
nelem
nt,all,mag,0.0
/com
/com  TF VOLUMES
/com  Merge coincident nodes on outer tf leg
csys,1
t=1e-5
kpsel,s,loc,z,-t,t
csys,15
kpsel,r,loc,x,tin3,tou3
lskp,1  $arls,1  $narea,1
nummrg,node,t  $nummrg,kp,t
/com
nall  $eall  $vlall  $aall  $lsall  $kpall
```

Appendix B - ANSYS 3-D force calculation algorithm

The following are a listing of ANSYS command files used in the postprocesser to calculate Lorentz forces acting on the current elements.

File lfrc.str

```
csys,0
vlscl,,1,14
evolu
nelem
etabl,x,cent,x    !get element x-location
etabl,y,cent,y    !get element y-location
etabl,b1,b,x      !get bx
etabl,b2,b,y      !get by
etabl,b3,b,z      !get bz
etabl,v,volu      !get element volume
/com
/com   form current density vector for each element
sexp,t1,x,,2
sexp,t2,y,,2
sadd,r,t1,t2,1,1
sexp,rinv,r,,-.5    ! form 1/r
smult,ct,rinv,x,1    !cos theta
smult,st,rinv,y,1    !sin theta
*do,i,1,7,1
vsel,s,,,i,i+7,7      !select pf5 upper and lower coil only
evolu
nelem
j%i%=ni%i%/(pdr%i%*pdz%i%)   !current density in pf5
sadd,jx,st,,-j%i%,0    !form jx
sadd,jy,ct,,j%i%,0    !form jy
sadd,jz,ct,,0,0,0    !form jz
vcross,fx,fy,fz,jx,jy,jz,b1,b2,b3  !force density
smult,ftx,fx,v,1    !total force on elem
smult,fty,fy,v,1
smult,ftz,fz,v,1
*enddo
vlall
evolu
nelem
```

File lgrp.str

```
/com     this set of commands selects a group
/com     group of elements between angles a1 and
/com     a2 and then evaluates the body force
/com     associated with the group of elements
/com
/com   needed to be defined on input are:
/com   nth : number of angular divisions
/com   ang : total angular span of pf mesh
/com   t : a small number i.e. .001
/com
/com   The second angle is calculated as a2=a1+nth*dela
*dim,for,array,50,2    !dimension force array
pi=3.14159265    !define pi
a1=0.0          !starting angle is 0 degrees
cdim=pdr%coil%/3      !get characteristic element dimension
ll=ang*pi*(pr%coil%+pdr%coil%/2)/180 !get arc length
nth=nint(ll/cdim+0.5) !number of angular divisions
dela=ang/nth      !angular increment
dell=ll/nth       !arc length associated with 1 element
/com
csys,1            !cylindrical cs
/com   Begin loop over angular chunks
*do,i,1,nth,1      !loop over nth angular chunks
/com   /gopr      !this command enable printing to screen
a2=a1+dela        !get rear angle a2
vlscl,,coil    !select nodes and elems in pf6u
evolu
nelem
nsel,r,loc,y,a1-t,a2+t  !reselect nodes in band
enode,1              !select elements
ssum                 !sum forces
*get,forx,ssum,,item,ftx  !sum fx total
*get,fory,ssum,,item,fty  !sum fy total
*get,forz,ssum,,item,ftz  !sum fz total
agl=a1+dela/2
agl=agl*pi/180
forr=forx*cos(agl)+fory*sin(agl)   !compute radial cmpt
for(i,1)=forr/dell          !store fradial per unit length
for(i,2)=forz/dell          !store faxial per unit length
a1=a2      ! set a1=a2 on output
*enddo
*status,for
```

Appendix C - Tables of EM forces acting on PF coils for equilibria #3

The following are tables of electromagnetic forces acting on the PF coil packs as a function of position along the length of the conductor. These results were obtained using the ANSYS three-dimensional Biot-Savart calculation. The current loadings correspond to t=9 s of the HC scenario.

Table C.1 – Calculated electromagnetic forces acting on PF coils 1-4 for equilibria # 3.

EM FORCES ON PF1-4U								
	PF1R	PF1Z	PF2R	PF2Z	PF3R	PF3Z	PF4R	PF4Z
angle (deg)	fr (N/m)	fz(N/m)	fr (N/m)	fz(N/m)	fr (N/m)	fz(N/m)	fr (N/m)	fz(N/m)
1.40625	3487078	2632307	414739	1143905	-16120	-151646	53673	-209750
4.21875	3487081	2685027	414736	1156023	-16101	-153673	54013	-214489
7.03125	3487090	2686363	414736	1156329	-16101	-153724	54021	-214594
9.84375	3487081	2633638	414739	1144207	-16120	-151697	53680	-209854
12.6563	3487079	2557711	414744	1126754	-16147	-148777	53190	-203043
15.4688	3487081	2504985	414747	1114633	-16166	-146749	52849	-198303
18.2813	3487083	2506317	414747	1114938	-16166	-146801	52857	-198409
21.0938	3487086	2559029	414745	1127054	-16147	-148828	53197	-203149
average	3487082	2595672	414742	1135480	-16134	-150237	53435	-206449

Table C.2 – Calculated electromagnetic forces acting on PF5 for equilibria # 3.

EM FORCES ON PF5								
	PF5L		PF5U		PF5U with Itf=0		PF5U with Itf=0	
angle (deg)	fr(N/m)	fz(N/m)	fr(N/m)	fz(N/m)	fr(N/m)	fz(N/m)	fr(N/m)	fz(N/m)
1.25	1868892	113192	1794247	-35884	1826886	74285	1826886	-74285
3.75	1911351	170816	1751670	21742.2	1826885	74285	1826885	-74285
6.25	1921352	184086	1741744	35011.9	1826882	74285	1826882	-74285
8.75	1893642	146479	1769397	-2594.6	1826880	74285	1826880	-74285
11.25	1841238	75720	1821753	-73355	1826879	74285	1826879	-74285
13.75	1788857	4961	1874130	-144116	1826879	74285	1826879	-74285
16.25	1761188	-32645	1901824	-181723	1826874	74285	1826874	-74285
18.75	1771143	-19375	1891853	-168454	1826870	74285	1826870	-74285
21.25	1813738	38250	1849412	-110829	1826879	74285	1826879	-74285
average	1841267	75720.4	1821781	-73356	1826879	74285	1826879	-74285

Table C.3 – Calculated electromagnetic forces acting on PF6 for equilibria # 3.

EM forces on PF6								
	PF6U		PF6L		PF6U ITF=0		PF6L ITF=0	
angle (deg)	fr(N/m)	fz(N/m)	fr(N/m)	fz(N/m)	fr(N/m)	fz(N/m)	fr(N/m)	fz(N/m)
0.35156	441530	-16711	551721	114963	493244	-58447	493244	58447
1.05469	329666	86365	663587	218039	493245	-58447	493245	58447
1.75781	231560	176748	761694	308422	493247	-58447	493247	58447
2.46094	154548	247550	838708	379223	493247	-58447	493247	58447
3.16406	102633	294954	890622	426628	493247	-58447	493247	58447
3.86719	75753	319036	917502	450710	493247	-58447	493247	58447
4.57031	70882	322739	922373	454412	493247	-58447	493247	58447
5.27344	83858	310076	909398	441748	493247	-58447	493247	58447
5.97656	110617	284915	882639	416587	493247	-58447	493247	58447
6.67969	147700	250506	845557	382178	493247	-58447	493247	58447
7.38281	192345	209403	800913	341074	493247	-58447	493247	58447
8.08594	242423	163543	750834	295214	493247	-58447	493247	58447
8.78906	296324	114372	696931	246043	493247	-58447	493247	58447
9.49219	352832	62965	640423	194636	493247	-58447	493247	58447
10.1953	411013	10134	582241	141805	493247	-58447	493247	58447

10.8984	470126	-43486	523128	88185	493247	-58447	493247	58447
11.6016	529538	-97359	463717	34313	493247	-58447	493247	58447
12.3047	588651	-150979	404604	-19306	493247	-58447	493247	58447
13.0078	650744	-203810	350334	-72138	493247	-58447	493247	58447
13.7109	707252	-255217	293825	-123544	493247	-58447	493247	58447
14.4141	761834	-304388	240604	-172715	493247	-58447	493247	58447
15.1172	811913	-350248	190525	-218575	493247	-58447	493247	58447
15.8203	856557	-391351	145881	-259678	493247	-58447	493247	58447
16.5234	893639	-425761	108798	-294087	493247	-58447	493247	58447
17.2266	915948	-450922	77589	-319248	493247	-58447	493247	58447
17.9297	928924	-463585	64613	-331912	493247	-58447	493247	58447
18.6328	924052	-459883	69484	-328210	493247	-58447	493247	58447
19.3359	897172	-435800	96364	-304128	493247	-58447	493247	58447
20.0391	845257	-388395	148279	-256723	493247	-58447	493247	58447
20.7422	768244	-317594	225291	-185923	493247	-58447	493247	58447
21.4453	670138	-227211	323398	-95539	493247	-58447	493247	58447
22.1484	558273	-124135	435263	7536.7	493247	-58447	493247	58447
average	500686	-70423	494276	61249.7	493247	-58447	493247	58447

Table C.4 – Calculated electromagnetic forces acting on PF7U for equilibria # 3.

EM forces on PF7		
	PF7R	PF7Z
angle(deg)	fr(N/m)	fz(N/m)
0.3125	8968	43664
0.9375	3914	62256
1.5625	-613	78843
2.1875	-4342.8	92388
2.8125	-7110.8	102278
3.4375	-8874	108379
4.0625	-9692	110961
4.6875	-9688	110534
5.3125	-9008	107689
5.9375	-7795	102990
6.5625	-6175	96915.7
7.1875	-4248	89847.9
7.8125	-2098.8	82079.5
8.4375	212.61	73826.7
9.0625	2640.41	65246.8
9.6875	5146.58	56452.8
10.3125	7703	47526.2
10.9375	10288	38527.9
11.5625	12883	29507
12.1875	15469	20509
12.8125	18026	11582
13.4375	20532	2788.3
14.0625	22958	-5791.5
14.6875	25271	-14044
15.3125	27421	-21813
15.9375	29346	-28880
16.5625	30966	-34955
17.1875	32179	-39654
17.8125	32859	-42497
18.4375	32864	-42925
19.0625	32045	-40344
19.6875	30282	-34242
20.3125	27514	-24352
20.9375	23784	-10807
21.5625	19257	5779.3
22.1875	14203	24371.7

Appendix D - ANSYS Axisymmetric command file

The following are ANSYS commands used to establish the axisymmetric electromagnetic model of the TPX PF coils.

```
/com 2-D axisymmetric model of TPX PF coils
et,1,plane53,,,1
emunit,mks
/com define permeabilities
mp,murx,1,1.0 *primatives, cs coil
mp,murx,2,1.0 * tf coil/ free space in 2D model
mp,murx,5,1.0 *pf5
mp,murx,6,1.0 *pf6
mp,murx,7,1.0 *pf7
mp,murx,8,1.0 *IC coil
mp,murx,9,1.0 *Plasma
mp,murx,10,1.0 *TF interconnect
/show,x11,,1
/com
/com DEFINE PF CURRENT SOURCE GEOMETRY
pr1=.81 $pz1=.251 $pdr1=.144 $pdz1=.478
pr2=.81 $pz2=.7065 $pdr2=.144 $pdz2=.383
pr3=.81 $pz3=1.0415 $pdr3=.144 $pdz3=.239
pr4=.81 $pz4=1.3055 $pdr4=.144 $pdz4=.239
pr5=1.213 $pz5=2.35 $pdr5=.192 $pdz5=.382
pr6=3.7585 $pz6=2.144 $pdr6=.143 $pdz6=.478
pr7=4.297 $pz7=1.1135 $pdr7=.144 $pdz7=.335
/com IC COIL GEOMETRY AND CURRENTS
pr8=2.9405 $pz8=0.6845 $pdr8=.045 $pdz8=.045
/com PLASMA GEOMETRY AND CURRENTS
pr9=2.25 $pz9=0.0 $pdr9=1.0 $pdz9=1.0
/com TF INTERCONNECT COIL
r10=3.1915 $z10=2.6924 $dr10=.023 $dz10=.027
/com PF CURRENTS for HC Scenario
ni1=-2953000. $ni2= -679000.
ni3= 115000. $ni4= 319000.
ni5= 3348000. $ni6=-1699000.
ni7= -202000. $ni8= 000.
ni9= 2000000.0
itf= 2814000.0 ! tf current level
/com itf=0
ntrn=84
icon=itf/ntrn
/com
/com TF CURRENT SOURCE GEOMETRY
/com tdr1=.2138 $tdz1=.3037 $tr1=2.29108 $tz1=1.16586
/com tdr2=.2138 $tdz2=.3037 $tr2=2.29108 $tz2=0.67564
/com tdr3=.2138 $tdz3=.3037 $tr3=-1.9223 $tz3=0.0
/com tdr4=.2138 $tdz4=.3037 $tz4=0.0
/com tta1=90.0 $tea1=180.0 $tin1=1.05156
/com tta2=9.11 $tea2=90.0 $tin2=1.5418
/com tta3=-9.11 $tea3=9.11 $tin3=5.809
/com tlen=2.3317 $thl=tlen/2
/com trm1=tin1+tdr1/2
/com tr4=tr1-trm1
/com trm2=tin2+tdr2/2
/com trm3=tin3+tdr3/2
/com ang=22.5 !meshed angular span of pf coils
/com acc=.00005 !Biot-savart integration accuracy
/com
/com
/com BEGIN PF MESH
/com CS MESH
csys,0
! recall variable ang is meshed angular span for pf coils
/com pf1
r1=pr1-pdr1/2 $r2=pr1+pdr1/2
z1=pz1-pdz1/2 $z2=pz1+pdz1/2
kmx=0
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
k,kmx+5,r2,0 $k,kmx+6,r1,0
l,1,2 $l,2,3 $l,3,4 $l,4,1 !radial
a,1,2,3,4
type,1
esize,pdr1/4 $mat,1 $amesh,1 !cs coil pf1
a,6,5,2,1
esize,pdr1/4 $mat,2 $amesh,2 !free space
/com pf2
*get,kmx,kp,,num,max
r1=pr2-pdr2/2 $r2=pr2+pdr2/2
z1=pz2-pdz2/2 $z2=pz2+pdz2/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4 $l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4 ! pf2
esize,pdr1/4 $mat,1 $amesh,3 !cs coil pf2
a,kmx-2,kmx-3,kmx+2,kmx+1
esize,pdr1/4 $mat,2 $amesh,4 !free space
/com pf3
*get,kmx,kp,,num,max
r1=pr3-pdr3/2 $r2=pr3+pdr3/2
z1=pz3-pdz3/2 $z2=pz3+pdz3/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4 $l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr1/4 $mat,1 $amesh,5 !cs coil pf3
a,kmx,kmx-1,kmx+2,kmx+1
esize,pdr1/4 $mat,2 $amesh,6 !free space
/com pf4
*get,kmx,kp,,num,max
r1=pr4-pdr4/2 $r2=pr4+pdr4/2
z1=pz4-pdz4/2 $z2=pz4+pdz4/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4 $l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr1/4 $mat,1 $amesh,7 !cs coil pf4
a,kmx,kmx-1,kmx+2,kmx+1
esize,pdr1/4 $mat,2 $amesh,8 !cs coils
/com
/com PF5
*get,kmx,kp,,num,max
r1=pr5-pdr5/2 $r2=pr5+pdr5/2
z1=pz5-pdz5/2 $z2=pz5+pdz5/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4 $l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr5/4 $mat,5 $amesh,9 !pf 5
/com
/com Volume pf6
*get,kmx,kp,,num,max
r1=pr6-pdr6/2 $r2=pr6+pdr6/2
z1=pz6-pdz6/2 $z2=pz6+pdz6/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4 $l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr6/4 $mat,6 $amesh,10 !pf6
/com
/com pf7
*get,kmx,kp,,num,max
r1=pr7-pdr7/2 $r2=pr7+pdr7/2
z1=pz7-pdz7/2 $z2=pz7+pdz7/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4 $l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr7/4 $mat,7 $amesh,11 !pf7
/com
/pnum,node,0
/com
/com
/com
/com
/com INCLUDE PLASMA
/com Mesh Plasma
*get,apl,area,,num,max
*get,kmx,kp,,num,max
r1=pr9-pdr9/2 $r2=pr9+pdr9/2
z1=0 $z2=pz9+pdz9/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4 $l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr9/5 $type,1 $mat,9
amesh,apl+1
/com
/com FREE SPACE REGION INSIDE CS
*get,kmx,kp,,num,max
z1=pz1-pdz1/2 $z2=pz4+pdz4/2
k,kmx+1,0,0
k,kmx+2,0,z2
l,kmx+1,kmx+2,15
l,6,kmx+1,12,2
l,18,kmx+2,12,2
lsel,s,,42,44 $lsel,a,,7 $lsel,a,,4 $lsel,a,,13 $lsel,a,,11
lsel,a,,19 $lsel,a,,17 $lsel,a,,25 $lsel,a,,23
al,all
*get,apl,area,,num,max
mat,2 $amesh,apl
lsall
/com AREA ABOVE CS
```

```
z1=pz5+pdz5/2
*get,kmx,kp,,num,max
k,kmx+1,0,z1
l,17,19,10
l,22,kmx+1,15,2
l,kmx,kmx+1,9
al,47,44,22,45,29,46
*get,apl,area,,num,max
mat,2  $amesh,apl
/com  AREA BETWEEN CS AND PLASMA
l,17,34,18,2
l,5,31,14,2
lsel,s,,48,49 $lsel,a,,41 $lsel,a,,6  $lsel,a,,2
lsel,a,,12  $lsel,a,,9  $lsel,a,,18  $lsel,a,,15
lsel,a,,24 $lsel,a,,21
al,all
*get,apl,area,,num,max
mat,2  $amesh,apl
/com  AREA ABOVE PLASMA
lsel,all
l,21,26,25,-2
l,33,23,15,-2
al,40,51,33,50,27,26,45,48
*get,apl,area,,num,max
mat,2  $amesh,apl
/com AREA BETWEEN PLASMA AND PF6/7
r1=pr7+pdr7/2
*get,kmx,kp,,num,max
k,kmx+1,r1,0
l,32,38,12
l,38,28,12,-5
l,24,30,12,-2
al,52,53,34,37,54,30,51,39
*get,apl,area,,num,max
mat,2  $amesh,apl
/com  AREA OUTSIDE PF6 AND PF7
r1=2*pr6+pdr6  $z1=2*pz6+pdz6
*get,kmx,kp,,num,max
k,kmx+1,r1,z1
k,kmx+2,r1,0
k,kmx+3,0,z1
l,25,kmx+1,20,3
l,kmx+1,kmx+2,10
l,38,kmx+2,10,3
al,53,57,56,55,31,54,36,35
*get,apl,area,,num,max
mat,2  $amesh,apl
l,37,kmx+3,10,2
l,kmx+1,kmx+3,20
al,46,28,50,32,55,59,58
*get,apl,area,,num,max
mat,2  $amesh,apl
/com  INFINITY REGION
r1=50*r1    $z1=50*z1
*get,kmx,kp,,num,max
k,kmx+1,r1,z1
k,kmx+2,r1,0
k,kmx+3,0,z1
l,kmx-1,kmx+2,20,50
l,kmx,kmx+3,20,50
l,kmx-2,kmx+1,25,50
l,kmx+1,kmx+2,6
l,kmx+1,kmx+3,8
al,60,63,62,56
al,62,64,61,59
*get,apl,area,,num,max
mat,2  $amesh,apl-1,apl
/com
/com  CURRENT LOADINGS
j1=ni1/(pdr1*pdz1)
j2=ni2/(pdr2*pdz2)
j3=ni3/(pdr3*pdz3)
j4=ni4/(pdr4*pdz4)
j5=ni5/(pdr5*pdz5)
j6=ni6/(pdr6*pdz6)
j7=ni7/(pdr7*pdz7)
j9=ni9/(pdr9*pdz9)
asel,s,,,1  $area  $bfe,all,js,3,j1
asel,s,,,3  $area  $bfe,all,js,3,j2
asel,s,,,5  $area  $bfe,all,js,3,j3
asel,s,,,7  $area  $bfe,all,js,3,j4
asel,s,,,9  $area  $bfe,all,js,3,j5
asel,s,,,10  $area  $bfe,all,js,3,j6
asel,s,,,11  $area  $bfe,all,js,3,j7
asel,s,,,12  $area  $bfe,all,js,3,j9
/com
/com   boundary conditions (fix mag. potential to zero)
lsel,s,,,42  $lsel,a,,47  $lsel,a,,58  $lsel,a,,61
nline,1
d,all,az,0.0
nall
eall
```

Appendix E - Westinghouse HOTMAP Axisymmetric command file

The following are HOTMAP commands used to establish the axisymmetric electromagnetic model of the TPX PF coils.

```
define parameter pr1 .81
define parameter pz1 .251
define parameter pdr1 .144
define parameter pdz1 .478
define parameter pr2 .81
define parameter pz2 .7065
define parameter pdr2 .144
define parameter pdz2 .383
define parameter pr3 .81
define parameter pz3 1.0415
define parameter pdr3 .144
define parameter pdz3 .239
define parameter pr4 .81
define parameter pz4 1.3055
define parameter pdr4 .144
define parameter pdz4 .239
define parameter pr5 1.213
define parameter pz5 2.35
define parameter pdr5 .192
define parameter pdz5 .382
define parameter pr6 3.7585
define parameter pz6 2.144
define parameter pdr6 .143
define parameter pdz6 .478
define parameter pr7 4.297
define parameter pz7 1.1135
define parameter pdr7 .144
define parameter pdz7 .335
define parameter pr8 2.9405
define parameter pz8 0.6845
define parameter pdr8 .045
define parameter pdz8 .045
$  PLASMA GEOMETRY AND CURRENTS
define parameter pr9 2.25
define parameter pz9 0.0
define parameter pdr9 1.0
define parameter pdz9 1.0
$  TF INTERCONNECT COIL
define parameter r10 3.1915
define parameter z10 2.6924
define parameter dr10 .023
define parameter dz10 .027
$  PF CURRENTS for HC Scenario
define parameter ni1 -2953000.
define parameter ni2 -679000.
define parameter ni3  115000.
define parameter ni4  319000.
define parameter ni5 3348000.
define parameter ni6 -1699000.
define parameter ni7 -202000.
define parameter ni8  000.
define parameter ni9 2000000.0
define parameter itf 2814000.0
define parameter ntrn 84
define parameter icon #itf/#ntrn
$
$  BEGIN PF MESH
$ CS MESH
$ pf1
define parameter r1 #pr1-#pdr1/2
define parameter r2 #pr1+#pdr1/2
define parameter z1 #pz1-#pdz1/2
define parameter z2 #pz1+#pdz1/2
point,p1,#r1,#z1
point,p2,#r2,#z1
point,p3,#r2,#z2
point,p4,#r1,#z2
point,p5,#r2,0
point,p6,#r1,0
line,l1,p1,p2 5
line,l2,p2,p3 15
line,l3,p3,p4 5
line,l4,p4,p1 15
$ pf2
define parameter r1 #pr2-#pdr2/2
define parameter r2 #pr2+#pdr2/2
define parameter z1 #pz2-#pdz2/2
define parameter z2 #pz2+#pdz2/2
point,p7,#r1,#z1
point,p8,#r2,#z1
point,p9,#r2,#z2
point,p10,#r1,#z2
line,l5,p7,p8 5
line,l6,p8,p9 15
line,l7,p9,p10 5
line,l8,p10,p7 15
$ pf3
define parameter r1 #pr3-#pdr3/2
define parameter r2 #pr3+#pdr3/2
define parameter z1 #pz3-#pdz3/2
define parameter z2 #pz3+#pdz3/2
point,p11,#r1,#z1
point,p12,#r2,#z1
point,p13,#r2,#z2
point,p14,#r1,#z2
line,l9,p11,p12 5
line,l10,p12,p13 10
line,l11,p13,p14  5
line,l12,p14,p11 10
define parameter r1 #pr4-#pdr4/2
define parameter r2 #pr4+#pdr4/2
define parameter z1 #pz4-#pdz4/2
define parameter z2 #pz4+#pdz4/2
point,p15,#r1,#z1
point,p16,#r2,#z1
point,p17,#r2,#z2
point,p18,#r1,#z2
line,l13,p15,p16 5
line,l14,p16,p17 10
line,l15,p17,p18 5
line,l16,p18,p15 10
$ PF5
define parameter r1 #pr5-#pdr5/2
define parameter r2 #pr5+#pdr5/2
define parameter z1 #pz5-#pdz5/2
define parameter z2 #pz5+#pdz5/2
point,p19,#r1,#z1
point,p20,#r2,#z1
point,p21,#r2,#z2
point,p22,#r1,#z2
line,l17,p19,p20 5
line,l18,p20,p21 10
line,l19,p21,p22 5
line,l20,p22,p19 10
$
$  pf6
define parameter r1 #pr6-#pdr6/2
define parameter r2 #pr6+#pdr6/2
define parameter z1 #pz6-#pdz6/2
define parameter z2 #pz6+#pdz6/2
point,p23,#r1,#z1
point,p24,#r2,#z1
point,p25,#r2,#z2
point,p26,#r1,#z2
line,l21,p23,p24 5
line,l22,p24,p25 10
line l23,p25 p26 5
line l27 p26 p23 10
$ pf7
define parameter r1 #pr7-#pdr7/2
define parameter r2 #pr7+#pdr7/2
define parameter z1 #pz7-#pdz7/2
define parameter z2 #pz7+#pdz7/2
point,p28,#r1,#z1
point,p29,#r2,#z1
point,p30,#r2,#z2
point,p31,#r1,#z2
line l28,p28 p29 5
line l29 p29 p30 8
line l30 p30 p31 5
line l31 p31 p28 8
$ /com
$ /com  INCLUDE PLASMA
$ /com  Mesh Plasma
define parameter r1 #pr9-#pdr9/2
define parameter r2 #pr9+#pdr9/2
```

```
define parameter z1 0
define parameter z2 #pz9+#pdz9/2
point,p32,#r1,#z1
point,p33,#r2,#z1
point,p34,#r2,#z2
point,p35,#r1,#z2
line,l32,p32,p33 10
line l33 p33 p34 5
line l34 p34 p35 10
line l35 p35 p32 5

$ /com
$ /com FREE SPACE REGION INSIDE CS
define parameter z1 #pz1-#pdz1/2
define parameter z2 #pz4+#pdz4/2
point,p36,0,0
point,p37,0,#z2
line,l36,p36,p37,15
line,l37,p6,p36,12,2
line,l38,p18,p37,12,2
$ /com  AREA ABOVE CS
define parameter z1 #pz5+#pdz5/2
point,p38,0,#z1
line,l39,p17,p19,16
line,l40,p22,p38,15,2
line,l41,p37,p38,9
$ /com  AREA BETWEEN CS AND PLASMA
line,l42,p17,p35,18,2
line,l43,p5,p32,14,2
$ /com  AREA ABOVE PLASMA
line,l44,p21,p26,25,2,center
line,l45,p34,p23,15,2,center
$ /com AREA BETWEEN PLASMA AND PF6/7
define parameter r1 #pr7+#pdr7/2
point,p39,#r1,0
line,l46,p33,p39,12
line,l47,p39,p28,12,,5
line,l48,p24,p31,12,,-2
$ /com  AREA OUTSIDE PF6 AND PF7
define parameter r1 2*#pr6+#pdr6
define parameter z1 2*#pz6+#pdz6
point,p40,#r1,#z1
point,p41,#r1,0
point,p42,0,#z1
line,l49,p25,p40,20,3
line,l50,p40,p41,10
line,l51,p39,p41,10,3
line,l52,p38,p42,10,2
line,l53,p40,p42,20
/com  INFINITY REGION
define parameter r1 50*#r1
define parameter z1 50*#z1
point,p43,#r1,#z1
point,p44,#r1,0
point,p45,0,#z1
line,l54,p41,p44,20,50
line,l55,p42,p45,20,50
line,l56,p40,p43,25,50
line,l57,p43,p44,6
line,l58,p43,p45,8
$ /com
$ /com  CURRENT LOADINGS
define parameter j1 #ni1/(#pdr1*#pdz1)
define parameter j2 #ni2/(#pdr2*#pdz2)
define parameter j3 #ni3/(#pdr3*#pdz3)
define parameter j4 #ni4/(#pdr4*#pdz4)
define parameter j5 #ni5/(#pdr5*#pdz5)
define parameter j6 #ni6/(#pdr6*#pdz6)
define parameter j7 #ni7/(#pdr7*#pdz7)
define parameter j9 #ni9/(#pdr9*#pdz9)
$
$
node off
$  MESH REGIONS
tria 1 1 1
4reg,r1,l1,l2,l3,l4
line l59 p3 p8 1
line l60 p4 p7 1
tria 1 1 10
4reg r2 l3 l59 l5 l60
tria 1 1 2
4reg,r3,l5 l6 l7 l8
line l61 p9 p12 1
line l62 p10 p11 1
tria 1 1 10
4reg r4 l7 l61 l9 l62
tria 1 1 3
4reg r5 l9 l10 l11 l12
line l63 p13 p16 1
line l64 p14 p15 1
tria 1 1 10
4reg r6 l11 l63 l13 l64
tria 1 1 4
4reg r7 l13 l14 l15 l16
line l65 p5 p6 5
line l66 p6 p1 1
line l67 p2 p5 1
tria 1 1 10
4reg r8 l65 l67 l1 l66
greg r9 l37 l66 l4 l60 l8 l62 l12 l64 l16 l38 l36
greg r10 l43 l35 l42 l14 l63 l10 l61 l6 l59 l2 l67
greg r11 l38 l15 l39 l20 l40 l41
tria 1 1 5
4reg r12 l17 l18 l19 l20
line l68 p20 p23 25 2 center
tria 1 1 10
greg r13 l68 l27 l44 l18
line l69 p17 p23 35 2 center
greg r14 l69 l68 l17 l39
greg r15 l34 l45 l69 l42
tria 1 1 8
4reg r16 l32 l33 l34 l35
tria 1 1 6
4reg r17 l21 l22 l23 l27
tria 1 1 7
4reg r18 l28 l29 l30 l31
tria 1 1 10
greg r19 l46 l47 l31 l48 l21 l45 l33
greg r20 l51 l50 l49 l22 l48 l30 l29 l28 l47
greg r21 l40 l19 l44 l23 l49 l53 l52
greg r22 l50 l54 l57 l56
greg r23 l53 l56 l58 l55
jump load
constraint fixed line 157 158
pot
```

Appendix F - Westinghouse MAFCO 3-D input file

The following is a MAFCO input file used to establish the electromagnetic model of the TPX coils.

```
$ * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
$   TPXREV3 data file
$   Dimensions from 9/94 drawings
$
$  Currents only on TF COILS
$
$* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
$
$       CARD I = 1;
$ NP   PLTSFC       GTITL
$---><--------><-------- 40-CHAR GLOBAL TITLE -------->
     1      .75 MODEL TOROID * SIXTEEN D-COILS
$ TPX TF Coils -- All Arcs -- Looking for Max Field
$
$$      CARD II = 2;
$$  PROBLEM DECK 1 * FIELD
$$                  (IN COIL 1 &
$     ICON   NI    NO IGRD
$    <---><---><---><---><---><---><--->
        00    5     6   03
$   17   27   33
$
$       CARD III = 3
$ LPS ARCS  HLX LINS  GCE GRDS FLDL              CASE TITLE
$---><---><---><---><---><---><---><--------- 40 CHARACTERS --------------->
    0  132     0     0     0    10     0 FORCES on PF 1-7
$$$ SOLID-ELEMENT MODELS OF COILS 1, 2, 16:
$$  COIL 1:   ( IN X-Z PLANE, AZIMUTH THETA = 0.00 )
$ SOLID ARC SEGMENT CARDS:
$$        CARD IV - B - 1,2.B                              (IARC=1)
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
   229.108       0.00   116.586   115.846      0.00     90.00 -2.814E-6  1
     90.00     180.00   105.156   126.536   -15.185    15.185
   229.108       0.00    67.564   164.870      0.00     90.00 -2.814E-6  1
      9.11     90.00    154.180   175.560   -15.185    15.185
  -192.230       0.00       0.0   591.590      0.00     90.00 -2.814E-6  1
     -9.11       9.11   580.900   602.280   -15.185    15.185
   229.108       0.00   -67.564   164.780      0.00     90.00 -2.814E-6  1
    -90.00      -9.11   154.180   175.560   -15.185    15.185
   229.108       0.00  -116.586   115.846      0.00     90.00 -2.814E-6  1
   -180.00     -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$        CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><---R=0---><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
   113.262       0.00       0.00       0.00       0.00  2.814E-6  2
    -10.69      10.69    -15.185    15.185  -116.586   116.586
$$  COIL 2:   ( IN X-Z PLANE, AZIMUTH THETA = 22.50 )
$$        CARD IV - B - 1,2.B                              (IARC=1)
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
   211.668    87.676   116.586   115.846     22.50     90.00 -2.814E-6  1
     90.00    180.00   105.156   126.536   -15.185    15.185
   211.668    87.676    67.564   164.870     22.50     90.00 -2.814E-6  1
      9.11     90.00   154.180   175.560   -15.185    15.185
  -177.597   -73.56       0.0   591.590     22.50     90.00 -2.814E-6  1
     -9.11      9.11   580.900   602.280   -15.185    15.185
   211.668    87.676   -67.564   164.780     22.50     90.00 -2.814E-6  1
    -90.00     -9.11   154.180   175.560   -15.185    15.185
   211.668    87.676  -116.586   115.846     22.50     90.00 -2.814E-6  1
   -180.00    -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$        CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><---R=0---><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
   104.640   43.343       0.00       0.00     22.50      0.00  2.814E-6  2
    -10.69     10.69    -15.185    15.185  -116.586   116.586
$$  COIL 3:   ( IN X-Z PLANE, AZIMUTH THETA = 45.00 )
$$        CARD IV - B - 1,2.B                              (IARC=1)
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
   162.004   162.004   116.586   115.846     45.00     90.00 -2.814E-6  1
     90.00    180.00   105.156   126.536   -15.185    15.185
   162.004   162.004    67.564   164.870     45.00     90.00 -2.814E-6  1
      9.11     90.00   154.180   175.560   -15.185    15.185
  -135.927  -135.927       0.0   591.590     45.00     90.00 -2.814E-6  1
     -9.11      9.11   580.900   602.280   -15.185    15.185
   162.004   162.004   -67.564   164.780     45.00     90.00 -2.814E-6  1
    -90.00     -9.11   154.180   175.560   -15.185    15.185
   162.004   162.004  -116.586   115.846     45.00     90.00 -2.814E-6  1
   -180.00    -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$        CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><---R=0---><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
    80.088    80.088       0.00       0.00     45.00      0.00  2.814E-6  2
    -10.69     10.69    -15.185    15.185  -116.586   116.586
$$  COIL 4:   ( IN X-Z PLANE, AZIMUTH THETA = 67.50 )
$$        CARD IV - B - 1,2.B                              (IARC=1)
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
    87.676   211.668   116.586   115.846     67.50     90.00 -2.814E-6  1
     90.00    180.00   105.156   126.536   -15.185    15.185
    87.676   211.668    67.564   164.870     67.50     90.00 -2.814E-6  1
      9.11     90.00   154.180   175.560   -15.185    15.185
  -73.563  -177.597       0.0   591.590     67.50     90.00 -2.814E-6  1
     -9.11      9.11   580.900   602.280   -15.185    15.185
    87.676   211.668   -67.564   164.780     67.50     90.00 -2.814E-6  1
    -90.00     -9.11   154.180   175.560   -15.185    15.185
    87.676   211.668  -116.586   115.846     67.50     90.00 -2.814E-6  1
   -180.00    -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$        CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><---R=0---><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
    43.343   104.640       0.00       0.00     67.50      0.00  2.814E-6  2
    -10.69     10.69    -15.185    15.185  -116.586   116.586

$$  COIL 5:   ( IN X-Z PLANE, AZIMUTH THETA = 90.00 )
$$        CARD IV - B - 1,2.B                              (IARC=1)
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
       0.00   229.108   116.586   115.846     90.00     90.00 -2.814E-6  1
     90.00    180.00   105.156   126.536   -15.185    15.185
       0.00   229.108    67.564   164.870     90.00     90.00 -2.814E-6  1
      9.11     90.00   154.180   175.560   -15.185    15.185
       0.00  -192.230       0.0   591.590     90.00     90.00 -2.814E-6  1
     -9.11      9.11   580.900   602.280   -15.185    15.185
       0.00   229.108   -67.564   164.780     90.00     90.00 -2.814E-6  1
    -90.00     -9.11   154.180   175.560   -15.185    15.185
       0.00   229.108  -116.586   115.846     90.00     90.00 -2.814E-6  1
   -180.00    -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$        CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><---R=0---><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
       0.0   113.262       0.00       0.00     90.00      0.00  2.814E-6  2
    -10.69     10.69    -15.185    15.185  -116.586   116.586
$$  COIL 6:   ( IN X-Z PLANE, AZIMUTH THETA = 112.50 )
$$        CARD IV - B - 1,2.B                              (IARC=1)
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
   -87.676   211.668   116.586   115.846    112.50     90.00 -2.814E-6  1
     90.00    180.00   105.156   126.536   -15.185    15.185
   -87.676   211.668    67.564   164.870    112.50     90.00 -2.814E-6  1
      9.11     90.00   154.180   175.560   -15.185    15.185
    73.563  -177.597       0.0   591.590    112.50     90.00 -2.814E-6  1
     -9.11      9.11   580.900   602.280   -15.185    15.185
   -87.676   211.668   -67.564   164.780    112.50     90.00 -2.814E-6  1
    -90.00     -9.11   154.180   175.560   -15.185    15.185
   -87.676   211.668  -116.586   115.846    112.50     90.00 -2.814E-6  1
   -180.00    -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$        CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><---R=0---><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
   -43.343   104.640       0.00       0.00    112.50      0.00  2.814E-6  2
    -10.69     10.69    -15.185    15.185  -116.586   116.586
$$  COIL 7:   ( IN X-Z PLANE, AZIMUTH THETA = 135.00 )
$$        CARD IV - B - 1,2.B                              (IARC=1)
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
  -162.004   162.004   116.586   115.846    135.00     90.00 -2.814E-6  1
     90.00    180.00   105.156   126.536   -15.185    15.185
  -162.004   162.004    67.564   164.870    135.00     90.00 -2.814E-6  1
      9.11     90.00   154.180   175.560   -15.185    15.185
   135.927  -135.927       0.0   591.590    135.00     90.00 -2.814E-6  1
     -9.11      9.11   580.900   602.280   -15.185    15.185
  -162.004   162.004   -67.564   164.780    135.00     90.00 -2.814E-6  1
    -90.00     -9.11   154.180   175.560   -15.185    15.185
  -162.004   162.004  -116.586   115.846    135.00     90.00 -2.814E-6  1
   -180.00    -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$        CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><---R=0---><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
   -80.088    80.088       0.00       0.00    135.00      0.00  2.814E-6  2
    -10.69     10.69    -15.185    15.185  -116.586   116.586
$$  COIL 8:   ( IN X-Z PLANE, AZIMUTH THETA = 157.50 )
$$        CARD IV - B - 1,2.B                              (IARC=1)
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
  -211.668    87.676   116.586   115.846    157.50     90.00 -2.814E-6  1
     90.00    180.00   105.156   126.536   -15.185    15.185
  -211.668    87.676    67.564   164.870    157.50     90.00 -2.814E-6  1
      9.11     90.00   154.180   175.560   -15.185    15.185
   177.597   -73.56       0.0   591.590    157.50     90.00 -2.814E-6  1
     -9.11      9.11   580.900   602.280   -15.185    15.185
  -211.668    87.676   -67.564   164.780    157.50     90.00 -2.814E-6  1
    -90.00     -9.11   154.180   175.560   -15.185    15.185
  -211.668    87.676  -116.586   115.846    157.50     90.00 -2.814E-6  1
   -180.00    -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$        CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><---R=0---><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
  -104.640   43.343       0.00       0.00    157.50      0.00  2.814E-6  2
    -10.69     10.69    -15.185    15.185  -116.586   116.586
$$  COIL 9:   ( IN X-Z PLANE, AZIMUTH THETA = 180.00 )
$$        CARD IV - B - 1,2.B                              (IARC=1)
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
  -229.108       0.00   116.586   115.846    180.00     90.00 -2.814E-6  1
     90.00    180.00   105.156   126.536   -15.185    15.185
  -229.108       0.00    67.564   164.870    180.00     90.00 -2.814E-6  1
      9.11     90.00   154.180   175.560   -15.185    15.185
   192.230       0.00       0.0   591.590    180.00     90.00 -2.814E-6  1
     -9.11      9.11   580.900   602.280   -15.185    15.185
  -229.108       0.00   -67.564   164.780    180.00     90.00 -2.814E-6  1
    -90.00     -9.11   154.180   175.560   -15.185    15.185
  -229.108       0.00  -116.586   115.846    180.00     90.00 -2.814E-6  1
   -180.00    -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$        CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><---R=0---><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
  -113.262       0.00       0.00       0.00    180.00      0.00  2.814E-6  2
    -10.69     10.69    -15.185    15.185  -116.586   116.586
$$  COIL 10:   ( IN X-Z PLANE, AZIMUTH THETA = -157.50 )
$$        CARD IV - B - 1,2.B                              (IARC=1)
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
  -211.668   -87.676   116.586   115.846   -157.50     90.00 -2.814E-6  1
     90.00    180.00   105.156   126.536   -15.185    15.185
  -211.668   -87.676    67.564   164.870   -157.50     90.00 -2.814E-6  1
      9.11     90.00   154.180   175.560   -15.185    15.185
```

```
   177.597     73.56       0.0   591.590   -157.50     90.00 -2.814E-6  1
     -9.11      9.11   580.900   602.280   -15.185    15.185
  -211.668   -87.676   -67.564   164.780   -157.50     90.00 -2.814E-6  1
   -90.00     -9.11   154.180   175.560   -15.185    15.185
  -211.668   -87.676  -116.586   115.846   -157.50     90.00 -2.814E-6  1
  -180.00    -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$       CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><--R=0--><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
  -104.640   -43.343       0.00       0.00   -157.50       0.00  2.814E-6  2
    -10.69     10.69   -15.185    15.185   -116.586   116.586
$$  COIL 11:   ( IN X-Z PLANE, AZIMUTH THETA = -135.00 )
$$       CARD IV - B - 1,2.B                          (IARC=1)
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
  -162.004  -162.004   116.586   115.846   -135.00     90.00 -2.814E-6  1
    90.00     180.00   105.156   126.536   -15.185    15.185
  -162.004  -162.004    67.564   164.870   -135.00     90.00 -2.814E-6  1
     9.11      90.00   154.180   175.560   -15.185    15.185
   135.927   135.927       0.0   591.590   -135.00     90.00 -2.814E-6  1
    -9.11      9.11   580.900   602.280   -15.185    15.185
  -162.004  -162.004   -67.564   164.780   -135.00     90.00 -2.814E-6  1
   -90.00     -9.11   154.180   175.560   -15.185    15.185
  -162.004  -162.004  -116.586   115.846   -135.00     90.00 -2.814E-6  1
  -180.00    -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$       CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><--R=0--><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
   -80.088   -80.088       0.00       0.00   -135.00       0.00  2.814E-6  2
    -10.69     10.69   -15.185    15.185   -116.586   116.586
$$  COIL 12:   ( IN X-Z PLANE, AZIMUTH THETA = -112.50 )
$$       CARD IV - B - 1,2.B                          (IARC=1)
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
   -87.676  -211.668   116.586   115.846   -112.50     90.00 -2.814E-6  1
    90.00     180.00   105.156   126.536   -15.185    15.185
   -87.676  -211.668    67.564   164.870   -112.50     90.00 -2.814E-6  1
     9.11      90.00   154.180   175.560   -15.185    15.185
    73.563   177.597       0.0   591.590   -112.50     90.00 -2.814E-6  1
    -9.11      9.11   580.900   602.280   -15.185    15.185
   -87.676  -211.668   -67.564   164.780   -112.50     90.00 -2.814E-6  1
   -90.00     -9.11   154.180   175.560   -15.185    15.185
   -87.676  -211.668  -116.586   115.846   -112.50     90.00 -2.814E-6  1
  -180.00    -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$       CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><--R=0--><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
   -43.343  -104.640       0.00       0.00   -112.50       0.00  2.814E-6  2
    -10.69     10.69   -15.185    15.185   -116.586   116.586
$$  COIL 13:   ( IN X-Z PLANE, AZIMUTH THETA = -90.00 )
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
      0.00  -229.108   116.586   115.846    -90.00     90.00 -2.814E-6  1
     90.00     180.00   105.156   126.536   -15.185    15.185
      0.00  -229.108    67.564   164.870    -90.00     90.00 -2.814E-6  1
      9.11      90.00   154.180   175.560   -15.185    15.185
      0.00   192.230       0.0   591.590    -90.00     90.00 -2.814E-6  1
     -9.11      9.11   580.900   602.280   -15.185    15.185
      0.00  -229.108   -67.564   164.780    -90.00     90.00 -2.814E-6  1
    -90.00     -9.11   154.180   175.560   -15.185    15.185
      0.00  -229.108  -116.586   115.846    -90.00     90.00 -2.814E-6  1
   -180.00    -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$       CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><--R=0--><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
      0.0  -113.262       0.00       0.00    -90.00       0.00  2.814E-6  2
    -10.69     10.69   -15.185    15.185   -116.586   116.586
$$  COIL 14:   ( IN X-Z PLANE, AZIMUTH THETA = -67.50 )
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
    87.676  -211.668   116.586   115.846    -67.50     90.00 -2.814E-6  1
    90.00     180.00   105.156   126.536   -15.185    15.185
    87.676  -211.668    67.564   164.870    -67.50     90.00 -2.814E-6  1
     9.11      90.00   154.180   175.560   -15.185    15.185
   -73.563   177.597       0.0   591.590    -67.50     90.00 -2.814E-6  1
    -9.11      9.11   580.900   602.280   -15.185    15.185
    87.676  -211.668   -67.564   164.780    -67.50     90.00 -2.814E-6  1
   -90.00     -9.11   154.180   175.560   -15.185    15.185
    87.676  -211.668  -116.586   115.846    -67.50     90.00 -2.814E-6  1
  -180.00    -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$       CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><--R=0--><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
    43.343  -104.640       0.00       0.00    -67.50       0.00  2.814E-6  2
    -10.69     10.69   -15.185    15.185   -116.586   116.586
$$  COIL 15:   ( IN X-Z PLANE, AZIMUTH THETA = -45.00 )
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
   162.004  -162.004   116.586   115.846    -45.00     90.00 -2.814E-6  1
    90.00     180.00   105.156   126.536   -15.185    15.185
   162.004  -162.004    67.564   164.870    -45.00     90.00 -2.814E-6  1
     9.11      90.00   154.180   175.560   -15.185    15.185
  -135.927   135.927       0.0   591.590    -45.00     90.00 -2.814E-6  1
    -9.11      9.11   580.900   602.280   -15.185    15.185
   162.004  -162.004   -67.564   164.780    -45.00     90.00 -2.814E-6  1
   -90.00     -9.11   154.180   175.560   -15.185    15.185
   162.004  -162.004  -116.586   115.846    -45.00     90.00 -2.814E-6  1
  -180.00    -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$       CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><--R=0--><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
    80.088   -80.088       0.00       0.00    -45.00       0.00  2.814E-6  2
    -10.69     10.69   -15.185    15.185   -116.586   116.586
$$  COIL 16:   ( IN X-Z PLANE, AZIMUTH THETA = -22.50 )
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
   211.668   -87.676   116.586   115.846    -22.50     90.00 -2.814E-6  1
    90.00     180.00   105.156   126.536   -15.185    15.185
   211.668   -87.676    67.564   164.870    -22.50     90.00 -2.814E-6  1
     9.11      90.00   154.180   175.560   -15.185    15.185
  -177.597    73.56       0.0   591.590    -22.50     90.00 -2.814E-6  1
    -9.11      9.11   580.900   602.280   -15.185    15.185
   211.668   -87.676   -67.564   164.780    -22.50     90.00 -2.814E-6  1
   -90.00     -9.11   154.180   175.560   -15.185    15.185
   211.668   -87.676  -116.586   115.846    -22.50     90.00 -2.814E-6  1
  -180.00    -90.00   105.156   126.536   -15.185    15.185
$$  SOLID STRAIGHT SEGMENT:
$$       CARD IV - B - 1,2.C       PP. 40,41      (IARC=2)
$---X----><---Y----><---Z----><--R=0--><-ALPHA--><--BETA--><---I----> IARC
$---X1---><---X2---><---Y1---><---Y2---><---Z1---><---Z2--->
    104.640   -43.343       0.00       0.00    -22.50       0.00  2.814E-6  2
    -10.69     10.69   -15.185    15.185   -116.586   116.586
$ CENTRAL SOLENOID AND POILOIDAL COILS
$ SOLID ARC
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
      0.00      0.00     25.1      81.0      0.00       0.00 -2.953E+6    1
      0.00     180.0    73.80     88.20     -23.9       23.9
      0.00      0.00     25.1      81.0      0.00       0.00 -2.953E+6    1
    180.00     360.0    73.80     88.20     -23.9       23.9
      0.00      0.00    -25.1      81.0      0.00       0.00 -2.953E+6    1
      0.00     180.0    73.80     88.20     -23.9       23.9
      0.00      0.00    -25.1      81.0      0.00       0.00 -2.953E+6    1
    180.00     360.0    73.80     88.20     -23.9       23.9
$ PF2 U&L
      0.00      0.00    70.65      81.0      0.00       0.00 -0.679E+6    1
      0.00     180.0    73.80     88.20    -19.15      19.15
      0.00      0.00    70.65      81.0      0.00       0.00 -0.679E+6    1
    180.00     360.0    73.80     88.20    -19.15      19.15
      0.00      0.00   -70.65      81.0      0.00       0.00 -0.679E+6    1
      0.00     180.0    73.80     88.20    -19.15      19.15
      0.00      0.00   -70.65      81.0      0.00       0.00 -0.679E+6    1
    180.00     360.0    73.80     88.20    -19.15      19.15
$ PF3 U&L
      0.00      0.00   104.15      81.0      0.00       0.00  0.115E+6    1
      0.00     180.0    73.80     88.20    -11.95      11.95
      0.00      0.00   104.15      81.0      0.00       0.00  0.115E+6    1
    180.00     360.0    73.80     88.20    -11.95      11.95
      0.00      0.00  -104.15      81.0      0.00       0.00  0.115E+6    1
      0.00     180.0    73.80     88.20    -11.95      11.95
      0.00      0.00  -104.15      81.0      0.00       0.00  0.115E+6    1
    180.00     360.0    73.80     88.20    -11.95      11.95
$ PF4 U&L
      0.00      0.00   130.55      81.0      0.00       0.00  0.319E+6    1
      0.00     180.0    73.80     88.20    -11.95      11.95
      0.00      0.00   130.55      81.0      0.00       0.00  0.319E+6    1
    180.00     360.0    73.80     88.20    -11.95      11.95
      0.00      0.00  -130.55      81.0      0.00       0.00  0.319E+6    1
      0.00     180.0    73.80     88.20    -11.95      11.95
      0.00      0.00  -130.55      81.0      0.00       0.00  0.319E+6    1
    180.00     360.0    73.80     88.20    -11.95      11.95
$ PF5 U&L
      0.00      0.00   235.0      121.3      0.00       0.00  3.348E+6    1
      0.00     180.0   111.7      130.90    -19.10      19.10
      0.00      0.00   235.0      121.3      0.00       0.00  3.348E+6    1
    180.00     360.0   111.7      130.90    -19.10      19.10
      0.00      0.00  -235.0      121.3      0.00       0.00  3.348E+6    1
      0.00     180.0   111.7      130.90    -19.10      19.10
      0.00      0.00  -235.0      121.3      0.00       0.00  3.348E+6    1
    180.00     360.0   111.7      130.90    -19.10      19.10
$ PF6 U&L
      0.00      0.00   214.4      375.8      0.00       0.00 -1.699E+6
      0.00     180.0   368.7      383.00    -23.90      23.90
      0.00      0.00   214.4      375.8      0.00       0.00 -1.699E+6
    180.00     360.0   368.7      383.00    -23.90      23.90
      0.00      0.00  -214.4      375.8      0.00       0.00 -1.699E+6    1
      0.00     180.0   368.7      383.00    -23.90      23.90
      0.00      0.00  -214.4      375.8      0.00       0.00 -1.699E+6    1
    180.00     360.0   368.7      383.00    -23.90      23.90
$ PF7 U&L
      0.00      0.00   111.35     429.7      0.00       0.00 -0.202E+6    1
      0.00     180.0   422.5      436.90    -16.75      16.75
      0.00      0.00   111.35     429.7      0.00       0.00 -0.202E+6    1
    180.00     360.0   422.5      436.90    -16.75      16.75
      0.00      0.00  -111.35     429.7      0.00       0.00 -0.202E+6    1
      0.00     180.0   422.5      436.90    -16.75      16.75
      0.00      0.00  -111.35     429.7      0.00       0.00 -0.202E+6    1
    180.00     360.0   422.5      436.90    -16.75      16.75
$ INTERNAL CONTROL (IC) U&L
      0.00      0.00    68.40     294.0      0.00       0.00 -0.202E-6    1
      0.00     180.0   291.75     296.25    -2.25       2.25
      0.00      0.00    68.40     294.0      0.00       0.00 -0.202E-6    1
    180.00     360.0   291.75     296.25    -2.25       2.25
      0.00      0.00   -68.40     294.0      0.00       0.00 -0.202E-6    1
      0.00     180.0   291.75     296.25    -2.25       2.25
      0.00      0.00   -68.40     294.0      0.00       0.00 -0.202E-6    1
    180.00     360.0   291.75     296.25    -2.25       2.25
$---X----><---Y----><---Z----><---R----><-ALPHA--><--BETA--><---I----> IARC
$--PHI1--><--PHI2--><---R1---><---R2---><---Z1---><---Z2--->
$ TF INTERCONNECT TURN
      0.00      0.00   259.10     334.8      0.00       0.00  33.48E+3    1
      0.00     180.0   333.55     336.05    -1.25       1.25
      0.00      0.00   259.10     334.8      0.00       0.00  33.48E+3    1
    180.00     360.0   333.55     336.05    -1.25       1.25
$ PLASMA
      0.00      0.00     0.00     225.0      0.00       0.00  2.000E+6    1
      0.00     180.0    175.0     275.00    -50.00      50.00
      0.00      0.00     0.00     225.0      0.00       0.00  2.000E+6    1
    180.00     360.0    175.0     275.00    -50.00      50.00
$$ R-Z FIELD GRID DESCRIPTIONS
$$       CARD V - A
$--RMIN--><--DELR--><--RMAX--><-THETA--><--ZMIN--><--DELZ--><--ZMAX-->
$  MIDPLANE SCAN ACROSS COIL 1:
$     88.000    10.000   106.000    00.000    00.000   000.000   000.000
$    106.000    10.000   210.000    00.000    00.000   000.000   000.000
$    210.000    20.000   410.000    00.000    00.000   000.000   000.000
$ COARSE SURVEY OF FIELD IN COIL 1:
$     88.000    10.000   106.000    00.000    00.000    50.000   235.000
$    106.000    10.000   210.000    00.000    00.000    50.000   235.000
$    210.000    20.000   410.000    00.000    00.000    50.000   235.000
$ COARSE SURVEY OF FIELD BETWEEN COILS 1 & 2:
$     90.000    10.000   410.000    11.250    00.000    10.000   240.000
$
$  FORCE CALCULATION
$$ FORCE GRID  INPUTS:
$$       CARD V - D.1          PP. 43,44        (IGRID = 3)
$       Z,Y  R,X  P,Z                          40 CHARACTERS:
$NARC    N    M    K  NPF IOP1 IOP2<--------------JTITLE-----------------
```

```
 97    8    8    3   -1   00   -2  PF1U FORCES 0 to 180 degs
101    8    8    3   -1   00   -2  PF2U FORCES 0 to 180 degs
105    8    8    3   -1   00   -2  PF3U FORCES 0 to 180 degs
109    8    8    3   -1   00   -2  PF4U FORCES 0 to 180 degs
113    8    8    3   -1   00   -2  PF5U FORCES 0 to 180 degs
117    8    8    3   -1   00   -2  PF6U FORCES 0 to 180 degs
121    8    8    3   -1   00   -2  PF7U FORCES 0 to 180 degs
125    8    8    3   -1   00   -2  IC FORCES 0 to 180 degs
129    8    8    3   -1   00   -2  TF interconnect FORCES 0 to 180 degs
131    8    8    3   -1   00   -2  PLASMA FORCES 0 to 180 degs
$ END OF PROBLEM 1
```

Appendix G - Listing of FORTRAN program pfrc.f

The following is a listing of FORTRAN program pfrc.f used to process several finite element force results and produce radial and vertical force coefficients.

```
      program pfrc
c
c  The purpose of this program is to process the HOTMAT force
c  calculations and form a force matrix relating the currents to
c  radial and z-directed forces
c
       implicit real*8(a-h,o-z)
       character*80 line
       real*8 xval(400), yval(400)
       real*8 kr(18,18), kz(18,18), diag
       open(1,file='frc.dat',form='formatted',status='old')
c
      numcur=18
      ict=0
100   continue
      read(1,77,end=99)line
77    format(80a)
      if(line(2:9).eq.'Total x-')then
         ict=ict+1
         read(line(35:50),'(e16.9)')xval(ict)
c         write(6,*)line,xval(ict)
      endif
      if(line(2:9).eq.'Total y-')then
         read(line(35:50),'(e16.9)')yval(ict)
c         write(6,*)line,yval(ict)
      endif
      go to 100
c
99    continue
      numred= ict
c
c  Write to kr, kz matrix and Combine the plasma forces
      iplas=15
c  process radial terms (i.e. r-directed) first
      write(6,*)' Process radial forces'
      write(6,*)' '
      write(6,*)'  Radial Force matrix terms'
      ict=0
      do 16 i=1,numcur
        do 17 j=i,numcur
        ict=ict+1
        if(i.eq.iplas)then
             ict=ict+1
             rfrc=xval(ict-1)+xval(ict)
        else
             rfrc=xval(ict)
        endif
         if(j.gt.i)then
            kr(i,j)=rfrc
            ict=ict+1
            kr(j,i)=xval(ict)
            if(j.eq.iplas)then
                ict=ict+1
                kr(j,i)=kr(j,i)+xval(ict)
```

```
            endif
          else
             diag=rfrc
             kr(i,j)=diag
          endif
 17       continue
 16     continue
 c
        do 41 i=1,numcur
         do 41 j=1,numcur
           if(i.ne.j)kr(i,j)=kr(i,j)-kr(i,i)
           write(6,119)i,j,kr(i,j)
 119      format('  i=',i4,'   j=',i4,'  kr=',f12.2)
 41     continue
 c
 c
 c  process axial terms (i.e. y-directed)
        write(6,*)' Process axial forces'
        write(6,*)' '
        write(6,*)'  Radial Axial matrix terms'
        ict=0
        do 116 i=1,numcur
          do 117 j=i,numcur
          ict=ict+1
          if(i.eq.iplas)then
               ict=ict+1
               rfrc=yval(ict-1)+yval(ict)
          else
               rfrc=yval(ict)
          endif
           if(j.gt.i)then
              kz(i,j)=rfrc
              ict=ict+1
              kz(j,i)=yval(ict)
              if(j.eq.iplas)then
                  ict=ict+1
                  kz(j,i)=kz(j,i)+yval(ict)
              endif
           else
              diag=rfrc
              kz(i,j)=diag
           endif
 117       continue
 116     continue
 c
        do 141 i=1,numcur
         do 141 j=1,numcur
           if(i.ne.j)kz(i,j)=kz(i,j)-kz(i,i)
           write(6,109)i,j,kz(i,j)
 109      format('  i=',i4,'   j=',i4,'  kz=',f12.2)
 141     continue
 c
 c
        write(6,*)' Number of forces read=',numred
        write(6,*)' Number of forces processed=',ict
        stop
        end
```

Appendix H - ANSYS Axisymmetric command file: refined PF3U, normal operating case

The following are ANSYS commands used to establish the axisymmetric electromagnetic model of the TPX PF coils using a refined mesh for coil pack PF3U. The PF3U coil pack shares the same elements with a detailed structural model.

```
/com FILE srcs10.str
/com William Hannan and Mark Kreftz
/com Westinghouse STC
/com November 21, 1994
ET, 1,plane13,,,1
local,11,0.0,0.0,0.90 $local,12,0 !rotated local coordinate
csys,0
/com
/com  PARAMETERS
*dim,pitch,array,20
rsm=.106*.0254      !inner radius of conduit
cw=.688*.0254       !cable width
fl=cw-2*rsm    !flat length of conduit wall
tc=.095*.0254       !conduit wall thickness
tins=.012*.0254     !insulation wrap thickness
rou=.201*.0254      !outer radius of conduit
r1=rou+tins    !outer radius of 1st insulating wrap
r2=r1+tins     !outer radius of 2nd insulating wrap
tg11=.016*.0254     !g11 sheet thickness
twrap=.301*.0254    !ground wall insulation thickness
csize=.942*.0254    !size of single turn cell i.e. offset in x,y
ric=28.237*.0254    !DWG 9414002B.DRW 6/28/94
innerrad=ric+twrap+2*tins+tc
xx=cw+tc+2*tins
r3=r2+twrap
nxt=6        !number of turns in a row
icsi=12      !last used coordinate system
ESIZE,.05*.0254     !default elem size
sml=.001*.0254      !a relatively small dimension
rdiv=2       !radial divisions on thin bands
pitch(1)=0*csize,1/4*csize,3/4*csize,1/2*csize,1/2*csize
pitch(6)=3/4*csize,1/4*csize,1*csize,0*csize,1/4*csize
/com
/title,EM model of conductor pack
/com  STRUCTURAL PROPERTIES
/com  Young's modulus
/com mp,ex,1,26.83e6                                !material 1 incoloy
/com mp,ex,2,3.191e6  $mp,ey,2,4.787e6    $mp,ez,2,4.787e6 !material 2 insul.
/com mp,ex,3,3.191e6  $mp,ey,3,4.787e6    $mp,ez,3,4.787e6 !material 3 insul.
/com mp,ex,4,3.191e6  $mp,ey,4,4.787e6    $mp,ez,4,4.787e6 !material 4 insul.
/com mp,ex,5,3.191e6  $mp,ey,5,4.787e6    $mp,ez,5,4.787e6 !material 5 insul.
/com mp,ex,6,3.191e6  $mp,ey,6,4.787e6    $mp,ez,6,4.787e6 !material 6 insul.
/com mp,ex,7,1e6                          !material 7 insul.
/com mp,ex,8,3.191e6  $mp,ey,8,4.787e6    $mp,ez,8,4.787e6 !material 8 insul.
/com mp,ex,9,3.191e6  $mp,ey,9,4.787e6    $mp,ez,9,4.787e6 !material 9 insul.
/com mp,ex,10,3.191e6 $mp,ey,10,4.787e6   $mp,ez,10,4.787e6 !material 10 insul.
/com
/com  thermal contractions
/com mp,alpx,1,5.59e-6                              !material 1
/com mp,alpx,2,24.8e-6 $mp,alpy,2,8.4e-6  $mp,alpz,2,8.4e-6 !material 2
/com mp,alpx,3,24.8e-6 $mp,alpy,3,8.4e-6  $mp,alpz,3,8.4e-6 !material 3
/com mp,alpx,4,24.8e-6 $mp,alpy,4,24.80e-6 $mp,alpz,4,8.4e-6 !material 4
/com mp,alpx,5,24.8e-6 $mp,alpy,5,8.4e-6  $mp,alpz,5,8.4e-6 !material 5
/com mp,alpx,6,24.8e-6 $mp,alpy,6,8.4e-6  $mp,alpz,6,8.4e-6 !material 6
/com mp,alpx,7,24.8e-6                      !material 7
/com mp,alpx,8,24.8e-6 $mp,alpy,8,8.4e-6  $mp,alpz,8,8.4e-6 !material 8
/com mp,alpx,9,24.8e-6 $mp,alpy,9,8.4e-6  $mp,alpz,9,8.4e-6 !material 9
/com mp,alpx,10,24.8e-6 $mp,alpy,10,8.4e-6 $mp,alpz,10,8.4e-6 !material 10
/com
/com mp,gxy,2,1.596e6
/com mp,gxy,3,1.596e6
/com mp,gxy,4,1.596e6
/com mp,gxy,5,1.596e6
/com mp,gxy,6,1.596e6
/com mp,gxy,8,1.596e6
/com mp,gxy,9,1.596e6
/com mp,gxy,10,1.596e6
/com
/com mp,nuxy,2,.21
/com mp,nuxy,3,.21
/com mp,nuxy,4,.21
/com mp,nuxy,5,.21
/com mp,nuxy,6,.21
/com mp,nuxy,8,.21
/com mp,nuxy,9,.21
/com mp,nuxy,10,.21
/com
/com  MAGNETIC PROPERTIES
emunit,mks      *mks units
/com  mp,murx,1,1.0   *relative permeability
mp,murx,2,1.0 $mp,murx,3,1.0 $mp,murx,4,1.0
mp,murx,5,1.0 $mp,murx,6,1.0 $mp,murx,7,1.0
mp,murx,8,1.0 $mp,murx,9,1.0 $mp,murx,10,1.0
mp,murx,11,1.0 $mp,murx,12,1.0 $mp,murx,13,1.0
mp,murx,14,1.0 $mp,murx,15,1.0 $mp,murx,16,1.0
mp,murx,17,1.0 $mp,murx,18,1.0 $mp,murx,19,1.0
mp,murx,20,1.0
/com
/com  BH curve for incoloy conduit
tb,bh,1     !B-H table for Incoloy conduit
*dim,h,,20
*dim,b,,20
h(1)=17675,6.39798,2.66430,1.96481,4.127476,.156034, !first 6 H pts.
b(1)= 0.2032,0.38222,0.53714,0.66793,0.77460,0.85714 !first 6 B pts.
h(7)=178795,.193150,.197544,.201048,.210589,.229079, !next 6 H pts.
b(7)= 0.9155,0.9498,0.9600,0.9680,0.9893,1.0290 !next 6 B pts.
h(13)=259612,.305161,.368730,.453322,.697586, !next 5 H pts.
b(13)= 1.0907,1.1758,1.2851,1.4196,1.7737 !next 5 B pts.
h(18)=1000000,2000000,5000000,
b(18)=2.18,3.44,7.21
*do,i,1,20
tbpt,defi,h(i),b(i)
*enddo
/com
/com  MAT #       DESCRIPTION
/com   1      INCOLOY CONDUIT
/com   2      CABLE WRAP  INNER
/com   3      CABLE WRAP  OUTER
/com   4      ROVING FILLER
/com   5      MID VERTICAL G11 SPACER
/com   6      UPPER/LOWER VERTICAL G11 SPACER
/com   7      EPOXY VOIDS
/com   8      G11 FILLER BLOCKS
/com   9      GROUNDWALL INSULATION
/com  10      HORIZONTAL G11 SHEETS
/com  11      PF1 CONDUCTOR REGION
/com  12      PF2 CONDUCTOR REGION
/com  13      PF3 CONDUCTOR REGION
/com  14      PF4 CONDUCTOR REGION
/com  15      PF5 CONDUCTOR REGION
/com  16      PF6 CONDUCTOR REGION
/com  17      PF7 CONDUCTOR REGION
/com  18      PLASMA CONDUCTOR REGION
/com  19      TF INTERCONNECT CONDUCTOR REGION
/com  20      Free Space REGION
/com
/com
/com  DEFINE PF CURRENT SOURCE GEOMETRY (Dimensions in m)
pr1=.81   $pz1=.251   $pdr1=.144   $pdz1=.478
pr2=.81   $pz2=.7065  $pdr2=.144   $pdz2=.383
pr3=.81   $pz3=1.0415 $pdr3=.144   $pdz3=.239
pr4=.81   $pz4=1.3055 $pdr4=.144   $pdz4=.239
pr5=1.213 $pz5=2.35   $pdr5=.192   $pdz5=.382
pr6=3.7585 $pz6=2.144  $pdr6=.143   $pdz6=.478
pr7=4.297 $pz7=1.1135 $pdr7=.144   $pdz7=.335
/com  IC COIL GEOMETRY AND CURRENTS
pr8=2.9405  $pz8=0.6845 $pdr8=.045 $pdz8=.045
/com  PLASMA GEOMETRY AND CURRENTS
pr9=2.25  $pz9=0.0  $pdr9=1.0  $pdz9=1.0
/com  TF INTERCONNECT COIL
r10=3.1915 $z10=2.6924 $dr10=.023 $dz10=.027
/com  PF CURRENTS for HC Scenario at t=9sec
/com ni1=-2953000.  $ni2= -679000. $ni3=  115000. $ni4=  319000.
/com ni5= 3348000.  $ni6=-1699000. $ni7= -202000.
/com ni8=    000.  $ni9= 2000000.0
/com  PF CURRENTS for HC Scenario at t=5 sec., initiation
ni1= 934000. $ni2= 2318000.  $ni3= 1448000.  $ni4= 1406000.
ni5=2770000. $ni6=  144000.  $ni7=  120000.
ni8=    000. $ni9=00.0
itf= 2814000.0      ! tf current level
/com  itf=0
ntrn=84
```

```
icon=itf/ntrn
/com
/com  TF CURRENT SOURCE GEOMETRY
/com  tdr1=.2138  $tdz1=.3037  $tr1=2.29108  $tz1=1.16586
/com  tdr2=.2138  $tdz2=.3037  $tr2=2.29108  $tz2=0.67564
/com  tdr3=.2138  $tdz3=.3037  $tr3=-1.9223  $tz3=0.0
/com  tdr4=.2138  $tdz4=.3037              $tz4=0.0
/com  tsa1=90.0  $tea1=180.0  $tin1=1.05156
/com  tsa2=9.11  $tea2=90.0  $tin2=1.5418
/com  tsa3=-9.11  $tea3=9.11  $tin3=5.809
/com  tlen=2.3317  $thl=tlen/2
/com  trm1=tin1+tdr1/2
/com  tr4=tr1-trm1
/com  trm2=tin2+tdr2/2
/com  trm3=tin3+tdr3/2
/com  ang=22.5  !meshed angular span of pf coils
/com  acc=.00005  !Biot-savart integration accuracy
/com
/com
/com  BEGIN LOOP OVER TURNS
ix=1
/com  ELEMENT COORDINATE SYSTEMS
local,icsl+1,1,rsm+(ix-1)*csize,rsm    !lower left corner
local,icsl+2,1,rsm+fl+(ix-1)*csize,rsm    !lower right
local,icsl+3,1,rsm+(ix-1)*csize,rsm+fl    !upper left
local,icsl+4,1,rsm+fl+(ix-1)*csize,rsm+fl !upper right
csys,0
/com  KEYPOINTS
*get,kst,kp,,num,max   !max kp number
*get,lst,line,,num,max   !max line number
*get,ast,area,,num,max   !max area number
K,kst+1,rsm+(ix-1)*csize                    !kp 1
K,kst+2,(ix-1)*csize,rsm                    !kp 2
KGEN,2,kst+1,,,fl  $KGEN,2,kst+2,,,fl  $KGEN,2,kst+2,,,cw,fl !kp 3-5
KGEN,2,kst+2,,,cw   $KGEN,2,kst+1,,,cw  $KGEN,2,kst+3,,,cw !kp 6-8
KGEN,2,kst+6,,,tc  $KGEN,2,kst+5,,,tc  $KGEN,2,kst+7,,,tc  !kp 9-11
KGEN,2,kst+8,,,tc  $KGEN,2,kst+4,,,-tc  $KGEN,2,kst+2,,,-tc  !kp 12-14
KGEN,2,kst+1,,,-tc $KGEN,2,kst+3,,,-tc $KGEN,3,kst+9,,,tins !kp 15-18
KGEN,3,kst+10,,,tins $KGEN,3,kst+11,,,tins  $KGEN,3,kst+12,,,tins !kp 19-24
KGEN,3,kst+13,,,-tins $KGEN,3,kst+14,,,-tins  $KGEN,3,kst+15,,,-tins !kp 25-30
KGEN,3,kst+16,,,-tins $KGEN,2,kst+32,,,r2  $KGEN,2,kst+24,,,r2  !kp 31-34
KGEN,2,kst+30,,,-r2  $KGEN,2,kst+22,,,-r2  $KGEN,2,kst+33,,,tg11 !kp 35-37
KGEN,2,kst+34,,,-tg11 $KGEN,2,kst+33,,,tg11  $KGEN,2,kst+37,,,tg11  !kp 38-40
KGEN,2,kst+18,,,tg11  $KGEN,2,kst+20,,,tg11  $KGEN,2,kst+38,,,tg11  !kp 41-43
KGEN,2,kst+34,,,tg11  $KGEN,2,kst+36,,,-tg11 $KGEN,2,kst+35,,,tg11 !kp 44-46
k,,cw/2+(ix-1)*csize,cw/2   !keypoint for larc command  kp 47
*get,knm,kp,,num,max !kp number of larc command
/com
/com  LINES
L,kst+6,kst+5   $L,kst+8,kst+7   $L,kst+4,kst+2   $L,kst+1,kst+3   !lines 1-4
L,kst+9,kst+10   $L,kst+12,kst+11  $L,kst+13,kst+14  $L,kst+15,kst+16 !lines 5-8
L,kst+17,kst+19  $L,kst+23,kst+21  $L,kst+25,kst+27  $L,kst+29,kst+31 !lines 9-12
L,kst+18,kst+20  $L,kst+24,kst+22  $L,kst+26,kst+28  $L,kst+30,kst+32 !lines 13-16
L,kst+39,kst+40  $L,kst+37,kst+33  $L,kst+33,kst+39  $L,kst+40,kst+37 !lines 17-20
L,kst+40,kst+41  $L,kst+41,kst+42  $L,kst+42,kst+43  $L,kst+43,kst+44 !lines 21-24
L,kst+37,kst+18  $L,kst+20,kst+38  $L,kst+38,kst+34  $L,kst+38,kst+43 !lines 25-28
L,kst+44,kst+34  $L,kst+34,kst+24  $L,kst+22,kst+36  $L,kst+36,kst+45 !lines 29-32
L,kst+45,kst+26  $L,kst+28,kst+46                    !lines 33-34
L,kst+46,kst+35  $L,kst+35,kst+30  $L,kst+3,kst+16  $L,kst+16,kst+31,rdiv  !lines 35-38
L,kst+31,kst+32,rdiv $L,kst+6,kst+9 $L,kst+9,kst+17,rdiv $L,kst+17,kst+18,rdiv !lines 39-42 thru
thickness wrap
L,kst+18,kst+41 $L,kst+5,kst+10 $L,kst+10,kst+19,rdiv $L,kst+19,kst+20,rdiv !lines 43-46
L,kst+20,kst+42  $L,kst+8,kst+12 $L,kst+12,kst+23,rdiv  $L,kst+23,kst+24,rdiv !lines 47-50
L,kst+7,kst+11  $L,kst+11,kst+21,rdiv $L,kst+21,kst+22,rdiv $L,kst+4,kst+13  !lines 51-54
L,kst+13,kst+25,rdiv $L,kst+25,kst+26,rdiv $L,kst+2,kst+14 $L,kst+14,kst+27,rdiv  !lines 55-58
L,kst+27,kst+28,rdiv $L,kst+1,kst+15 $L,kst+15,kst+29,rdiv $L,kst+29,kst+30,rdiv !lines 59-62
/com
/com  ARCS
LARC,kst+3,kst+6,knm,rsm   $LARC,kst+5,kst+8,knm,rsm   !lines 63-64
LARC,kst+7,kst+4,knm,rsm   $LARC,kst+2,kst+1,knm,rsm   !lines 65-66
LARC,kst+16,kst+9,knm,rou,8  $LARC,kst+10,kst+12,knm,rou,8 !lines 67-68 arc length at
corner
LARC,kst+11,kst+13,knm,rou,8 $LARC,kst+14,kst+15,knm,rou,8 !lines 69-70 for wrap lines 67-
78
LARC,kst+31,kst+17,knm,r1,8  $LARC,kst+19,kst+23,knm,r1,8  !lines 71-72
LARC,kst+21,kst+25,knm,r1,8  $LARC,kst+27,kst+29,knm,r1,8  !lines 73-74
LARC,kst+32,kst+18,knm,r2,8  $LARC,kst+20,kst+24,knm,r2,8  !lines 75-76
LARC,kst+22,kst+26,knm,r2,8  $LARC,kst+28,kst+30,knm,r2,8  !lines 77-78
L,kst+32,kst+33                    !line 79
/com
/com
/com  start areas
/com  Begin with outside wrap areas
/com   mesh outer wrap  AREAS 1-8
AL,lst+76,lst+50,lst+72,lst+46  $AL,lst+14,lst+53,lst+10,lst+50
AL,lst+77,lst+56,lst+73,lst+53
AL,lst+15,lst+59,lst+11,lst+56  $AL,lst+78,lst+62,lst+74,lst+59
AL,lst+16,lst+39,lst+12,lst+62
AL,lst+75,lst+42,lst+71,lst+39  $AL,lst+13,lst+46,lst+9,lst+42
/com
/com   second (inner)wrap layer  AREAS 9-16
AL,lst+72,lst+49,lst+68,lst+45  $AL,lst+10,lst+52,lst+6,lst+49
AL,lst+73,lst+55,lst+69,lst+52
AL,lst+11,lst+58,lst+7,lst+55  $AL,lst+74,lst+61,lst+70,lst+58
AL,lst+12,lst+38,lst+8,lst+61
AL,lst+71,lst+41,lst+67,lst+38  $AL,lst+9,lst+45,lst+5,lst+41
/com
/com   more areas  conduit regions  AREAS 17-24
AL,lst+2,lst+48,lst+6,lst+51   $AL,lst+65,lst+51,lst+69,lst+54
AL,lst+3,lst+54,lst+7,lst+57
AL,lst+66,lst+57,lst+70,lst+60  $AL,lst+4,lst+60,lst+8,lst+37
AL,lst+63,lst+37,lst+67,lst+40
AL,lst+1,lst+40,lst+5,lst+44   $AL,lst+64,lst+44,lst+68,lst+48
/com
/com   start roving areas  AREAS 25-28
AL,lst+77,lst+31,lst+32,lst+33  $AL,lst+78,lst+34,lst+35,lst+36
AL,lst+75,lst+79,lst+18,lst+25  $AL,lst+76,lst+26,lst+27,lst+30
/com
/com   bottom right corner area   AREA 29
AL,lst+18,lst+19,lst+17,lst+20
/com
/com   G11 spacers  (3 total)  AREA 30-32
AL,lst+25,lst+20,lst+21,lst+43  $AL,lst+13,lst+43,lst+22,lst+47
AL,lst+26,lst+47,lst+23,lst+28
/com
/com   top right corner area   AREA 33
AL,lst+27,lst+28,lst+24,lst+29
/com
/com   set area attributes and mesh
eshape,3
asel,s,,,ast+1  $mat,3  $type,1 $esys,icsl+4  $amesh,all
asel,s,,,ast+3  $mat,3  $type,1 $esys,icsl+3  $amesh,all
asel,s,,,ast+5  $mat,3  $type,1 $esys,icsl+1  $amesh,all
asel,s,,,ast+7  $mat,3  $type,1 $esys,icsl+2  $amesh,all
ASEL,s,,,ast+2,ast+6,4  $mat,3  $type,1 $esys,11 $amesh,all  !material 3 , elem type 2 (esys with
i-j side)
ASEL,s,,,ast+4,ast+8,4  $mat,3  $type,1 $esys,12 $amesh,all  !material 3 , elem type 2 (esys with
i-j side)
/com
asel,s,,,ast+9   $mat,2  $type,1 $esys,icsl+4 $amesh,all
asel,s,,,ast+11  $mat,2  $type,1 $esys,icsl+3 $amesh,all
asel,s,,,ast+13  $mat,2  $type,1 $esys,icsl+1 $amesh,all
asel,s,,,ast+15  $mat,2  $type,1 $esys,icsl+2 $amesh,all
ASEL,s,,,ast+10,ast+14,4  $mat,2  $type,1 $esys,11 $amesh,all  !material 3 , elem type 2 (esys
with i-j side)
ASEL,s,,,ast+12,ast+16,4  $mat,2  $type,1 $esys,12 $amesh,all  !material 3 , elem type 2 (esys
with i-j side)
/com
ASEL,s,,,ast+17,ast+24  $mat,1  $type,1 $esys,12 $amesh,all  ! material 1 , type 1
ASEL,S,,,ast+25,ast+28  $mat,4  $type,1 $esys,12 $amesh,all   !roving areas
ASEL,S,,,ast+31   $mat,5  $type,1 $esys,12  $amesh,all   !G11 spacer mat 5, type 2
ASEL,S,,,ast+30,ast+32,2 $mat,6 $type,1 $esys,12 $amesh,all   !G11 spacer mat 6, type 1
ASEL,S,,,ast+29,ast+33,4 $mat,7 $type,1 $esys,11 $amesh,all   !corner areas epoxy, mat 7, type
2
asel,all
icsl=icsl+4
/com
/com   translate in radial and vertical direction
*get,ast,area,,num,max   !max area number
z1=pz3-pdz3/2
nrow=10
ncol=6
*do,ROW,1,nrow
*do,COL,1,ncol
*get,ast,area,,num,max
X=innerrad+csize*(COL-1)+pitch(ROW)
Y=z1+csize*(ROW-1)
agen,2,1,33,,X,Y
local,icsl+1,1,X+rsm,Y+rsm
local,icsl+2,1,X+rsm+fl,Y+rsm
local,icsl+3,1,X+rsm,Y+rsm+fl
local,icsl+4,1,X+rsm+fl,Y+rsm+fl
asel,s,,,ast+5 $asel,a,,,ast+13  $esrea  $emodif,all,esys,icsl+1
asel,s,,,ast+7 $asel,a,,,ast+15  $esrea  $emodif,all,esys,icsl+2
asel,s,,,ast+11 $asel,a,,,ast+3   $esrea  $emodif,all,esys,icsl+3
asel,s,,,ast+1  $asel,a,,,ast+9   $esrea  $emodif,all,esys,icsl+4
asel,all
esel,all
icsl=icsl+4
csys,0
*enddo
*enddo
del=.02*.0254
aclear,1,33,1  $adele,1,33,1,1   *delete original areas
/com
/com   Fill in gaps
lgen,2,140,141,,-pitch(1)-del,0  $lcomb,1,2,0
lgen,2,136,137,,-pitch(1)-del,0  $lcomb,2,3,0
lgen,2,90,,,-pitch(1)-del,0
lgen,2,140,141,,-pitch(1)+(ncol+1)*csize+del,0  $lcomb,4,5,0
```

```
lgen,2,136,137,,-pitch(1)+(ncol+1)*csize+del,0 $lcomb,5,6,0
lgen,2,90,,-pitch(1)+(ncol+1)*csize+del,0
lsla,u
lgen,nrow,all,,,csize $l,5,13
lgen,nrow-1,61,,,csize $l,11,19
lgen,nrow-1,70,,,csize
ldele,1,,,1 $ldele,4,,,1 $ldele,56,,,1 $ldele,59,,,1
asel,s,,,59 $asel,a,,,1840 $asel,a,,,225 $asel,a,,,227,228
asel,a,,,2008 $asel,a,,,2012,2013
aclear,all
adele,all,,,1
lsel,all
lgen,2,4741,,,csize-pitch(nrow)+del+tg11
lgen,2,494,,,csize-pitch(1)+del+tg11
lgen,2,4353,,,-pitch(nrow)-del
lgen,2,93,,,-pitch(1)-del
lsel,all
nummrg,node,,0254*1e-4 $nummrg,kpoi,,0254*1e-4
L,58,315 $L,5,81 $L,13,358 $L,16,357 $L,25,634 $L,28,633 $L,37,910
L,40,909 $L,2810,1186 $L,2813,1185 $L,1462,2822
L,1461,2825 $L,1738,2834 $L,1737,2837 $L,2014,2846
L,2013,2849 $L,2290,2858 $ L,2289,2861 $L,2566,2870 $ L,2536,82
al,59,3,2,139,137,136,90,93,79
al,7,9,8,141,611,610,564,615,614,140
al,13,15,14,215,1085,1084,1038,1089,1088,169
AL,19,21,20,219,1559,1558,1512,1563,1562,216
AL,25,27,26,248,2033,2032,1986,2037,2036,220
AL,31,33,32,295,2507,2506,2460,2511,2510,294
AL,37,39,38,299,2981,2980,2934,2985,2984,298
AL,43,45,44,373,3455,3454,3408,3459,3458,327
AL,49,51,50,377,3929,3928,3882,3933,3932,374
AL,55,57,56,406,4353,4356,4407,4406,378
L,290,8 $L,323,11
AL,494,546,549,551,553,453,5,6,4,452
AL,1018,1021,1023,1025,1027,457,11,12,10,456
L,594,19 $L,599,22 $L,870,31
L,875,34 $L,1146,43
AL,1018,1021,1023,1025,1027,457,11,12,10,456
AL,1492,1495,1497,1499,1501,531,17,18,16,485
L,1151,46 $L,1422,2816
AL,1966,1969,1971,1973,1975,535,23,24,22,532
L,1427,2819 $L,1698,2828
AL,2440,2443,2445,2447,2449,537,29,30,28,536
L,1703,2831
AL,2914,2917,2919,2921,2923,539,35,36,34,538
L,1974,2840 $L,1979,2843 $L,2250,2852
AL,3388,3391,3393,3395,3397,544,41,42,40,543
L,2255,2855 $L,2526,2864
AL,3862,3865,3867,3869,3871,547,47,48,46,545
L,2531,2867 $L,2802,2876
AL,4336,4339,4341,4343,4345,689,53,54,52,643
L,2763,3
AL,4810,4813,4815,4814,4741,693,1,60,58,690
aatt,8,,1,11
esize,,12*0.0254
amesh,all
asel,none
/com
/com  STITCH GAPS BETWEEN LAYERS
esize,,05*0.0254
*do,dum,0,nrow-2
lsel,s,loc,y,z1+xx+dum*csize-sml,z1+xx+tg11+dum*csize
al,all
*enddo
aatt,10,,1,11
amesh,all
/com
/com  MESH STRAIGHT SECTIONS OF GROUND WRAP
ESIZE,,20*.0254    !default elem size
asel,none
ksel,s,kp,,6,83,77 $kgen,2,all,,,-twrap
ksel,s,kp,,2,9,7 $kgen,2,all,,,twrap
ksel,s,kp,,3,82,79 $kgen,2,all,,,twrap
ksel,s,kp,,8,315,307 $kgen,2,all,,,-twrap
ksel,all
l,83,10 $l,10,4 $l,4,6 $l,9,17 $l,17,12 $l,12,2
l,82,23 $l,23,18 $l,3,18 $l,29,315 $l,24,29 $l,8,24
lsel,s,,,722 $lsel,a,,,694 $lsel,a,,,55,57,2 $lsel,a,,,49,51
lsel,a,,,43,45 $lsel,a,,,37,39 $lsel,a,,,31,33 $lsel,a,,,25,27
lsel,a,,,19,21 $lsel,a,,,13,15 $lsel,a,,,7,9 $lsel,a,,,2,3
lsel,a,,,61,69 $lsel,a,,,768
al,all
lsel,s,,,5,6 $lsel,a,,,70,78 $lsel,a,,,10,12 $lsel,a,,,16,18
lsel,a,,,22,24 $lsel,a,,,28,30 $lsel,a,,,34,36 $lsel,a,,,40,42
lsel,a,,,46,48 $lsel,a,,,52,54 $lsel,a,,,58,60,2
lsel,a,,,772,773 $lsel,a,,,769
al,all
aatt,9,,1,12
amesh,all   *areas 30 and 31
asel,none
lsel,s,loc,y,z1+xx+(nrow-1)*csize,z1+xx+(nrow-1)*csize+twrap
/com lsel,a,,,801 $lsel,a,,,847,848
al,all
lsel,s,loc,y,z1+xx-csize+tg11-sml,z1+xx-csize+tg11+sml
lsel,a,,,851,852 $lsel,a,,,880
al,all
aatt,9,,1,11
amesh,all    *areas 32 and 33
/com
/com  MESH OUTSIDE GROUND WRAP ARC REGIONS
asel,none
lsel,all
larc,4,29,10,r3 $larc,10,23,18,r3 $larc,18,12,17,r3 $larc,17,24,29,r3
csys,17
clocal,5000,1,((pitch(1)-1)*csize)
csys,235
clocal,5001,1,((pitch(nrow)-1)*csize)
csys,38
clocal,5002,1,pitch(1)*csize
csys,256
clocal,5003,1,pitch(nrow)*csize
csys,0
al,926,59,768,851
aatt,9,,1,5000
amesh,all
asel,none
al,694,56,801,927
aatt,9,,1,5001
amesh,all
asel,none
al,4,769,880,931
aatt,9,,1,5002
amesh,all
asel,none
al,848,1,773,930
aatt,9,,1,5003
amesh,all
esel,all $asel,all $lsel,all
/com
/com  Mesh current region
asel,none
lsel,all
ksel,all
*do,ROW,1,nrow
*do,COL,1,ncol
iof=((row-1)*ncol+col-1)*79
al,127+iof,129+iof,131+iof,133+iof,135+iof,120+iof,123+iof,125+iof
*enddo
*enddo
mat,13
amesh,all
/com
/com
/com  BEGIN REGION EXTERNAL TO PF3
/com
/com  BEGIN PF MESH
/com  CS MESH
csys,0
asel,none
! recall variable ang is meshed angular span for pf coils
/com  pf1
r1=pr1-pdr1/2   $r2=pr1+pdr1/2
z1=pz1-pdz1/2   $z2=pz1+pdz1/2
*get,kmx,kp,,num,max
k,kmx+1,r1,z1  $k,kmx+2,r2,z1   $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
k,kmx+5,r2,0  $k,kmx+6,r1,0
kll=kmx+6
klr=kmx+5
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4 $l,kmx+4,kmx+1  !radial
a,kmx+1,kmx+2,kmx+3,kmx+4
type,1
esize,pdr1/6 $mat,11   $amesh,all  !cs coil pf1
asel,none $a,kmx+6,kmx+5,kmx+2,kmx+1
esize,pdr1/6 $mat,20   $amesh,all  !free space
/com  pf2
*get,kmx,kp,,num,max
r1=pr2-pdr2/2   $r2=pr2+pdr2/2
z1=pz2-pdz2/2   $z2=pz2+pdz2/2
k,kmx+1,r1,z1  $k,kmx+2,r2,z1   $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4 $l,kmx+4,kmx+1
asel,none $a,kmx+1,kmx+2,kmx+3,kmx+4    ! pf2
esize,pdr1/6 $mat,12   $amesh,all  !cs coil pf2
asel,none $a,kmx-2,kmx-3,kmx+2,kmx+1
esize,pdr1/6 $mat,20   $amesh,all  !free space
/com  pf3
*get,kmx,kp,,num,max
/com r1=pr3-pdr3/2   $r2=pr3+pdr3/2
/com z1=pz3-pdz3/2   $z2=pz3+pdz3/2
/com k,kmx+1,r1,z1  $k,kmx+2,r2,z1   $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
/com l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4 $l,kmx+4,kmx+1
```

```
/com a,kmx+1,kmx+2,kmx+3,kmx+4
/com esize,pdr1/6 $mat,13 $amesh,5 !cs coil pf3
l,24,kmx-1,3,2 $l,29,kmx,3,2
asel,none $a,kmx,kmx-1,24,29
esize,pdr1/6 $mat,20 $amesh,all !free space
/com pf4
*get,kmx,kp,,num,max
r1=pr4-pdr4/2 $r2=pr4+pdr4/2
z1=pz4-pdz4/2 $z2=pz4+pdz4/2
kul=kmx+4
kur=kmx+3
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4 $l,kmx+4,kmx+1
asel,none $a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr1/6 $mat,14 $amesh,all !cs coil pf4
l,18,kmx+2,3,2 $l,23,kmx+1,3,2
asel,none $a,23,18,kmx+2,kmx+1
esize,pdr1/6 $mat,20 $amesh,all !cs coils
/com
/com PF5
*get,kmx,kp,,num,max
r1=pr5-pdr5/2 $r2=pr5+pdr5/2
z1=pz5-pdz5/2 $z2=pz5+pdz5/2
k5ll=kmx+1
k5lr=kmx+2
k5ur=kmx+3
k5ul=kmx+4
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4 $l,kmx+4,kmx+1
asel,none $a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr5/4 $mat,15 $amesh,all !pf 5
/com
/com Volume pf6
*get,kmx,kp,,num,max
r1=pr6-pdr6/2 $r2=pr6+pdr6/2
z1=pz6-pdz6/2 $z2=pz6+pdz6/2
k6ll=kmx+1
k6lr=kmx+2
k6ur=kmx+3
k6ul=kmx+4
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4 $l,kmx+4,kmx+1
asel,none $a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr6/4 $mat,16 $amesh,all !pf6
/com
/com pf7
*get,kmx,kp,,num,max
r1=pr7-pdr7/2 $r2=pr7+pdr7/2
z1=pz7-pdz7/2 $z2=pz7+pdz7/2
k7ll=kmx+1
k7lr=kmx+2
k7ur=kmx+3
k7ul=kmx+4
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4 $l,kmx+4,kmx+1
asel,none $a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr7/4 $mat,17 $amesh,all !pf7
/com
/com
/com
/com
/com
/com INCLUDE PLASMA
/com Mesh Plasma
*get,apl,area,,num,max
*get,kmx,kp,,num,max
r1=pr9-pdr9/2 $r2=pr9+pdr9/2
z1=0 $z2=pz9+pdz9/2
kpll=kmx+1
kplr=kmx+2
kpur=kmx+3
kpul=kmx+4
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2 $k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4 $l,kmx+4,kmx+1
asel,none $a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr9/5 $type,1 $mat,19
amesh,all
/com
/com FREE SPACE REGION INSIDE CS
*get,kmx,kp,,num,max
z1=pz1-pdz1/2 $z2=pz4+pdz4/2
k,kmx+1,0,0
k,kmx+2,0,z2
lsel,none
l,kmx+1,kmx+2,15
l,kll,kmx+1,12,2
l,kul,kmx+2,12,2
lsel,a,,1163 $lsel,a,,1009 $lsel,a,,1243 $lsel,a,,1196
lsel,a,,1247 $lsel,a,,926 $lsel,a,,722 $lsel,a,,927
lsel,a,,1354 $lsel,a,,1325
asel,none
al,all
/com *get,apl,area,,num,max
mat,20 $amesh,all
lall
/com AREA ABOVE CS
z1=pz5+pdz5/2
*get,kmx,kp,,num,max
kmdz=kmx+1
k,kmx+1,0,z1
l,kur,k5ll,10
l,k5ul,kmx+1,15,2
l,kmx,kmx+1,9
al,1721,1322,1749,1405,1795,1796
*get,apl,area,,num,max
mat,20 $amesh,apl
/com AREA BETWEEN CS AND PLASMA
lsel,none
asel,none
l,kur,kpul,18,2
l,klr,kpll,14,2
lsel,a,,1117 $lsel,a,,1800 $lsel,a,,1716
lsel,a,,1799 $lsel,a,,1321 $lsel,a,,1326 $lsel,a,,930
lsel,a,,772 $lsel,a,,931 $lsel,a,,1246
lsel,a,,1167 $lsel,a,,1242 $lsel,a,,1005
al,all
/com *get,apl,area,,num,max
mat,20 $amesh,all
/com AREA ABOVE PLASMA
lsel,all
asel,none
l,k5ur,k6ul,25,-2
l,kpur,k6ll,15,-2
al,1874,1483,1828,1401,1400,1749,1799,1670
mat,20 $amesh,all
/com AREA BETWEEN PLASMA AND PF6/7
r1=pr7+pdr7/2
asel,none
*get,kmx,kp,,num,max
kmdr=kmx+1
k,kmdr,r1,0
l,kplr,kmdr,12
l,kmdr,k7lr,12,.5
l,k6lr,k7ul,12,-2
al,1874,1642,1875,1878,1484,1638,1879,1433
mat,20 $amesh,all
/com AREA OUTSIDE PF6 AND PF7
r1=2*pr6+pdr6 $z1=2*pz6+pdz6
asel,none
*get,kmx,kp,,num,max
k,kmx+1,r1,z1
k,kmx+2,r1,0
k,kmx+3,0,z1
l,k6ur,kmx+1,20,3
l,kmx+1,kmx+2,10
l,kmdr,kmx+2,10,3
al,1954,1953,1907,1479,1879,1637,1591,1878
mat,20 $amesh,all
l,kmdz,kmx+3,10,2
l,kmx+1,kmx+3,20
asel,none
al,1795,1404,1828,1480,1907,1958,1957
mat,20 $amesh,all
/com INFINITY REGION
r1=50*r1 $z1=50*z1
*get,kmx,kp,,num,max
k,kmx+1,r1,z1
k,kmx+2,r1,0
k,kmx+3,0,z1
l,kmx-1,kmx+2,20,50
l,kmx,kmx+3,20,50
l,kmx-2,kmx+1,25,50
l,kmx+1,kmx+2,6
l,kmx+1,kmx+3,8
asel,none
al,2065,2115,2112,1953
al,2112,2116,2111,1958
mat,20 $amesh,all
/com
/com CURRENT LOADINGS
j1=ni1/(pdr1*pdz1)
j2=ni2/(pdr2*pdz2)
j3=ni3/0.01795
j4=ni4/(pdr4*pdz4)
j5=ni5/(pdr5*pdz5)
j6=ni6/(pdr6*pdz6)
j7=ni7/(pdr7*pdz7)
j9=ni9/(pdr9*pdz9)
esel,s,mat,,11 $bfe,all,js,3,j1
esel,s,mat,,12 $bfe,all,js,3,j2
```

```
esel,s,mat,,13  $bfe,all,js,3,j3
esel,s,mat,,14  $bfe,all,js,3,j4
esel,s,mat,,15  $bfe,all,js,3,j5
esel,s,mat,,16  $bfe,all,js,3,j6
esel,s,mat,,17  $bfe,all,js,3,j7
esel,s,mat,,19  $bfe,all,js,3,j9
/com
/com  Define surface for Maxwell stress evaluation
esel,s,mat,,13
easel,mat,1
nelem
nsel,r,ext
einv        !get elements external to coodiut
sf,all,mxwf,0.
/com
/com  boundary conditions (fix mag. vector potential to zero)
lsel,s,,2111  $lsel,a,,1957 $lsel,a,,1796 $lsel,a,,1717
nline,1
d,all,az,0.0
nall
eall
fini
/solution
nsubst,5
kbc,0
neqit,1
lswrite
nsubst,1
kbc,1
neqit,20
cnvtol,csg,,1e-6
lswrite
lssolve,1,2
```

Appendix I - ANSYS Axisymmetric command file: refined PF3U, fault case

The following are ANSYS commands used to establish an axisymmetric electromagnetic model of the TPX PF coils using a refined mesh for coil pack PF3U. This model includes both upper and lower coils, the vacuum vessel, cryostat, inner and outer passive structure, internal control coils and the tf interconnect ring coil. The PF3U coil pack shares the same elements as a detailed structural model.

```
//com 2-D axisymmetric model of TPX PF coils
/com et,1,plane53,,,1
/com compress numbering sequence
numcmp,line
numcmp,area
/com clear memory
ast= $cn= $col= $csize= $cw= $del= $dr10= $dz10=
$fl= $icon=
ics1= $innerrad= $iof= $itf= $ix= $knm= $kst= $kdiv=
lst= $ncol= $nl1= $ni2= $ni3= $ni4= $ni5= $ni6=
$ni7=
ni8= $ni9= $nrow= $ntm= $nxt= $pdr1= $pdr2=
$pdr3=
pdr4= $pdr5= $pdr6= $pdr7= $pdr8= $pdr9= $pdz1=
$pdz2=
pdz3= $pdz4= $pdz5= $pdz6= $pdz7= $pdz8= $pdz9=
pz1= $pz2= $pz3= $pz4= $pz5= $pz6= $pz7= $pz8=
$pz9=
pr1= $pr2= $pr3= $pr4= $pr5= $pr6= $pr7= $pr8=
$pr9=
r1= $r10= $r2= $r3= $rdiv= $ric= $rou= $row= $rsm=
$sm1=
sp= $tc= $tg11= $tins1= $tins2= $twrap= $x= $xx=
y= $z1= $z10= $pitch=
emunit,mks
/com define permeabilities
/com mp,murx,11,1.0 * PF1 coil
/com mp,murx,12,1.0 * PF2 coil
/com mp,murx,13,1.0 * PF3 coil Conductor region
/com mp,murx,14,1.0 * PF4 coil
/com mp,murx,15,1.0 *pf5
/com mp,murx,16,1.0 *pf6
/com mp,murx,17,1.0 *pf7
/com mp,murx,18,1.0 *IC coil, TF Interconnect
/com mp,murx,19,1.0 *Plasma
/com mp,murx,20,1.0 * tf coil/ free space in 2D
model
mp,murx,21,1.0 *eddy paths
mp,murx,23,1.0 *PF3L (must be different than PF3U)
/com
/com
/com DEFINE PF CURRENT SOURCE
GEOMETRY
pr1=.81 $pz1=.251 $pdr1=.144 $pdz1=.478
pr2=.81 $pz2=.7065 $pdr2=.144 $pdz2=.383
pr3=.81 $pz3=1.0415 $pdr3=.144 $pdz3=.239
pr4=.81 $pz4=1.3055 $pdr4=.144 $pdz4=.239
pr5=1.213 $pz5=2.35 $pdr5=.192 $pdz5=.382
pr6=3.7585 $pz6=2.144 $pdr6=.143 $pdz6=.478
pr7=4.297 $pz7=1.1135 $pdr7=.144 $pdz7=.335
/com IC COIL GEOMETRY AND CURRENTS
pr8=2.9405 $pz8=0.6845 $pdr8=.045 $pdz8=.045
/com PLASMA GEOMETRY AND CURRENTS
pr9=2.25 $pz9=0.0 $pdr9=1.0 $pdz9=1.0
pdr9=0.7*pdr9 !reduce plasma size by 70% to avoid
interference
/com TF INTERCONNECT COIL
r10=3.3480 $z10=2.5910 $dr10=.0254 $dz10=.0254
/com
/com
/com TF CURRENT SOURCE GEOMETRY
/com tdr1=.2138 $tdz1=.3037 $tr1=2.29108
$tz1=1.16586
/com tdr2=.2138 $tdz2=.3037 $tr2=2.29108
$tz2=0.67564
/com tdr3=.2138 $tdz3=.3037 $tr3=-1.9223 $tz3=0.0
/com tdr4=.2138 $tdz4=.3037 $tz4=0.0
/com tsa1=90.0 $tea1=180.0 $tin1=1.05156
/com tsa2=9.11 $tea2=90.0 $tin2=1.5418
/com tsa3=-9.11 $tea3=9.11 $tin3=5.809
/com tlen=2.3317 $thl=tlen/2
/com trm1=tin1+tdr1/2
/com tr4=tr1-trm1
/com trm2=tin2+tdr2/2
/com trm3=tin3+tdr3/2
/com ang=22.5 !meshed angular span of pf coils
/com acc=.00005 !Biot-savart integration accuracy
/com
ksel,none $lsel,none $asel,none $esel,none
$nsel,none
/com
/com BEGIN PF MESH
/com CS MESH
csys,0
koff=10000 *keypoint offset
/com pf1
r1=pr1-pdr1/2 $r2=pr1+pdr1/2
z1=pz1-pdz1/2 $z2=pz1+pdz1/2
kmx=koff
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
k,kmx+5,r2,0 $k,kmx+6,r1,0
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1 !radial
a,kmx+1,kmx+2,kmx+3,kmx+4
type,1
esize,pdr1/4 $mat,11 $*get,apf1,area,,num,max
$amesh,apf1 !cs coil pf1
a,kmx+6,kmx+5,kmx+2,kmx+1
esize,pdr1/4 $mat,20 $*get,acur,area,,num,max
$amesh,acur !free space
/com pf2
kmx=kmx+6
r1=pr2-pdr2/2 $r2=pr2+pdr2/2
z1=pz2-pdz2/2 $z2=pz2+pdz2/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4 ! pf2
esize,pdr1/4 $mat,12 $*get,apf2,area,,num,max
$amesh,apf2 !cs coil pf2
a,kmx-2,kmx-3,kmx+2,kmx+1
esize,pdr1/4 $mat,20 $*get,acur,area,,num,max
$amesh,acur !free space
/com pf3
kmx=kmx+4
r1=pr3-pdr3/2 $r2=pr3+pdr3/2
z1=pz3-pdz3/2 $z2=pz3+pdz3/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr1/4 $mat,23 $*get,apf3,area,,num,max
$amesh,apf3 !cs coil pf3
a,kmx,kmx-1,kmx+2,kmx+1
esize,pdr1/4 $mat,20 $*get,acur,area,,num,max
$amesh,acur !free space
/com pf4
kmx=kmx+4
r1=pr4-pdr4/2 $r2=pr4+pdr4/2
z1=pz4-pdz4/2 $z2=pz4+pdz4/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr1/4 $mat,14 $*get,apf4,area,,num,max
$amesh,apf4 !cs coil pf4
a,kmx,kmx-1,kmx+2,kmx+1
esize,pdr1/4 $mat,20 $*get,acur,area,,num,max
$amesh,acur !cs coils
/com
/com PF5
kmx=kmx+4
r1=pr5-pdr5/2 $r2=pr5+pdr5/2
z1=pz5-pdz5/2 $z2=pz5+pdz5/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr5/4 $mat,15 $*get,apf5,area,,num,max
$amesh,apf5 !pf5
/com
/com Volume pf6
kmx=kmx+4
r1=pr6-pdr6/2 $r2=pr6+pdr6/2
z1=pz6-pdz6/2 $z2=pz6+pdz6/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr6/4 $mat,16 $*get,apf6,area,,num,max
$amesh,apf6 !pf6
/com
/com pf7
kmx=kmx+4
r1=pr7-pdr7/2 $r2=pr7+pdr7/2
z1=pz7-pdz7/2 $z2=pz7+pdz7/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr7/4 $mat,17 $*get,apf7,area,,num,max
$amesh,apf7 !pf7
/com
/pnum,node,0
/com
/com
/com
/com pf8 IC coil
*get,aic,area,,num,max
kmx=kmx+4
r1=pr8-pdr8/2 $r2=pr8+pdr8/2
z1=pz8-pdz8/2 $z2=pz8+pdz8/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr8 $mat,18 $amesh,aic+1 !IC coil
/com
/com
/com INCLUDE PLASMA
/com Mesh Plasma
*get,apl,area,,num,max
kmx=kmx+4
r1=pr9-pdr9/2 $r2=pr9+pdr9/2
z1=0 $z2=pz9+pdz9/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr9/6 $type,1 $mat,19
amesh,apl+1
/com
/com
/com TF LEAD
*get,atf,area,,num,max
kmx=kmx+4
r1=r10-dr10/2 $r2=r10+dr10/2
z1=z10-dz10/2 $z2=z10+dz10/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
```

```
esize,pdr10 $type,1 $mat,18
zmesh,atf+1
/com
/com
/com
/com  VACUUM VESSEL, UPPER HALF
kmx=kmx+4
r1= $z1=        !clear memory locations
*get,avv,area_num,max
ra27=1.3560 $za27=0.0000 $rb27=1.3690
$zb27=0.0000
rc27=1.3690 $zc27=0.2800 $rd27=1.3560
$zd27=0.2800
ra28=1.3560 $za28=0.2800 $rb28=1.3690
$zb28=0.2800
rc28=1.3690 $zc28=0.5600 $rd28=1.3560
$zd28=0.5600
ra29=1.3560 $za29=0.5600 $rb29=1.3690
$zb29=0.5600
rc29=1.3690 $zc29=0.8400 $rd29=1.3560
$zd29=0.8400
ra30=1.3560 $za30=0.8400 $rb30=1.3690
$zb30=0.8400
rc30=1.3690 $zc30=1.1200 $rd30=1.3560
$zd30=1.1200
ra31=1.3560 $za31=1.1200 $rb31=1.3690
$zb31=1.1200
rc31=1.4010 $zc31=1.3630 $rd31=1.3890
$zd31=1.3670
ra32=1.3890 $za32=1.3670 $rb32=1.4010
$zb32=1.3630
rc32=1.4950 $zc32=1.5900 $rd32=1.4840
$zd32=1.5960
ra33=1.4840 $za33=1.5960 $rb33=1.4950
$zb33=1.5900
rc33=1.6440 $zc33=1.7850 $rd33=1.6350
$zd33=1.7940
ra34=1.6350 $za34=1.7940 $rb34=1.6440
$zb34=1.7850
rc34=1.8390 $zc34=1.9340 $rd34=1.8330
$zd34=1.9450
ra35=1.8330 $za35=1.9450 $rb35=1.8390
$zb35=1.9340
rc35=2.0660 $zc35=2.0280 $rd35=2.0620
$zd35=2.0400
ra36=2.0620 $za36=2.0400 $rb36=2.0660
$zb36=2.0280
rc36=2.3090 $zc36=2.0600 $rd36=2.3090
$zd36=2.0730
ra37=2.3090 $za37=2.0730 $rb37=2.3090
$zb37=2.0600
rc37=2.5670 $zc37=2.0310 $rd37=2.5700
$zd37=2.0430
ra38=2.5700 $za38=2.0430 $rb38=2.5670
$zb38=2.0310
rc38=2.8130 $zc38=1.9450 $rd38=2.8180
$zd38=1.9560
ra39=2.8180 $za39=1.9560 $rb39=2.8130
$zb39=1.9450
rc39=3.0330 $zc39=1.8070 $rd39=3.0410
$zd39=1.8170
ra40=3.0410 $za40=1.8170 $rb40=3.0330
$zb40=1.8070
rc40=3.2160 $zc40=1.6230 $rd40=3.2260
$zd40=1.6310
ra41=3.2260 $za41=1.6310 $rb41=3.2160
$zb41=1.6230
rc41=3.3550 $zc41=1.4030 $rd41=3.3660
$zd41=1.4080
ra42=3.3660 $za42=1.4080 $rb42=3.3550
$zb42=1.4030
rc42=3.4410 $zc42=1.1570 $rd42=3.4530
$zd42=1.1600
ra43=3.4530 $za43=1.1600 $rb43=3.4410
$zb43=1.1570
rc43=3.4700 $zc43=0.8990 $rd43=3.4820
$zd43=0.8990
ra44=1.5090 $za44=0.0000 $rb44=1.5210
$zb44=0.0000
rc44=1.5210 $zc44=0.2960 $rd44=1.5090
$zd44=0.2960
ra45=1.5090 $za45=0.2960 $rb45=1.5210
$zb45=0.2960
rc45=1.5210 $zc45=0.5930 $rd45=1.5090
$zd45=0.5930
ra46=1.5090 $za46=0.5930 $rb46=1.5210
$zb46=0.5930
rc46=1.5210 $zc46=0.8890 $rd46=1.5090
$zd46=0.8890
ra47=1.5090 $za47=0.8890 $rb47=1.5210
$zb47=0.8890
rc47=1.5210 $zc47=1.1860 $rd47=1.5090
$zd47=1.1860
ra48=1.5090 $za48=1.1860 $rb48=1.5210
$zb48=1.1860
rc48=1.5460 $zc48=1.3640 $rd48=1.5340
$zd48=1.3680
ra49=1.5340 $za49=1.3680 $rb49=1.5460
$zb49=1.3640
rc49=1.6190 $zc49=1.5290 $rd49=1.6080
$zd49=1.5360
ra50=1.6080 $za50=1.5360 $rb50=1.6190
$zb50=1.5290
rc50=1.7330 $zc50=1.6680 $rd50=1.7240
$zd50=1.6770
ra51=1.7240 $za51=1.6770 $rb51=1.7330
$zb51=1.6680
rc51=1.8810 $zc51=1.7710 $rd51=1.8750
$zd51=1.7820
ra52=1.8750 $za52=1.7820 $rb52=1.8810
$zb52=1.7710
rc52=2.0510 $zc52=1.8290 $rd52=2.0490
$zd52=1.8420
ra53=2.0490 $za53=1.8420 $rb53=2.0510
$zb53=1.8290
rc53=2.3290 $zc53=1.8420 $rd53=2.3300
$zd53=1.8540
ra54=2.3300 $za54=1.8540 $rb54=2.3290
$zb54=1.8420
rc54=2.5970 $zc54=1.7740 $rd54=2.6020
$zd54=1.7850
ra55=2.6020 $za55=1.7850 $rb55=2.5970
$zb55=1.7740
rc55=2.8350 $zc55=1.6300 $rd55=2.8430
$zd55=1.6400
ra56=2.8430 $za56=1.6400 $rb56=2.8350
$zb56=1.6300
rc56=3.0210 $zc56=1.4250 $rd56=3.0320
$zd56=1.4320
ra57=3.0320 $za57=1.4320 $rb57=3.0210
$zb57=1.4250
rc57=3.1390 $zc57=1.1740 $rd57=3.1520
$zd57=1.1770
ra58=3.1520 $za58=1.1770 $rb58=3.1390
$zb58=1.1740
rc58=3.1800 $zc58=0.8990 $rd58=3.1930
$zd58=0.8990
ra59=3.1930 $za59=0.8990 $rb59=3.1800
$zb59=0.8990
rc59=3.1800 $zc59=0.7620 $rd59=3.1930
$zd59=0.7620
ra60=3.4820 $za60=0.8990 $rb60=3.4700
$zb60=0.8990
rc60=3.4700 $zc60=0.7620 $rd60=3.4820
$zd60=0.7620
ra61=3.1930 $za61=0.8990 $rb61=3.1930
$zb61=0.8860
rc61=3.3310 $zc61=0.8860 $rd61=3.3310
$zd61=0.8990
ra62=3.3310 $za62=0.8990 $rb62=3.3310
$zb62=0.8860
rc62=3.4700 $zc62=0.8860 $rd62=3.4700
$zd62=0.8990
ra63=3.1930 $za63=0.7750 $rb63=3.1930
$zb63=0.7620
rc63=3.3310 $zc63=0.7620 $rd63=3.3310
$zd63=0.7750
ra64=3.3310 $za64=0.7750 $rb64=3.3310
$zb64=0.7620
rc64=3.4700 $zc64=0.7620 $rd64=3.4700
$zd64=0.7750
ra65=3.4820 $za65=0.7750 $rb65=3.4820
$zb65=0.7620
rc65=3.5590 $zc65=0.7620 $rd65=3.5590
$zd65=0.7750
ra66=3.5710 $za66=0.7750 $rb66=3.5590
$zb66=0.7750
rc66=3.5590 $zc66=0.5160 $rd66=3.5710
$zd66=0.5160
ra67=3.5710 $za67=0.5160 $rb67=3.5590
$zb67=0.5160
rc67=3.5590 $zc67=0.2580 $rd67=3.5710
$zd67=0.2580
ra68=3.5710 $za68=0.2580 $rb68=3.5590
$zb68=0.2580
rc68=3.5590 $zc68=0.0000 $rd68=3.5710
$zd68=0.0000
/com
k,kmx+1,ra27,za27 $k,kmx+2,rb27,zb27
k,kmx+3,rc27,zc27 $k,kmx+4,rd27,zd27
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra28,za28 $k,kmx+2,rb28,zb28
k,kmx+3,rc28,zc28 $k,kmx+4,rd28,zd28
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra29,za29 $k,kmx+2,rb29,zb29
k,kmx+3,rc29,zc29 $k,kmx+4,rd29,zd29
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra30,za30 $k,kmx+2,rb30,zb30
k,kmx+3,rc30,zc30 $k,kmx+4,rd30,zd30
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra31,za31 $k,kmx+2,rb31,zb31
k,kmx+3,rc31,zc31 $k,kmx+4,rd31,zd31
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra32,za32 $k,kmx+2,rb32,zb32
k,kmx+3,rc32,zc32 $k,kmx+4,rd32,zd32
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra33,za33 $k,kmx+2,rb33,zb33
k,kmx+3,rc33,zc33 $k,kmx+4,rd33,zd33
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra34,za34 $k,kmx+2,rb34,zb34
k,kmx+3,rc34,zc34 $k,kmx+4,rd34,zd34
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra35,za35 $k,kmx+2,rb35,zb35
k,kmx+3,rc35,zc35 $k,kmx+4,rd35,zd35
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra36,za36 $k,kmx+2,rb36,zb36
k,kmx+3,rc36,zc36 $k,kmx+4,rd36,zd36
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra37,za37 $k,kmx+2,rb37,zb37
k,kmx+3,rc37,zc37 $k,kmx+4,rd37,zd37
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra38,za38 $k,kmx+2,rb38,zb38
k,kmx+3,rc38,zc38 $k,kmx+4,rd38,zd38
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra39,za39 $k,kmx+2,rb39,zb39
k,kmx+3,rc39,zc39 $k,kmx+4,rd39,zd39
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra40,za40 $k,kmx+2,rb40,zb40
k,kmx+3,rc40,zc40 $k,kmx+4,rd40,zd40
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra41,za41 $k,kmx+2,rb41,zb41
k,kmx+3,rc41,zc41 $k,kmx+4,rd41,zd41
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra42,za42 $k,kmx+2,rb42,zb42
```

```
k,kmx+3,rc42,zc42 $k,kmx+4,rd42,zd42
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra43,za43 $k,kmx+2,rb43,zb43
k,kmx+3,rc43,zc43 $k,kmx+4,rd43,zd43
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra44,za44 $k,kmx+2,rb44,zb44
k,kmx+3,rc44,zc44 $k,kmx+4,rd44,zd44
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra45,za45 $k,kmx+2,rb45,zb45
k,kmx+3,rc45,zc45 $k,kmx+4,rd45,zd45
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra46,za46 $k,kmx+2,rb46,zb46
k,kmx+3,rc46,zc46 $k,kmx+4,rd46,zd46
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra47,za47 $k,kmx+2,rb47,zb47
k,kmx+3,rc47,zc47 $k,kmx+4,rd47,zd47
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra48,za48 $k,kmx+2,rb48,zb48
k,kmx+3,rc48,zc48 $k,kmx+4,rd48,zd48
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra49,za49 $k,kmx+2,rb49,zb49
k,kmx+3,rc49,zc49 $k,kmx+4,rd49,zd49
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra50,za50 $k,kmx+2,rb50,zb50
k,kmx+3,rc50,zc50 $k,kmx+4,rd50,zd50
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra51,za51 $k,kmx+2,rb51,zb51
k,kmx+3,rc51,zc51 $k,kmx+4,rd51,zd51
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra52,za52 $k,kmx+2,rb52,zb52
k,kmx+3,rc52,zc52 $k,kmx+4,rd52,zd52
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra53,za53 $k,kmx+2,rb53,zb53
k,kmx+3,rc53,zc53 $k,kmx+4,rd53,zd53
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra54,za54 $k,kmx+2,rb54,zb54
k,kmx+3,rc54,zc54 $k,kmx+4,rd54,zd54
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra55,za55 $k,kmx+2,rb55,zb55
k,kmx+3,rc55,zc55 $k,kmx+4,rd55,zd55
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra56,za56 $k,kmx+2,rb56,zb56
k,kmx+3,rc56,zc56 $k,kmx+4,rd56,zd56
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra57,za57 $k,kmx+2,rb57,zb57
k,kmx+3,rc57,zc57 $k,kmx+4,rd57,zd57
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra58,za58 $k,kmx+2,rb58,zb58
k,kmx+3,rc58,zc58 $k,kmx+4,rd58,zd58
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra59,za59 $k,kmx+2,rb59,zb59
k,kmx+3,rc59,zc59 $k,kmx+4,rd59,zd59
l,kmx+1,kmx+2 $l,kmx+2,kmx+3
$*get,lc,line,,num,max
l,kmx+3,kmx+4 $l,kmx+4,kmx+1
$*get,ld,line,,num,max
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra60,za60 $k,kmx+2,rb60,zb60
k,kmx+3,rc60,zc60 $k,kmx+4,rd60,zd60
l,kmx+1,kmx+2 $l,kmx+2,kmx+3
$*get,lx,line,,num,max
l,kmx+3,kmx+4 $l,kmx+4,kmx+1
$*get,ly,line,,num,max
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra61,za61 $k,kmx+2,rb61,zb61
k,kmx+3,rc61,zc61 $k,kmx+4,rd61,zd61
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra62,za62 $k,kmx+2,rb62,zb62
k,kmx+3,rc62,zc62 $k,kmx+4,rd62,zd62
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra63,za63 $k,kmx+2,rb63,zb63
k,kmx+3,rc63,zc63 $k,kmx+4,rd63,zd63
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra64,za64 $k,kmx+2,rb64,zb64
k,kmx+3,rc64,zc64 $k,kmx+4,rd64,zd64
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra65,za65 $k,kmx+2,rb65,zb65
k,kmx+3,rc65,zc65 $k,kmx+4,rd65,zd65
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra66,za66 $k,kmx+2,rb66,zb66
k,kmx+3,rc66,zc66 $k,kmx+4,rd66,zd66
l,kmx+1,kmx+2 $l,kmx+2,kmx+3
$*get,la,line,,num,max
l,kmx+3,kmx+4 $l,kmx+4,kmx+1
$*get,lb,line,,num,max
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra67,za67 $k,kmx+2,rb67,zb67
k,kmx+3,rc67,zc67 $k,kmx+4,rd67,zd67
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra68,za68 $k,kmx+2,rb68,zb68
k,kmx+3,rc68,zc68 $k,kmx+4,rd68,zd68
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
/com
/com ****************************
/com  rework area avv+34, and avv+40
adel,avv+33 $adel,avv+34 $adel,avv+40
ldel,ld
l,kmx-19,kmx-26
ldel,lx $ldel,ly
l,kmx-21,kmx-12 $l,kmx-11,kmx-31
ldel,la $ldel,lb
l,kmx-9,kmx-5 $l,kmx-7,kmx-4
nummrg,kp,,1e-4
al,lc-3,lc,lc+1,ld+13,ld,ld+5
al,lx-67,lx+9,lx,lx+17,lx+1,lx+19,lx+2
al,la,la+1,lb,la-1,la-3
/com  lx= $ly= $lc= $ld=
/com ****************************
esize,pdr6/2  $type,1 $mat,21
amesh,avv+1  $amesh,avv+2 $amesh,avv+3
amesh,avv+4  $amesh,avv+5  $amesh,avv+6
amesh,avv+7  $amesh,avv+8  $amesh,avv+9
amesh,avv+10 $amesh,avv+11 $amesh,avv+12
amesh,avv+13 $amesh,avv+14 $amesh,avv+15
amesh,avv+16 $amesh,avv+17 $amesh,avv+18
amesh,avv+19 $amesh,avv+20 $amesh,avv+21
amesh,avv+22 $amesh,avv+23 $amesh,avv+24
amesh,avv+25 $amesh,avv+26 $amesh,avv+27
amesh,avv+28 $amesh,avv+29 $amesh,avv+30
amesh,avv+31 $amesh,avv+32 $amesh,avv+33
amesh,avv+34 $amesh,avv+35 $amesh,avv+36
amesh,avv+37 $amesh,avv+38 $amesh,avv+39
amesh,avv+40 $amesh,avv+41 $amesh,avv+42
/com delete params
ra27= $ra28= $ra29= $ra30= $ra31= $ra32= $ra33=
$ra34= $ra35=
rb27= $rb28= $rb29= $rb30= $rb31= $rb32= $rb33=
$rb34= $rb35=
rc27= $rc28= $rc29= $rc30= $rc31= $rc32= $rc33=
$rc34= $rc35=
rd27= $rd28= $rd29= $rd30= $rd31= $rd32= $rd33=
$rd34= $rd35=
za27= $za28= $za29= $za30= $za31= $za32= $za33=
$za34= $za35=
zb27= $zb28= $zb29= $zb30= $zb31= $zb32= $zb33=
$zb34= $zb35=
zc27= $zc28= $zc29= $zc30= $zc31= $zc32= $zc33=
$zc34= $zc35=
zd27= $zd28= $zd29= $zd30= $zd31= $zd32= $zd33=
$zd34= $zd35=
ra37= $ra38= $ra39= $ra40= $ra41= $ra42= $ra43=
$ra44= $ra45= $ra46=
rb37= $rb38= $rb39= $rb40= $rb41= $rb42= $rb43=
$rb44= $rb45= $rb46=
rc37= $rc38= $rc39= $rc40= $rc41= $rc42= $rc43=
$rc44= $rc45= $rc46=
rd37= $rd38= $rd39= $rd40= $rd41= $rd42= $rd43=
$rd44= $rd45= $rd46=
za37= $za38= $za39= $za40= $za41= $za42= $za43=
$za44= $za45= $za46=
zb37= $zb38= $zb39= $zb40= $zb41= $zb42= $zb43=
$zb44= $zb45= $zb46=
zc37= $zc38= $zc39= $zc40= $zc41= $zc42= $zc43=
$zc44= $zc45= $zc46=
zd37= $zd38= $zd39= $zd40= $zd41= $zd42= $zd43=
$zd44= $zd45= $zd46=
ra47= $ra48= $ra49= $ra50= $ra51= $ra52= $ra53=
$ra54= $ra55= $ra56=
rb47= $rb48= $rb49= $rb50= $rb51= $rb52= $rb53=
$rb54= $rb55= $rb56=
rc47= $rc48= $rc49= $rc50= $rc51= $rc52= $rc53=
$rc54= $rc55= $rc56=
rd47= $rd48= $rd49= $rd50= $rd51= $rd52= $rd53=
$rd54= $rd55= $rd56=
za47= $za48= $za49= $za50= $za51= $za52= $za53=
$za54= $za55= $za56=
zb47= $zb48= $zb49= $zb50= $zb51= $zb52= $zb53=
$zb54= $zb55= $zb56=
zc47= $zc48= $zc49= $zc50= $zc51= $zc52= $zc53=
$zc54= $zc55= $zc56=
zd47= $zd48= $zd49= $zd50= $zd51= $zd52= $zd53=
$zd54= $zd55= $zd56=
ra57= $ra58= $ra59= $ra60= $ra61= $ra62= $ra63=
$ra64= $ra65= $ra66=
rb57= $rb58= $rb59= $rb60= $rb61= $rb62= $rb63=
$rb64= $rb65= $rb66=
rc57= $rc58= $rc59= $rc60= $rc61= $rc62= $rc63=
$rc64= $rc65= $rc66=
rd57= $rd58= $rd59= $rd60= $rd61= $rd62= $rd63=
$rd64= $rd65= $rd66=
za57= $za58= $za59= $za60= $za61= $za62= $za63=
$za64= $za65= $za66=
zb57= $zb58= $zb59= $zb60= $zb61= $zb62= $zb63=
$zb64= $zb65= $zb66=
zc57= $zc58= $zc59= $zc60= $zc61= $zc62= $zc63=
$zc64= $zc65= $zc66=
zd57= $zd58= $zd59= $zd60= $zd61= $zd62= $zd63=
$zd64= $zd65= $zd66=
/com
/com
/com
/com  UPPER INBOARD STRUCTURE
/com  parameter table is full, so start numbering at 27
rather
/com  than 111. This way we overwrite vacuum vessel
labels
```

```
ra27=1.5940 $za27=0.1380 $rb27=1.6270
$zb27=0.1380
rc27=1.6270 $zc27=0.2450 $rd27=1.5940
$zd27=0.2450
ra28=1.5940 $za28=0.2450 $rb28=1.6270
$zb28=0.2450
rc28=1.6270 $zc28=0.3530 $rd28=1.5940
$zd28=0.3530
ra29=1.5940 $za29=0.3530 $rb29=1.6270
$zb29=0.3530
rc29=1.6270 $zc29=0.4600 $rd29=1.5940
$zd29=0.4600
ra30=1.5940 $za30=0.4600 $rb30=1.6270
$zb30=0.4600
rc30=1.6270 $zc30=0.5680 $rd30=1.5940
$zd30=0.5680
ra31=1.5940 $za31=0.5680 $rb31=1.6270
$zb31=0.5680
rc31=1.6270 $zc31=0.6760 $rd31=1.5940
$zd31=0.6760
/com
*get,ais,area,,num,max
kmx=kmx+4
k,kmx+1,ra27,za27 $k,kmx+2,rb27,zb27
k,kmx+3,rc27,zc27 $k,kmx+4,rd27,zd27
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra28,za28 $k,kmx+2,rb28,zb28
k,kmx+3,rc28,zc28 $k,kmx+4,rd28,zd28
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra29,za29 $k,kmx+2,rb29,zb29
k,kmx+3,rc29,zc29 $k,kmx+4,rd29,zd29
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra30,za30 $k,kmx+2,rb30,zb30
k,kmx+3,rc30,zc30 $k,kmx+4,rd30,zd30
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra31,za31 $k,kmx+2,rb31,zb31
k,kmx+3,rc31,zc31 $k,kmx+4,rd31,zd31
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
nummrg,kp,1e-4
esize,pdr6/2 $type,1 $mat,21
amesh,ais+1 $amesh,ais+2 $amesh,ais+3
amesh,ais+4 $amesh,ais+5
/com delete params
ra27= $ra28= $ra29= $ra30= $ra31=
rb27= $rb28= $rb29= $rb30= $rb31=
rc27= $rc28= $rc29= $rc30= $rc31=
rd27= $rd28= $rd29= $rd30= $rd31=
za27= $za28= $za29= $za30= $za31=
zb27= $zb28= $zb29= $zb30= $zb31=
zc27= $zc28= $zc29= $zc30= $zc31=
zd27= $zd28= $zd29= $zd30= $zd31=
/com
/com
/com
/com  UPPER OUBOARD STRUCTURE
/com  parameter table is full, so start numbering at 27
rather
/com  than 121.  This way we overwrite vacuum vessel
labels
ra27=2.3350 $za27=1.1560 $rb27=2.3030
$zb27=1.1560
rc27=2.3030 $zc27=1.0380 $rd27=2.3350
$zd27=1.0380
ra28=2.3350 $za28=1.0380 $rb28=2.3030
$zb28=1.0380
rc28=2.3030 $zc28=0.9200 $rd28=2.3350
$zd28=0.9200
ra29=2.3350 $za29=0.9200 $rb29=2.3030
$zb29=0.9200
rc29=2.3520 $zc29=0.8750 $rd29=2.3850
$zd29=0.8750
ra30=2.3850 $za30=0.8750 $rb30=2.3520
$zb30=0.8750
rc30=2.4020 $zc30=0.8310 $rd30=2.4350
$zd30=0.8310
ra31=2.5370 $za31=0.9190 $rb31=2.5040
$zb31=0.9190
rc31=2.5050 $zc31=0.8210 $rd31=2.5380
$zd31=0.8210
ra32=2.5380 $za32=0.8210 $rb32=2.5050
$zb32=0.8210
rc32=2.5060 $zc32=0.7220 $rd32=2.5390
$zd32=0.7220
ra33=2.5390 $za33=0.7220 $rb33=2.5060
$zb33=0.7220
rc33=2.5610 $zc33=0.6490 $rd33=2.5940
$zd33=0.6490
ra34=2.5940 $za34=0.6490 $rb34=2.5610
$zb34=0.6490
rc34=2.6160 $zc34=0.5770 $rd34=2.6490
$zd34=0.5770
ra35=2.6490 $za35=0.5770 $rb35=2.6160
$zb35=0.5770
rc35=2.6600 $zc35=0.4980 $rd35=2.6930
$zd35=0.4980
ra36=2.6930 $za36=0.4980 $rb36=2.6600
$zb36=0.4980
rc36=2.7040 $zc36=0.4190 $rd36=2.7370
$zd36=0.4190
/com
*get,aos,area,,num,max
kmx=kmx+4
k,kmx+1,ra27,za27 $k,kmx+2,rb27,zb27
k,kmx+3,rc27,zc27 $k,kmx+4,rd27,zd27
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra28,za28 $k,kmx+2,rb28,zb28
k,kmx+3,rc28,zc28 $k,kmx+4,rd28,zd28
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra29,za29 $k,kmx+2,rb29,zb29
k,kmx+3,rc29,zc29 $k,kmx+4,rd29,zd29
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra30,za30 $k,kmx+2,rb30,zb30
k,kmx+3,rc30,zc30 $k,kmx+4,rd30,zd30
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra31,za31 $k,kmx+2,rb31,zb31
k,kmx+3,rc31,zc31 $k,kmx+4,rd31,zd31
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra32,za32 $k,kmx+2,rb32,zb32
k,kmx+3,rc32,zc32 $k,kmx+4,rd32,zd32
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra33,za33 $k,kmx+2,rb33,zb33
k,kmx+3,rc33,zc33 $k,kmx+4,rd33,zd33
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra34,za34 $k,kmx+2,rb34,zb34
k,kmx+3,rc34,zc34 $k,kmx+4,rd34,zd34
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra35,za35 $k,kmx+2,rb35,zb35
k,kmx+3,rc35,zc35 $k,kmx+4,rd35,zd35
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra36,za36 $k,kmx+2,rb36,zb36
k,kmx+3,rc36,zc36 $k,kmx+4,rd36,zd36
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
nummrg,kp,1e-4
esize,pdr6/2 $type,1 $mat,21
amesh,aos+1 $amesh,aos+2 $amesh,aos+3
amesh,aos+4 $amesh,aos+5 $amesh,aos+6
amesh,aos+7 $amesh,aos+8 $amesh,aos+9
amesh,aos+10
/com delete params
ra27= $ra28= $ra29= $ra30= $ra31= $ra32= $ra33=
$ra34= $ra35= $ra36=
rb27= $rb28= $rb29= $rb30= $rb31= $rb32= $rb33=
$rb34= $rb35= $rb36=
rc27= $rc28= $rc29= $rc30= $rc31= $rc32= $rc33=
$rc34= $rc35= $rc36=
rd27= $rd28= $rd29= $rd30= $rd31= $rd32= $rd33=
$rd34= $rd35= $rd36=
za27= $za28= $za29= $za30= $za31= $za32= $za33=
$za34= $za35= $za36=
zb27= $zb28= $zb29= $zb30= $zb31= $zb32= $zb33=
$zb34= $zb35= $zb36=
zc27= $zc28= $zc29= $zc30= $zc31= $zc32= $zc33=
$zc34= $zc35= $zc36=
zd27= $zd28= $zd29= $zd30= $zd31= $zd32= $zd33=
$zd34= $zd35= $zd36=
/com
/com
/com
/com  OUTER CRYOSTAT STRUCTURE
/com  parameter table is full, so start numbering at 27
rather
/com  than 121.  This way we overwrite vacuum vessel
labels
ra27=0.0000 $za27=3.8090 $rb27=0.0000
$zb27=3.7450
rc27=0.7790 $zc27=3.7450 $rd27=0.7790
$zd27=3.8090
ra28=0.7790 $za28=3.8090 $rb28=0.7790
$zb28=3.7450
rc28=1.5580 $zc28=3.7450 $rd28=1.5580
$zd28=3.8090
ra29=1.5580 $za29=3.8090 $rb29=1.5580
$zb29=3.7450
rc29=2.3370 $zc29=3.7450 $rd29=2.3370
$zd29=3.8090
ra30=2.3370 $za30=3.8090 $rb30=2.3370
$zb30=3.7450
rc30=3.1160 $zc30=3.7450 $rd30=3.1160
$zd30=3.8090
ra31=3.1160 $za31=3.8090 $rb31=3.1160
$zb31=3.7450
rc31=3.8950 $zc31=3.7450 $rd31=3.8950
$zd31=3.8090
ra32=3.8950 $za32=3.8090 $rb32=3.8950
$zb32=3.7450
rc32=4.6740 $zc32=3.7450 $rd32=4.6740
$zd32=3.8090
ra33=4.7370 $za33=3.8090 $rb33=4.6740
$zb33=3.8090
rc33=4.6740 $zc33=3.7450 $rd33=4.7370
$zd33=3.7450
ra34=4.7370 $za34=3.7450 $rb34=4.6740
$zb34=3.7450
rc34=4.6740 $zc34=2.4840 $rd34=4.7370
$zd34=2.4840
ra35=4.7370 $za35=2.4840 $rb35=4.6740
$zb35=2.4840
rc35=4.6740 $zc35=1.8310 $rd35=4.7370
$zd35=1.8310
ra36=4.7370 $za36=1.8310 $rb36=4.6740
$zb36=1.8310
rc36=4.6740 $zc36=1.2210 $rd36=4.7370
$zd36=1.2210
ra37=4.7370 $za37=1.2210 $rb37=4.6740
$zb37=1.2210
rc37=4.6740 $zc37=0.6100 $rd37=4.7370
$zd37=0.6100
ra38=4.7370 $za38=0.6100 $rb38=4.6740
$zb38=0.6100
rc38=4.6740 $zc38=0.0000 $rd38=4.7370
$zd38=0.0000
rinf=2*ra33
zinf=2*za33
/com
*get,acr,area,,num,max
kmx=kmx+4
k,kmx+1,ra27,za27 $k,kmx+2,rb27,zb27
k,kmx+3,rc27,zc27 $k,kmx+4,rd27,zd27
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra28,za28 $k,kmx+2,rb28,zb28
k,kmx+3,rc28,zc28 $k,kmx+4,rd28,zd28
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
```

```
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra29,za29 $k,kmx+2,rb29,zb29
k,kmx+3,rc29,zc29 $k,kmx+4,rd29,zd29
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra30,za30 $k,kmx+2,rb30,zb30
k,kmx+3,rc30,zc30 $k,kmx+4,rd30,zd30
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra31,za31 $k,kmx+2,rb31,zb31
k,kmx+3,rc31,zc31 $k,kmx+4,rd31,zd31
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra32,za32 $k,kmx+2,rb32,zb32
k,kmx+3,rc32,zc32 $k,kmx+4,rd32,zd32
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra33,za33 $k,kmx+2,rb33,zb33
k,kmx+3,rc33,zc33 $k,kmx+4,rd33,zd33
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra34,za34 $k,kmx+2,rb34,zb34
k,kmx+3,rc34,zc34 $k,kmx+4,rd34,zd34
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra35,za35 $k,kmx+2,rb35,zb35
k,kmx+3,rc35,zc35 $k,kmx+4,rd35,zd35
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra36,za36 $k,kmx+2,rb36,zb36
k,kmx+3,rc36,zc36 $k,kmx+4,rd36,zd36
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra37,za37 $k,kmx+2,rb37,zb37
k,kmx+3,rc37,zc37 $k,kmx+4,rd37,zd37
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra38,za38 $k,kmx+2,rb38,zb38
k,kmx+3,rc38,zc38 $k,kmx+4,rd38,zd38
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
nummrg,kp,1e-4
esize,pdr6/2 $type,1 $mat,21
amesh,acr+1 $amesh,acr+2 $amesh,acr+3
amesh,acr+4 $amesh,acr+5 $amesh,acr+6
amesh,acr+7 $amesh,acr+8 $amesh,acr+9
amesh,acr+10 $amesh,acr+11 $amesh,acr+12
/com delete params
ra27= $ra28= $ra29= $ra30= $ra31= $ra32= $ra33=
$ra34= $ra35= $ra36=
rb27= $rb28= $rb29= $rb30= $rb31= $rb32= $rb33=
$rb34= $rb35= $rb36=
rc27= $rc28= $rc29= $rc30= $rc31= $rc32= $rc33=
$rc34= $rc35= $rc36=
rd27= $rd28= $rd29= $rd30= $rd31= $rd32= $rd33=
$rd34= $rd35= $rd36=
za27= $za28= $za29= $za30= $za31= $za32= $za33=
$za34= $za35= $za36=
zb27= $zb28= $zb29= $zb30= $zb31= $zb32= $zb33=
$zb34= $zb35= $zb36=
zc27= $zc28= $zc29= $zc30= $zc31= $zc32= $zc33=
$zc34= $zc35= $zc36=
zd27= $zd28= $zd29= $zd30= $zd31= $zd32= $zd33=
$zd34= $zd35= $zd36=
ra37= $ra38=
rb37= $rb38=
rc37= $rc38=
rd37= $rd38=
za37= $za38=
zb37= $zb38=
zc37= $zc38=
zd37= $zd38=
/com
/com
/com FREE SPACE REGIONS
/com inside of cs
kmx=kmx+4
*get,afre,area,,num,max
z1=pz1-pdz1/2  $z2=pz4+pdz4/2
k,kmx+1,0,0
k,kmx+2,0,z2
lsel,none
l,kmx+1,kmx+2,15
l,koff+6,kmx+1,12,2
l,koff+18,kmx+2,12,2
ksel,s,,koff+1 $ksel,a,,koff+4 $ksel,a,,koff+6
$ksel,a,,koff+7
ksel,a,,koff+10 $ksel,a,,koff+11 $ksel,a,,koff+14
$ksel,a,,koff+15
ksel,a,,koff+18 $ksel,a,,koff+319 $ksel,a,,koff+320
lskp,1
al,all
*get,ax,area,,num,max
mat,20 $amesh,ax $lsall $kpall
/com
/com Area above cs
z1=pz5+pdz5/2
kmx=kmx+2
k,kmx+1,0,z1
l,koff+17,koff+19,10
l,koff+22,kmx+1,15,2
l,kmx,kmx+1,9
ksel,s,,koff+17 $ksel,a,,koff+18 $ksel,a,,koff+19
$ksel,a,,koff+22
ksel,a,,koff+320 $ksel,a,,koff+321
lskp,1 $al,all
*get,ax,area,,num,max
mat,20 $amesh,ax $lsall $kpall
/com
/com  Area between cs and vacuum vessel
l,koff+5,koff+43,12,2
l,koff+16,koff+58,12,2
ksel,s,,koff+2 $ksel,a,,koff+3 $ksel,a,,koff+5
$ksel,a,,koff+8
ksel,a,,koff+9 $ksel,a,,koff+12 $ksel,a,,koff+13
$ksel,a,,koff+43
ksel,a,,koff+46 $ksel,a,,koff+50 $ksel,a,,koff+54
ksel,a,,koff+58 $ksel,a,,koff+16
lskp,1
al,all $*get,ax,area,,num,max $amesh,ax
/com
/com area just above cs between vv and cs
lsel,all $kpall
l,koff+20,koff+70,12
ksel,s,,koff+16 $ksel,a,,koff+17 $ksel,a,,koff+19
ksel,a,,koff+20 $ksel,a,,koff+58 $ksel,a,,koff+62
$ksel,a,,koff+66
ksel,a,,koff+70 $lskp,1
al,all $*get,ax,area,,num,max $amesh,ax  $lsall  $kpall
/com
/com  above vacuum vessel
l,koff+39,koff+90,14,3
l,koff+42,koff+21,30,2
ksel,s,,koff+20 $ksel,a,,koff+21 $ksel,a,,koff+39
$ksel,a,,koff+42
ksel,a,,koff+70 $ksel,a,,koff+74 $ksel,a,,koff+78
$ksel,a,,koff+82
ksel,a,,koff+86 $ksel,a,,koff+90 $lskp,1
al,all $*get,ax,area,,num,max $amesh,ax
lsel,all $kpall
/com
/com  above vv right side region to pf6
/com
l,koff+26,koff+40,12
l,koff+23,koff+98,12,2
ksel,s,,koff+23 $ksel,a,,koff+26 $ksel,a,,koff+39
$ksel,a,,koff+40
ksel,a,,koff+90 $ksel,a,,koff+94 $ksel,a,,koff+98
$lskp,1
al,all $*get,ax,area,,num,max $amesh,ax
/com
/com  area to right of vv
lsel,all $kpall
l,koff+27,koff+110,12,2
l,koff+30,koff+24,18
ksel,s,,koff+23 $ksel,a,,koff+24 $ksel,a,,koff+27
$ksel,a,,koff+30
ksel,a,,koff+98 $ksel,a,,koff+102 $ksel,a,,koff+106
ksel,a,,koff+110 $lskp,1
al,all $*get,ax,area,,num,max $amesh,ax
/com
/com  lower right of vv
lsel,all $kpall
l,koff+210,koff+317,12
l,koff+28,koff+313,9,2
ksel,s,,koff+27 $ksel,a,,koff+28 $ksel,a,,koff+110
$ksel,a,,koff+195
ksel,a,,koff+198 $ksel,a,,koff+199 $ksel,a,,koff+202
ksel,a,,koff+206 $ksel,a,,koff+210 $ksel,a,,koff+313
ksel,a,,koff+317 $lskp,1
al,all $*get,ax,area,,num,max $amesh,ax
lsel,all $kpall
/com
/com  INSIDE OF VV LOWER RIGHT
l,koff+36,koff+209,15
l,koff+37,koff+265,1
l,koff+266,koff+31,6
l,koff+33,koff+173,6
ksel,s,,koff+31 $ksel,a,,koff+32 $ksel,a,,koff+33
$ksel,a,,koff+36
ksel,a,,koff+37 $ksel,a,,koff+173 $ksel,a,,koff+174
ksel,a,,koff+177 $ksel,a,,koff+178 $ksel,a,,koff+189
ksel,a,,koff+197 $ksel,a,,koff+201 $ksel,a,,koff+205
ksel,a,,koff+209 $ksel,a,,koff+265 $ksel,a,,koff+266
ksel,a,,koff+269 $ksel,a,,koff+270 $lskp,1
ksel,s,,koff+265 $ksel,a,,koff+266 $lslk,u,1
al,all $*get,ax,area,,num,max $amesh,ax
lsall $kpall
/com
l,koff+247,koff+161,12
ksel,s,,koff+31 $ksel,a,,koff+33 $ksel,a,,koff+34
$ksel,a,,koff+161
ksel,a,,koff+165 $ksel,a,,koff+169 $ksel,a,,koff+173
ksel,a,,koff+247 $ksel,a,,koff+250 $ksel,a,,koff+254
ksel,a,,koff+258 $ksel,a,,koff+262 $ksel,a,,koff+266
$lskp,1
al,all $*get,ax,area,,num,max $amesh,ax
lsall $kpall
/com
l,koff+145,koff+232,12
l,koff+246,koff+249,2
ksel,s,,koff+145 $ksel,a,,koff+149 $ksel,a,,koff+153
ksel,a,,koff+157
ksel,a,,koff+161 $ksel,a,,koff+231 $ksel,a,,koff+232
ksel,a,,koff+234 $ksel,a,,koff+238 $ksel,a,,koff+242
ksel,a,,koff+246 $ksel,a,,koff+247 $ksel,a,,koff+248
ksel,a,,koff+249 $lskp,1
al,all $*get,ax,area,,num,max $amesh,ax
lsall $kpall
/com
l,koff+121,koff+237,16
ksel,s,,koff+121 $ksel,a,,koff+125 $ksel,a,,koff+129
ksel,a,,koff+133
ksel,a,,koff+137 $ksel,a,,koff+141 $ksel,a,,koff+145
ksel,a,,koff+232 $ksel,a,,koff+233 $ksel,a,,koff+237
lskp,1
al,all $*get,ax,area,,num,max $amesh,ax
lsall $kpall
/com
l,koff+230,koff+121,5
l,koff+229,koff+38,6
ksel,s,,koff+37 $ksel,a,,koff+38 $ksel,a,,koff+121
ksel,a,,koff+229
ksel,a,,koff+230 $ksel,a,,koff+237 $ksel,a,,koff+241
ksel,a,,koff+245 $ksel,a,,koff+246 $ksel,a,,koff+249
ksel,a,,koff+253 $ksel,a,,koff+257 $ksel,a,,koff+261
ksel,a,,koff+265  $lskp,1
al,all $*get,ax,area,,num,max $amesh,ax
lsall $kpall
/com
l,koff+35,koff+112,8
ksel,s,,koff+35 $ksel,a,,koff+38 $ksel,a,,koff+112
ksel,a,,koff+113
ksel,a,,koff+117 $ksel,a,,koff+121 $ksel,a,,koff+211
ksel,a,,koff+212 $ksel,a,,koff+213 $ksel,a,,koff+214
ksel,a,,koff+217 $ksel,a,,koff+218 $ksel,a,,koff+221
ksel,a,,koff+222 $ksel,a,,koff+225 $ksel,a,,koff+226
ksel,a,,koff+229  $ksel,a,,koff+230 $lskp,1
ksel,s,,koff+230 $ksel,a,,koff+229 $lslk,u,1
ksel,s,,koff+226 $ksel,a,,koff+225 $lslk,u,1
ksel,s,,koff+222 $ksel,a,,koff+221 $lslk,u,1
ksel,s,,koff+218 $ksel,a,,koff+217 $lslk,u,1
ksel,s,,koff+214 $ksel,a,,koff+213 $lslk,u,1
al,all $*get,ax,area,,num,max $amesh,ax
lsall $kpall
/com
/com  REGION BETWEEN VV
l,koff+44,koff+111,4
l,koff+57,koff+126,4
ksel,s,,koff+44 $ksel,a,,koff+45 $ksel,a,,koff+49
```

```
ksel,a,,koff+53
ksel,a,,koff+57 $ksel,a,,koff+111 $ksel,a,,koff+114
ksel,a,,koff+118 $ksel,a,,koff+122 $ksel,a,,koff+126
lsbp,1
al,all $*get,ax,area,,num,max $amesh,ax
lsall $kpall
/com
l,koff+77,koff+146,4
ksel,s,,koff+57 $ksel,a,,koff+61 $ksel,a,,koff+65
ksel,a,,koff+69
ksel,a,,koff+73 $ksel,a,,koff+77 $ksel,a,,koff+126
ksel,a,,koff+130 $ksel,a,,koff+134 $ksel,a,,koff+138
ksel,a,,koff+142 $ksel,a,,koff+146
lsbp,1
al,all $*get,ax,area,,num,max $amesh,ax
lsall $kpall
/com
ksel,s,,koff+77 $ksel,a,,koff+81 $ksel,a,,koff+85
ksel,a,,koff+89
ksel,a,,koff+93 $ksel,a,,koff+97 $ksel,a,,koff+101
ksel,a,,koff+105 $ksel,a,,koff+109 $ksel,a,,koff+146
ksel,a,,koff+150 $ksel,a,,koff+154 $ksel,a,,koff+158
ksel,a,,koff+162 $ksel,a,,koff+166 $ksel,a,,koff+170
ksel,a,,koff+182
lsbp,1
al,all $*get,ax,area,,num,max $amesh,ax
lsall $kpall
/com
ksel,s,,koff+180 $ksel,a,,koff+181 $ksel,a,,koff+185
ksel,a,,koff+187
ksel,a,,koff+190 $ksel,a,,koff+194
lsbp,1
al,all $*get,ax,area,,num,max $amesh,ax
lsall $kpall
/com
/com  External to PF6 and 7 but inside cryostat
l,koff+41,koff+289,20,3
ksel,s,,koff+24 $ksel,a,,koff+25 $ksel,a,,koff+26
ksel,a,,koff+28
ksel,a,,koff+29 $ksel,a,,koff+30 $ksel,a,,koff+40
ksel,a,,koff+41 $ksel,a,,koff+289 $ksel,a,,koff+293
ksel,a,,koff+301 $ksel,a,,koff+305 $ksel,a,,koff+309
ksel,a,,koff+313
lsbp,1
al,all $*get,ax,area,,num,max $amesh,ax
lsall $kpall
/com
l,koff+21,koff+277,15
ksel,s,,koff+21 $ksel,a,,koff+41 $ksel,a,,koff+42
ksel,a,,koff+277
ksel,a,,koff+281 $ksel,a,,koff+285 $ksel,a,,koff+289
lsbp,1
al,all $*get,ax,area,,num,max $amesh,ax
lsall $kpall
/com
l,koff+321,koff+272,14
ksel,s,,koff+21 $ksel,a,,koff+22 $ksel,a,,koff+272
ksel,a,,koff+273
ksel,a,,koff+277 $ksel,a,,koff+321
lsbp,1
al,all $*get,ax,area,,num,max $amesh,ax
lsall $kpall
/com
/com  EXTERNAL to CRYOSTAT
kmx=kmx+1
*get,ainf,area,,num,max
k,kmx+1,rinf,0
k,kmx+2,rinf,zinf
k,kmx+3,0,zinf
l,kmx+1,kmx+2,15
l,kmx+2,kmx+3,15
l,koff+318,kmx+1,15,4
l,koff+295,kmx+2,20,4,5
l,koff+271,kmx+3,15,4
ksel,s,,koff+295 $ksel,a,,koff+298 $ksel,a,,koff+302
ksel,a,,koff+306
ksel,a,,koff+310 $ksel,a,,koff+314 $ksel,a,,koff+318
ksel,a,,koff+322 $ksel,a,,koff+323
lsbp,1
al,all $amesh,ainf+1
lsall $kpall
/com
ksel,s,,koff+271 $ksel,a,,koff+274 $ksel,a,,koff+278
ksel,a,,koff+282
ksel,a,,koff+286 $ksel,a,,koff+290 $ksel,a,,koff+294
ksel,a,,koff+295 $ksel,a,,koff+323 $ksel,a,,koff+324
lsbp,1
al,all $amesh,ainf+2
lsel,all $kpall
/com
/com  DISTANT INFINITY SPACE
kmx=kmx+3
k,kmx+1,10*rinf,0
k,kmx+2,10*rinf,10*zinf
k,kmx+3,0,10*zinf
l,kmx+1,kmx+2,6
l,kmx+2,kmx+3,6
l,koff+322,kmx+1,12,15
l,koff+323,kmx+2,15,15
l,koff+324,kmx+3,12,15
a,koff+322,kmx+1,kmx+2,koff+323
a,koff+323,kmx+2,kmx+3,koff+324
amesh,ainf+3  $amesh,ainf+4
/com
/com  MIRROR areas
kof2=10000
*get,atop,area,,num,max
arsym,y,1,avv,1,kof2,0,0    !PF COILS
*get,bvv,area,,num,max
arsym,y,avv+1,ais,1,kof2,0,0  !Vacuum vessel
*get,bis,area,,num,max
arsym,y,ais+1,aos,1,kof2,0,0  !Inner structure
*get,bos,area,,num,max
arsym,y,aos+1,acr,1,kof2,0,0  !Outer structure
*get,bcr,area,,num,max
arsym,y,acr+1,afre,1,kof2,0,0  !cyostat
*get,bfre,area,,num,max
arsym,y,afre+1,ainf,1,kof2,0,0 !Inner free space
regions
*get,binf,area,,num,max
arsym,y,ainf+1,atop,1,kof2,0,0 !Infinity regions
/com
/com  Merge only EM regions
asel,all  $asel,u,,,1,apf1-1  $lsar  $kpls $area $nelem
nummrg,node,,1e-4
nummrg,kp,,1e-4

/com  CURRENT LOADINGS
/com  PF CURRENTS for CASE #3
ni1=0.0      !plasma current
j9=ni1/(pdr9*pdz9)
asel,s,,apf1+1  $area  $bfe,all,js,3,j9
asel,s,,atop+apf1+1-(apf1-1) $area $bfe,all,js,3,j9
j9= $ni1=   !clear parameters
/com  PF coils AMPERE TURN LOADING
ni10=1.5619e4  $ni11=2.60722e4 $ni12=1.09393e4
$ni13=5.8967e4
ni14=4.10035e6 $ni15=9.05121e4 $ni16=1.35168e4
$ni17=1.61962e5
ni18=1.12543e4 $ni19=2.62879e4 $ni20=1.17267e5
$ni21=1.37304e5
ni22=7.22264e4 $ni23=7.84451e4
ju1=ni10/(pdr1*pdz1) $jl1=ni11/(pdr1*pdz1) $ni10=
$ni11=
ju2=ni12/(pdr2*pdz2) $jl2=ni13/(pdr2*pdz2) $ni12=
$ni13=
ju3=ni14/(pdr3*pdz3) $jl3=ni15/(pdr3*pdz3) $ni15=
ju4=ni16/(pdr4*pdz4) $jl4=ni17/(pdr4*pdz4) $ni16=
$ni17=
ju5=ni18/(pdr5*pdz5) $jl5=ni19/(pdr5*pdz5) $ni18=
$ni19=
ju6=ni20/(pdr6*pdz6) $jl6=ni21/(pdr6*pdz6) $ni20=
$ni21=
ju7=ni22/(pdr7*pdz7) $jl7=ni23/(pdr7*pdz7) $ni22=
$ni23=
asel,s,,apf1  $area  $bfe,all,js,3,ju1
asel,s,,atop+1  $area  $bfe,all,js,3,jl1
asel,s,,apf2  $area  $bfe,all,js,3,ju2
asel,s,,atop+apf2-(apf1-1)  $area  $bfe,all,js,3,jl2
asel,s,mat,,13  $asum $*get,ar,area,,area $area
ju3=ni14/ar  $bfe,all,js,3,ju3 $ni14=
asel,s,,atop+apf3-(apf1-1)  $area  $bfe,all,js,3,jl3
asel,s,,apf4  $area  $bfe,all,js,3,ju4
asel,s,,atop+apf4-(apf1-1)  $area  $bfe,all,js,3,jl4
asel,s,,apf5  $area  $bfe,all,js,3,ju5
asel,s,,atop+apf5-(apf1-1)  $area  $bfe,all,js,3,jl5
asel,s,,apf6  $area  $bfe,all,js,3,ju6
asel,s,,atop+apf6-(apf1-1)  $area  $bfe,all,js,3,jl6
asel,s,,apf7  $area  $bfe,all,js,3,ju7
asel,s,,atop+apf7-(apf1-1)  $area  $bfe,all,js,3,jl7
jl1= $jl2= $jl3= $jl4= $jl5= $jl6= $jl7=
ju1= $ju2= $ju3= $ju4= $ju5= $ju6= $ju7=
/com
/com  IC coils, then TF hoop turn
ni24=0.00  $ni25=0.00  $ni26=3.3480e4
ju8=ni24/(pdr8*pdz8) $jl8=ni25/(pdr8*pdz8) $ni24=
$ni25=
ju10=ni26/(dr10*dz10) $ni26=
asel,s,,aic+1  $area  $bfe,all,js,3,ju8
asel,s,,atop+aic+1-(apf1-1)  $area  $bfe,all,js,3,jl8
asel,s,,atf+1  $area  $bfe,all,js,3,ju10
ju8= $jl8= $ju10=
/com
/com  UPPER Vacuum vessel currents
ni27=7.24447e1 $ni28=5.96056e1 $ni29=4.93653e1
$ni30=4.22675e1
ni31=3.40261e1 $ni32=3.80169e1 $ni33=3.79671e1
$ni34=3.95404e1
ni35=4.21961e1 $ni36=4.60633e1 $ni37=5.36393e1
$ni38=5.88161e1
ni39=6.73825e1 $ni40=7.70635e1 $ni41=8.07673e1
$ni42=8.54854e1
ni43=7.54777e1 $ni44=7.01884e1 $ni45=5.86607e1
$ni46=5.01280e1
ni47=4.48721e1 $ni48=2.70273e1 $ni49=3.08478e1
$ni50=3.10363e1
ni51=3.08976e1 $ni52=3.23901e1 $ni53=5.30377e1
$ni54=5.67878e1
ni55=6.72518e1 $ni56=7.71891e1 $ni57=8.68794e1
$ni58=8.10756e1
ni59=3.96629e1 $ni60=3.87621e1 $ni61=4.06087e1
$ni62=4.20904e1
ni63=4.05698e1 $ni64=4.19390e1 $ni65=1.94731e1
$ni66=6.05616e1
ni67=5.99434e1 $ni68=6.02536e1
asel,s,,avv+1 $asum $*get,ar,area,,area $area
jx=ni27/ar  $bfe,all,js,3,jx
asel,s,,avv+2 $asum $*get,ar,area,,area $area
jx=ni28/ar  $bfe,all,js,3,jx
asel,s,,avv+3 $asum $*get,ar,area,,area $area
jx=ni29/ar  $bfe,all,js,3,jx
asel,s,,avv+4 $asum $*get,ar,area,,area $area
jx=ni30/ar  $bfe,all,js,3,jx
asel,s,,avv+5 $asum $*get,ar,area,,area $area
jx=ni31/ar  $bfe,all,js,3,jx
asel,s,,avv+6 $asum $*get,ar,area,,area $area
jx=ni32/ar  $bfe,all,js,3,jx
asel,s,,avv+7 $asum $*get,ar,area,,area $area
jx=ni33/ar  $bfe,all,js,3,jx
asel,s,,avv+8 $asum $*get,ar,area,,area $area
jx=ni34/ar  $bfe,all,js,3,jx
asel,s,,avv+9 $asum $*get,ar,area,,area $area
jx=ni35/ar  $bfe,all,js,3,jx
asel,s,,avv+10 $asum $*get,ar,area,,area $area
jx=ni36/ar  $bfe,all,js,3,jx
asel,s,,avv+11 $asum $*get,ar,area,,area $area
jx=ni37/ar  $bfe,all,js,3,jx
asel,s,,avv+12 $asum $*get,ar,area,,area $area
jx=ni38/ar  $bfe,all,js,3,jx
asel,s,,avv+13 $asum $*get,ar,area,,area $area
jx=ni39/ar  $bfe,all,js,3,jx
asel,s,,avv+14 $asum $*get,ar,area,,area $area
jx=ni40/ar  $bfe,all,js,3,jx
asel,s,,avv+15 $asum $*get,ar,area,,area $area
jx=ni41/ar  $bfe,all,js,3,jx
asel,s,,avv+16 $asum $*get,ar,area,,area $area
jx=ni42/ar  $bfe,all,js,3,jx
asel,s,,avv+17 $asum $*get,ar,area,,area $area
jx=ni43/ar  $bfe,all,js,3,jx
asel,s,,avv+18 $asum $*get,ar,area,,area $area
jx=ni44/ar  $bfe,all,js,3,jx
asel,s,,avv+19 $asum $*get,ar,area,,area $area
jx=ni45/ar  $bfe,all,js,3,jx
asel,s,,avv+20 $asum $*get,ar,area,,area $area
jx=ni46/ar  $bfe,all,js,3,jx
asel,s,,avv+21 $asum $*get,ar,area,,area $area
jx=ni47/ar  $bfe,all,js,3,jx
asel,s,,avv+22 $asum $*get,ar,area,,area $area
jx=ni48/ar  $bfe,all,js,3,jx
asel,s,,avv+23 $asum $*get,ar,area,,area $area
jx=ni49/ar  $bfe,all,js,3,jx
asel,s,,avv+24 $asum $*get,ar,area,,area $area
jx=ni50/ar  $bfe,all,js,3,jx
asel,s,,avv+25 $asum $*get,ar,area,,area $area
jx=ni51/ar  $bfe,all,js,3,jx
asel,s,,avv+26 $asum $*get,ar,area,,area $area
jx=ni52/ar  $bfe,all,js,3,jx
asel,s,,avv+27 $asum $*get,ar,area,,area $area
jx=ni53/ar  $bfe,all,js,3,jx
asel,s,,avv+28 $asum $*get,ar,area,,area $area
jx=ni54/ar  $bfe,all,js,3,jx
asel,s,,avv+29 $asum $*get,ar,area,,area $area
jx=ni55/ar  $bfe,all,js,3,jx
asel,s,,avv+30 $asum $*get,ar,area,,area $area
jx=ni56/ar  $bfe,all,js,3,jx
asel,s,,avv+31 $asum $*get,ar,area,,area $area
jx=ni57/ar  $bfe,all,js,3,jx
asel,s,,avv+32 $asum $*get,ar,area,,area $area
jx=ni58/ar  $bfe,all,js,3,jx
asel,s,,avv+33 $asum $*get,ar,area,,area $area
```

```
jx=ni59/ar $bfe.all.js.3.jx
asel.s...avv+34 $asum $*get.ar.area..area $carea
jx=ni60/ar $bfe.all.js.3.jx
asel.s...avv+35 $asum $*get.ar.area..area $carea
jx=ni61/ar $bfe.all.js.3.jx
asel.s...avv+36 $asum $*get.ar.area..area $carea
jx=ni62/ar $bfe.all.js.3.jx
asel.s...avv+37 $asum $*get.ar.area..area $carea
jx=ni63/ar $bfe.all.js.3.jx
asel.s...avv+38 $asum $*get.ar.area..area $carea
jx=ni64/ar $bfe.all.js.3.jx
asel.s...avv+39 $asum $*get.ar.area..area $carea
jx=ni65/ar $bfe.all.js.3.jx
asel.s...avv+40 $asum $*get.ar.area..area $carea
jx=ni66/ar $bfe.all.js.3.jx
asel.s...avv+41 $asum $*get.ar.area..area $carea
jx=ni67/ar $bfe.all.js.3.jx
asel.s...avv+42 $asum $*get.ar.area..area $carea
jx=ni68/ar $bfe.all.js.3.jx
ni27= $ni28= $ni29= $ni30= $ni31= $ni32= $ni33=
$ni34=
ni35= $ni36= $ni37= $ni38= $ni39= $ni40= $ni41=
$ni42=
ni43= $ni44= $ni45= $ni46= $ni47= $ni48= $ni49=
$ni50=
ni51= $ni52= $ni53= $ni54= $ni55= $ni56= $ni57=
$ni58=
ni59= $ni60= $ni61= $ni62= $ni63= $ni64= $ni65=
$ni66=
ni67= $ni68=
/com
/com  LOWER Vacuum vessel currents
ni69=8.75285e1 $ni70=1.03878e2 $ni71=1.18922e2
$ni72=1.29128e2
ni73=1.10352e2 $ni74=1.09183e2 $ni75=9.02032e1
$ni76=7.89128e1
ni77=7.30144e1 $ni78=7.13729e1 $ni79=7.62906e1
$ni80=7.83789e1
ni81=8.55563e1 $ni82=9.44671e1 $ni83=9.62264e1
$ni84=9.93199e1
ni85=8.56209e1 $ni86=8.40727e1 $ni87=9.85495e1
$ni88=1.08342e2
ni89=1.13709e2 $ni90=7.10505e1 $ni91=7.59624e1
$ni92=6.83987e1
ni93=6.04008e1 $ni94=5.68095e1 $ni95=8.32683e1
$ni96=8.05915e1
ni97=8.89536e1 $ni98=9.71222e1 $ni99=1.05234e2
$ni100=9.51021e1
ni101=4.54061e1 $ni102=4.31478e1 $ni103=4.64172e1
$ni104=4.74246e1
ni105=4.57401e1 $ni106=4.66576e1 $ni107=2.14694e1
$ni108=6.57266e1
ni109=6.31155e1 $ni110=6.13248e1
asel.s...bvv+1 $asum $*get.ar.area..area $carea
jx=ni69/ar $bfe.all.js.3.jx
asel.s...bvv+2 $asum $*get.ar.area..area $carea
jx=ni70/ar $bfe.all.js.3.jx
asel.s...bvv+3 $asum $*get.ar.area..area $carea
jx=ni71/ar $bfe.all.js.3.jx
asel.s...bvv+4 $asum $*get.ar.area..area $carea
jx=ni72/ar $bfe.all.js.3.jx
asel.s...bvv+5 $asum $*get.ar.area..area $carea
jx=ni73/ar $bfe.all.js.3.jx
asel.s...bvv+6 $asum $*get.ar.area..area $carea
jx=ni74/ar $bfe.all.js.3.jx
asel.s...bvv+7 $asum $*get.ar.area..area $carea
jx=ni75/ar $bfe.all.js.3.jx
asel.s...bvv+8 $asum $*get.ar.area..area $carea
jx=ni76/ar $bfe.all.js.3.jx
asel.s...bvv+9 $asum $*get.ar.area..area $carea
jx=ni77/ar $bfe.all.js.3.jx
asel.s...bvv+10 $asum $*get.ar.area..area $carea
jx=ni78/ar $bfe.all.js.3.jx
asel.s...bvv+11 $asum $*get.ar.area..area $carea
jx=ni79/ar $bfe.all.js.3.jx
asel.s...bvv+12 $asum $*get.ar.area..area $carea
jx=ni80/ar $bfe.all.js.3.jx
asel.s...bvv+13 $asum $*get.ar.area..area $carea
jx=ni81/ar $bfe.all.js.3.jx
asel.s...bvv+14 $asum $*get.ar.area..area $carea
jx=ni82/ar $bfe.all.js.3.jx
asel.s...bvv+15 $asum $*get.ar.area..area $carea
jx=ni83/ar $bfe.all.js.3.jx
asel.s...bvv+16 $asum $*get.ar.area..area $carea
jx=ni84/ar $bfe.all.js.3.jx
asel.s...bvv+17 $asum $*get.ar.area..area $carea
jx=ni85/ar $bfe.all.js.3.jx
asel.s...bvv+18 $asum $*get.ar.area..area $carea
jx=ni86/ar $bfe.all.js.3.jx
asel.s...bvv+19 $asum $*get.ar.area..area $carea
jx=ni87/ar $bfe.all.js.3.jx
asel.s...bvv+20 $asum $*get.ar.area..area $carea
jx=ni88/ar $bfe.all.js.3.jx
asel.s...bvv+21 $asum $*get.ar.area..area $carea
jx=ni89/ar $bfe.all.js.3.jx
asel.s...bvv+22 $asum $*get.ar.area..area $carea
jx=ni90/ar $bfe.all.js.3.jx
asel.s...bvv+23 $asum $*get.ar.area..area $carea
jx=ni91/ar $bfe.all.js.3.jx
asel.s...bvv+24 $asum $*get.ar.area..area $carea
jx=ni92/ar $bfe.all.js.3.jx
asel.s...bvv+25 $asum $*get.ar.area..area $carea
jx=ni93/ar $bfe.all.js.3.jx
asel.s...bvv+26 $asum $*get.ar.area..area $carea
jx=ni94/ar $bfe.all.js.3.jx
asel.s...bvv+27 $asum $*get.ar.area..area $carea
jx=ni95/ar $bfe.all.js.3.jx
asel.s...bvv+28 $asum $*get.ar.area..area $carea
jx=ni96/ar $bfe.all.js.3.jx
asel.s...bvv+29 $asum $*get.ar.area..area $carea
jx=ni97/ar $bfe.all.js.3.jx
asel.s...bvv+30 $asum $*get.ar.area..area $carea
jx=ni98/ar $bfe.all.js.3.jx
asel.s...bvv+31 $asum $*get.ar.area..area $carea
jx=ni99/ar $bfe.all.js.3.jx
asel.s...bvv+32 $asum $*get.ar.area..area $carea
jx=ni100/ar $bfe.all.js.3.jx
asel.s...bvv+33 $asum $*get.ar.area..area $carea
jx=ni101/ar $bfe.all.js.3.jx
asel.s...bvv+34 $asum $*get.ar.area..area $carea
jx=ni102/ar $bfe.all.js.3.jx
asel.s...bvv+35 $asum $*get.ar.area..area $carea
jx=ni103/ar $bfe.all.js.3.jx
asel.s...bvv+36 $asum $*get.ar.area..area $carea
jx=ni104/ar $bfe.all.js.3.jx
asel.s...bvv+37 $asum $*get.ar.area..area $carea
jx=ni105/ar $bfe.all.js.3.jx
asel.s...bvv+38 $asum $*get.ar.area..area $carea
jx=ni106/ar $bfe.all.js.3.jx
asel.s...bvv+39 $asum $*get.ar.area..area $carea
jx=ni107/ar $bfe.all.js.3.jx
asel.s...bvv+40 $asum $*get.ar.area..area $carea
jx=ni108/ar $bfe.all.js.3.jx
asel.s...bvv+41 $asum $*get.ar.area..area $carea
jx=ni109/ar $bfe.all.js.3.jx
asel.s...bvv+42 $asum $*get.ar.area..area $carea
jx=ni110/ar $bfe.all.js.3.jx
ni69= $ni70= $ni71= $ni72= $ni73= $ni74= $ni75=
$ni76=
ni77= $ni78= $ni79= $ni80= $ni81= $ni82= $ni83=
$ni84=
ni85= $ni86= $ni87= $ni88= $ni89= $ni90= $ni91=
$ni92=
ni93= $ni94= $ni95= $ni96= $ni97= $ni98= $ni99=
$ni100=
ni101= $ni102= $ni103= $ni104= $ni105= $ni106=
$ni107= $ni108=
ni109= $ni110=
/com
/com  Upper Inboard Structure currents
ni111=-8.95326e-1 $ni112=-2.20181e2 $ni113=-
4.19444e2
ni114=-6.03197e2 $ni115=-7.48448e2
asel.s...ais+1 $asum $*get.ar.area..area $carea
jx=ni111/ar $bfe.all.js.3.jx
asel.s...ais+2 $asum $*get.ar.area..area $carea
jx=ni112/ar $bfe.all.js.3.jx
asel.s...ais+3 $asum $*get.ar.area..area $carea
jx=ni113/ar $bfe.all.js.3.jx
asel.s...ais+4 $asum $*get.ar.area..area $carea
jx=ni114/ar $bfe.all.js.3.jx
asel.s...ais+5 $asum $*get.ar.area..area $carea
jx=ni115/ar $bfe.all.js.3.jx
ni111= $ni112= $ni113= $ni114= $ni115=
/com
/com
/com  Lower Inboard Structure currents
ni116=8.73489e2 $ni117=1.14273e3 $ni118=1.37030e3
ni119=1.59238e3 $ni120=1.74959e3
asel.s...bis+1 $asum $*get.ar.area..area $carea
jx=ni116/ar $bfe.all.js.3.jx
asel.s...bis+2 $asum $*get.ar.area..area $carea
jx=ni117/ar $bfe.all.js.3.jx
asel.s...bis+3 $asum $*get.ar.area..area $carea
jx=ni118/ar $bfe.all.js.3.jx
asel.s...bis+4 $asum $*get.ar.area..area $carea
jx=ni119/ar $bfe.all.js.3.jx
asel.s...bis+5 $asum $*get.ar.area..area $carea
jx=ni120/ar $bfe.all.js.3.jx
ni116= $ni117= $ni118= $ni119= $ni120=
/com
/com  Upper OUTboard Structure currents
ni121=-8.15460e2 $ni122=-7.80974e2 $ni123=-
2.25805e2
ni124=-1.77083e2 $ni125=-2.02406e2 $ni126=-
1.72733e2
ni127=-1.20836e1 $ni128=6.79890e1
$ni129=6.68512e1
ni130=1.35305e2
asel.s...aos+1 $asum $*get.ar.area..area $carea
jx=ni121/ar $bfe.all.js.3.jx
asel.s...aos+2 $asum $*get.ar.area..area $carea
jx=ni122/ar $bfe.all.js.3.jx
asel.s...aos+3 $asum $*get.ar.area..area $carea
jx=ni123/ar $bfe.all.js.3.jx
asel.s...aos+4 $asum $*get.ar.area..area $carea
jx=ni124/ar $bfe.all.js.3.jx
asel.s...aos+5 $asum $*get.ar.area..area $carea
jx=ni125/ar $bfe.all.js.3.jx
asel.s...aos+6 $asum $*get.ar.area..area $carea
jx=ni126/ar $bfe.all.js.3.jx
asel.s...aos+7 $asum $*get.ar.area..area $carea
jx=ni127/ar $bfe.all.js.3.jx
asel.s...aos+8 $asum $*get.ar.area..area $carea
jx=ni128/ar $bfe.all.js.3.jx
asel.s...aos+9 $asum $*get.ar.area..area $carea
jx=ni129/ar $bfe.all.js.3.jx
asel.s...aos+10 $asum $*get.ar.area..area $carea
jx=ni130/ar $bfe.all.js.3.jx
ni121= $ni122= $ni123= $ni124= $ni125=
ni126= $ni127= $ni128= $ni129= $ni130=
/com
/com
/com  Lower OUTboard Structure currents
ni131=-8.15460e2 $ni132=-7.80974e2 $ni133=-
2.25805e2
ni134=-1.77083e2 $ni135=-2.02406e2 $ni136=-
1.72733e2
ni137=-1.20836e1 $ni138=6.79890e1
$ni139=6.68512e1
ni140=1.35305e2
asel.s...bos+1 $asum $*get.ar.area..area $carea
jx=ni131/ar $bfe.all.js.3.jx
asel.s...bos+2 $asum $*get.ar.area..area $carea
jx=ni132/ar $bfe.all.js.3.jx
asel.s...bos+3 $asum $*get.ar.area..area $carea
jx=ni133/ar $bfe.all.js.3.jx
asel.s...bos+4 $asum $*get.ar.area..area $carea
jx=ni134/ar $bfe.all.js.3.jx
asel.s...bos+5 $asum $*get.ar.area..area $carea
jx=ni135/ar $bfe.all.js.3.jx
asel.s...bos+6 $asum $*get.ar.area..area $carea
jx=ni136/ar $bfe.all.js.3.jx
asel.s...bos+7 $asum $*get.ar.area..area $carea
jx=ni137/ar $bfe.all.js.3.jx
asel.s...bos+8 $asum $*get.ar.area..area $carea
jx=ni138/ar $bfe.all.js.3.jx
asel.s...bos+9 $asum $*get.ar.area..area $carea
jx=ni139/ar $bfe.all.js.3.jx
asel.s...bos+10 $asum $*get.ar.area..area $carea
jx=ni140/ar $bfe.all.js.3.jx
ni131= $ni132= $ni133= $ni134= $ni135=
ni136= $ni137= $ni138= $ni139= $ni140=
/com
/com  Upper Cryostat currents
ni141=2.61950e2 $ni142=5.91613e2 $ni143=9.13906e2
ni144=1.18446e3 $ni145=1.35224e3 $ni146=1.36103e3
ni147=1.21296e3 $ni148=1.51931e3 $ni149=1.82871e3
ni150=8.57118e2 $ni151=8.95189e2 $ni152=8.53514e2
asel.s...acr+1 $asum $*get.ar.area..area $carea
jx=ni141/ar $bfe.all.js.3.jx
asel.s...acr+2 $asum $*get.ar.area..area $carea
jx=ni142/ar $bfe.all.js.3.jx
asel.s...acr+3 $asum $*get.ar.area..area $carea
jx=ni143/ar $bfe.all.js.3.jx
asel.s...acr+4 $asum $*get.ar.area..area $carea
jx=ni144/ar $bfe.all.js.3.jx
asel.s...acr+5 $asum $*get.ar.area..area $carea
jx=ni145/ar $bfe.all.js.3.jx
asel.s...acr+6 $asum $*get.ar.area..area $carea
jx=ni146/ar $bfe.all.js.3.jx
asel.s...acr+7 $asum $*get.ar.area..area $carea
jx=ni147/ar $bfe.all.js.3.jx
asel.s...acr+8 $asum $*get.ar.area..area $carea
jx=ni148/ar $bfe.all.js.3.jx
asel.s...acr+9 $asum $*get.ar.area..area $carea
jx=ni149/ar $bfe.all.js.3.jx
asel.s...acr+10 $asum $*get.ar.area..area $carea
jx=ni150/ar $bfe.all.js.3.jx
asel.s...acr+11 $asum $*get.ar.area..area $carea
```

```
jx=ni151/ar $bfe,all,js,3,jx
asel,s,,,acr+12 $asum $*get,ar,area,,area $carea
jx=ni152/ar $bfe,all,js,3,jx
ni141= $ni142= $ni143= $ni144= $ni145=
ni146= $ni147= $ni148= $ni149= $ni150= $ni151=
$ni152=
/com
/com
/com  Lower Cryostat currents
ni153=4.19836e2 $ni154=8.92109e2 $ni155=1.26212e3
ni156=1.51307e3 $ni157=1.63711e3 $ni158=1.59049e3
ni159=1.39254e3 $ni160=1.72938e3 $ni161=2.05104e3
ni162=9.39152e2 $ni163=9.52700e2 $ni164=8.73231e2
asel,s,,,bcr+1 $asum $*get,ar,area,,area $carea
jx=ni153/ar $bfe,all,js,3,jx
asel,s,,,bcr+2 $asum $*get,ar,area,,area $carea
jx=ni154/ar $bfe,all,js,3,jx
asel,s,,,bcr+3 $asum $*get,ar,area,,area $carea
jx=ni155/ar $bfe,all,js,3,jx
asel,s,,,bcr+4 $asum $*get,ar,area,,area $carea
jx=ni156/ar $bfe,all,js,3,jx
asel,s,,,bcr+5 $asum $*get,ar,area,,area $carea
jx=ni157/ar $bfe,all,js,3,jx
asel,s,,,bcr+6 $asum $*get,ar,area,,area $carea
jx=ni158/ar $bfe,all,js,3,jx
asel,s,,,bcr+7 $asum $*get,ar,area,,area $carea
jx=ni159/ar $bfe,all,js,3,jx
asel,s,,,bcr+8 $asum $*get,ar,area,,area $carea
jx=ni160/ar $bfe,all,js,3,jx
asel,s,,,bcr+9 $asum $*get,ar,area,,area $carea
jx=ni161/ar $bfe,all,js,3,jx
asel,s,,,bcr+10 $asum $*get,ar,area,,area $carea
jx=ni162/ar $bfe,all,js,3,jx
asel,s,,,bcr+11 $asum $*get,ar,area,,area $carea
jx=ni163/ar $bfe,all,js,3,jx
asel,s,,,bcr+12 $asum $*get,ar,area,,area $carea
jx=ni164/ar $bfe,all,js,3,jx
ni153= $ni154= $ni155= $ni156= $ni157=
ni158= $ni159= $ni160= $ni161= $ni162= $ni163=
$ni164=
/com
/com
/com  Clear PF3 region
asel,all  $carea  $nelem
aclear,apf3
/com
/com  boundary conditions (fix potential to zero)
ksel,s,,,kof2+koff+327 $ksel,a,,,kof2+koff+326
$ksel,a,,,koff+325
ksel,a,,,koff+326 $ksel,a,,,koff+327
lskp,1
nline,1
d,all,az,0.0
/com
/com
/com  STITCH PF3U
/com  clear coarse magnetic mesh
asel,all  $asel,u,,,1,apf1  $lsar $kpls $carea $nelem
aclear,afre+1 $aclear,afre+3 $aclear,apf3+1
aclear,apf4+1
/com  delete areas
adel,apf3 $adel,afre+1,,,1 $adel,afre+3,,,1
adel,apf3+1,,,1 $adel,apf4+1,,,1
/com  reform line on r=0 boundary
l,koff+319,koff+320,20
lsall  $kpall  $eall $nall
/com  form areas above and below PF3U
a,koff+10,koff+9,26,22 $mat,20  $amesh,1773
a,16,21,koff+16,koff+15 $mat,20 $amesh,1774
/com  form area between r=0 and cs (inside cs)
ksel,s,,,koff+6  $ksel,a,,,koff+1 $ksel,a,,,koff+4
$ksel,a,,,koff+7
ksel,a,,,koff+18 $ksel,a,,,koff+319 $ksel,a,,,koff+320
ksel,a,,,koff+10 $ksel,a,,,22  $ksel,a,,,4 $ksel,a,,,9
ksel,a,,,16  $ksel,a,,,koff+15
lskp,1 $al,all  $mat,20  $amesh,1776
/com  form area outboard of PF3U
ksel,s,,,koff+2 $ksel,a,,,koff+5 $ksel,a,,,koff+43
ksel,a,,,koff+46 $ksel,a,,,koff+50 $ksel,a,,,koff+54
ksel,a,,,koff+58 $ksel,a,,,21 $ksel,a,,,11 $ksel,a,,,10
ksel,a,,,26 $ksel,a,,,koff+9 $ksel,a,,,koff+8
$ksel,a,,,koff+3
ksel,a,,,koff+16  $lskp,1  $al,all $mat,20 $amesh,1852
/com
/com
nall  $eall
kpall  $lsall  $arall
```

Appendix J - ANSYS Axisymmetric command file: refined PF1L, normal-operating case

The following are ANSYS commands used to establish an axisymmetric electromagnetic model of the TPX PF coils using a refined mesh for the upper half of coil pack PF1L. This model includes both upper and lower coils, the vacuum vessel, cryostat, inner and outer passive structure, internal control coils and the tf interconnect ring coil. The PF1L coil pack shares the same elements as a detailed structural model

```
/com 2-D axisymmetric model of TPX PF coils
/com et,1,plane53,,,1
/com
/com Mirror conductor pack to get PF1L
/com arsym,y,all,,,,0,1
/com compress numbering sequence
numcmp,line
numcmp,area
/com clear memory
ast= $cn= $col= $csize= $cw= $del= $dr10= $dz10=
$fl= $icon=
ics1= $innerrad= $iof= $itf= $ix= $knm= $kst= $ldiv=
lst= $ncol= $ni1= $ni2= $ni3= $ni4= $ni5= $ni6=
$ni7=
ni8= $ni9= $nrow= $ntm= $nxt= $pdr1= $pdr2=
$pdr3=
pdr4= $pdr5= $pdr6= $pdr7= $pdr8= $pdr9= $pdz1=
$pdz2=
pdz3= $pdz4= $pdz5= $pdz6= $pdz7= $pdz8= $pdz9=
pz1= $pz2= $pz3= $pz4= $pz5= $pz6= $pz7= $pz8=
$pz9=
pr1= $pr2= $pr3= $pr4= $pr5= $pr6= $pr7= $pr8=
$pr9=
r1= $r10= $r2= $r3= $rdiv= $ric= $rou= $row= $rsm=
$sm1=
sp= $tc= $tg11= $tins1= $tins2= $twrap= $x= $xx=
y= $z1= $z10= $pitch=
emunit,mks
/com define permeabilities
/com mp,murx,11,1.0 * PF1 coil
/com mp,murx,12,1.0 * PF2 coil
/com mp,murx,13,1.0 * PF3 coil Conductor region
/com mp,murx,14,1.0 * PF4 coil
/com mp,murx,15,1.0 *pf5
/com mp,murx,16,1.0 *pf6
/com mp,murx,17,1.0 *pf7
/com mp,murx,18,1.0 *IC coil, TF Interconnect
/com mp,murx,19,1.0 *Plasma
/com mp,murx,20,1.0 * tf coil/ free space in 2D
model
mp,murx,21,1.0 *eddy paths
mp,murx,23,1.0 *PF3L (must be different than PF3U)
mp,murx,31,1.0 *PF1L Lower half
/com
/com
/com DEFINE PF CURRENT SOURCE
GEOMETRY
pr1=.81 $pz1=.251 $pdr1=.144 $pdz1=.478
pr2=.81 $pz2=.7065 $pdr2=.144 $pdz2=.383
pr3=.81 $pz3=1.0415 $pdr3=.144 $pdz3=.239
pr4=.81 $pz4=1.3055 $pdr4=.144 $pdz4=.239
pr5=1.213 $pz5=2.35 $pdr5=.192 $pdz5=.382
pr6=3.7585 $pz6=2.144 $pdr6=.143 $pdz6=.478
pr7=4.297 $pz7=1.1135 $pdr7=.144 $pdz7=.335
/com IC COIL GEOMETRY AND CURRENTS
pr8=2.9405 $pz8=0.6845 $pdr8=.045 $pdz8=.045
/com PLASMA GEOMETRY AND CURRENTS
pr9=2.25 $pz9=0.0 $pdr9=1.0 $pdz9=1.0
pdr9=0.7*pdr9 !reduce plasma size by 70% to avoid
interference
/com TF INTERCONNECT COIL
r10=3.3480 $z10=2.5910 $dr10=.0254 $dz10=.0254
/com
/com
/com TF CURRENT SOURCE GEOMETRY
/com tdr1=.2138 $tdz1=.3037 $tr1=2.29108
$tz1=1.16586
/com tdr2=.2138 $tdz2=.3037 $tr2=2.29108
$tz2=0.67564
/com tdr3=.2138 $tdz3=.3037 $tr3=-1.9223 $tz3=0.0
/com tdr4=.2138 $tdz4=.3037 $tz4=0.0
/com tsa1=90.0 $tea1=180.0 $tin1=1.05156
/com tsa2=9.11 $tea2=90.0 $tin2=1.5418
/com tsa3=-9.11 $tea3=9.11 $tin3=5.809
/com tden=2.3317 $thi=tden/2
/com trm1=tin1+tdr1/2
/com tr4=tr1-trm1
/com trm2=tin2+tdr2/2
/com trm3=tin3+tdr3/2
/com ang=22.5 !meshed angular span of pf coils
/com acc=.00005 !Biot-savart integration accuracy
/com
ksel,none $lsel,none $asel,none $esel,none
$nsel,none
/com
/com BEGIN PF MESH
/com CS MESH
csys,0
koff=10000 *keypoint offset
/com pf1
r1=pr1-pdr1/2 $r2=pr1+pdr1/2
z1=pz1-pdz1/2 $z2=pz1+pdz1/2
kmx=koff
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
k,kmx+5,r2,0 $k,kmx+6,r1,0
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1 !radial
a,kmx+1,kmx+2,kmx+3,kmx+4
type,1
esize,pdr1/8 $mat,11 $*get,apf1,area,,num,max
$amesh,apf1 !cs coil pf1
a,kmx+6,kmx+5,kmx+2,kmx+1
esize,pdr1/8 $mat,20 $*get,acur,area,,num,max
$amesh,acur !free space
/com pf2
kmx=kmx+6
r1=pr2-pdr2/2 $r2=pr2+pdr2/2
z1=pz2-pdz2/2 $z2=pz2+pdz2/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4 ! pf2
esize,pdr1/4 $mat,12 $*get,apf2,area,,num,max
$amesh,apf2 !cs coil pf2
a,kmx-2,kmx-3,kmx+2,kmx+1
esize,pdr1/4 $mat,20 $*get,acur,area,,num,max
$amesh,acur !free space
/com pf3
kmx=kmx+4
r1=pr3-pdr3/2 $r2=pr3+pdr3/2
z1=pz3-pdz3/2 $z2=pz3+pdz3/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr1/4 $mat,23 $*get,apf3,area,,num,max
$amesh,apf3 !cs coil pf3
a,kmx,kmx-1,kmx+2,kmx+1
esize,pdr1/4 $mat,20 $*get,acur,area,,num,max
$amesh,acur !free space
/com pf4
kmx=kmx+4
r1=pr4-pdr4/2 $r2=pr4+pdr4/2
z1=pz4-pdz4/2 $z2=pz4+pdz4/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr1/4 $mat,14 $*get,apf4,area,,num,max
$amesh,apf4 !cs coil pf4
a,kmx,kmx-1,kmx+2,kmx+1
esize,pdr1/4 $mat,20 $*get,acur,area,,num,max
$amesh,acur !cs coils
/com
/com PF5
kmx=kmx+4
r1=pr5-pdr5/2 $r2=pr5+pdr5/2
z1=pz5-pdz5/2 $z2=pz5+pdz5/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr5/4 $mat,15 $*get,apf5,area,,num,max
$amesh,apf5 !pf 5
/com
/com Volume pf6
kmx=kmx+4
r1=pr6-pdr6/2 $r2=pr6+pdr6/2
z1=pz6-pdz6/2 $z2=pz6+pdz6/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr6/4 $mat,16 $*get,apf6,area,,num,max
$amesh,apf6 !pf6
/com
/com pf7
kmx=kmx+4
r1=pr7-pdr7/2 $r2=pr7+pdr7/2
z1=pz7-pdz7/2 $z2=pz7+pdz7/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr7/4 $mat,17 $*get,apf7,area,,num,max
$amesh,apf7 !pf7
/com
/pnum,node,0
/com
/com
/com
/com pf8 IC coil
*get,aic,area,,num,max
kmx=kmx+4
r1=pr8-pdr8/2 $r2=pr8+pdr8/2
z1=pz8-pdz8/2 $z2=pz8+pdz8/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr8 $mat,18 $amesh,aic+1 !IC coil
/com
/com
/com INCLUDE PLASMA
/com Mesh Plasma
*get,apl,area,,num,max
kmx=kmx+4
r1=pr9-pdr9/2 $r2=pr9+pdr9/2
z1=0 $z2=pz9+pdz9/2
k,kmx+1,r1,z1 $k,kmx+2,r2,z1 $k,kmx+3,r2,z2
$k,kmx+4,r1,z2
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr9/6 $type,1 $mat,19
amesh,apl+1
/com
/com
/com TF LEAD
*get,atf,area,,num,max
```

```
kmx=kmx+4
r1=r10-dr10/2 $r2=r10+dr10/2
z1=z10-dz10/2 $z2=z10+dz10/2
k.kmx+1,r1,z1 $k.kmx+2,r2,z1 $k.kmx+3,r2,z2
$k.kmx+4,r1,z2
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
esize,pdr10 $type,1 $mat,18
zmesh,ztf+1
/com
/com
/com
/com VACUUM VESSEL, UPPER HALF
kmx=kmx+4
r1= $z1=          !clear memory locations
*get,avv,area_num,max
ra27=1.3560 $za27=0.0000 $rb27=1.3690
$zb27=0.0000
rc27=1.3690 $zc27=0.2800 $rd27=1.3560
$zd27=0.2800
ra28=1.3560 $za28=0.2800 $rb28=1.3690
$zb28=0.2800
rc28=1.3690 $zc28=0.5600 $rd28=1.3560
$zd28=0.5600
ra29=1.3560 $za29=0.5600 $rb29=1.3690
$zb29=0.5600
rc29=1.3690 $zc29=0.8400 $rd29=1.3560
$zd29=0.8400
ra30=1.3560 $za30=0.8400 $rb30=1.3690
$zb30=0.8400
rc30=1.3690 $zc30=1.1200 $rd30=1.3560
$zd30=1.1200
ra31=1.3560 $za31=1.1200 $rb31=1.3690
$zb31=1.1200
rc31=1.4010 $zc31=1.3630 $rd31=1.3890
$zd31=1.3670
ra32=1.3890 $za32=1.3670 $rb32=1.4010
$zb32=1.3630
rc32=1.4950 $zc32=1.5900 $rd32=1.4840
$zd32=1.5960
ra33=1.4840 $za33=1.5960 $rb33=1.4950
$zb33=1.5900
rc33=1.6440 $zc33=1.7850 $rd33=1.6350
$zd33=1.7940
ra34=1.6350 $za34=1.7940 $rb34=1.6440
$zb34=1.7850
rc34=1.8390 $zc34=1.9340 $rd34=1.8330
$zd34=1.9450
ra35=1.8330 $za35=1.9450 $rb35=1.8390
$zb35=1.9340
rc35=2.0660 $zc35=2.0280 $rd35=2.0620
$zd35=2.0400
ra36=2.0620 $za36=2.0400 $rb36=2.0660
$zb36=2.0280
rc36=2.3090 $zc36=2.0600 $rd36=2.3090
$zd36=2.0730
ra37=2.3090 $za37=2.0730 $rb37=2.3090
$zb37=2.0600
rc37=2.5670 $zc37=2.0310 $rd37=2.5700
$zd37=2.0430
ra38=2.5700 $za38=2.0430 $rb38=2.5670
$zb38=2.0310
rc38=2.8130 $zc38=1.9450 $rd38=2.8180
$zd38=1.9560
ra39=2.8180 $za39=1.9560 $rb39=2.8130
$zb39=1.9450
rc39=3.0330 $zc39=1.8070 $rd39=3.0410
$zd39=1.8170
ra40=3.0410 $za40=1.8170 $rb40=3.0330
$zb40=1.8070
rc40=3.2160 $zc40=1.6230 $rd40=3.2260
$zd40=1.6310
ra41=3.2260 $za41=1.6310 $rb41=3.2160
$zb41=1.6230
rc41=3.3550 $zc41=1.4030 $rd41=3.3660
$zd41=1.4080
ra42=3.3660 $za42=1.4080 $rb42=3.3550
$zb42=1.4030
rc42=3.4410 $zc42=1.1570 $rd42=3.4530
$zd42=1.1600
ra43=3.4530 $za43=1.1600 $rb43=3.4410
$zb43=1.1570
rc43=3.4700 $zc43=0.8990 $rd43=3.4820
$zd43=0.8990
ra44=1.5090 $za44=0.0000 $rb44=1.5210
$zb44=0.0000
rc44=1.5210 $zc44=0.2960 $rd44=1.5090
$zd44=0.2960
ra45=1.5090 $za45=0.2960 $rb45=1.5210
$zb45=0.2960
rc45=1.5210 $zc45=0.5930 $rd45=1.5090
$zd45=0.5930
ra46=1.5090 $za46=0.5930 $rb46=1.5210
$zb46=0.5930
rc46=1.5210 $zc46=0.8890 $rd46=1.5090
$zd46=0.8890
ra47=1.5090 $za47=0.8890 $rb47=1.5210
$zb47=0.8890
rc47=1.5210 $zc47=1.1860 $rd47=1.5090
$zd47=1.1860
ra48=1.5090 $za48=1.1860 $rb48=1.5210
$zb48=1.1860
rc48=1.5460 $zc48=1.3640 $rd48=1.5340
$zd48=1.3680
ra49=1.5340 $za49=1.3680 $rb49=1.5460
$zb49=1.3640
rc49=1.6190 $zc49=1.5290 $rd49=1.6080
$zd49=1.5360
ra50=1.6080 $za50=1.5360 $rb50=1.6190
$zb50=1.5290
rc50=1.7330 $zc50=1.6680 $rd50=1.7240
$zd50=1.6770
ra51=1.7240 $za51=1.6770 $rb51=1.7330
$zb51=1.6680
rc51=1.8810 $zc51=1.7710 $rd51=1.8750
$zd51=1.7820
ra52=1.8750 $za52=1.7820 $rb52=1.8810
$zb52=1.7710
rc52=2.0510 $zc52=1.8290 $rd52=2.0490
$zd52=1.8420
ra53=2.0490 $za53=1.8420 $rb53=2.0510
$zb53=1.8290
rc53=2.3290 $zc53=1.8420 $rd53=2.3300
$zd53=1.8540
ra54=2.3300 $za54=1.8540 $rb54=2.3290
$zb54=1.8420
rc54=2.5970 $zc54=1.7740 $rd54=2.6020
$zd54=1.7850
ra55=2.6020 $za55=1.7850 $rb55=2.5970
$zb55=1.7740
rc55=2.8350 $zc55=1.6300 $rd55=2.8430
$zd55=1.6400
ra56=2.8430 $za56=1.6400 $rb56=2.8350
$zb56=1.6300
rc56=3.0210 $zc56=1.4250 $rd56=3.0320
$zd56=1.4320
ra57=3.0320 $za57=1.4320 $rb57=3.0210
$zb57=1.4250
rc57=3.1390 $zc57=1.1740 $rd57=3.1520
$zd57=1.1770
ra58=3.1520 $za58=1.1770 $rb58=3.1390
$zb58=1.1740
rc58=3.1800 $zc58=0.8990 $rd58=3.1930
$zd58=0.8990
ra59=3.1930 $za59=0.8990 $rb59=3.1800
$zb59=0.8990
rc59=3.1800 $zc59=0.7620 $rd59=3.1930
$zd59=0.7620
ra60=3.4820 $za60=0.8990 $rb60=3.4700
$zb60=0.8990
rc60=3.4700 $zc60=0.7620 $rd60=3.4820
$zd60=0.7620
ra61=3.1930 $za61=0.8990 $rb61=3.1930
$zb61=0.8860
rc61=3.3310 $zc61=0.8860 $rd61=3.3310
$zd61=0.8990
ra62=3.3310 $za62=0.8990 $rb62=3.3310
$zb62=0.8860
rc62=3.4700 $zc62=0.8860 $rd62=3.4700
$zd62=0.8990
ra63=3.1930 $za63=0.7750 $rb63=3.1930
$zb63=0.7620
rc63=3.3310 $zc63=0.7620 $rd63=3.3310
$zd63=0.7750
ra64=3.3310 $za64=0.7750 $rb64=3.3310
$zb64=0.7620
rc64=3.4700 $zc64=0.7620 $rd64=3.4700
$zd64=0.7750
ra65=3.4820 $za65=0.7750 $rb65=3.4820
$zb65=0.7620
rc65=3.5590 $zc65=0.7620 $rd65=3.5590
$zd65=0.7750
ra66=3.5710 $za66=0.7750 $rb66=3.5590
$zb66=0.7750
rc66=3.5590 $zc66=0.5160 $rd66=3.5710
$zd66=0.5160
ra67=3.5710 $za67=0.5160 $rb67=3.5590
$zb67=0.5160
rc67=3.5590 $zc67=0.2580 $rd67=3.5710
$zd67=0.2580
ra68=3.5710 $za68=0.2580 $rb68=3.5590
$zb68=0.2580
rc68=3.5590 $zc68=0.0000 $rd68=3.5710
$zd68=0.0000
/com
k.kmx+1,ra27,za27 $k.kmx+2,rb27,zb27
k.kmx+3,rc27,zc27 $k.kmx+4,rd27,zd27
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra28,za28 $k.kmx+2,rb28,zb28
k.kmx+3,rc28,zc28 $k.kmx+4,rd28,zd28
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra29,za29 $k.kmx+2,rb29,zb29
k.kmx+3,rc29,zc29 $k.kmx+4,rd29,zd29
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra30,za30 $k.kmx+2,rb30,zb30
k.kmx+3,rc30,zc30 $k.kmx+4,rd30,zd30
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra31,za31 $k.kmx+2,rb31,zb31
k.kmx+3,rc31,zc31 $k.kmx+4,rd31,zd31
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra32,za32 $k.kmx+2,rb32,zb32
k.kmx+3,rc32,zc32 $k.kmx+4,rd32,zd32
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra33,za33 $k.kmx+2,rb33,zb33
k.kmx+3,rc33,zc33 $k.kmx+4,rd33,zd33
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra34,za34 $k.kmx+2,rb34,zb34
k.kmx+3,rc34,zc34 $k.kmx+4,rd34,zd34
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra35,za35 $k.kmx+2,rb35,zb35
k.kmx+3,rc35,zc35 $k.kmx+4,rd35,zd35
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra36,za36 $k.kmx+2,rb36,zb36
k.kmx+3,rc36,zc36 $k.kmx+4,rd36,zd36
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra37,za37 $k.kmx+2,rb37,zb37
k.kmx+3,rc37,zc37 $k.kmx+4,rd37,zd37
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra38,za38 $k.kmx+2,rb38,zb38
k.kmx+3,rc38,zc38 $k.kmx+4,rd38,zd38
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra39,za39 $k.kmx+2,rb39,zb39
k.kmx+3,rc39,zc39 $k.kmx+4,rd39,zd39
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra40,za40 $k.kmx+2,rb40,zb40
k.kmx+3,rc40,zc40 $k.kmx+4,rd40,zd40
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
```

```
kmx=kmx+4
k.kmx+1,ra41,za41 $k.kmx+2,rb41,zb41
k.kmx+3,rc41,zc41 $k.kmx+4,rd41,zd41
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra42,za42 $k.kmx+2,rb42,zb42
k.kmx+3,rc42,zc42 $k.kmx+4,rd42,zd42
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra43,za43 $k.kmx+2,rb43,zb43
k.kmx+3,rc43,zc43 $k.kmx+4,rd43,zd43
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra44,za44 $k.kmx+2,rb44,zb44
k.kmx+3,rc44,zc44 $k.kmx+4,rd44,zd44
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra45,za45 $k.kmx+2,rb45,zb45
k.kmx+3,rc45,zc45 $k.kmx+4,rd45,zd45
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra46,za46 $k.kmx+2,rb46,zb46
k.kmx+3,rc46,zc46 $k.kmx+4,rd46,zd46
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra47,za47 $k.kmx+2,rb47,zb47
k.kmx+3,rc47,zc47 $k.kmx+4,rd47,zd47
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra48,za48 $k.kmx+2,rb48,zb48
k.kmx+3,rc48,zc48 $k.kmx+4,rd48,zd48
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra49,za49 $k.kmx+2,rb49,zb49
k.kmx+3,rc49,zc49 $k.kmx+4,rd49,zd49
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra50,za50 $k.kmx+2,rb50,zb50
k.kmx+3,rc50,zc50 $k.kmx+4,rd50,zd50
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra51,za51 $k.kmx+2,rb51,zb51
k.kmx+3,rc51,zc51 $k.kmx+4,rd51,zd51
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra52,za52 $k.kmx+2,rb52,zb52
k.kmx+3,rc52,zc52 $k.kmx+4,rd52,zd52
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra53,za53 $k.kmx+2,rb53,zb53
k.kmx+3,rc53,zc53 $k.kmx+4,rd53,zd53
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra54,za54 $k.kmx+2,rb54,zb54
k.kmx+3,rc54,zc54 $k.kmx+4,rd54,zd54
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra55,za55 $k.kmx+2,rb55,zb55
k.kmx+3,rc55,zc55 $k.kmx+4,rd55,zd55
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra56,za56 $k.kmx+2,rb56,zb56
k.kmx+3,rc56,zc56 $k.kmx+4,rd56,zd56
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra57,za57 $k.kmx+2,rb57,zb57
k.kmx+3,rc57,zc57 $k.kmx+4,rd57,zd57
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra58,za58 $k.kmx+2,rb58,zb58
k.kmx+3,rc58,zc58 $k.kmx+4,rd58,zd58
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra59,za59 $k.kmx+2,rb59,zb59
k.kmx+3,rc59,zc59 $k.kmx+4,rd59,zd59
l.kmx+1,kmx+2 $l.kmx+2,kmx+3
$*get.lc,line_num,max
l.kmx+3,kmx+4 $l.kmx+4,kmx+1
$*get.ld,line_num,max
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra60,za60 $k.kmx+2,rb60,zb60
k.kmx+3,rc60,zc60 $k.kmx+4,rd60,zd60
l.kmx+1,kmx+2 $l.kmx+2,kmx+3
$*get.lx,line_num,max
l.kmx+3,kmx+4 $l.kmx+4,kmx+1
$*get.ly,line_num,max
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra61,za61 $k.kmx+2,rb61,zb61
k.kmx+3,rc61,zc61 $k.kmx+4,rd61,zd61
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra62,za62 $k.kmx+2,rb62,zb62
k.kmx+3,rc62,zc62 $k.kmx+4,rd62,zd62
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra63,za63 $k.kmx+2,rb63,zb63
k.kmx+3,rc63,zc63 $k.kmx+4,rd63,zd63
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra64,za64 $k.kmx+2,rb64,zb64
k.kmx+3,rc64,zc64 $k.kmx+4,rd64,zd64
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra65,za65 $k.kmx+2,rb65,zb65
k.kmx+3,rc65,zc65 $k.kmx+4,rd65,zd65
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra66,za66 $k.kmx+2,rb66,zb66
k.kmx+3,rc66,zc66 $k.kmx+4,rd66,zd66
l.kmx+1,kmx+2 $l.kmx+2,kmx+3
$*get.la,line_num,max
l.kmx+3,kmx+4 $l.kmx+4,kmx+1
$*get.lb,line_num,max
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra67,za67 $k.kmx+2,rb67,zb67
k.kmx+3,rc67,zc67 $k.kmx+4,rd67,zd67
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k.kmx+1,ra68,za68 $k.kmx+2,rb68,zb68
k.kmx+3,rc68,zc68 $k.kmx+4,rd68,zd68
l.kmx+1,kmx+2 $l.kmx+2,kmx+3 $l.kmx+3,kmx+4
$l.kmx+4,kmx+1
a.kmx+1,kmx+2,kmx+3,kmx+4
/com
/com  ********************************
/com  rework area avv+34, and avv+40
adel,avv+33 $adel,avv+34 $adel,avv+40
ldel,ld
l,kmx-19,kmx-26
ldel,lx $ldel,ly
l,kmx-21,kmx-12 $l,kmx-11,kmx-31
ldel,la $ldel,lb
l,kmx-9,kmx-5 $l,kmx-7,kmx-4
nummrg,kp,1e-4
al,lc-3,lc,lc+1,ld+13,ld,ld+5
al,lx-67,lx+9,lx,lx+17,lx+1,lx+19,lx+2
al,la,la+1,lb,la-1,la-3
/com  lx= $ly= $lc= $ld=
/com  ********************************
esize,pdr6/2  $type,1 $mat,21
amesh,avv+1  $amesh,avv+2 $amesh,avv+3
amesh,avv+4  $amesh,avv+5  $amesh,avv+6
amesh,avv+7  $amesh,avv+8  $amesh,avv+9
amesh,avv+10 $amesh,avv+11 $amesh,avv+12
amesh,avv+13 $amesh,avv+14 $amesh,avv+15
amesh,avv+16 $amesh,avv+17 $amesh,avv+18
amesh,avv+19 $amesh,avv+20 $amesh,avv+21
amesh,avv+22 $amesh,avv+23 $amesh,avv+24
amesh,avv+25 $amesh,avv+26 $amesh,avv+27
amesh,avv+28 $amesh,avv+29 $amesh,avv+30
amesh,avv+31 $amesh,avv+32 $amesh,avv+33
amesh,avv+34 $amesh,avv+35 $amesh,avv+36
amesh,avv+37 $amesh,avv+38 $amesh,avv+39
amesh,avv+40 $amesh,avv+41 $amesh,avv+42
/com delete params
rx27= $rx28= $rx29= $rx30= $rx31= $rx32= $rx33=
$rx34= $rx35=
rb27= $rb28= $rb29= $rb30= $rb31= $rb32= $rb33=
$rb34= $rb35=
rc27= $rc28= $rc29= $rc30= $rc31= $rc32= $rc33=
$rc34= $rc35=
rd27= $rd28= $rd29= $rd30= $rd31= $rd32= $rd33=
$rd34= $rd35=
za27= $za28= $za29= $za30= $za31= $za32= $za33=
$za34= $za35=
zb27= $zb28= $zb29= $zb30= $zb31= $zb32= $zb33=
$zb34= $zb35=
zc27= $zc28= $zc29= $zc30= $zc31= $zc32= $zc33=
$zc34= $zc35=
zd27= $zd28= $zd29= $zd30= $zd31= $zd32= $zd33=
$zd34= $zd35=
ra37= $ra38= $ra39= $ra40= $ra41= $ra42= $ra43=
$ra44= $ra45= $ra46=
rb37= $rb38= $rb39= $rb40= $rb41= $rb42= $rb43=
$rb44= $rb45= $rb46=
rc37= $rc38= $rc39= $rc40= $rc41= $rc42= $rc43=
$rc44= $rc45= $rc46=
rd37= $rd38= $rd39= $rd40= $rd41= $rd42= $rd43=
$rd44= $rd45= $rd46=
za37= $za38= $za39= $za40= $za41= $za42= $za43=
$za44= $za45= $za46=
zb37= $zb38= $zb39= $zb40= $zb41= $zb42= $zb43=
$zb44= $zb45= $zb46=
zc37= $zc38= $zc39= $zc40= $zc41= $zc42= $zc43=
$zc44= $zc45= $zc46=
zd37= $zd38= $zd39= $zd40= $zd41= $zd42= $zd43=
$zd44= $zd45= $zd46=
ra47= $ra48= $ra49= $ra50= $ra51= $ra52= $ra53=
$ra54= $ra55= $ra56=
rb47= $rb48= $rb49= $rb50= $rb51= $rb52= $rb53=
$rb54= $rb55= $rb56=
rc47= $rc48= $rc49= $rc50= $rc51= $rc52= $rc53=
$rc54= $rc55= $rc56=
rd47= $rd48= $rd49= $rd50= $rd51= $rd52= $rd53=
$rd54= $rd55= $rd56=
za47= $za48= $za49= $za50= $za51= $za52= $za53=
$za54= $za55= $za56=
zb47= $zb48= $zb49= $zb50= $zb51= $zb52= $zb53=
$zb54= $zb55= $zb56=
zc47= $zc48= $zc49= $zc50= $zc51= $zc52= $zc53=
$zc54= $zc55= $zc56=
zd47= $zd48= $zd49= $zd50= $zd51= $zd52= $zd53=
$zd54= $zd55= $zd56=
ra57= $ra58= $ra59= $ra60= $ra61= $ra62= $ra63=
$ra64= $ra65= $ra66=
rb57= $rb58= $rb59= $rb60= $rb61= $rb62= $rb63=
$rb64= $rb65= $rb66=
rc57= $rc58= $rc59= $rc60= $rc61= $rc62= $rc63=
$rc64= $rc65= $rc66=
rd57= $rd58= $rd59= $rd60= $rd61= $rd62= $rd63=
$rd64= $rd65= $rd66=
za57= $za58= $za59= $za60= $za61= $za62= $za63=
$za64= $za65= $za66=
zb57= $zb58= $zb59= $zb60= $zb61= $zb62= $zb63=
$zb64= $zb65= $zb66=
zc57= $zc58= $zc59= $zc60= $zc61= $zc62= $zc63=
$zc64= $zc65= $zc66=
zd57= $zd58= $zd59= $zd60= $zd61= $zd62= $zd63=
$zd64= $zd65= $zd66=
```

```
/com
/com
/com
/com UPPER INBOARD STRUCTURE
/com parameter table is full, so start numbering at 27
rather
/com than 111. This way we overwrite vacuum vessel
labels
ra27=1.5940 $za27=0.1380 $rb27=1.6270
$zb27=0.1380
rc27=1.6270 $zc27=0.2450 $rd27=1.5940
$zd27=0.2450
ra28=1.5940 $za28=0.2450 $rb28=1.6270
$zb28=0.2450
rc28=1.6270 $zc28=0.3530 $rd28=1.5940
$zd28=0.3530
ra29=1.5940 $za29=0.3530 $rb29=1.6270
$zb29=0.3530
rc29=1.6270 $zc29=0.4600 $rd29=1.5940
$zd29=0.4600
ra30=1.5940 $za30=0.4600 $rb30=1.6270
$zb30=0.4600
rc30=1.6270 $zc30=0.5680 $rd30=1.5940
$zd30=0.5680
ra31=1.5940 $za31=0.5680 $rb31=1.6270
$zb31=0.5680
rc31=1.6270 $zc31=0.6760 $rd31=1.5940
$zd31=0.6760
/com
*get,ais.area,,num.max
kmx=kmx+4
k,kmx+1,ra27,za27 $k,kmx+2,rb27,zb27
k,kmx+3,rc27,zc27 $k,kmx+4,rd27,zd27
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra28,za28 $k,kmx+2,rb28,zb28
k,kmx+3,rc28,zc28 $k,kmx+4,rd28,zd28
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra29,za29 $k,kmx+2,rb29,zb29
k,kmx+3,rc29,zc29 $k,kmx+4,rd29,zd29
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra30,za30 $k,kmx+2,rb30,zb30
k,kmx+3,rc30,zc30 $k,kmx+4,rd30,zd30
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra31,za31 $k,kmx+2,rb31,zb31
k,kmx+3,rc31,zc31 $k,kmx+4,rd31,zd31
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
numrmrg,kp,1e-4
esize,pdr6/2 $type,1 $mat,21
amesh,ais+1 $amesh,ais+2 $amesh,ais+3
amesh,ais+4 $amesh,ais+5
/com delete params
ra27= $ra28= $ra29= $ra30= $ra31=
rb27= $rb28= $rb29= $rb30= $rb31=
rc27= $rc28= $rc29= $rc30= $rc31=
rd27= $rd28= $rd29= $rd30= $rd31=
za27= $za28= $za29= $za30= $za31=
zb27= $zb28= $zb29= $zb30= $zb31=
zc27= $zc28= $zc29= $zc30= $zc31=
zd27= $zd28= $zd29= $zd30= $zd31=
/com
/com
/com
/com UPPER OUBOARD STRUCTURE
/com parameter table is full, so start numbering at 27
rather
/com than 121. This way we overwrite vacuum vessel
labels
ra27=2.3350 $za27=1.1560 $rb27=2.3030
$zb27=1.1560
rc27=2.3030 $zc27=1.0380 $rd27=2.3350
$zd27=1.0380
ra28=2.3350 $za28=1.0380 $rb28=2.3030
$zb28=1.0380
rc28=2.3030 $zc28=0.9200 $rd28=2.3350
$zd28=0.9200
ra29=2.3350 $za29=0.9200 $rb29=2.3030
$zb29=0.9200
rc29=2.3520 $zc29=0.8750 $rd29=2.3850
$zd29=0.8750
ra30=2.3850 $za30=0.8750 $rb30=2.3520
$zb30=0.8750
rc30=2.4020 $zc30=0.8310 $rd30=2.4350
$zd30=0.8310
ra31=2.5370 $za31=0.9190 $rb31=2.5040
$zb31=0.9190
rc31=2.5050 $zc31=0.8210 $rd31=2.5380
$zd31=0.8210
ra32=2.5380 $za32=0.8210 $rb32=2.5050
$zb32=0.8210
rc32=2.5060 $zc32=0.7220 $rd32=2.5390
$zd32=0.7220
ra33=2.5390 $za33=0.7220 $rb33=2.5060
$zb33=0.7220
rc33=2.5610 $zc33=0.6490 $rd33=2.5940
$zd33=0.6490
ra34=2.5940 $za34=0.6490 $rb34=2.5610
$zb34=0.6490
rc34=2.6160 $zc34=0.5770 $rd34=2.6490
$zd34=0.5770
ra35=2.6490 $za35=0.5770 $rb35=2.6160
$zb35=0.5770
rc35=2.6600 $zc35=0.4980 $rd35=2.6930
$zd35=0.4980
ra36=2.6930 $za36=0.4980 $rb36=2.6600
$zb36=0.4980
rc36=2.7040 $zc36=0.4190 $rd36=2.7370
$zd36=0.4190
/com
*get,aos.area,,num.max
kmx=kmx+4
k,kmx+1,ra27,za27 $k,kmx+2,rb27,zb27
k,kmx+3,rc27,zc27 $k,kmx+4,rd27,zd27
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra28,za28 $k,kmx+2,rb28,zb28
k,kmx+3,rc28,zc28 $k,kmx+4,rd28,zd28
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra29,za29 $k,kmx+2,rb29,zb29
k,kmx+3,rc29,zc29 $k,kmx+4,rd29,zd29
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra30,za30 $k,kmx+2,rb30,zb30
k,kmx+3,rc30,zc30 $k,kmx+4,rd30,zd30
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra31,za31 $k,kmx+2,rb31,zb31
k,kmx+3,rc31,zc31 $k,kmx+4,rd31,zd31
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra32,za32 $k,kmx+2,rb32,zb32
k,kmx+3,rc32,zc32 $k,kmx+4,rd32,zd32
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra33,za33 $k,kmx+2,rb33,zb33
k,kmx+3,rc33,zc33 $k,kmx+4,rd33,zd33
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra34,za34 $k,kmx+2,rb34,zb34
k,kmx+3,rc34,zc34 $k,kmx+4,rd34,zd34
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra35,za35 $k,kmx+2,rb35,zb35
k,kmx+3,rc35,zc35 $k,kmx+4,rd35,zd35
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra36,za36 $k,kmx+2,rb36,zb36
k,kmx+3,rc36,zc36 $k,kmx+4,rd36,zd36
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
numrmrg,kp,1e-4
esize,pdr6/2 $type,1 $mat,21
amesh,aos+1 $amesh,aos+2 $amesh,aos+3
amesh,aos+4 $amesh,aos+5 $amesh,aos+6
amesh,aos+7 $amesh,aos+8 $amesh,aos+9
amesh,aos+10
/com delete params
ra27= $ra28= $ra29= $ra30= $ra31= $ra32= $ra33=
$ra34= $ra35= $ra36=
rb27= $rb28= $rb29= $rb30= $rb31= $rb32= $rb33=
$rb34= $rb35= $rb36=
rc27= $rc28= $rc29= $rc30= $rc31= $rc32= $rc33=
$rc34= $rc35= $rc36=
rd27= $rd28= $rd29= $rd30= $rd31= $rd32= $rd33=
$rd34= $rd35= $rd36=
za27= $za28= $za29= $za30= $za31= $za32= $za33=
$za34= $za35= $za36=
zb27= $zb28= $zb29= $zb30= $zb31= $zb32= $zb33=
$zb34= $zb35= $zb36=
zc27= $zc28= $zc29= $zc30= $zc31= $zc32= $zc33=
$zc34= $zc35= $zc36=
zd27= $zd28= $zd29= $zd30= $zd31= $zd32= $zd33=
$zd34= $zd35= $zd36=
/com
/com
/com
/com OUTER CRYOSTAT STRUCTURE
/com parameter table is full, so start numbering at 27
rather
/com than 121. This way we overwrite vacuum vessel
labels
ra27=0.0000 $za27=3.8090 $rb27=0.0000
$zb27=3.7450
rc27=0.7790 $zc27=3.7450 $rd27=0.7790
$zd27=3.8090
ra28=0.7790 $za28=3.8090 $rb28=0.7790
$zb28=3.7450
rc28=1.5580 $zc28=3.7450 $rd28=1.5580
$zd28=3.8090
ra29=1.5580 $za29=3.8090 $rb29=1.5580
$zb29=3.7450
rc29=2.3370 $zc29=3.7450 $rd29=2.3370
$zd29=3.8090
ra30=2.3370 $za30=3.8090 $rb30=2.3370
$zb30=3.7450
rc30=3.1160 $zc30=3.7450 $rd30=3.1160
$zd30=3.8090
ra31=3.1160 $za31=3.8090 $rb31=3.1160
$zb31=3.7450
rc31=3.8950 $zc31=3.7450 $rd31=3.8950
$zd31=3.8090
ra32=3.8950 $za32=3.8090 $rb32=3.8950
$zb32=3.7450
rc32=4.6740 $zc32=3.7450 $rd32=4.6740
$zd32=3.8090
ra33=4.7370 $za33=3.8090 $rb33=4.6740
$zb33=3.8090
rc33=4.6740 $zc33=3.7450 $rd33=4.7370
$zd33=3.7450
ra34=4.7370 $za34=3.7450 $rb34=4.6740
$zb34=3.7450
rc34=4.6740 $zc34=2.4840 $rd34=4.7370
$zd34=2.4840
ra35=4.7370 $za35=2.4840 $rb35=4.6740
$zb35=2.4840
rc35=4.6740 $zc35=1.8310 $rd35=4.7370
$zd35=1.8310
ra36=4.7370 $za36=1.8310 $rb36=4.6740
$zb36=1.8310
rc36=4.6740 $zc36=1.2210 $rd36=4.7370
$zd36=1.2210
ra37=4.7370 $za37=1.2210 $rb37=4.6740
$zb37=1.2210
rc37=4.6740 $zc37=0.6100 $rd37=4.7370
$zd37=0.6100
ra38=4.7370 $za38=0.6100 $rb38=4.6740
$zb38=0.6100
rc38=4.6740 $zc38=0.0000 $rd38=4.7370
$zd38=0.0000
rinf=2*ra33
zinf=2*za33
/com
*get,acr.area,,num.max
kmx=kmx+4
k,kmx+1,ra27,za27 $k,kmx+2,rb27,zb27
k,kmx+3,rc27,zc27 $k,kmx+4,rd27,zd27
```

```
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra28,za28 $k,kmx+2,rb28,zb28
k,kmx+3,rc28,zc28 $k,kmx+4,rd28,zd28
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra29,za29 $k,kmx+2,rb29,zb29
k,kmx+3,rc29,zc29 $k,kmx+4,rd29,zd29
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra30,za30 $k,kmx+2,rb30,zb30
k,kmx+3,rc30,zc30 $k,kmx+4,rd30,zd30
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra31,za31 $k,kmx+2,rb31,zb31
k,kmx+3,rc31,zc31 $k,kmx+4,rd31,zd31
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra32,za32 $k,kmx+2,rb32,zb32
k,kmx+3,rc32,zc32 $k,kmx+4,rd32,zd32
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra33,za33 $k,kmx+2,rb33,zb33
k,kmx+3,rc33,zc33 $k,kmx+4,rd33,zd33
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra34,za34 $k,kmx+2,rb34,zb34
k,kmx+3,rc34,zc34 $k,kmx+4,rd34,zd34
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra35,za35 $k,kmx+2,rb35,zb35
k,kmx+3,rc35,zc35 $k,kmx+4,rd35,zd35
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra36,za36 $k,kmx+2,rb36,zb36
k,kmx+3,rc36,zc36 $k,kmx+4,rd36,zd36
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra37,za37 $k,kmx+2,rb37,zb37
k,kmx+3,rc37,zc37 $k,kmx+4,rd37,zd37
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
kmx=kmx+4
k,kmx+1,ra38,za38 $k,kmx+2,rb38,zb38
k,kmx+3,rc38,zc38 $k,kmx+4,rd38,zd38
l,kmx+1,kmx+2 $l,kmx+2,kmx+3 $l,kmx+3,kmx+4
$l,kmx+4,kmx+1
a,kmx+1,kmx+2,kmx+3,kmx+4
nummrg,kp,1e-4
esize,pdr6/2 $type,1 $mat,21
amesh,acr+1 $amesh,acr+2 $amesh,acr+3
amesh,acr+4 $amesh,acr+5 $amesh,acr+6
amesh,acr+7 $amesh,acr+8 $amesh,acr+9
amesh,acr+10 $amesh,acr+11 $amesh,acr+12
/com delete params
ra27= $ra28= $ra29= $ra30= $ra31= $ra32= $ra33=
$ra34= $ra35= $ra36=
rb27= $rb28= $rb29= $rb30= $rb31= $rb32= $rb33=
$rb34= $rb35= $rb36=
rc27= $rc28= $rc29= $rc30= $rc31= $rc32= $rc33=
$rc34= $rc35= $rc36=
rd27= $rd28= $rd29= $rd30= $rd31= $rd32= $rd33=
$rd34= $rd35= $rd36=
za27= $za28= $za29= $za30= $za31= $za32= $za33=
$za34= $za35= $za36=
zb27= $zb28= $zb29= $zb30= $zb31= $zb32= $zb33=
$zb34= $zb35= $zb36=
zc27= $zc28= $zc29= $zc30= $zc31= $zc32= $zc33=
$zc34= $zc35= $zc36=
zd27= $zd28= $zd29= $zd30= $zd31= $zd32= $zd33=
$zd34= $zd35= $zd36=
ra37= $ra38=
rb37= $rb38=
rc37= $rc38=
rd37= $rd38=
za37= $za38=
zb37= $zb38=
zc37= $zc38=
zd37= $zd38=
/com
/com
/com FREE SPACE REGIONS
/com inside of cs
kmx=kmx+4
*get,afre,area,,num,max
z1=pz1-pdz1/2  $z2=pz4+pdz4/2
k,kmx+1,0,0
k,kmx+2,0,z2
lsel,none
l,kmx+1,kmx+2,15
l,koff+6,kmx+1,12,2
l,koff+18,kmx+2,12,2
ksel,s,,koff+1 $ksel,a,,koff+4 $ksel,a,,koff+6
$ksel,a,,koff+7
ksel,a,,koff+10 $ksel,a,,koff+11 $ksel,a,,koff+14
$ksel,a,,koff+15
ksel,a,,koff+18 $ksel,a,,koff+319 $ksel,a,,koff+320
lskp,1
al,all
*get,ax,area,,num,max
mat,20  $amesh,ax $lsll $kpall
/com
/com  Area above cs
z1=pz5+pdz5/2
kmx=kmx+2
k,kmx+1,0,z1
l,koff+17,koff+19,10
l,koff+22,kmx+1,15,2
l,kmx,kmx+1,9
ksel,s,,koff+17 $ksel,a,,koff+18 $ksel,a,,koff+19
$ksel,a,,koff+22
ksel,a,,koff+320 $ksel,a,,koff+321
lskp,1 $al,all
*get,ax,area,,num,max
mat,20  $amesh,ax $lsll $kpall
/com
/com  Area between cs and vacuum vessel
l,koff+5,koff+43,12,2
l,koff+16,koff+58,12,2
ksel,s,,koff+2 $ksel,a,,koff+3 $ksel,a,,koff+5
$ksel,a,,koff+8
ksel,a,,koff+9 $ksel,a,,koff+12 $ksel,a,,koff+13
$ksel,a,,koff+43
ksel,a,,koff+46 $ksel,a,,koff+50 $ksel,a,,koff+54
ksel,a,,koff+58 $ksel,a,,koff+16
lskp,1
al,all  $*get,ax,area,,num,max $amesh,ax
/com
/com area just above cs between vv and cs
lsel,all  $kpall
l,koff+20,koff+70,12
ksel,s,,koff+16 $ksel,a,,koff+17 $ksel,a,,koff+19
ksel,a,,koff+20 $ksel,a,,koff+58 $ksel,a,,koff+62
$ksel,a,,koff+66
ksel,a,,koff+70 $lskp,1
al,all  $*get,ax,area,,num,max $amesh,ax  $lsll  $kpall
/com
/com  above vacuum vessel
l,koff+39,koff+90,14,3
l,koff+42,koff+21,30,2
ksel,s,,koff+20 $ksel,a,,koff+21 $ksel,a,,koff+39
$ksel,a,,koff+42
ksel,a,,koff+70 $ksel,a,,koff+74 $ksel,a,,koff+78
$ksel,a,,koff+82
ksel,a,,koff+86 $ksel,a,,koff+90 $lskp,1
al,all  $*get,ax,area,,num,max $amesh,ax
lsel,all  $kpall
/com
/com  above vv right side region to pf6
/com
l,koff+26,koff+40,12
l,koff+23,koff+98,12,2
ksel,s,,koff+23 $ksel,a,,koff+26 $ksel,a,,koff+39
$ksel,a,,koff+40
ksel,a,,koff+90 $ksel,a,,koff+94 $ksel,a,,koff+98
$lskp,1
al,all  $*get,ax,area,,num,max $amesh,ax
/com
/com  area to right of vv
lsel,all  $kpall
l,koff+27,koff+110,12,2
l,koff+30,koff+24,18
ksel,s,,koff+23 $ksel,a,,koff+24 $ksel,a,,koff+27
$ksel,a,,koff+30
ksel,a,,koff+98 $ksel,a,,koff+102 $ksel,a,,koff+106
ksel,a,,koff+110 $lskp,1
al,all  $*get,ax,area,,num,max $amesh,ax
/com
/com  lower right of vv
lsel,all  $kpall
l,koff+210,koff+317,12
l,koff+28,koff+313,9,2
ksel,s,,koff+27 $ksel,a,,koff+28 $ksel,a,,koff+110
$ksel,a,,koff+195
ksel,a,,koff+198 $ksel,a,,koff+199 $ksel,a,,koff+202
ksel,a,,koff+206 $ksel,a,,koff+210 $ksel,a,,koff+313
ksel,a,,koff+317 $lskp,1
al,all  $*get,ax,area,,num,max $amesh,ax
lsel,all  $kpall
/com
/com  INSIDE OF VV LOWER RIGHT
l,koff+36,koff+209,15
l,koff+37,koff+265,1
l,koff+266,koff+31,6
l,koff+33,koff+173,6
ksel,s,,koff+31 $ksel,a,,koff+32 $ksel,a,,koff+33
$ksel,a,,koff+36
ksel,a,,koff+37 $ksel,a,,koff+173 $ksel,a,,koff+174
ksel,a,,koff+177 $ksel,a,,koff+178 $ksel,a,,koff+189
ksel,a,,koff+197 $ksel,a,,koff+201 $ksel,a,,koff+205
ksel,a,,koff+209 $ksel,a,,koff+265 $ksel,a,,koff+266
ksel,a,,koff+269 $ksel,a,,koff+270 $lskp,1
ksel,s,,koff+265 $ksel,a,,koff+266 $lslk,u,1
al,all  $*get,ax,area,,num,max $amesh,ax
lsll  $kpall
/com
l,koff+247,koff+161,12
ksel,s,,koff+31 $ksel,a,,koff+33 $ksel,a,,koff+34
$ksel,a,,koff+161
ksel,a,,koff+165 $ksel,a,,koff+169 $ksel,a,,koff+173
ksel,a,,koff+247 $ksel,a,,koff+250 $ksel,a,,koff+254
ksel,a,,koff+258 $ksel,a,,koff+262 $ksel,a,,koff+266
$lskp,1
al,all  $*get,ax,area,,num,max $amesh,ax
lsll  $kpall
/com
l,koff+145,koff+232,12
l,koff+246,koff+249,2
ksel,s,,koff+145 $ksel,a,,koff+149 $ksel,a,,koff+153
ksel,a,,koff+157
ksel,a,,koff+161 $ksel,a,,koff+231 $ksel,a,,koff+232
ksel,a,,koff+234 $ksel,a,,koff+238 $ksel,a,,koff+242
ksel,a,,koff+246 $ksel,a,,koff+247 $ksel,a,,koff+248
ksel,a,,koff+249  $lskp,1
al,all  $*get,ax,area,,num,max $amesh,ax
lsll  $kpall
/com
l,koff+121,koff+237,16
ksel,s,,koff+121 $ksel,a,,koff+125 $ksel,a,,koff+129
ksel,a,,koff+133
ksel,a,,koff+137 $ksel,a,,koff+141 $ksel,a,,koff+145
ksel,a,,koff+232 $ksel,a,,koff+233 $ksel,a,,koff+237
lskp,1
al,all  $*get,ax,area,,num,max $amesh,ax
lsll  $kpall
/com
l,koff+230,koff+121,5
l,koff+229,koff+38,6
ksel,s,,koff+37 $ksel,a,,koff+38 $ksel,a,,koff+121
ksel,a,,koff+229
ksel,a,,koff+230 $ksel,a,,koff+237 $ksel,a,,koff+241
ksel,a,,koff+245 $ksel,a,,koff+246 $ksel,a,,koff+249
ksel,a,,koff+253 $ksel,a,,koff+257 $ksel,a,,koff+261
ksel,a,,koff+265  $lskp,1
al,all  $*get,ax,area,,num,max $amesh,ax
lsll  $kpall
/com
l,koff+35,koff+112,8
ksel,s,,koff+35 $ksel,a,,koff+38 $ksel,a,,koff+112
ksel,a,,koff+113
ksel,a,,koff+117 $ksel,a,,koff+121 $ksel,a,,koff+211
ksel,a,,koff+212 $ksel,a,,koff+213 $ksel,a,,koff+214
ksel,a,,koff+217 $ksel,a,,koff+218 $ksel,a,,koff+221
ksel,a,,koff+222 $ksel,a,,koff+225 $ksel,a,,koff+226
ksel,a,,koff+229  $ksel,a,,koff+230 $lskp,1
ksel,s,,koff+230 $ksel,a,,koff+229 $lslk,u,1
ksel,s,,koff+226 $ksel,a,,koff+225 $lslk,u,1
ksel,s,,koff+222 $ksel,a,,koff+221 $lslk,u,1
ksel,s,,koff+218 $ksel,a,,koff+217 $lslk,u,1
```

```
ksel,s,,koff+214 $ksel,a,,koff+213 $lslk,u,1
al,all S*get,ax,area,,num,max $amesh,ax
lsll $kpall
/com
/com REGION BETWEEN VV
l,koff+44,koff+111,4
l,koff+57,koff+126,4
ksel,s,,koff+44 $ksel,a,,koff+45 $ksel,a,,koff+49
ksel,a,,koff+53
ksel,a,,koff+57 $ksel,a,,koff+111 $ksel,a,,koff+114
ksel,a,,koff+118 $ksel,a,,koff+122 $ksel,a,,koff+126
lskp,1
al,all S*get,ax,area,,num,max $amesh,ax
lsll $kpall
/com
l,koff+77,koff+146,4
ksel,s,,koff+57 $ksel,a,,koff+61 $ksel,a,,koff+65
ksel,a,,koff+69
ksel,a,,koff+73 $ksel,a,,koff+77 $ksel,a,,koff+126
ksel,a,,koff+130 $ksel,a,,koff+134 $ksel,a,,koff+138
ksel,a,,koff+142 $ksel,a,,koff+146
lskp,1
al,all S*get,ax,area,,num,max $amesh,ax
lsll $kpall
/com
ksel,s,,koff+77 $ksel,a,,koff+81 $ksel,a,,koff+85
ksel,a,,koff+89
ksel,a,,koff+93 $ksel,a,,koff+97 $ksel,a,,koff+101
ksel,a,,koff+105 $ksel,a,,koff+109 $ksel,a,,koff+146
ksel,a,,koff+150 $ksel,a,,koff+154 $ksel,a,,koff+158
ksel,a,,koff+162 $ksel,a,,koff+166 $ksel,a,,koff+170
ksel,a,,koff+182
lskp,1
al,all S*get,ax,area,,num,max $amesh,ax
lsll $kpall
/com
ksel,s,,koff+180 $ksel,a,,koff+181 $ksel,a,,koff+185
ksel,a,,koff+187
ksel,a,,koff+190 $ksel,a,,koff+194
lskp,1
al,all S*get,ax,area,,num,max $amesh,ax
lsll $kpall
/com
/com External to PF6 and 7 but inside cryostat
l,koff+41,koff+289,20,3
ksel,s,,koff+24 $ksel,a,,koff+25 $ksel,a,,koff+26
ksel,a,,koff+28
ksel,a,,koff+29 $ksel,a,,koff+30 $ksel,a,,koff+40
ksel,a,,koff+41 $ksel,a,,koff+289 $ksel,a,,koff+293
ksel,a,,koff+301 $ksel,a,,koff+305 $ksel,a,,koff+309
ksel,a,,koff+313
lskp,1
al,all S*get,ax,area,,num,max $amesh,ax
lsll $kpall
/com
l,koff+21,koff+277,15
ksel,s,,koff+21 $ksel,a,,koff+41 $ksel,a,,koff+42
ksel,a,,koff+277
ksel,a,,koff+281 $ksel,a,,koff+285 $ksel,a,,koff+289
lskp,1
al,all S*get,ax,area,,num,max $amesh,ax
lsll $kpall
/com
l,koff+321,koff+272,14
ksel,s,,koff+21 $ksel,a,,koff+22 $ksel,a,,koff+272
ksel,a,,koff+273
ksel,a,,koff+277 $ksel,a,,koff+321
lskp,1
al,all S*get,ax,area,,num,max $amesh,ax
lsll $kpall
/com
/com EXTERNAL to CRYOSTAT
kmx=kmx+1
*get,rinf,area,,num,max
k,kmx+1,rnf,0
k,kmx+2,rinf,zinf
k,kmx+3,0,zinf
l,kmx+1,kmx+2,15
l,kmx+2,kmx+3,15
l,koff+318,kmx+1,15,4
l,koff+295,kmx+2,20,4,5
l,koff+271,kmx+3,15,4
ksel,s,,koff+295 $ksel,a,,koff+298 $ksel,a,,koff+302
ksel,a,,koff+306
ksel,a,,koff+310 $ksel,a,,koff+314 $ksel,a,,koff+318
ksel,a,,koff+322 $ksel,a,,koff+323
lskp,1
al,all $amesh,rinf+1
lsll $kpall
/com
ksel,s,,koff+271 $ksel,a,,koff+274 $ksel,a,,koff+278
ksel,a,,koff+282
ksel,a,,koff+286 $ksel,a,,koff+290 $ksel,a,,koff+294
ksel,a,,koff+295 $ksel,a,,koff+323 $ksel,a,,koff+324
lskp,1
al,all $amesh,rinf+2
lsel,all $kpall
/com
/com DISTANT INFINITY SPACE
kmx=kmx+3
k,kmx+1,10*rinf,0
k,kmx+2,10*rinf,10*zinf
k,kmx+3,0,10*zinf
l,kmx+1,kmx+2,6
l,kmx+2,kmx+3,6
l,koff+322,kmx+1,12,15
l,koff+323,kmx+2,15,15
l,koff+324,kmx+3,12,15
a,koff+322,kmx+1,kmx+2,koff+323
a,koff+323,kmx+2,kmx+3,koff+324
amesh,rinf+3  $amesh,rinf+4
/com
/com MIRROR areas
kof2=10000
*get,top,area,,num,max
arsym,y,1,avv,1,kof2,0,0  !PF COILS
*get,bvv,area,,num,max
arsym,y,avv+1,ais,1,kof2,0,0  !Vacuum vessel
*get,bis,area,,num,max
arsym,y,ais+1,aos,1,kof2,0,0  !Inner structure
*get,bos,area,,num,max
arsym,y,aos+1,acr,1,kof2,0,0  !Outer structure
*get,bcr,area,,num,max
arsym,y,acr+1,afre,1,kof2,0,0  !cyostat
*get,bfre,area,,num,max
arsym,y,afre+1,rinf,1,kof2,0,0 !Inner free space
regions
*get,binf,area,,num,max
arsym,y,rinf+1,top,1,kof2,0,0 !Infinity regions
/com
/com  Merge only EM regions
asel,all  $asel,u,,1,apf1-1  $lsar  $kpls $earea $nelem
nummrg,node,1e-4
nummrg,kp,1e-4
/com
/com  Clear PF1L region
asel,all  $earea  $nelem
aclear,top+1
/com
/com
/com  boundary conditions (fix potential to zero)
ksel,s,,kof2+koff+327 $ksel,a,,kof2+koff+326
$ksel,a,,koff+325
ksel,a,,koff+326 $ksel,a,,koff+327
lskp,1
nline,1
d,all,az,0.0
/com
/com
/com STITCH PF1U
/com  clear coarse magnetic mesh
asel,all  $asel,u,,1,apf1-1  $lsar $kpls $earea $nelem
aclear,top+afre+2-apf1 $aclear,top-apf1+afre+4
aclear,top+2
/com  delete areas
adel,top+1 $adel,top+afre+2-apf1,,1
adel,top+afre+4-apf1,,1
adel,top+2,,1
/com  reform line on r=0 boundary
l,koff+319,koff+koff+320,20
lsll  $kpall  $eall $nall
/com  form areas above and below PF1L
a,22,26,koff+5,koff+6 $mat,20  $amesh,1877
a,2*koff+4,2*koff+3,21,16 $mat,31 $esize,pdr1/8
$amesh,1878
/com  form area between r=0 and cs (inside cs)
ksel,s,,koff+6 $ksel,a,,2*koff+1 $ksel,a,,2*koff+4
ksel,a,,2*koff+7
ksel,a,,2*koff+18 $ksel,a,,koff+319
$ksel,a,,2*koff+320
ksel,a,,2*koff+10 $ksel,a,,22  $ksel,a,,4 $ksel,a,,9
ksel,a,,16  $ksel,a,,2*koff+15 $ksel,a,,2*koff+11
ksel,a,,2*koff+14
lskp,1 $al,all  $mat,20  $amesh,1960
/com  form area outboard of PF3L
ksel,s,,2*koff+2 $ksel,a,,koff+5 $ksel,a,,koff+43
ksel,a,,2*koff+46 $ksel,a,,2*koff+50
$ksel,a,,2*koff+54
ksel,a,,2*koff+58 $ksel,a,,21 $ksel,a,,11 $ksel,a,,10
ksel,a,,26 $ksel,a,,2*koff+9 $ksel,a,,2*koff+8
$ksel,a,,2*koff+3
ksel,a,,2*koff+16  $ksel,a,,2*koff+12
$ksel,a,,2*koff+13
lskp,1 $al,all
mat,20 $amesh,1962
/com
/com
/com  CURRENT LOADINGS
/com  PF CURRENTS for Equilibria #16
ni1=2.0e6  !plasma current
j9=ni1/(pdr9*pdz9)
asel,s,,apl+1  $earea  $bfe,all,js,3,j9
asel,s,,atop+apl+1-(apf1-1) $earea $bfe,all,js,3,j9
j9=  $ni1=  !clear parameters
/com  PF coils AMPERE TURN LOADING
ni10=-2.997e6  $ni11=-2.997e6  $ni12=-0.751e6
$ni13=-0.751e6
ni14=0.310e6 $ni15=-0.178e6 $ni16=0.437e6
$ni17=0.069e6
ni18=1.892e6 $ni19=3.413e6 $ni20=-1.471e6 $ni21=-
1.874e6
ni22=-0.169e6 $ni23=-0.169e6
ju1=ni10/(pdr1*pdz1) $jl1=ni11/(pdr1*pdz1) $ni10=
ju2=ni12/(pdr2*pdz2) $jl2=ni13/(pdr2*pdz2) $ni12=
$ni13=
ju3=ni14/(pdr3*pdz3) $jl3=ni15/(pdr3*pdz3) $ni15=
ju4=ni16/(pdr4*pdz4) $jl4=ni17/(pdr4*pdz4) $ni16=
$ni17=
ju5=ni18/(pdr5*pdz5) $jl5=ni19/(pdr5*pdz5) $ni18=
$ni19=
ju6=ni20/(pdr6*pdz6) $jl6=ni21/(pdr6*pdz6) $ni20=
$ni21=
ju7=ni22/(pdr7*pdz7) $jl7=ni23/(pdr7*pdz7) $ni22=
$ni23=
asel,s,,apf1  $earea  $bfe,all,js,3,ju1  !PF1U
/com  asel,s,,atop+1  $earea  $bfe,all,js,3,jl1
/com  Calculate currents density for PF1L
asel,s,mat,,13  $asum $*get,ar,area,,area $earea
jl1=0.5*ni11/ar  $bfe,all,js,3,jl1  !PF1L TOP
asel,s,mat,,31  $asum $*get,ar,area,,area $earea
jl1=0.5*ni11/ar  $bfe,all,js,3,jl1 $ni11=  !PF1L
BOT
asel,s,,apf2  $earea  $bfe,all,js,3,ju2  !PF2U
asel,s,,atop+apf2-(apf1-1)  $earea  $bfe,all,js,3,jl2
!PF2L
asel,s,,apf3  $earea  $bfe,all,js,3,ju3  !PF3U
asel,s,,atop+apf3-(apf1-1)  $earea  $bfe,all,js,3,jl3
!PF3L
asel,s,,apf4  $earea  $bfe,all,js,3,ju4  !PF4U
asel,s,,atop+apf4-(apf1-1)  $earea  $bfe,all,js,3,jl4
!PF4L
asel,s,,apf5  $earea  $bfe,all,js,3,ju5  !PF5U
asel,s,,atop+apf5-(apf1-1)  $earea  $bfe,all,js,3,jl5
!PF5L
asel,s,,apf6  $earea  $bfe,all,js,3,ju6  !PF6U
asel,s,,atop+apf6-(apf1-1)  $earea  $bfe,all,js,3,jl6
!PF6L
asel,s,,apf7  $earea  $bfe,all,js,3,ju7  !PF7U
asel,s,,atop+apf7-(apf1-1)  $earea  $bfe,all,js,3,jl7
!PF7L
jl1=  $jl2=  $jl3=  $jl4=  $jl5=  $jl6=  $jl7=
ju1=  $ju2=  $ju3=  $ju4=  $ju5=  $ju6=  $ju7=
/com
/com  IC coils, then TF hoop turn
ni24=0.00  $ni25=0.00  $ni26=3.3480e4
ju8=ni24/(pdr8*pdz8) $jl8=ni25/(pdr8*pdz8) $ni24=
$ni25=
ju10=ni26/(dr10*dz10) $ni26=
asel,s,,aic+1  $earea  $bfe,all,js,3,ju8
!ICUPPER
asel,s,,atop+aic+1-(apf1-1)  $earea  $bfe,all,js,3,jl8
!ICLOWER
asel,s,,atf+1  $earea  $bfe,all,js,3,ju10  !TFIC
ju8=  $jl8=  $ju10=
/com
nall $eall $kpall $lsall $aall
```

Appendix K - WECAN/PLUS command files used for establishing three detailed MAFCO models of 60 turn CS coil

The following are WECAN/PLUS command files used to establish MAFCO models of a 60 turn central solenoid PF coil. The models define the individual turns, radial and vertical transitions and routing of the current return within the conductor pack.

Spiral Case - File gspir.str

```
$ SIXTY TURN SPIRAL COIL
$
define parameter rm 81
define parameter dr 2.54
define parameter dz 2.54
define parameter jog 0
define parameter lift 104.15
$ coil centers
define parameter rc1 -#dr/4
define parameter rc2 #dr/4
$ radii for spirals
define parameter r1 #rm-3*#dr
define parameter r2 #rm-#dr*11/4
define parameter r3 #rm-#dr*10/4
define parameter r4 #rm-#dr*9/4
define parameter r5 #rm-2*#dr
define parameter r6 #rm-#dr*7/4
define parameter r7 #rm-#dr*6/4
define parameter r8 #rm-#dr*5/4
define parameter r9 #rm-#dr
define parameter r10 #rm-#dr*3/4
define parameter r11 #rm-#dr/2
define parameter r12 #rm-#dr/4
define parameter r13 #rm
define parameter r14 #rm+#dr/4
define parameter r15 #rm+#dr*2/4
define parameter r16 #rm+#dr*3/4
define parameter r17 #rm+#dr
define parameter r18 #rm+#dr*5/4
define parameter r19 #rm+#dr*6/4
define parameter r20 #rm+#dr*7/4
define parameter r21 #rm+#dr*2
define parameter r22 #rm+#dr*9/4
define parameter r23 #rm+#dr*10/4
define parameter r24 #rm+#dr*11/4
define parameter r25 #rm+#dr*3
$
$ Individual layer heights
define parameter z1 #lift-#dz*9/2
define parameter z2 #lift-#dz*7/2
define parameter z3 #lift-#dz*5/2
define parameter z4 #lift-#dz*3/2
define parameter z5 #lift-#dz*1/2
define parameter z6 #lift+#dz*1/2
define parameter z7 #lift+#dz*3/2
define parameter z8 #lift+#dz*5/2
define parameter z9 #lift+#dz*7/2
define parameter z10 #lift+#dz*9/2
$
$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$ FIRST COIL SET
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$
$ Determine node numbers
define parameter off 0
define parameter n1 #off+1
define parameter n2 #off+2
define parameter n3 #off+3
define parameter n4 #off+4
define parameter n5 #off+5
define parameter n6 #off+6
define parameter n7 #off+7
define parameter n8 #off+8
define parameter n9 #off+9
define parameter n10 #off+10
define parameter n11 #off+11
define parameter n12 #off+12
define parameter n13 #off+13
define parameter n14 #off+14
define parameter n15 #off+15
define parameter n16 #off+16
define parameter n17 #off+17
define parameter n18 #off+18
define parameter n19 #off+19
define parameter n20 #off+20
define parameter n21 #off+21
define parameter n22 #off+22
define parameter n23 #off+23
define parameter n24 #off+24
define parameter n25 #off+25
define parameter n26 #off+26
define parameter n41 #off+41
define parameter s1 #n1
define parameter strt #s1
$
$ LOWERMOST COIL
$ INNER RADIUS
node #n1,#r1,0,#z1
node #n2,#rc1,#r2,#z1
node #n3,-#r3,0,#z1
node #n4,#rc1,0,#z1
element,quad,2,1,1,4,#n1,#n2,#n3,#n4
node,#n5,#rc2,-#r4,#z1
node,#n6,#r5,0,#z1
node #n41,#rc2,0,#z1
elem,quad,2,1,1,4,#n3,#n5,#n6,#n41
$ 2ND RADIUS
node #n7,#rc1,#r6,#z1
node #n8,-#r7,0 ,#z1
element,quad,2,1,1,4,#n6,#n7,#n8,#n4
node #n9,#rc2,-#r8,#z1
node,#n10,#r9,0,#z1
elem,quad,2,1,1,4,#n8,#n9,#n10,#n41
$ 3RD RADIUS
node #n11,#rc1,#r10,#z1
node #n12,-#r11,0,#z1
element,quad,2,1,1,4,#n10,#n11,#n12,#n4
node #n13,#rc2,-#r12,#z1
node,#n14,#r13,0,#z1
elem,quad,2,1,1,4,#n12,#n13,#n14,#n41
$ 4TH RADIUS
node #n15,#rc1,#r14,#z1
node #n16,-#r15,0,#z1
element,quad,2,1,1,4,#n14,#n15,#n16,#n4
node #n17,#rc2,-#r16,#z1
node,#n18,#r17,0,#z1
elem,quad,2,1,1,4,#n16,#n17,#n18,#n41
$ 5Th RADIUS
node #n19,#rc1,#r18,#z1
node #n20,-#r19,0,#z1
element,quad,2,1,1,4,#n18,#n19,#n20,#n4
node #n21,#rc2,-#r20,#z1
node,#n22,#r21,0,#z1
elem,quad,2,1,1,4,#n20,#n21,#n22,#n41
$ 6Th RADIUS
node #n23,#rc1,#r22,#z1
node #n24,-#r23,0,#z1
element,quad,2,1,1,4,#n22,#n23,#n24,#n4
node #n25,#rc2,-#r24,#z1
node,#n26,#r25,0,#z1
elem,quad,2,1,1,4,#n24,#n25,#n26,#n41
define parameter e1 #n26
$
$ UPPER COIL
$ OUTER RADIUS
define parameter off 100
define parameter k1 #off+1
define parameter k2 #off+2
define parameter k3 #off+3
define parameter k4 #off+4
define parameter k5 #off+5
define parameter k6 #off+6
define parameter k7 #off+7
define parameter k8 #off+8
define parameter k9 #off+9
define parameter k10 #off+10
define parameter k11 #off+11
define parameter k12 #off+12
define parameter k13 #off+13
define parameter k14 #off+14
define parameter k15 #off+15
define parameter k16 #off+16
define parameter k17 #off+17
define parameter k18 #off+18
define parameter k19 #off+19
define parameter k20 #off+20
define parameter k21 #off+21
define parameter k22 #off+22
define parameter k23 #off+23
define parameter k24 #off+24
define parameter k25 #off+25
define parameter k26 #off+26
define parameter k41 #off+41
define parameter s2 #k1
define parameter e2 #k26
define parameter epan #e2
$ 6TH Radius
node #k1,#r25,0,#z2
node #k2,#rc2,#r24,#z2
node #k3,-#r23,0,#z2
node #k4,#rc2,0,#z2
element,quad,2,1,1,4,#k1,#k2,#k3,#k4
node,#k5,#rc1,-#r22,#z2
node,#k6,#r21,0,#z2
node #k41,#rc1,0,#z2
elem,quad,2,1,1,4,#k3,#k5,#k6,#k41
$ 5Th RADIUS
node #k7,#rc2,#r20,#z2
node #k8,-#r19,0,#z2
element,quad,2,1,1,4,#k6,#k7,#k8,#k4
node #k9,#rc1,-#r18,#z2
node,#k10,#r17,0,#z2
elem,quad,2,1,1,4,#k8,#k9,#k10,#k41
$ 4Th RADIUS
node #k11,#rc2,#r16,#z2
node #k12,-#r15,0,#z2
element,quad,2,1,1,4,#k10,#k11,#k12,#k4
node #k13,#rc1,-#r14,#z2
node,#k14,#r13,0,#z2
elem,quad,2,1,1,4,#k12,#k13,#k14,#k41
$ 3Rd RADIUS
node #k15,#rc2,#r12,#z2
node #k16,-#r11,0,#z2
element,quad,2,1,1,4,#k14,#k15,#k16,#k4
node #k17,#rc1,-#r10,#z2
node,#k18,#r9,0,#z2
elem,quad,2,1,1,4,#k16,#k17,#k18,#k41
```

```
$ 2Nd RADIUS
node #k19,#rc2,#r8,#z2
node #k20,-#r7.0,#z2
element,quad,2,1,1,4,#k18,#k19,#k20,#k4
node #k21,#rc1,-#r6,#z2
node,#k22,#r5.0,#z2
elem,quad,2,1,1,4,#k20,#k21,#k22,#k41
$ 1ST RADIUS
node #k23,#rc2,#r4,#z2
node #k24,-#r3.0,#z2
element,quad,2,1,1,4,#k22,#k23,#k24,#k4
node #k25,#rc1,-#r2,#z2
node,#k26,#r1.0,#z2
elem,quad,2,1,1,4,#k24,#k25,#k26,#k41
$
$
$
$ CONNECT INNER AND OUTER RADIUS
elem,beam,4,1,1,2,#e1,#s2
$
$
$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$ Second COIL SET (Layers 3 and 4)
$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$
$ Determine node numbers
define parameter off 200
define parameter n1 #off+1
define parameter n2 #off+2
define parameter n3 #off+3
define parameter n4 #off+4
define parameter n5 #off+5
define parameter n6 #off+6
define parameter n7 #off+7
define parameter n8 #off+8
define parameter n9 #off+9
define parameter n10 #off+10
define parameter n11 #off+11
define parameter n12 #off+12
define parameter n13 #off+13
define parameter n14 #off+14
define parameter n15 #off+15
define parameter n16 #off+16
define parameter n17 #off+17
define parameter n18 #off+18
define parameter n19 #off+19
define parameter n20 #off+20
define parameter n21 #off+21
define parameter n22 #off+22
define parameter n23 #off+23
define parameter n24 #off+24
define parameter n25 #off+25
define parameter n26 #off+26
define parameter n41 #off+41
define parameter s1 #n1
$
$ INNER RADIUS
node #n1,#r1.0,#z3
node #n2,#rc1,#r2,#z3
node #n3,-#r3.0,#z3
node #n4,#rc1.0,#z3
element,quad,2,1,1,4,#n1,#n2,#n3,#n4
node,#n5,#rc2,-#r4,#z3
node,#n6,#r5.0,#z3
node #n41,#rc2.0,#z3
elem,quad,2,1,1,4,#n3,#n5,#n6,#n41
$ 2ND RADIUS
node #n7,#rc1,#r6,#z3
node #n8,-#r7.0 ,#z3
element,quad,2,1,1,4,#n6,#n7,#n8,#n4
node #n9,#rc2,-#r8,#z3
node,#n10,#r9.0,#z3
elem,quad,2,1,1,4,#n8,#n9,#n10,#n41
$ 3RD RADIUS
node #n11,#rc1,#r10,#z3
node #n12,-#r11.0,#z3
element,quad,2,1,1,4,#n10,#n11,#n12,#n4
node #n13,#rc2,-#r12,#z3
node,#n14,#r13.0,#z3
elem,quad,2,1,1,4,#n12,#n13,#n14,#n41
$ 4TH RADIUS
node #n15,#rc1,#r14,#z3
node #n16,-#r15.0,#z3
element,quad,2,1,1,4,#n14,#n15,#n16,#n4
node #n17,#rc2,-#r16,#z3
node,#n18,#r17.0,#z3
elem,quad,2,1,1,4,#n16,#n17,#n18,#n41
$ 5Th RADIUS
node #n19,#rc1,#r18,#z3
node #n20,-#r19.0,#z3
element,quad,2,1,1,4,#n18,#n19,#n20,#n4
node #n21,#rc2,-#r20,#z3
node,#n22,#r21.0,#z3
elem,quad,2,1,1,4,#n20,#n21,#n22,#n41
$ 6Th RADIUS
node #n23,#rc1,#r22,#z3
node #n24,-#r23.0,#z3
element,quad,2,1,1,4,#n22,#n23,#n24,#n4
node #n25,#rc2,-#r24,#z3
node,#n26,#r25.0,#z3
elem,quad,2,1,1,4,#n24,#n25,#n26,#n41
define parameter e1 #n26
$
$ UPPER COIL
$ OUTER RADIUS
define parameter off 300
define parameter k1 #off+1
define parameter k2 #off+2
define parameter k3 #off+3
define parameter k4 #off+4
define parameter k5 #off+5
define parameter k6 #off+6
define parameter k7 #off+7
define parameter k8 #off+8
define parameter k9 #off+9
define parameter k10 #off+10
define parameter k11 #off+11
define parameter k12 #off+12
define parameter k13 #off+13
define parameter k14 #off+14
define parameter k15 #off+15
define parameter k16 #off+16
define parameter k17 #off+17
define parameter k18 #off+18
define parameter k19 #off+19
define parameter k20 #off+20
define parameter k21 #off+21
define parameter k22 #off+22
define parameter k23 #off+23
define parameter k24 #off+24
define parameter k25 #off+25
define parameter k26 #off+26
define parameter k41 #off+41
define parameter s2 #k1
define parameter e2 #k26
$ 6TH Radius
node #k1,#r25.0,#z4
node #k2,#rc2,#r24,#z4
node #k3,-#r23.0,#z4
node #k4,#rc2.0,#z4
element,quad,2,1,1,4,#k1,#k2,#k3,#k4
node,#k5,#rc1,-#r22,#z4
node,#k6,#r21.0,#z4
node #k41,#rc1.0,#z4
elem,quad,2,1,1,4,#k3,#k5,#k6,#k41
$ 5Th RADIUS
node #k7,#rc2,#r20,#z4
node #k8,-#r19.0,#z4
element,quad,2,1,1,4,#k6,#k7,#k8,#k4
node #k9,#rc1,-#r18,#z4
node,#k10,#r17.0,#z4
elem,quad,2,1,1,4,#k8,#k9,#k10,#k41
$ 4Th RADIUS
node #k11,#rc2,#r16,#z4
node #k12,-#r15.0,#z4
element,quad,2,1,1,4,#k10,#k11,#k12,#k4
node #k13,#rc1,-#r14,#z4
node,#k14,#r13.0,#z4
elem,quad,2,1,1,4,#k12,#k13,#k14,#k41
$ 3Rd RADIUS
node #k15,#rc2,#r12,#z4
node #k16,-#r11.0,#z4
element,quad,2,1,1,4,#k14,#k15,#k16,#k4
node #k17,#rc1,-#r10,#z4
node,#k18,#r9.0,#z4
elem,quad,2,1,1,4,#k16,#k17,#k18,#k41
$ 2Nd RADIUS
node #k19,#rc2,#r8,#z4
node #k20,-#r7.0,#z4
element,quad,2,1,1,4,#k18,#k19,#k20,#k4
node #k21,#rc1,-#r6,#z4
node,#k22,#r5.0,#z4
elem,quad,2,1,1,4,#k20,#k21,#k22,#k41
$ 1ST RADIUS
node #k23,#rc2,#r4,#z4
node #k24,-#r3.0,#z4
element,quad,2,1,1,4,#k22,#k23,#k24,#k4
node #k25,#rc1,-#r2,#z4
node,#k26,#r1.0,#z4
elem,quad,2,1,1,4,#k24,#k25,#k26,#k41
$
$
$ CONNECT Upper and Lower Layer
elem,beam,4,1,1,2,#e1,#s2
$
$
$ CONNECT TO PREVIOUS PANCAKE
elem,beam,4,1,1,2,#epan,#s1
$ redefine end of pancake
define parameter epan,#e2
$
$
$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$ Third COIL SET (Layers 5 and 6)
$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$
$ Determine node numbers
define parameter off 400
define parameter n1 #off+1
define parameter n2 #off+2
define parameter n3 #off+3
define parameter n4 #off+4
define parameter n5 #off+5
define parameter n6 #off+6
define parameter n7 #off+7
define parameter n8 #off+8
define parameter n9 #off+9
define parameter n10 #off+10
define parameter n11 #off+11
define parameter n12 #off+12
define parameter n13 #off+13
define parameter n14 #off+14
define parameter n15 #off+15
define parameter n16 #off+16
define parameter n17 #off+17
define parameter n18 #off+18
define parameter n19 #off+19
define parameter n20 #off+20
define parameter n21 #off+21
define parameter n22 #off+22
define parameter n23 #off+23
define parameter n24 #off+24
define parameter n25 #off+25
define parameter n26 #off+26
define parameter n41 #off+41
define parameter s1 #n1
$
$ INNER RADIUS
node #n1,#r1.0,#z5
node #n2,#rc1,#r2,#z5
node #n3,-#r3.0,#z5
node #n4,#rc1.0,#z5
element,quad,2,1,1,4,#n1,#n2,#n3,#n4
node,#n5,#rc2,-#r4,#z5
node,#n6,#r5.0,#z5
node #n41,#rc2.0,#z5
elem,quad,2,1,1,4,#n3,#n5,#n6,#n41
$ 2ND RADIUS
node #n7,#rc1,#r6,#z5
node #n8,-#r7.0 ,#z5
element,quad,2,1,1,4,#n6,#n7,#n8,#n4
node #n9,#rc2,-#r8,#z5
node,#n10,#r9.0,#z5
elem,quad,2,1,1,4,#n8,#n9,#n10,#n41
$ 3RD RADIUS
node #n11,#rc1,#r10,#z5
node #n12,-#r11.0,#z5
element,quad,2,1,1,4,#n10,#n11,#n12,#n4
node #n13,#rc2,-#r12,#z5
node,#n14,#r13.0,#z5
elem,quad,2,1,1,4,#n12,#n13,#n14,#n41
$ 4TH RADIUS
node #n15,#rc1,#r14,#z5
node #n16,-#r15.0,#z5
element,quad,2,1,1,4,#n14,#n15,#n16,#n4
node #n17,#rc2,-#r16,#z5
node,#n18,#r17.0,#z5
elem,quad,2,1,1,4,#n16,#n17,#n18,#n41
$ 5Th RADIUS
node #n19,#rc1,#r18,#z5
node #n20,-#r19.0,#z5
element,quad,2,1,1,4,#n18,#n19,#n20,#n4
node #n21,#rc2,-#r20,#z5
node,#n22,#r21.0,#z5
elem,quad,2,1,1,4,#n20,#n21,#n22,#n41
$ 6Th RADIUS
node #n23,#rc1,#r22,#z5
node #n24,-#r23.0,#z5
```

```
element,quad,2,1,1,4,#n22,#n23,#n24,#n4
node #n25,#rc2,-#r24,#z5
node,#n26,#r25,0,#z5
elem,quad,2,1,1,4,#n24,#n25,#n26,#n41
define parameter e1 #n26
$
$ UPPER COIL
$ OUTER RADIUS
define parameter off 500
define parameter k1 #off+1
define parameter k2 #off+2
define parameter k3 #off+3
define parameter k4 #off+4
define parameter k5 #off+5
define parameter k6 #off+6
define parameter k7 #off+7
define parameter k8 #off+8
define parameter k9 #off+9
define parameter k10 #off+10
define parameter k11 #off+11
define parameter k12 #off+12
define parameter k13 #off+13
define parameter k14 #off+14
define parameter k15 #off+15
define parameter k16 #off+16
define parameter k17 #off+17
define parameter k18 #off+18
define parameter k19 #off+19
define parameter k20 #off+20
define parameter k21 #off+21
define parameter k22 #off+22
define parameter k23 #off+23
define parameter k24 #off+24
define parameter k25 #off+25
define parameter k26 #off+26
define parameter k41 #off+41
define parameter s2 #k1
define parameter e2 #k26
$ 6TH Radius
node #k1,#r25,0,#z6
node #k2,#rc2,#r24,#z6
node #k3,-#r23,0,#z6
node #k4,#rc2,0,#z6
element,quad,2,1,1,4,#k1,#k2,#k3,#k4
node,#k5,#rc1,-#r22,#z6
node,#k6,#r21,0,#z6
node #k41,#rc1,0,#z6
elem,quad,2,1,1,4,#k3,#k5,#k6,#k41
$ 5Th RADIUS
node #k7,#rc2,#r20,#z6
node #k8,-#r19,0,#z6
element,quad,2,1,1,4,#k6,#k7,#k8,#k4
node #k9,#rc1,-#r18,#z6
node,#k10,#r17,0,#z6
elem,quad,2,1,1,4,#k8,#k9,#k10,#k41
$ 4Th RADIUS
node #k11,#rc2,#r16,#z6
node #k12,-#r15,0,#z6
element,quad,2,1,1,4,#k10,#k11,#k12,#k4
node #k13,#rc1,-#r14,#z6
node,#k14,#r13,0,#z6
elem,quad,2,1,1,4,#k12,#k13,#k14,#k41
$ 3Rd RADIUS
node #k15,#rc2,#r12,#z6
node #k16,-#r11,0,#z6
element,quad,2,1,1,4,#k14,#k15,#k16,#k4
node #k17,#rc1,-#r10,#z6
node,#k18,#r9,0,#z6
elem,quad,2,1,1,4,#k16,#k17,#k18,#k41
$ 2Nd RADIUS
node #k19,#rc2,#r8,#z6
node #k20,-#r7,0,#z6
element,quad,2,1,1,4,#k18,#k19,#k20,#k4
node #k21,#rc1,-#r6,#z6
node,#k22,#r5,0,#z6
elem,quad,2,1,1,4,#k20,#k21,#k22,#k41
$ 1ST RADIUS
node #k23,#rc2,#r4,#z6
node #k24,-#r3,0,#z6
element,quad,2,1,1,4,#k22,#k23,#k24,#k4
node #k25,#rc1,-#r2,#z6
node,#k26,#r1,0,#z6
elem,quad,2,1,1,4,#k24,#k25,#k26,#k41
$
$
$ CONNECT Upper and Lower Layer
elem,beam,4,1,1,2,#e1,#s2
$
$
$ CONNECT TO PREVIOUS PANCAKE
elem,beam,4,1,1,2,#epan,#s1
$ redefine end of pancake
define parameter epan,#e2
$
$
$
$
$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$ Fourth COIL SET  (Layers 7 and 8)
$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$
$ Determine node numbers
define parameter off 600
define parameter n1 #off+1
define parameter n2 #off+2
define parameter n3 #off+3
define parameter n4 #off+4
define parameter n5 #off+5
define parameter n6 #off+6
define parameter n7 #off+7
define parameter n8 #off+8
define parameter n9 #off+9
define parameter n10 #off+10
define parameter n11 #off+11
define parameter n12 #off+12
define parameter n13 #off+13
define parameter n14 #off+14
define parameter n15 #off+15
define parameter n16 #off+16
define parameter n17 #off+17
define parameter n18 #off+18
define parameter n19 #off+19
define parameter n20 #off+20
define parameter n21 #off+21
define parameter n22 #off+22
define parameter n23 #off+23
define parameter n24 #off+24
define parameter n25 #off+25
define parameter n26 #off+26
define parameter n41 #off+41
define parameter s1 #n1
$
$ INNER RADIUS
node #n1,#r1,0,#z7
node #n2,#rc1,#r2,#z7
node #n3,-#r3,0,#z7
node #n4,#rc1,0,#z7
element,quad,2,1,1,4,#n1,#n2,#n3,#n4
node,#n5,#rc2,-#r4,#z7
node,#n6,#r5,0,#z7
node #n41,#rc2,0,#z7
elem,quad,2,1,1,4,#n3,#n5,#n6,#n41
$ 2ND RADIUS
node #n7,#rc1,#r6,#z7
node #n8,-#r7,0 ,#z7
element,quad,2,1,1,4,#n6,#n7,#n8,#n4
node #n9,#rc2,-#r8,#z7
node,#n10,#r9,0,#z7
elem,quad,2,1,1,4,#n8,#n9,#n10,#n41
$ 3RD RADIUS
node #n11,#rc1,#r10,#z7
node #n12,-#r11,0,#z7
element,quad,2,1,1,4,#n10,#n11,#n12,#n4
node #n13,#rc2,-#r12,#z7
node,#n14,#r13,0,#z7
elem,quad,2,1,1,4,#n12,#n13,#n14,#n41
$ 4TH RADIUS
node #n15,#rc1,#r14,#z7
node #n16,-#r15,0,#z7
element,quad,2,1,1,4,#n14,#n15,#n16,#n4
node #n17,#rc2,-#r16,#z7
node,#n18,#r17,0,#z7
elem,quad,2,1,1,4,#n16,#n17,#n18,#n41
$ 5Th RADIUS
node #n19,#rc1,#r18,#z7
node #n20,-#r19,0,#z7
element,quad,2,1,1,4,#n18,#n19,#n20,#n4
node #n21,#rc2,-#r20,#z7
node,#n22,#r21,0,#z7
elem,quad,2,1,1,4,#n20,#n21,#n22,#n41
$ 6Th RADIUS
node #n23,#rc1,#r22,#z7
node #n24,-#r23,0,#z7
element,quad,2,1,1,4,#n22,#n23,#n24,#n4
node #n25,#rc2,-#r24,#z7
node,#n26,#r25,0,#z7
elem,quad,2,1,1,4,#n24,#n25,#n26,#n41
define parameter e1 #n26
$
$ UPPER COIL
$ OUTER RADIUS
define parameter off 700
define parameter k1 #off+1
define parameter k2 #off+2
define parameter k3 #off+3
define parameter k4 #off+4
define parameter k5 #off+5
define parameter k6 #off+6
define parameter k7 #off+7
define parameter k8 #off+8
define parameter k9 #off+9
define parameter k10 #off+10
define parameter k11 #off+11
define parameter k12 #off+12
define parameter k13 #off+13
define parameter k14 #off+14
define parameter k15 #off+15
define parameter k16 #off+16
define parameter k17 #off+17
define parameter k18 #off+18
define parameter k19 #off+19
define parameter k20 #off+20
define parameter k21 #off+21
define parameter k22 #off+22
define parameter k23 #off+23
define parameter k24 #off+24
define parameter k25 #off+25
define parameter k26 #off+26
define parameter k41 #off+41
define parameter s2 #k1
define parameter e2 #k26
$ 6TH Radius
node #k1,#r25,0,#z8
node #k2,#rc2,#r24,#z8
node #k3,-#r23,0,#z8
node #k4,#rc2,0,#z8
element,quad,2,1,1,4,#k1,#k2,#k3,#k4
node,#k5,#rc1,-#r22,#z8
node,#k6,#r21,0,#z8
node #k41,#rc1,0,#z8
elem,quad,2,1,1,4,#k3,#k5,#k6,#k41
$ 5Th RADIUS
node #k7,#rc2,#r20,#z8
node #k8,-#r19,0,#z8
element,quad,2,1,1,4,#k6,#k7,#k8,#k4
node #k9,#rc1,-#r18,#z8
node,#k10,#r17,0,#z8
elem,quad,2,1,1,4,#k8,#k9,#k10,#k41
$ 4Th RADIUS
node #k11,#rc2,#r16,#z8
node #k12,-#r15,0,#z8
element,quad,2,1,1,4,#k10,#k11,#k12,#k4
node #k13,#rc1,-#r14,#z8
node,#k14,#r13,0,#z8
elem,quad,2,1,1,4,#k12,#k13,#k14,#k41
$ 3Rd RADIUS
node #k15,#rc2,#r12,#z8
node #k16,-#r11,0,#z8
element,quad,2,1,1,4,#k14,#k15,#k16,#k4
node #k17,#rc1,-#r10,#z8
node,#k18,#r9,0,#z8
elem,quad,2,1,1,4,#k16,#k17,#k18,#k41
$ 2Nd RADIUS
node #k19,#rc2,#r8,#z8
node #k20,-#r7,0,#z8
element,quad,2,1,1,4,#k18,#k19,#k20,#k4
node #k21,#rc1,-#r6,#z8
node,#k22,#r5,0,#z8
elem,quad,2,1,1,4,#k20,#k21,#k22,#k41
$ 1ST RADIUS
node #k23,#rc2,#r4,#z8
node #k24,-#r3,0,#z8
element,quad,2,1,1,4,#k22,#k23,#k24,#k4
node #k25,#rc1,-#r2,#z8
node,#k26,#r1,0,#z8
elem,quad,2,1,1,4,#k24,#k25,#k26,#k41
$
$
$ CONNECT Upper and Lower Layer
elem,beam,4,1,1,2,#e1,#s2
$
$
$ CONNECT TO PREVIOUS PANCAKE
elem,beam,4,1,1,2,#epan,#s1
$ redefine end of pancake
define parameter epan,#e2
$
$
$
$
```

```
$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$ Fifth COIL SET (Layers 9 and 10)
$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$
$ Determine node numbers
define parameter off 800
define parameter n1 #off+1
define parameter n2 #off+2
define parameter n3 #off+3
define parameter n4 #off+4
define parameter n5 #off+5
define parameter n6 #off+6
define parameter n7 #off+7
define parameter n8 #off+8
define parameter n9 #off+9
define parameter n10 #off+10
define parameter n11 #off+11
define parameter n12 #off+12
define parameter n13 #off+13
define parameter n14 #off+14
define parameter n15 #off+15
define parameter n16 #off+16
define parameter n17 #off+17
define parameter n18 #off+18
define parameter n19 #off+19
define parameter n20 #off+20
define parameter n21 #off+21
define parameter n22 #off+22
define parameter n23 #off+23
define parameter n24 #off+24
define parameter n25 #off+25
define parameter n26 #off+26
define parameter n41 #off+41
define parameter s1 #n1
$
$ INNER RADIUS
node #n1,#r1.0,#z9
node #n2,#rc1,#r2,#z9
node #n3,-#r3.0,#z9
node #n4,#rc1.0,#z9
element,quad,2,1,1,4,#n1,#n2,#n3,#n4
node,#n5,#rc2,-#r4,#z9
node,#n6,#r5.0,#z9
node #n41,#rc2.0,#z9
elem,quad,2,1,1,4,#n3,#n5,#n6,#n41
$ 2ND RADIUS
node #n7,#rc1,#r6,#z9
node #n8,-#r7.0 ,#z9
element,quad,2,1,1,4,#n6,#n7,#n8,#n4
node #n9,#rc2,-#r8,#z9
node,#n10,#r9.0,#z9
elem,quad,2,1,1,4,#n8,#n9,#n10,#n41
$ 3RD RADIUS
node #n11,#rc1,#r10,#z9
node #n12,-#r11.0,#z9
element,quad,2,1,1,4,#n10,#n11,#n12,#n4
node #n13,#rc2,-#r12,#z9
node,#n14,#r13.0,#z9
elem,quad,2,1,1,4,#n12,#n13,#n14,#n41
$ 4TH RADIUS
node #n15,#rc1,#r14,#z9
node #n16,-#r15.0,#z9
element,quad,2,1,1,4,#n14,#n15,#n16,#n4
node #n17,#rc2,-#r16,#z9
node,#n18,#r17.0,#z9
elem,quad,2,1,1,4,#n16,#n17,#n18,#n41
$ 5Th RADIUS
node #n19,#rc1,#r18,#z9
node #n20,-#r19.0,#z9
element,quad,2,1,1,4,#n18,#n19,#n20,#n4
node #n21,#rc2,-#r20,#z9
node,#n22,#r21.0,#z9
elem,quad,2,1,1,4,#n20,#n21,#n22,#n41
$ 6Th RADIUS
node #n23,#rc1,#r22,#z9
node #n24,-#r23.0,#z9
element,quad,2,1,1,4,#n22,#n23,#n24,#n4
node #n25,#rc2,-#r24,#z9
node,#n26,#r25.0,#z9
elem,quad,2,1,1,4,#n24,#n25,#n26,#n41
define parameter e1 #n26
$
$ UPPER COIL
$ OUTER RADIUS
define parameter off 900
define parameter k1 #off+1
define parameter k2 #off+2
define parameter k3 #off+3
define parameter k4 #off+4
define parameter k5 #off+5
define parameter k6 #off+6
define parameter k7 #off+7
define parameter k8 #off+8
define parameter k9 #off+9
define parameter k10 #off+10
define parameter k11 #off+11
define parameter k12 #off+12
define parameter k13 #off+13
define parameter k14 #off+14
define parameter k15 #off+15
define parameter k16 #off+16
define parameter k17 #off+17
define parameter k18 #off+18
define parameter k19 #off+19
define parameter k20 #off+20
define parameter k21 #off+21
define parameter k22 #off+22
define parameter k23 #off+23
define parameter k24 #off+24
define parameter k25 #off+25
define parameter k26 #off+26
define parameter k41 #off+41
define parameter s2 #k1
define parameter e2 #k26
$ 6TH Radius
node #k1,#r25.0,#z10
node #k2,#rc2,#r24,#z10
node #k3,-#r23.0,#z10
node #k4,#rc2.0,#z10
element,quad,2,1,1,4,#k1,#k2,#k3,#k4
node,#k5,#rc1,-#r22,#z10
node,#k6,#r21.0,#z10
node #k41,#rc1.0,#z10
elem,quad,2,1,1,4,#k3,#k5,#k6,#k41
$ 5Th RADIUS
node #k7,#rc2,#r20,#z10
node #k8,-#r19.0,#z10
element,quad,2,1,1,4,#k6,#k7,#k8,#k4
node #k9,#rc1,-#r18,#z10
node,#k10,#r17.0,#z10
elem,quad,2,1,1,4,#k8,#k9,#k10,#k41
$ 4Th RADIUS
node #k11,#rc2,#r16,#z10
node #k12,-#r15.0,#z10
element,quad,2,1,1,4,#k10,#k11,#k12,#k4
node #k13,#rc1,-#r14,#z10
node,#k14,#r13.0,#z10
elem,quad,2,1,1,4,#k12,#k13,#k14,#k41
$ 3Rd RADIUS
node #k15,#rc2,#r12,#z10
node #k16,-#r11.0,#z10
element,quad,2,1,1,4,#k14,#k15,#k16,#k4
node #k17,#rc1,-#r10,#z10
node,#k18,#r9.0,#z10
elem,quad,2,1,1,4,#k16,#k17,#k18,#k41
$ 2Nd RADIUS
node #k19,#rc2,#r8,#z10
node #k20,-#r7.0,#z10
element,quad,2,1,1,4,#k18,#k19,#k20,#k4
node #k21,#rc1,-#r6,#z10
node,#k22,#r5.0,#z10
elem,quad,2,1,1,4,#k20,#k21,#k22,#k41
$ 1ST RADIUS
node #k23,#rc2,#r4,#z10
node #k24,-#r3.0,#z10
element,quad,2,1,1,4,#k22,#k23,#k24,#k4
node #k25,#rc1,-#r2,#z10
node,#k26,#r1.0,#z10
elem,quad,2,1,1,4,#k24,#k25,#k26,#k41
$
$
$ CONNECT Upper and Lower Layer
elem,beam,4,1,1,2,#e1,#s2
$
$
$ CONNECT TO PREVIOUS PANCAKE
elem,beam,4,1,1,2,#epan,#s1
$ redefine end of pancake
define parameter epan,#e2
$
$
$
$ BRING LEAD BACK DOWN TO CLOSE
PATH
elem,beam,4,1,1,2,#epan,#strt
$
default node start 10000
point p1 225 0
point p2 0  225
point p3 -225 0
point p4 0  -225
point p0 0 0
arc a1 p1 p2 p0 32
arc a2 p2 p3 p0 32
arc a3 p3 p4 p0 32
arc a4 p4 p1 p0 32
node name off
```

Constant Radius/Jog Case - File gclok.str

```
define parameter rm 81
define parameter dr 2.54
define parameter dz 2.54
define parameter jog -15
define parameter lift 104.15
define parameter r1 #rm-#dr*5/2
define parameter r2 #rm-#dr*3/2
define parameter r3 #rm-#dr*1/2
define parameter r4 #rm+#dr*1/2
define parameter r5 #rm+#dr*3/2
define parameter r6 #rm+#dr*5/2
define parameter z1 #lift-#dz*9/2
define parameter z2 #lift-#dz*7/2
define parameter z3 #lift-#dz*5/2
define parameter z4 #lift-#dz*3/2
define parameter z5 #lift-#dz*1/2
define parameter z6 #lift+#dz*1/2
define parameter z7 #lift+#dz*3/2
define parameter z8 #lift+#dz*5/2
define parameter z9 #lift+#dz*7/2
define parameter z10 #lift+#dz*9/2
define parameter adv -0.00360
define parameter a2 #adv
define parameter a3 #a2+#adv
define parameter a4 #a3+#adv
define parameter a5 #a4+#adv
define parameter a6 #a5+#adv
define parameter a7 #a6+#adv
define parameter a8 #a7+#adv
define parameter a9 #a8+#adv
define parameter a10 #a9+#adv
coord,1,cylind
coord,2,cylind,0,0,0,#a2
coord,3,cylind,0,0,0,#a3
coord,4,cylind,0,0,0,#a4
coord,5,cylind,0,0,0,#a5
coord,6,cylind,0,0,0,#a6
coord,7,cylind,0,0,0,#a7
coord,8,cylind,0,0,0,#a8
coord,9,cylind,0,0,0,#a9
coord,10,cylind,0,0,0,#a10
default coord 1
$
$
$$$$$$$$$$$$$$$$$$
$ FIRST COIL PAIR
$$$$$$$$$$$$$$$$$$
$ INNER RADIUS
$ DETERMINE NODE NUMBERS
define parameter off 0
define parameter n1 #off+1
define parameter n2 #off+2
define parameter n3 #off+3
define parameter n4 #off+4
define parameter n5 #off+5
define parameter n6 #off+6
define parameter n7 #off+7
define parameter n8 #off+8
define parameter n9 #off+9
define parameter n10 #off+10
define parameter n11 #off+11
define parameter n12 #off+12
define parameter n13 #off+13
```

```
define parameter n14 #off+14
define parameter n15 #off+15
define parameter n16 #off+16
define parameter n17 #off+17
define parameter n18 #off+18
define parameter n19 #off+19
define parameter n20 #off+20
define parameter n21 #off+21
define parameter n22 #off+22
define parameter n23 #off+23
define parameter n24 #off+24
define parameter n25 #off+25
define parameter n26 #off+26
define parameter n27 #off+27
define parameter n28 #off+28
define parameter n29 #off+29
define parameter n30 #off+30
define parameter n31 #off+31
define parameter n32 #off+32
define parameter n33 #off+33
define parameter n34 #off+34
define parameter n35 #off+35
define parameter n36 #off+36
define parameter n37 #off+37
define parameter n38 #off+38
define parameter n39 #off+39
define parameter n40 #off+40
define parameter n41 #off+41
define parameter n42 #off+42
define parameter n43 #off+43
define parameter n44 #off+44
define parameter n45 #off+45
define parameter n46 #off+46
define parameter n47 #off+47
define parameter n48 #off+48
define parameter n49 #off+49
define parameter n50 #off+50
define parameter n51 #off+51
define parameter nst #n1
node #n1,#r1.0,#z1
node #n2,#r1.90,#z1
node #n3,#r1.180,#z1
node #n4,0.0,#z1
element,quad,2,1,1,4,#n1,#n2,#n3,#n4
node,#n5,#r1,-90,#z1
node,#n6,#r1,#jog,#z1
elem,quad,2,1,1,4,#n3,#n5,#n6,#n4
$
$ 2ND RADIUS
node #n7,#r2.0,#z1
node #n8,#r2.90,#z1
node #n9,#r2.180,#z1
element,quad,2,1,1,4,#n7,#n8,#n9,#n4
node,#n10,#r2,-90,#z1
node,#n11,#r2,#jog,#z1
elem,quad,2,1,1,4,#n9,#n10,#n11,#n4
$
$ CONNECT 1ST AND 2ND RADIUS
$ lower layer
elem,beam,4,1,1,2,#n6,#n7
$
$ 3RD RADIUS
node #n17,#r3.0,#z1
node #n18,#r3.90,#z1
node #n19,#r3.180,#z1
element,quad,2,1,1,4,#n17,#n18,#n19,#n4
node,#n20,#r3,-90,#z1
node,#n21,#r3,#jog,#z1
elem,quad,2,1,1,4,#n19,#n20,#n21,#n4
$
$ CONNECT 2ND AND 3RD RADIUS
$ lower layer
elem,beam,4,1,1,2,#n11,#n17
$
$ 4TH RADIUS
node #n27,#r4.0,#z1
node #n28,#r4.90,#z1
node #n29,#r4.180,#z1
element,quad,2,1,1,4,#n27,#n28,#n29,#n4
node,#n30,#r4,-90,#z1
node,#n31,#r4,#jog,#z1
elem,quad,2,1,1,4,#n29,#n30,#n31,#n4
$
$ CONNECT 3RD AND 4TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n21,#n27
$
$ 5TH RADIUS
node #n37,#r5.0,#z1
node #n38,#r5.90,#z1
node #n39,#r5.180,#z1
element,quad,2,1,1,4,#n37,#n38,#n39,#n4
node,#n40,#r5,-90,#z1
node,#n41,#r5,#jog,#z1
elem,quad,2,1,1,4,#n39,#n40,#n41,#n4
$
$ CONNECT 4TH AND 5TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n31,#n37
$
$ 6TH RADIUS
node #n47,#r6.0,#z1
node #n48,#r6.90,#z1
node #n49,#r6.180,#z1
element,quad,2,1,1,4,#n47,#n48,#n49,#n4
node,#n50,#r6,-90,#z1
node,#n51,#r6,#adv,#z1
elem,quad,2,1,1,4,#n49,#n50,#n51,#n4
$
$ CONNECT 5TH AND 6TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n41,#n47
$
$
default coord 2
$ UPPER LAYER (IN Z) COIL
$ OUTER MOST RADIUS
$ DETERMINE NODE NUMBERS
define parameter off 1000
define parameter k1 #off+1
define parameter k2 #off+2
define parameter k3 #off+3
define parameter k4 #off+4
define parameter k5 #off+5
define parameter k6 #off+6
define parameter k7 #off+7
define parameter k8 #off+8
define parameter k9 #off+9
define parameter k10 #off+10
define parameter k11 #off+11
define parameter k12 #off+12
define parameter k13 #off+13
define parameter k14 #off+14
define parameter k15 #off+15
define parameter k16 #off+16
define parameter k17 #off+17
define parameter k18 #off+18
define parameter k19 #off+19
define parameter k20 #off+20
define parameter k21 #off+21
define parameter k22 #off+22
define parameter k23 #off+23
define parameter k24 #off+24
define parameter k25 #off+25
define parameter k26 #off+26
define parameter k27 #off+27
define parameter k28 #off+28
define parameter k29 #off+29
define parameter k30 #off+30
define parameter k31 #off+31
define parameter k32 #off+32
define parameter k33 #off+33
define parameter k34 #off+34
define parameter k35 #off+35
define parameter k36 #off+36
define parameter k37 #off+37
define parameter k38 #off+38
define parameter k39 #off+39
define parameter k40 #off+40
define parameter k41 #off+41
define parameter k42 #off+42
define parameter k43 #off+43
define parameter k44 #off+44
define parameter k45 #off+45
define parameter k46 #off+46
define parameter k47 #off+47
define parameter k48 #off+48
define parameter k49 #off+49
define parameter k50 #off+50
define parameter k51 #off+51
node #k1,#r6.0,#z2
node #k2,#r6.90,#z2
node #k3,#r6.180,#z2
node #k4,0.0,#z2
element,quad,2,1,1,4,#k1,#k2,#k3,#k4
node,#k5,#r6,-90,#z2
node,#k6,#r6,#jog,#z2
elem,quad,2,1,1,4,#k3,#k5,#k6,#k4
$
$ 5TH RADIUS
node #k7,#r5.0,#z2
node #k8,#r5.90,#z2
node #k9,#r5.180,#z2
element,quad,2,1,1,4,#k7,#k8,#k9,#k4
node,#k10,#r5,-90,#z2
node,#k11,#r5,#jog,#z2
elem,quad,2,1,1,4,#k9,#k10,#k11,#k4
$
$ CONNECT 6TH AND 5TH RADIUS
elem,beam,4,1,1,2,#k6,#k7
$
$ 4TH RADIUS
node #k17,#r4.0,#z2
node #k18,#r4.90,#z2
node #k19,#r4.180,#z2
element,quad,2,1,1,4,#k17,#k18,#k19,#k4
node,#k20,#r4,-90,#z2
node,#k21,#r4,#jog,#z2
elem,quad,2,1,1,4,#k19,#k20,#k21,#k4
$
$ CONNECT 5TH AND 4TH RADIUS
elem,beam,4,1,1,2,#k11,#k17
$
$ 3RD RADIUS
node #k27,#r3.0,#z2
node #k28,#r3.90,#z2
node #k29,#r3.180,#z2
element,quad,2,1,1,4,#k27,#k28,#k29,#k4
node,#k30,#r3,-90,#z2
node,#k31,#r3,#jog,#z2
elem,quad,2,1,1,4,#k29,#k30,#k31,#k4
$
$ CONNECT 4TH AND 3TH RADIUS
elem,beam,4,1,1,2,#k21,#k27
$
$ 2ND RADIUS
node #k37,#r2.0,#z2
node #k38,#r2.90,#z2
node #k39,#r2.180,#z2
element,quad,2,1,1,4,#k37,#k38,#k39,#k4
node,#k40,#r2,-90,#z2
node,#k41,#r2,#jog,#z2
elem,quad,2,1,1,4,#k39,#k40,#k41,#k4
$
$ CONNECT 3RD AND 2ND RADIUS
elem,beam,4,1,1,2,#k31,#k37
$
$ 1ST RADIUS
node #k47,#r1.0,#z2
node #k48,#r1.90,#z2
node #k49,#r1.180,#z2
element,quad,2,1,1,4,#k47,#k48,#k49,#k4
node,#k50,#r1,-90,#z2
node,#k51,#r1,#adv,#z2
elem,quad,2,1,1,4,#k49,#k50,#k51,#k4
$
$ CONNECT 2ND AND 1ST RADIUS
elem,beam,4,1,1,2,#k41,#k47
$
$
$ LOWER TO UPPER LAYER CONNECTION
elem,beam,4,1,1,2,#n51,#k1
$
$
$
$
$$$$$$$$$$$$$$$$$$$$$$
$ SECOND COIL PAIR
$$$$$$$$$$$$$$$$$$$$$$
$ INNER RADIUS
$ DETERMINE NODE NUMBERS
default coord 3
define parameter off 100
define parameter n1 #off+1
define parameter n2 #off+2
define parameter n3 #off+3
define parameter n4 #off+4
define parameter n5 #off+5
define parameter n6 #off+6
define parameter n7 #off+7
define parameter n8 #off+8
define parameter n9 #off+9
define parameter n10 #off+10
define parameter n11 #off+11
define parameter n12 #off+12
define parameter n13 #off+13
define parameter n14 #off+14
define parameter n15 #off+15
define parameter n16 #off+16
define parameter n17 #off+17
```

```
define parameter n18 #off+18
define parameter n19 #off+19
define parameter n20 #off+20
define parameter n21 #off+21
define parameter n22 #off+22
define parameter n23 #off+23
define parameter n24 #off+24
define parameter n25 #off+25
define parameter n26 #off+26
define parameter n27 #off+27
define parameter n28 #off+28
define parameter n29 #off+29
define parameter n30 #off+30
define parameter n31 #off+31
define parameter n32 #off+32
define parameter n33 #off+33
define parameter n34 #off+34
define parameter n35 #off+35
define parameter n36 #off+36
define parameter n37 #off+37
define parameter n38 #off+38
define parameter n39 #off+39
define parameter n40 #off+40
define parameter n41 #off+41
define parameter n42 #off+42
define parameter n43 #off+43
define parameter n44 #off+44
define parameter n45 #off+45
define parameter n46 #off+46
define parameter n47 #off+47
define parameter n48 #off+48
define parameter n49 #off+49
define parameter n50 #off+50
define parameter n51 #off+51
node #n1,#r1.0,#z3
node #n2,#r1.90,#z3
node #n3,#r1.180,#z3
node #n4,0.0,#z3
element,quad,2,1,1,4,#n1,#n2,#n3,#n4
node,#n5,#r1,-90,#z3
node,#n6,#r1,#jog,#z3
elem,quad,2,1,1,4,#n3,#n5,#n6,#n4
$
$ 2ND RADIUS
node #n7,#r2.0,#z3
node #n8,#r2.90,#z3
node #n9,#r2.180,#z3
element,quad,2,1,1,4,#n7,#n8,#n9,#n4
node,#n10,#r2,-90,#z3
node,#n11,#r2,#jog,#z3
elem,quad,2,1,1,4,#n9,#n10,#n11,#n4
$
$ CONNECT 1ST AND 2ND RADIUS
$ lower layer
elem,beam,4,1,1,2,#n6,#n7
$
$ 3RD RADIUS
node #n17,#r3.0,#z3
node #n18,#r3.90,#z3
node #n19,#r3.180,#z3
element,quad,2,1,1,4,#n17,#n18,#n19,#n4
node,#n20,#r3,-90,#z3
node,#n21,#r3,#jog,#z3
elem,quad,2,1,1,4,#n19,#n20,#n21,#n4
$
$ CONNECT 2ND AND 3RD RADIUS
$ lower layer
elem,beam,4,1,1,2,#n11,#n17
$
$ 4TH RADIUS
node #n27,#r4.0,#z3
node #n28,#r4.90,#z3
node #n29,#r4.180,#z3
element,quad,2,1,1,4,#n27,#n28,#n29,#n4
node,#n30,#r4,-90,#z3
node,#n31,#r4,#jog,#z3
elem,quad,2,1,1,4,#n29,#n30,#n31,#n4
$
$ CONNECT 3RD AND 4TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n21,#n27
$
$ 5TH RADIUS
node #n37,#r5.0,#z3
node #n38,#r5.90,#z3
node #n39,#r5.180,#z3
element,quad,2,1,1,4,#n37,#n38,#n39,#n4
node,#n40,#r5,-90,#z3
node,#n41,#r5,#jog,#z3
elem,quad,2,1,1,4,#n39,#n40,#n41,#n4
$
$ CONNECT 4TH AND 5TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n31,#n37
$
$ 6TH RADIUS
node #n47,#r6.0,#z3
node #n48,#r6.90,#z3
node #n49,#r6,180,#z3
element,quad,2,1,1,4,#n47,#n48,#n49,#n4
node,#n50,#r6,-90,#z3
node,#n51,#r6,#adv,#z3
elem,quad,2,1,1,4,#n49,#n50,#n51,#n4
$
$ CONNECT 5TH AND 6TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n41,#n47
$
$
$ UPPER LAYER (IN Z) COIL
$ OUTER MOST RADIUS
$ DETERMINE NODE NUMBERS
default coord 4
define parameter off 1100
define parameter k1 #off+1
define parameter k2 #off+2
define parameter k3 #off+3
define parameter k4 #off+4
define parameter k5 #off+5
define parameter k6 #off+6
define parameter k7 #off+7
define parameter k8 #off+8
define parameter k9 #off+9
define parameter k10 #off+10
define parameter k11 #off+11
define parameter k12 #off+12
define parameter k13 #off+13
define parameter k14 #off+14
define parameter k15 #off+15
define parameter k16 #off+16
define parameter k17 #off+17
define parameter k18 #off+18
define parameter k19 #off+19
define parameter k20 #off+20
define parameter k21 #off+21
define parameter k22 #off+22
define parameter k23 #off+23
define parameter k24 #off+24
define parameter k25 #off+25
define parameter k26 #off+26
define parameter k27 #off+27
define parameter k28 #off+28
define parameter k29 #off+29
define parameter k30 #off+30
define parameter k31 #off+31
define parameter k32 #off+32
define parameter k33 #off+33
define parameter k34 #off+34
define parameter k35 #off+35
define parameter k36 #off+36
define parameter k37 #off+37
define parameter k38 #off+38
define parameter k39 #off+39
define parameter k40 #off+40
define parameter k41 #off+41
define parameter k42 #off+42
define parameter k43 #off+43
define parameter k44 #off+44
define parameter k45 #off+45
define parameter k46 #off+46
define parameter k47 #off+47
define parameter k48 #off+48
define parameter k49 #off+49
define parameter k50 #off+50
define parameter k51 #off+51
node #k1,#r6.0,#z4
node #k2,#r6.90,#z4
node #k3,#r6,180,#z4
node #k4,0.0,#z4
element,quad,2,1,1,4,#k1,#k2,#k3,#k4
node,#k5,#r6,-90,#z4
node,#k6,#r6,#jog,#z4
elem,quad,2,1,1,4,#k3,#k5,#k6,#k4
$
$ 5TH RADIUS
node #k7,#r5.0,#z4
node #k8,#r5.90,#z4
node #k9,#r5,180,#z4
element,quad,2,1,1,4,#k7,#k8,#k9,#k4
node,#k10,#r5,-90,#z4
node,#k11,#r5,#jog,#z4
elem,quad,2,1,1,4,#k9,#k10,#k11,#k4
$
$ CONNECT 6TH AND 5TH RADIUS
elem,beam,4,1,1,2,#k6,#k7
$
$ 4TH RADIUS
node #k17,#r4.0,#z4
node #k18,#r4.90,#z4
node #k19,#r4,180,#z4
element,quad,2,1,1,4,#k17,#k18,#k19,#k4
node,#k20,#r4,-90,#z4
node,#k21,#r4,#jog,#z4
elem,quad,2,1,1,4,#k19,#k20,#k21,#k4
$
$ CONNECT 5TH AND 4TH RADIUS
elem,beam,4,1,1,2,#k11,#k17
$
$ 3RD RADIUS
node #k27,#r3.0,#z4
node #k28,#r3.90,#z4
node #k29,#r3,180,#z4
element,quad,2,1,1,4,#k27,#k28,#k29,#k4
node,#k30,#r3,-90,#z4
node,#k31,#r3,#jog,#z4
elem,quad,2,1,1,4,#k29,#k30,#k31,#k4
$
$ CONNECT 4TH AND 3TH RADIUS
elem,beam,4,1,1,2,#k21,#k27
$
$ 2ND RADIUS
node #k37,#r2.0,#z4
node #k38,#r2.90,#z4
node #k39,#r2,180,#z4
element,quad,2,1,1,4,#k37,#k38,#k39,#k4
node,#k40,#r2,-90,#z4
node,#k41,#r2,#jog,#z4
elem,quad,2,1,1,4,#k39,#k40,#k41,#k4
$
$ CONNECT 3RD AND 2ND RADIUS
elem,beam,4,1,1,2,#k31,#k37
$
$ 1ST RADIUS
node #k47,#r1.0,#z4
node #k48,#r1.90,#z4
node #k49,#r1,180,#z4
element,quad,2,1,1,4,#k47,#k48,#k49,#k4
node,#k50,#r1,-90,#z4
node,#k51,#r1,#adv,#z4
elem,quad,2,1,1,4,#k49,#k50,#k51,#k4
$
$ CONNECT 2ND AND 1ST RADIUS
elem,beam,4,1,1,2,#k41,#k47
$
$
$ LOWER TO UPPER LAYER CONNECTION
elem,beam,4,1,1,2,#n51,#k1
$
$
$$$$$$$$$$$$
$ FIRST TO SECOND COIL PAIR
CONNECTION
define parameter xx #k51-100
elem,beam,4,1,1,2,#xx,#n1
$$$$$$$$$
$
$
$$$$$$$$$$$$$$$$$$$$$$
$ THIRD COIL PAIR
$$$$$$$$$$$$$$$$$$$$$$
$ INNER RADIUS
$ DETERMINE NODE NUMBERS
default coord 5
define parameter off 200
define parameter n1 #off+1
define parameter n2 #off+2
define parameter n3 #off+3
define parameter n4 #off+4
define parameter n5 #off+5
define parameter n6 #off+6
define parameter n7 #off+7
define parameter n8 #off+8
define parameter n9 #off+9
define parameter n10 #off+10
define parameter n11 #off+11
define parameter n12 #off+12
define parameter n13 #off+13
define parameter n14 #off+14
define parameter n15 #off+15
define parameter n16 #off+16
```

```
define parameter n17 #off+17
define parameter n18 #off+18
define parameter n19 #off+19
define parameter n20 #off+20
define parameter n21 #off+21
define parameter n22 #off+22
define parameter n23 #off+23
define parameter n24 #off+24
define parameter n25 #off+25
define parameter n26 #off+26
define parameter n27 #off+27
define parameter n28 #off+28
define parameter n29 #off+29
define parameter n30 #off+30
define parameter n31 #off+31
define parameter n32 #off+32
define parameter n33 #off+33
define parameter n34 #off+34
define parameter n35 #off+35
define parameter n36 #off+36
define parameter n37 #off+37
define parameter n38 #off+38
define parameter n39 #off+39
define parameter n40 #off+40
define parameter n41 #off+41
define parameter n42 #off+42
define parameter n43 #off+43
define parameter n44 #off+44
define parameter n45 #off+45
define parameter n46 #off+46
define parameter n47 #off+47
define parameter n48 #off+48
define parameter n49 #off+49
define parameter n50 #off+50
define parameter n51 #off+51
node #n1,#r1.0,#z5
node #n2,#r1.90,#z5
node #n3,#r1.180,#z5
node #n4,0.0,#z5
element,quad,2,1,1,4,#n1,#n2,#n3,#n4
node,#n5,#r1,-90,#z5
node,#n6,#r1,#jog,#z5
elem,quad,2,1,1,4,#n3,#n5,#n6,#n4
$
$ 2ND RADIUS
node #n7,#r2.0,#z5
node #n8,#r2.90,#z5
node #n9,#r2.180,#z5
element,quad,2,1,1,4,#n7,#n8,#n9,#n4
node,#n10,#r2,-90,#z5
node,#n11,#r2,#jog,#z5
elem,quad,2,1,1,4,#n9,#n10,#n11,#n4
$
$ CONNECT 1ST AND 2ND RADIUS
$ lower layer
elem,beam,4,1,1,2,#n6,#n7
$
$ 3RD RADIUS
node #n17,#r3.0,#z5
node #n18,#r3.90,#z5
node #n19,#r3.180,#z5
element,quad,2,1,1,4,#n17,#n18,#n19,#n4
node,#n20,#r3,-90,#z5
node,#n21,#r3,#jog,#z5
elem,quad,2,1,1,4,#n19,#n20,#n21,#n4
$
$ CONNECT 2ND AND 3RD RADIUS
$ lower layer
elem,beam,4,1,1,2,#n11,#n17
$
$ 4TH RADIUS
node #n27,#r4.0,#z5
node #n28,#r4.90,#z5
node #n29,#r4.180,#z5
element,quad,2,1,1,4,#n27,#n28,#n29,#n4
node,#n30,#r4,-90,#z5
node,#n31,#r4,#jog,#z5
elem,quad,2,1,1,4,#n29,#n30,#n31,#n4
$
$ CONNECT 3RD AND 4TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n21,#n27
$
$ 5TH RADIUS
node #n37,#r5.0,#z5
node #n38,#r5.90,#z5
node #n39,#r5.180,#z5
element,quad,2,1,1,4,#n37,#n38,#n39,#n4
node,#n40,#r5,-90,#z5
node,#n41,#r5,#jog,#z5
elem,quad,2,1,1,4,#n39,#n40,#n41,#n4
$
$ CONNECT 4TH AND 5TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n31,#n37
$
$ 6TH RADIUS
node #n47,#r6.0,#z5
node #n48,#r6.90,#z5
node #n49,#r6.180,#z5
element,quad,2,1,1,4,#n47,#n48,#n49,#n4
node,#n50,#r6,-90,#z5
node,#n51,#r6,#adv,#z5
elem,quad,2,1,1,4,#n49,#n50,#n51,#n4
$
$ CONNECT 5TH AND 6TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n41,#n47
$
$
$ UPPER LAYER (IN Z) COIL
$ OUTER MOST RADIUS
$ DETERMINE NODE NUMBERS
default coord 6
define parameter off 1200
define parameter k1 #off+1
define parameter k2 #off+2
define parameter k3 #off+3
define parameter k4 #off+4
define parameter k5 #off+5
define parameter k6 #off+6
define parameter k7 #off+7
define parameter k8 #off+8
define parameter k9 #off+9
define parameter k10 #off+10
define parameter k11 #off+11
define parameter k12 #off+12
define parameter k13 #off+13
define parameter k14 #off+14
define parameter k15 #off+15
define parameter k16 #off+16
define parameter k17 #off+17
define parameter k18 #off+18
define parameter k19 #off+19
define parameter k20 #off+20
define parameter k21 #off+21
define parameter k22 #off+22
define parameter k23 #off+23
define parameter k24 #off+24
define parameter k25 #off+25
define parameter k26 #off+26
define parameter k27 #off+27
define parameter k28 #off+28
define parameter k29 #off+29
define parameter k30 #off+30
define parameter k31 #off+31
define parameter k32 #off+32
define parameter k33 #off+33
define parameter k34 #off+34
define parameter k35 #off+35
define parameter k36 #off+36
define parameter k37 #off+37
define parameter k38 #off+38
define parameter k39 #off+39
define parameter k40 #off+40
define parameter k41 #off+41
define parameter k42 #off+42
define parameter k43 #off+43
define parameter k44 #off+44
define parameter k45 #off+45
define parameter k46 #off+46
define parameter k47 #off+47
define parameter k48 #off+48
define parameter k49 #off+49
define parameter k50 #off+50
define parameter k51 #off+51
node #k1,#r6.0,#z6
node #k2,#r6.90,#z6
node #k3,#r6.180,#z6
node #k4.0.0,#z6
element,quad,2,1,1,4,#k1,#k2,#k3,#k4
node,#k5,#r6,-90,#z6
node,#k6,#r6,#jog,#z6
elem,quad,2,1,1,4,#k3,#k5,#k6,#k4
$
$ 5TH RADIUS
node #k7,#r5.0,#z6
node #k8,#r5.90,#z6
node #k9,#r5.180,#z6
element,quad,2,1,1,4,#k7,#k8,#k9,#k4
node,#k10,#r5,-90,#z6
node,#k11,#r5,#jog,#z6
elem,quad,2,1,1,4,#k9,#k10,#k11,#k4
$
$ CONNECT 6TH AND 5TH RADIUS
elem,beam,4,1,1,2,#k6,#k7
$
$ 4TH RADIUS
node #k17,#r4.0,#z6
node #k18,#r4.90,#z6
node #k19,#r4,180,#z6
element,quad,2,1,1,4,#k17,#k18,#k19,#k4
node,#k20,#r4,-90,#z6
node,#k21,#r4,#jog,#z6
elem,quad,2,1,1,4,#k19,#k20,#k21,#k4
$
$ CONNECT 5TH AND 4TH RADIUS
elem,beam,4,1,1,2,#k11,#k17
$
$ 3RD RADIUS
node #k27,#r3.0,#z6
node #k28,#r3.90,#z6
node #k29,#r3,180,#z6
element,quad,2,1,1,4,#k27,#k28,#k29,#k4
node,#k30,#r3,-90,#z6
node,#k31,#r3,#jog,#z6
elem,quad,2,1,1,4,#k29,#k30,#k31,#k4
$
$ CONNECT 4TH AND 3TH RADIUS
elem,beam,4,1,1,2,#k21,#k27
$
$ 2ND RADIUS
node #k37,#r2.0,#z6
node #k38,#r2,90,#z6
node #k39,#r2,180,#z6
element,quad,2,1,1,4,#k37,#k38,#k39,#k4
node,#k40,#r2,-90,#z6
node,#k41,#r2,#jog,#z6
elem,quad,2,1,1,4,#k39,#k40,#k41,#k4
$
$ CONNECT 3RD AND 2ND RADIUS
elem,beam,4,1,1,2,#k31,#k37
$
$ 1ST RADIUS
node #k47,#r1,0,#z6
node #k48,#r1,90,#z6
node #k49,#r1,180,#z6
element,quad,2,1,1,4,#k47,#k48,#k49,#k4
node,#k50,#r1,-90,#z6
node,#k51,#r1,#adv,#z6
elem,quad,2,1,1,4,#k49,#k50,#k51,#k4
$
$ CONNECT 2ND AND 1ST RADIUS
elem,beam,4,1,1,2,#k41,#k47
$
$
$ LOWER TO UPPER LAYER CONNECTION
elem,beam,4,1,1,2,#n51,#k1
$
$
$$$$$$$$$$$$
$ SECOND TO THIRD COIL PAIR
CONNECTION
define parameter xx #k51-100
elem,beam,4,1,1,2,#xx,#n1
$$$$$$$$$
$
$$$$$$$$$$$$$$$$$$$$$$$$
$ THIRD COIL PAIR
$$$$$$$$$$$$$$$$$$$$$$$$
$ INNER RADIUS
$ DETERMINE NODE NUMBERS
default coord 7
define parameter off 300
define parameter n1 #off+1
define parameter n2 #off+2
define parameter n3 #off+3
define parameter n4 #off+4
define parameter n5 #off+5
define parameter n6 #off+6
define parameter n7 #off+7
define parameter n8 #off+8
define parameter n9 #off+9
define parameter n10 #off+10
define parameter n11 #off+11
define parameter n12 #off+12
define parameter n13 #off+13
define parameter n14 #off+14
define parameter n15 #off+15
define parameter n16 #off+16
```

```
define parameter n17 #off+17
define parameter n18 #off+18
define parameter n19 #off+19
define parameter n20 #off+20
define parameter n21 #off+21
define parameter n22 #off+22
define parameter n23 #off+23
define parameter n24 #off+24
define parameter n25 #off+25
define parameter n26 #off+26
define parameter n27 #off+27
define parameter n28 #off+28
define parameter n29 #off+29
define parameter n30 #off+30
define parameter n31 #off+31
define parameter n32 #off+32
define parameter n33 #off+33
define parameter n34 #off+34
define parameter n35 #off+35
define parameter n36 #off+36
define parameter n37 #off+37
define parameter n38 #off+38
define parameter n39 #off+39
define parameter n40 #off+40
define parameter n41 #off+41
define parameter n42 #off+42
define parameter n43 #off+43
define parameter n44 #off+44
define parameter n45 #off+45
define parameter n46 #off+46
define parameter n47 #off+47
define parameter n48 #off+48
define parameter n49 #off+49
define parameter n50 #off+50
define parameter n51 #off+51
node #n1,#r1.0,#z7
node #n2,#r1.90,#z7
node #n3,#r1.180,#z7
node #n4.0.0,#z7
element,quad,2,1,1,4,#n1,#n2,#n3,#n4
node,#n5,#r1,-90,#z7
node,#n6,#r1,#jog,#z7
elem,quad,2,1,1,4,#n3,#n5,#n6,#n4
$
$ 2ND RADIUS
node #n7,#r2.0,#z7
node #n8,#r2.90,#z7
node #n9,#r2,180,#z7
element,quad,2,1,1,4,#n7,#n8,#n9,#n4
node,#n10,#r2,-90,#z7
node,#n11,#r2,#jog,#z7
elem,quad,2,1,1,4,#n9,#n10,#n11,#n4
$
$ CONNECT 1ST AND 2ND RADIUS
$ lower layer
elem,beam,4,1,1,2,#n6,#n7
$
$ 3RD RADIUS
node #n17,#r3.0,#z7
node #n18,#r3.90,#z7
node #n19,#r3,180,#z7
element,quad,2,1,1,4,#n17,#n18,#n19,#n4
node,#n20,#r3,-90,#z7
node,#n21,#r3,#jog,#z7
elem,quad,2,1,1,4,#n19,#n20,#n21,#n4
$
$ CONNECT 2ND AND 3RD RADIUS
$ lower layer
elem,beam,4,1,1,2,#n11,#n17
$
$ 4TH RADIUS
node #n27,#r4.0,#z7
node #n28,#r4,90,#z7
node #n29,#r4,180,#z7
element,quad,2,1,1,4,#n27,#n28,#n29,#n4
node,#n30,#r4,-90,#z7
node,#n31,#r4,#jog,#z7
elem,quad,2,1,1,4,#n29,#n30,#n31,#n4
$
$ CONNECT 3RD AND 4TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n21,#n27
$
$ 5TH RADIUS
node #n37,#r5.0,#z7
node #n38,#r5.90,#z7
node #n39,#r5,180,#z7
element,quad,2,1,1,4,#n37,#n38,#n39,#n4
node,#n40,#r5,-90,#z7
node,#n41,#r5,#jog,#z7
elem,quad,2,1,1,4,#n39,#n40,#n41,#n4
$
$ CONNECT 4TH AND 5TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n31,#n37
$
$ 6TH RADIUS
node #n47,#r6.0,#z7
node #n48,#r6,90,#z7
node #n49,#r6,180,#z7
element,quad,2,1,1,4,#n47,#n48,#n49,#n4
node,#n50,#r6,-90,#z7
node,#n51,#r6,#adv,#z7
elem,quad,2,1,1,4,#n49,#n50,#n51,#n4
$
$ CONNECT 5TH AND 6TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n41,#n47
$
$
$ UPPER LAYER (IN Z) COIL
$ OUTER MOST RADIUS
$ DETERMINE NODE NUMBERS
default coord 8
define parameter off 1300
define parameter k1 #off+1
define parameter k2 #off+2
define parameter k3 #off+3
define parameter k4 #off+4
define parameter k5 #off+5
define parameter k6 #off+6
define parameter k7 #off+7
define parameter k8 #off+8
define parameter k9 #off+9
define parameter k10 #off+10
define parameter k11 #off+11
define parameter k12 #off+12
define parameter k13 #off+13
define parameter k14 #off+14
define parameter k15 #off+15
define parameter k16 #off+16
define parameter k17 #off+17
define parameter k18 #off+18
define parameter k19 #off+19
define parameter k20 #off+20
define parameter k21 #off+21
define parameter k22 #off+22
define parameter k23 #off+23
define parameter k24 #off+24
define parameter k25 #off+25
define parameter k26 #off+26
define parameter k27 #off+27
define parameter k28 #off+28
define parameter k29 #off+29
define parameter k30 #off+30
define parameter k31 #off+31
define parameter k32 #off+32
define parameter k33 #off+33
define parameter k34 #off+34
define parameter k35 #off+35
define parameter k36 #off+36
define parameter k37 #off+37
define parameter k38 #off+38
define parameter k39 #off+39
define parameter k40 #off+40
define parameter k41 #off+41
define parameter k42 #off+42
define parameter k43 #off+43
define parameter k44 #off+44
define parameter k45 #off+45
define parameter k46 #off+46
define parameter k47 #off+47
define parameter k48 #off+48
define parameter k49 #off+49
define parameter k50 #off+50
define parameter k51 #off+51
node #k1,#r6.0,#z8
node #k2,#r6,90,#z8
node #k3,#r6,180,#z8
node #k4.0.0,#z8
element,quad,2,1,1,4,#k1,#k2,#k3,#k4
node,#k5,#r6,-90,#z8
node,#k6,#r6,#jog,#z8
elem,quad,2,1,1,4,#k3,#k5,#k6,#k4
$
$ 5TH RADIUS
node #k7,#r5.0,#z8
node #k8,#r5,90,#z8
node #k9,#r5,180,#z8
element,quad,2,1,1,4,#k7,#k8,#k9,#k4
node,#k10,#r5,-90,#z8
node,#k11,#r5,#jog,#z8
elem,quad,2,1,1,4,#k9,#k10,#k11,#k4
$
$ CONNECT 6TH AND 5TH RADIUS
elem,beam,4,1,1,2,#k6,#k7
$
$ 4TH RADIUS
node #k17,#r4.0,#z8
node #k18,#r4,90,#z8
node #k19,#r4,180,#z8
element,quad,2,1,1,4,#k17,#k18,#k19,#k4
node,#k20,#r4,-90,#z8
node,#k21,#r4,#jog,#z8
elem,quad,2,1,1,4,#k19,#k20,#k21,#k4
$
$ CONNECT 5TH AND 4TH RADIUS
elem,beam,4,1,1,2,#k11,#k17
$
$ 3RD RADIUS
node #k27,#r3.0,#z8
node #k28,#r3.90,#z8
node #k29,#r3,180,#z8
element,quad,2,1,1,4,#k27,#k28,#k29,#k4
node,#k30,#r3,-90,#z8
node,#k31,#r3,#jog,#z8
elem,quad,2,1,1,4,#k29,#k30,#k31,#k4
$
$ CONNECT 4TH AND 3TH RADIUS
elem,beam,4,1,1,2,#k21,#k27
$
$ 2ND RADIUS
node #k37,#r2.0,#z8
node #k38,#r2.90,#z8
node #k39,#r2,180,#z8
element,quad,2,1,1,4,#k37,#k38,#k39,#k4
node,#k40,#r2,-90,#z8
node,#k41,#r2,#jog,#z8
elem,quad,2,1,1,4,#k39,#k40,#k41,#k4
$
$ CONNECT 3RD AND 2ND RADIUS
elem,beam,4,1,1,2,#k31,#k37
$
$ 1ST RADIUS
node #k47,#r1.0,#z8
node #k48,#r1.90,#z8
node #k49,#r1,180,#z8
element,quad,2,1,1,4,#k47,#k48,#k49,#k4
node,#k50,#r1,-90,#z8
node,#k51,#r1,#adv,#z8
elem,quad,2,1,1,4,#k49,#k50,#k51,#k4
$
$ CONNECT 2ND AND 1ST RADIUS
elem,beam,4,1,1,2,#k41,#k47
$
$
$ LOWER TO UPPER LAYER CONNECTION
elem,beam,4,1,1,2,#n51,#k1
$
$
$$$$$$$$$$$$
$ THIRD TO FOURTH COIL PAIR
CONNECTION
define parameter xx #k51-100
elem,beam,4,1,1,2,#xx,#n1
$$$$$$$$$
$
$
$$$$$$$$$$$$$$$$$$$$$$$$
$ FIFTH COIL PAIR
$$$$$$$$$$$$$$$$$$$$$$$$
$ INNER RADIUS
$ DETERMINE NODE NUMBERS
default coord 9
define parameter off 400
define parameter n1 #off+1
define parameter n2 #off+2
define parameter n3 #off+3
define parameter n4 #off+4
define parameter n5 #off+5
define parameter n6 #off+6
define parameter n7 #off+7
define parameter n8 #off+8
define parameter n9 #off+9
define parameter n10 #off+10
define parameter n11 #off+11
define parameter n12 #off+12
define parameter n13 #off+13
define parameter n14 #off+14
define parameter n15 #off+15
```

```
define parameter n16 #off+16
define parameter n17 #off+17
define parameter n18 #off+18
define parameter n19 #off+19
define parameter n20 #off+20
define parameter n21 #off+21
define parameter n22 #off+22
define parameter n23 #off+23
define parameter n24 #off+24
define parameter n25 #off+25
define parameter n26 #off+26
define parameter n27 #off+27
define parameter n28 #off+28
define parameter n29 #off+29
define parameter n30 #off+30
define parameter n31 #off+31
define parameter n32 #off+32
define parameter n33 #off+33
define parameter n34 #off+34
define parameter n35 #off+35
define parameter n36 #off+36
define parameter n37 #off+37
define parameter n38 #off+38
define parameter n39 #off+39
define parameter n40 #off+40
define parameter n41 #off+41
define parameter n42 #off+42
define parameter n43 #off+43
define parameter n44 #off+44
define parameter n45 #off+45
define parameter n46 #off+46
define parameter n47 #off+47
define parameter n48 #off+48
define parameter n49 #off+49
define parameter n50 #off+50
define parameter n51 #off+51
node #n1,#r1.0,#z9
node #n2,#r1.90,#z9
node #n3,#r1,180,#z9
node #n4,0.0,#z9
element,quad,2,1,1,4,#n1,#n2,#n3,#n4
node,#n5,#r1,-90,#z9
node,#n6,#r1,#jog,#z9
elem,quad,2,1,1,4,#n3,#n5,#n6,#n4
$
$ 2ND RADIUS
node #n7,#r2.0,#z9
node #n8,#r2,90,#z9
node #n9,#r2,180,#z9
element,quad,2,1,1,4,#n7,#n8,#n9,#n4
node,#n10,#r2,-90,#z9
node,#n11,#r2,#jog,#z9
elem,quad,2,1,1,4,#n9,#n10,#n11,#n4
$
$ CONNECT 1ST AND 2ND RADIUS
$ lower layer
elem,beam,4,1,1,2,#n6,#n7
$
$ 3RD RADIUS
node #n17,#r3.0,#z9
node #n18,#r3,90,#z9
node #n19,#r3,180,#z9
element,quad,2,1,1,4,#n17,#n18,#n19,#n4
node,#n20,#r3,-90,#z9
node,#n21,#r3,#jog,#z9
elem,quad,2,1,1,4,#n19,#n20,#n21,#n4
$
$ CONNECT 2ND AND 3RD RADIUS
$ lower layer
elem,beam,4,1,1,2,#n11,#n17
$
$ 4TH RADIUS
node #n27,#r4.0,#z9
node #n28,#r4,90,#z9
node #n29,#r4,180,#z9
element,quad,2,1,1,4,#n27,#n28,#n29,#n4
node,#n30,#r4,-90,#z9
node,#n31,#r4,#jog,#z9
elem,quad,2,1,1,4,#n29,#n30,#n31,#n4
$
$ CONNECT 3RD AND 4TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n21,#n27
$
$ 5TH RADIUS
node #n37,#r5.0,#z9
node #n38,#r5,90,#z9
node #n39,#r5,180,#z9
element,quad,2,1,1,4,#n37,#n38,#n39,#n4
node,#n40,#r5,-90,#z9
node,#n41,#r5,#jog,#z9
elem,quad,2,1,1,4,#n39,#n40,#n41,#n4
$
$ CONNECT 4TH AND 5TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n31,#n37
$
$ 6TH RADIUS
node #n47,#r6.0,#z9
node #n48,#r6,90,#z9
node #n49,#r6,180,#z9
element,quad,2,1,1,4,#n47,#n48,#n49,#n4
node,#n50,#r6,-90,#z9
node,#n51,#r6,#adv,#z9
elem,quad,2,1,1,4,#n49,#n50,#n51,#n4
$
$ CONNECT 5TH AND 6TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n41,#n47
$
$
$ UPPER LAYER (IN Z) COIL
$ OUTER MOST RADIUS
$ DETERMINE NODE NUMBERS
default coord 10
define parameter off 1400
define parameter k1 #off+1
define parameter k2 #off+2
define parameter k3 #off+3
define parameter k4 #off+4
define parameter k5 #off+5
define parameter k6 #off+6
define parameter k7 #off+7
define parameter k8 #off+8
define parameter k9 #off+9
define parameter k10 #off+10
define parameter k11 #off+11
define parameter k12 #off+12
define parameter k13 #off+13
define parameter k14 #off+14
define parameter k15 #off+15
define parameter k16 #off+16
define parameter k17 #off+17
define parameter k18 #off+18
define parameter k19 #off+19
define parameter k20 #off+20
define parameter k21 #off+21
define parameter k22 #off+22
define parameter k23 #off+23
define parameter k24 #off+24
define parameter k25 #off+25
define parameter k26 #off+26
define parameter k27 #off+27
define parameter k28 #off+28
define parameter k29 #off+29
define parameter k30 #off+30
define parameter k31 #off+31
define parameter k32 #off+32
define parameter k33 #off+33
define parameter k34 #off+34
define parameter k35 #off+35
define parameter k36 #off+36
define parameter k37 #off+37
define parameter k38 #off+38
define parameter k39 #off+39
define parameter k40 #off+40
define parameter k41 #off+41
define parameter k42 #off+42
define parameter k43 #off+43
define parameter k44 #off+44
define parameter k45 #off+45
define parameter k46 #off+46
define parameter k47 #off+47
define parameter k48 #off+48
define parameter k49 #off+49
define parameter k50 #off+50
define parameter k51 #off+51
node #k1,#r6.0,#z10
node #k2,#r6,90,#z10
node #k3,#r6,180,#z10
node #k4,0.0,#z10
element,quad,2,1,1,4,#k1,#k2,#k3,#k4
node,#k5,#r6,-90,#z10
node,#k6,#r6,#jog,#z10
elem,quad,2,1,1,4,#k3,#k5,#k6,#k4
$
$ 5TH RADIUS
node #k7,#r5.0,#z10
node #k8,#r5,90,#z10
node #k9,#r5,180,#z10
element,quad,2,1,1,4,#k7,#k8,#k9,#k4
node,#k10,#r5,-90,#z10
node,#k11,#r5,#jog,#z10
elem,quad,2,1,1,4,#k9,#k10,#k11,#k4
$
$ CONNECT 6TH AND 5TH RADIUS
elem,beam,4,1,1,2,#k6,#k7
$
$ 4TH RADIUS
node #k17,#r4.0,#z10
node #k18,#r4,90,#z10
node #k19,#r4,180,#z10
element,quad,2,1,1,4,#k17,#k18,#k19,#k4
node,#k20,#r4,-90,#z10
node,#k21,#r4,#jog,#z10
elem,quad,2,1,1,4,#k19,#k20,#k21,#k4
$
$ CONNECT 5TH AND 4TH RADIUS
elem,beam,4,1,1,2,#k11,#k17
$
$ 3RD RADIUS
node #k27,#r3.0,#z10
node #k28,#r3,90,#z10
node #k29,#r3,180,#z10
element,quad,2,1,1,4,#k27,#k28,#k29,#k4
node,#k30,#r3,-90,#z10
node,#k31,#r3,#jog,#z10
elem,quad,2,1,1,4,#k29,#k30,#k31,#k4
$
$ CONNECT 4TH AND 3TH RADIUS
elem,beam,4,1,1,2,#k21,#k27
$
$ 2ND RADIUS
node #k37,#r2.0,#z10
node #k38,#r2,90,#z10
node #k39,#r2,180,#z10
element,quad,2,1,1,4,#k37,#k38,#k39,#k4
node,#k40,#r2,-90,#z10
node,#k41,#r2,#jog,#z10
elem,quad,2,1,1,4,#k39,#k40,#k41,#k4
$
$ CONNECT 3RD AND 2ND RADIUS
elem,beam,4,1,1,2,#k31,#k37
$
$ 1ST RADIUS
node #k47,#r1.0,#z10
node #k48,#r1,90,#z10
node #k49,#r1,180,#z10
element,quad,2,1,1,4,#k47,#k48,#k49,#k4
node,#k50,#r1,-90,#z10
node,#k51,#r1,#adv,#z10
elem,quad,2,1,1,4,#k49,#k50,#k51,#k4
define parameter nend #k51
$
$ CONNECT 2ND AND 1ST RADIUS
elem,beam,4,1,1,2,#k41,#k47
$
$
$ LOWER TO UPPER LAYER CONNECTION
elem,beam,4,1,1,2,#n51,#k1
$
$
$$$$$$$$$$$$
$ FOURTH TO FIFTH COIL PAIR
CONNECTION
define parameter xx #k51-100
elem,beam,4,1,1,2,#xx,#n1
$$$$$$$$$
$
$ RETURN LEAD to CLOSE PATH
elem,beam,4,1,1,2,#nend,#nst
$
$
$ OBSERVATION POINTS
default node start 10000
default coord 1
point p1 225 0
point p2 225 90
point p3 225 180
point p4 225 270
point p0 0 0
arc a1 p1 p2 p0 512
$ arc a2 p2 p3 p0 32
$ arc a3 p3 p4 p0 32
$ arc a4 p4 p1 p0 32
node name on
```

Constant Radius/Jog Case with helical return lead- File gclok2.str

```
define parameter rm 81
define parameter dr 2.54
define parameter dz 2.54
define parameter jog -15
define parameter lift 104.15
define parameter r1 #rm-#dr*5/2
define parameter r2 #rm-#dr*3/2
define parameter r3 #rm-#dr*1/2
define parameter r4 #rm+#dr*1/2
define parameter r5 #rm+#dr*3/2
define parameter r6 #rm+#dr*5/2
define parameter z1 #lift-#dz*9/2
define parameter z2 #lift-#dz*7/2
define parameter z3 #lift-#dz*5/2
define parameter z4 #lift-#dz*3/2
define parameter z5 #lift-#dz*1/2
define parameter z6 #lift+#dz*1/2
define parameter z7 #lift+#dz*3/2
define parameter z8 #lift+#dz*5/2
define parameter z9 #lift+#dz*7/2
define parameter z10 #lift+#dz*9/2
define parameter adv -36.0
define parameter a2 #adv
define parameter a3 #a2+#adv
define parameter a4 #a3+#adv
define parameter a5 #a4+#adv
define parameter a6 #a5+#adv
define parameter a7 #a6+#adv
define parameter a8 #a7+#adv
define parameter a9 #a8+#adv
define parameter a10 #a9+#adv
coord,1,cylind
coord,2,cylind,0.0,0.0,#a2
coord,3,cylind,0.0,0.0,#a3
coord,4,cylind,0.0,0.0,#a4
coord,5,cylind,0.0,0.0,#a5
coord,6,cylind,0.0,0.0,#a6
coord,7,cylind,0.0,0.0,#a7
coord,8,cylind,0.0,0.0,#a8
coord,9,cylind,0.0,0.0,#a9
coord,10,cylind,0.0,0.0,#a10
default coord 1
$
$
$$$$$$$$$$$$$$$$$$$
$ FIRST COIL PAIR
$$$$$$$$$$$$$$$$$$$
$ INNER RADIUS
$ DETERMINE NODE NUMBERS
define parameter off 0
define parameter n1 #off+1
define parameter n2 #off+2
define parameter n3 #off+3
define parameter n4 #off+4
define parameter n5 #off+5
define parameter n6 #off+6
define parameter n7 #off+7
define parameter n8 #off+8
define parameter n9 #off+9
define parameter n10 #off+10
define parameter n11 #off+11
define parameter n12 #off+12
define parameter n13 #off+13
define parameter n14 #off+14
define parameter n15 #off+15
define parameter n16 #off+16
define parameter n17 #off+17
define parameter n18 #off+18
define parameter n19 #off+19
define parameter n20 #off+20
define parameter n21 #off+21
define parameter n22 #off+22
define parameter n23 #off+23
define parameter n24 #off+24
define parameter n25 #off+25
define parameter n26 #off+26
define parameter n27 #off+27
define parameter n28 #off+28
define parameter n29 #off+29
define parameter n30 #off+30
define parameter n31 #off+31
define parameter n32 #off+32
define parameter n33 #off+33
define parameter n34 #off+34
define parameter n35 #off+35
define parameter n36 #off+36
define parameter n37 #off+37
define parameter n38 #off+38
define parameter n39 #off+39
define parameter n40 #off+40
define parameter n41 #off+41
define parameter n42 #off+42
define parameter n43 #off+43
define parameter n44 #off+44
define parameter n45 #off+45
define parameter n46 #off+46
define parameter n47 #off+47
define parameter n48 #off+48
define parameter n49 #off+49
define parameter n50 #off+50
define parameter n51 #off+51
define parameter nst #n1
node #n1,#r1,0.,#z1
node #n2,#r1,90.,#z1
node #n3,#r1,180.,#z1
node #n4,0.0,#z1
element,quad,2,1,1,4,#n1,#n2,#n3,#n4
node,#n5,#r1,-90.,#z1
node,#n6,#r1,#jog,#z1
elem,quad,2,1,1,4,#n3,#n5,#n6,#n4
$
$ 2ND RADIUS
node #n7,#r2,0.,#z1
node #n8,#r2,90.,#z1
node #n9,#r2,180.,#z1
element,quad,2,1,1,4,#n7,#n8,#n9,#n4
node,#n10,#r2,-90.,#z1
node,#n11,#r2,#jog,#z1
elem,quad,2,1,1,4,#n9,#n10,#n11,#n4
$
$ CONNECT 1ST AND 2ND RADIUS
$ lower layer
elem,beam,4,1,1,2,#n6,#n7
$
$ 3RD RADIUS
node #n17,#r3,0.,#z1
node #n18,#r3,90.,#z1
node #n19,#r3,180.,#z1
element,quad,2,1,1,4,#n17,#n18,#n19,#n4
node,#n20,#r3,-90.,#z1
node,#n21,#r3,#jog,#z1
elem,quad,2,1,1,4,#n19,#n20,#n21,#n4
$
$ CONNECT 2ND AND 3RD RADIUS
$ lower layer
elem,beam,4,1,1,2,#n11,#n17
$
$ 4TH RADIUS
node #n27,#r4,0.,#z1
node #n28,#r4,90.,#z1
node #n29,#r4,180.,#z1
element,quad,2,1,1,4,#n27,#n28,#n29,#n4
node,#n30,#r4,-90.,#z1
node,#n31,#r4,#jog,#z1
elem,quad,2,1,1,4,#n29,#n30,#n31,#n4
$
$ CONNECT 3RD AND 4TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n21,#n27
$
$ 5TH RADIUS
node #n37,#r5,0.,#z1
node #n38,#r5,90.,#z1
node #n39,#r5,180.,#z1
element,quad,2,1,1,4,#n37,#n38,#n39,#n4
node,#n40,#r5,-90.,#z1
node,#n41,#r5,#jog,#z1
elem,quad,2,1,1,4,#n39,#n40,#n41,#n4
$
$ CONNECT 4TH AND 5TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n31,#n37
$
$ 6TH RADIUS
node #n47,#r6,0.,#z1
node #n48,#r6,90.,#z1
node #n49,#r6,180.,#z1
element,quad,2,1,1,4,#n47,#n48,#n49,#n4
node,#n50,#r6,-90.,#z1
node,#n51,#r6,#adv,#z1
elem,quad,2,1,1,4,#n49,#n50,#n51,#n4
$
$ CONNECT 5TH AND 6TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n41,#n47
$
$
default coord 2
$ UPPER LAYER (IN Z) COIL
$ OUTER MOST RADIUS
$ DETERMINE NODE NUMBERS
define parameter off 1000
define parameter k1 #off+1
define parameter k2 #off+2
define parameter k3 #off+3
define parameter k4 #off+4
define parameter k5 #off+5
define parameter k6 #off+6
define parameter k7 #off+7
define parameter k8 #off+8
define parameter k9 #off+9
define parameter k10 #off+10
define parameter k11 #off+11
define parameter k12 #off+12
define parameter k13 #off+13
define parameter k14 #off+14
define parameter k15 #off+15
define parameter k16 #off+16
define parameter k17 #off+17
define parameter k18 #off+18
define parameter k19 #off+19
define parameter k20 #off+20
define parameter k21 #off+21
define parameter k22 #off+22
define parameter k23 #off+23
define parameter k24 #off+24
define parameter k25 #off+25
define parameter k26 #off+26
define parameter k27 #off+27
define parameter k28 #off+28
define parameter k29 #off+29
define parameter k30 #off+30
define parameter k31 #off+31
define parameter k32 #off+32
define parameter k33 #off+33
define parameter k34 #off+34
define parameter k35 #off+35
define parameter k36 #off+36
define parameter k37 #off+37
define parameter k38 #off+38
define parameter k39 #off+39
define parameter k40 #off+40
define parameter k41 #off+41
define parameter k42 #off+42
define parameter k43 #off+43
define parameter k44 #off+44
define parameter k45 #off+45
define parameter k46 #off+46
define parameter k47 #off+47
define parameter k48 #off+48
define parameter k49 #off+49
define parameter k50 #off+50
define parameter k51 #off+51
node #k1,#r6,0.,#z2
node #k2,#r6,90.,#z2
node #k3,#r6,180.,#z2
node #k4,0.0,#z2
element,quad,2,1,1,4,#k1,#k2,#k3,#k4
node,#k5,#r6,-90.,#z2
node,#k6,#r6,#jog,#z2
elem,quad,2,1,1,4,#k3,#k5,#k6,#k4
$
$ 5TH RADIUS
node #k7,#r5,0.,#z2
node #k8,#r5,90.,#z2
node #k9,#r5,180.,#z2
element,quad,2,1,1,4,#k7,#k8,#k9,#k4
node,#k10,#r5,-90.,#z2
node,#k11,#r5,#jog,#z2
elem,quad,2,1,1,4,#k9,#k10,#k11,#k4
$
$ CONNECT 6TH AND 5TH RADIUS
```

```
elem,beam,4,1,1,2,#k6,#k7
$
$ 4TH RADIUS
node #k17,#r4.0,#z2
node #k18,#r4,90,#z2
node #k19,#r4,180,#z2
element,quad,2,1,1,4,#k17,#k18,#k19,#k4
node,#k20,#r4,-90,#z2
node,#k21,#r4,#jog,#z2
elem,quad,2,1,1,4,#k19,#k20,#k21,#k4
$
$ CONNECT 5TH AND 4TH RADIUS
elem,beam,4,1,1,2,#k11,#k17
$
$ 3RD RADIUS
node #k27,#r3.0,#z2
node #k28,#r3,90,#z2
node #k29,#r3,180,#z2
element,quad,2,1,1,4,#k27,#k28,#k29,#k4
node,#k30,#r3,-90,#z2
node,#k31,#r3,#jog,#z2
elem,quad,2,1,1,4,#k29,#k30,#k31,#k4
$
$ CONNECT 4TH AND 3TH RADIUS
elem,beam,4,1,1,2,#k21,#k27
$
$ 2ND RADIUS
node #k37,#r2.0,#z2
node #k38,#r2,90,#z2
node #k39,#r2,180,#z2
element,quad,2,1,1,4,#k37,#k38,#k39,#k4
node,#k40,#r2,-90,#z2
node,#k41,#r2,#jog,#z2
elem,quad,2,1,1,4,#k39,#k40,#k41,#k4
$
$ CONNECT 3RD AND 2ND RADIUS
elem,beam,4,1,1,2,#k31,#k37
$
$ 1ST RADIUS
node #k47,#r1.0,#z2
node #k48,#r1,90,#z2
node #k49,#r1,180,#z2
element,quad,2,1,1,4,#k47,#k48,#k49,#k4
node,#k50,#r1,-90,#z2
node,#k51,#r1,#adv,#z2
elem,quad,2,1,1,4,#k49,#k50,#k51,#k4
$
$ CONNECT 2ND AND 1ST RADIUS
elem,beam,4,1,1,2,#k41,#k47
$
$
$ LOWER TO UPPER LAYER CONNECTION
elem,beam,4,1,1,2,#n51,#k1
$
$
$
$
$$$$$$$$$$$$$$$$$$$$$$
$ SECOND COIL PAIR
$$$$$$$$$$$$$$$$$$$$$$
$ INNER RADIUS
$ DETERMINE NODE NUMBERS
default coord 3
define parameter off 100
define parameter n1 #off+1
define parameter n2 #off+2
define parameter n3 #off+3
define parameter n4 #off+4
define parameter n5 #off+5
define parameter n6 #off+6
define parameter n7 #off+7
define parameter n8 #off+8
define parameter n9 #off+9
define parameter n10 #off+10
define parameter n11 #off+11
define parameter n12 #off+12
define parameter n13 #off+13
define parameter n14 #off+14
define parameter n15 #off+15
define parameter n16 #off+16
define parameter n17 #off+17
define parameter n18 #off+18
define parameter n19 #off+19
define parameter n20 #off+20
define parameter n21 #off+21
define parameter n22 #off+22
define parameter n23 #off+23
define parameter n24 #off+24
define parameter n25 #off+25
define parameter n26 #off+26
define parameter n27 #off+27
define parameter n28 #off+28
define parameter n29 #off+29
define parameter n30 #off+30
define parameter n31 #off+31
define parameter n32 #off+32
define parameter n33 #off+33
define parameter n34 #off+34
define parameter n35 #off+35
define parameter n36 #off+36
define parameter n37 #off+37
define parameter n38 #off+38
define parameter n39 #off+39
define parameter n40 #off+40
define parameter n41 #off+41
define parameter n42 #off+42
define parameter n43 #off+43
define parameter n44 #off+44
define parameter n45 #off+45
define parameter n46 #off+46
define parameter n47 #off+47
define parameter n48 #off+48
define parameter n49 #off+49
define parameter n50 #off+50
define parameter n51 #off+51
node #n1,#r1.0,#z3
node #n2,#r1,90,#z3
node #n3,#r1,180,#z3
node #n4,0.0,#z3
element,quad,2,1,1,4,#n1,#n2,#n3,#n4
node,#n5,#r1,-90,#z3
node,#n6,#r1,#jog,#z3
elem,quad,2,1,1,4,#n3,#n5,#n6,#n4
$
$ 2ND RADIUS
node #n7,#r2.0,#z3
node #n8,#r2,90,#z3
node #n9,#r2,180,#z3
element,quad,2,1,1,4,#n7,#n8,#n9,#n4
node,#n10,#r2,-90,#z3
node,#n11,#r2,#jog,#z3
elem,quad,2,1,1,4,#n9,#n10,#n11,#n4
$
$ CONNECT 1ST AND 2ND RADIUS
$ lower layer
elem,beam,4,1,1,2,#n6,#n7
$
$ 3RD RADIUS
node #n17,#r3.0,#z3
node #n18,#r3,90,#z3
node #n19,#r3,180,#z3
element,quad,2,1,1,4,#n17,#n18,#n19,#n4
node,#n20,#r3,-90,#z3
node,#n21,#r3,#jog,#z3
elem,quad,2,1,1,4,#n19,#n20,#n21,#n4
$
$ CONNECT 2ND AND 3RD RADIUS
$ lower layer
elem,beam,4,1,1,2,#n11,#n17
$
$ 4TH RADIUS
node #n27,#r4.0,#z3
node #n28,#r4,90,#z3
node #n29,#r4,180,#z3
element,quad,2,1,1,4,#n27,#n28,#n29,#n4
node,#n30,#r4,-90,#z3
node,#n31,#r4,#jog,#z3
elem,quad,2,1,1,4,#n29,#n30,#n31,#n4
$
$ CONNECT 3RD AND 4TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n21,#n27
$
$ 5TH RADIUS
node #n37,#r5.0,#z3
node #n38,#r5,90,#z3
node #n39,#r5,180,#z3
element,quad,2,1,1,4,#n37,#n38,#n39,#n4
node,#n40,#r5,-90,#z3
node,#n41,#r5,#jog,#z3
elem,quad,2,1,1,4,#n39,#n40,#n41,#n4
$
$ CONNECT 4TH AND 5TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n31,#n37
$
$ 6TH RADIUS
node #n47,#r6.0,#z3
node #n48,#r6,90,#z3
node #n49,#r6,180,#z3
element,quad,2,1,1,4,#n47,#n48,#n49,#n4
node,#n50,#r6,-90,#z3
node,#n51,#r6,#adv,#z3
elem,quad,2,1,1,4,#n49,#n50,#n51,#n4
$
$ CONNECT 5TH AND 6TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n41,#n47
$
$
$ UPPER LAYER (IN Z) COIL
$ OUTER MOST RADIUS
$ DETERMINE NODE NUMBERS
default coord 4
define parameter off 1100
define parameter k1 #off+1
define parameter k2 #off+2
define parameter k3 #off+3
define parameter k4 #off+4
define parameter k5 #off+5
define parameter k6 #off+6
define parameter k7 #off+7
define parameter k8 #off+8
define parameter k9 #off+9
define parameter k10 #off+10
define parameter k11 #off+11
define parameter k12 #off+12
define parameter k13 #off+13
define parameter k14 #off+14
define parameter k15 #off+15
define parameter k16 #off+16
define parameter k17 #off+17
define parameter k18 #off+18
define parameter k19 #off+19
define parameter k20 #off+20
define parameter k21 #off+21
define parameter k22 #off+22
define parameter k23 #off+23
define parameter k24 #off+24
define parameter k25 #off+25
define parameter k26 #off+26
define parameter k27 #off+27
define parameter k28 #off+28
define parameter k29 #off+29
define parameter k30 #off+30
define parameter k31 #off+31
define parameter k32 #off+32
define parameter k33 #off+33
define parameter k34 #off+34
define parameter k35 #off+35
define parameter k36 #off+36
define parameter k37 #off+37
define parameter k38 #off+38
define parameter k39 #off+39
define parameter k40 #off+40
define parameter k41 #off+41
define parameter k42 #off+42
define parameter k43 #off+43
define parameter k44 #off+44
define parameter k45 #off+45
define parameter k46 #off+46
define parameter k47 #off+47
define parameter k48 #off+48
define parameter k49 #off+49
define parameter k50 #off+50
define parameter k51 #off+51
node #k1,#r6.0,#z4
node #k2,#r6,90,#z4
node #k3,#r6,180,#z4
node #k4,0.0,#z4
element,quad,2,1,1,4,#k1,#k2,#k3,#k4
node,#k5,#r6,-90,#z4
node,#k6,#r6,#jog,#z4
elem,quad,2,1,1,4,#k3,#k5,#k6,#k4
$
$ 5TH RADIUS
node #k7,#r5.0,#z4
node #k8,#r5,90,#z4
node #k9,#r5,180,#z4
element,quad,2,1,1,4,#k7,#k8,#k9,#k4
node,#k10,#r5,-90,#z4
node,#k11,#r5,#jog,#z4
elem,quad,2,1,1,4,#k9,#k10,#k11,#k4
$
$ CONNECT 6TH AND 5TH RADIUS
elem,beam,4,1,1,2,#k6,#k7
$
$ 4TH RADIUS
node #k17,#r4,0,#z4
node #k18,#r4,90,#z4
```

```
node #k19,#r4,180,#z4
element,quad,2,1,1,4,#k17,#k18,#k19,#k4
node,#k20,#r4,-90,#z4
node,#k21,#r4,#jog,#z4
elem,quad,2,1,1,4,#k19,#k20,#k21,#k4
$
$ CONNECT 5TH AND 4TH RADIUS
elem,beam,4,1,1,2,#k11,#k17
$
$ 3RD RADIUS
node #k27,#r3,0,#z4
node #k28,#r3,90,#z4
node #k29,#r3,180,#z4
element,quad,2,1,1,4,#k27,#k28,#k29,#k4
node,#k30,#r3,-90,#z4
node,#k31,#r3,#jog,#z4
elem,quad,2,1,1,4,#k29,#k30,#k31,#k4
$
$ CONNECT 4TH AND 3TH RADIUS
elem,beam,4,1,1,2,#k21,#k27
$
$ 2ND RADIUS
node #k37,#r2,0,#z4
node #k38,#r2,90,#z4
node #k39,#r2,180,#z4
element,quad,2,1,1,4,#k37,#k38,#k39,#k4
node,#k40,#r2,-90,#z4
node,#k41,#r2,#jog,#z4
elem,quad,2,1,1,4,#k39,#k40,#k41,#k4
$
$ CONNECT 3RD AND 2ND RADIUS
elem,beam,4,1,1,2,#k31,#k37
$
$ 1ST RADIUS
node #k47,#r1,0,#z4
node #k48,#r1,90,#z4
node #k49,#r1,180,#z4
element,quad,2,1,1,4,#k47,#k48,#k49,#k4
node,#k50,#r1,-90,#z4
node,#k51,#r1,#adv,#z4
elem,quad,2,1,1,4,#k49,#k50,#k51,#k4
$
$ CONNECT 2ND AND 1ST RADIUS
elem,beam,4,1,1,2,#k41,#k47
$
$
$ LOWER TO UPPER LAYER CONNECTION
elem,beam,4,1,1,2,#n51,#k1
$
$
$$$$$$$$$$$
$ FIRST TO SECOND COIL PAIR
CONNECTION
define parameter xx #k51-100
elem,beam,4,1,1,2,#xx,#n1
$$$$$$$$$
$
$
$$$$$$$$$$$$$$$$$$$$$$
$ THIRD COIL PAIR
$$$$$$$$$$$$$$$$$$$$$$
$ INNER RADIUS
$ DETERMINE NODE NUMBERS
default coord 5
define parameter off 200
define parameter n1 #off+1
define parameter n2 #off+2
define parameter n3 #off+3
define parameter n4 #off+4
define parameter n5 #off+5
define parameter n6 #off+6
define parameter n7 #off+7
define parameter n8 #off+8
define parameter n9 #off+9
define parameter n10 #off+10
define parameter n11 #off+11
define parameter n12 #off+12
define parameter n13 #off+13
define parameter n14 #off+14
define parameter n15 #off+15
define parameter n16 #off+16
define parameter n17 #off+17
define parameter n18 #off+18
define parameter n19 #off+19
define parameter n20 #off+20
define parameter n21 #off+21
define parameter n22 #off+22
define parameter n23 #off+23
define parameter n24 #off+24
define parameter n25 #off+25
define parameter n26 #off+26
define parameter n27 #off+27
define parameter n28 #off+28
define parameter n29 #off+29
define parameter n30 #off+30
define parameter n31 #off+31
define parameter n32 #off+32
define parameter n33 #off+33
define parameter n34 #off+34
define parameter n35 #off+35
define parameter n36 #off+36
define parameter n37 #off+37
define parameter n38 #off+38
define parameter n39 #off+39
define parameter n40 #off+40
define parameter n41 #off+41
define parameter n42 #off+42
define parameter n43 #off+43
define parameter n44 #off+44
define parameter n45 #off+45
define parameter n46 #off+46
define parameter n47 #off+47
define parameter n48 #off+48
define parameter n49 #off+49
define parameter n50 #off+50
define parameter n51 #off+51
node #n1,#r1,0,#z5
node #n2,#r1,90,#z5
node #n3,#r1,180,#z5
node #n4,0,0,#z5
element,quad,2,1,1,4,#n1,#n2,#n3,#n4
node,#n5,#r1,-90,#z5
node,#n6,#r1,#jog,#z5
elem,quad,2,1,1,4,#n3,#n5,#n6,#n4
$
$ 2ND RADIUS
node #n7,#r2,0,#z5
node #n8,#r2,90,#z5
node #n9,#r2,180,#z5
element,quad,2,1,1,4,#n7,#n8,#n9,#n4
node,#n10,#r2,-90,#z5
node,#n11,#r2,#jog,#z5
elem,quad,2,1,1,4,#n9,#n10,#n11,#n4
$
$ CONNECT 1ST AND 2ND RADIUS
$ lower layer
elem,beam,4,1,1,2,#n6,#n7
$
$ 3RD RADIUS
node #n17,#r3,0,#z5
node #n18,#r3,90,#z5
node #n19,#r3,180,#z5
element,quad,2,1,1,4,#n17,#n18,#n19,#n4
node,#n20,#r3,-90,#z5
node,#n21,#r3,#jog,#z5
elem,quad,2,1,1,4,#n19,#n20,#n21,#n4
$
$ CONNECT 2ND AND 3RD RADIUS
$ lower layer
elem,beam,4,1,1,2,#n11,#n17
$
$ 4TH RADIUS
node #n27,#r4,0,#z5
node #n28,#r4,90,#z5
node #n29,#r4,180,#z5
element,quad,2,1,1,4,#n27,#n28,#n29,#n4
node,#n30,#r4,-90,#z5
node,#n31,#r4,#jog,#z5
elem,quad,2,1,1,4,#n29,#n30,#n31,#n4
$
$ CONNECT 3RD AND 4TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n21,#n27
$
$ 5TH RADIUS
node #n37,#r5,0,#z5
node #n38,#r5,90,#z5
node #n39,#r5,180,#z5
element,quad,2,1,1,4,#n37,#n38,#n39,#n4
node,#n40,#r5,-90,#z5
node,#n41,#r5,#jog,#z5
elem,quad,2,1,1,4,#n39,#n40,#n41,#n4
$
$ CONNECT 4TH AND 5TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n31,#n37
$
$ 6TH RADIUS
node #n47,#r6,0,#z5
node #n48,#r6,90,#z5
node #n49,#r6,180,#z5
element,quad,2,1,1,4,#n47,#n48,#n49,#n4
node,#n50,#r6,-90,#z5
node,#n51,#r6,#adv,#z5
elem,quad,2,1,1,4,#n49,#n50,#n51,#n4
$
$ CONNECT 5TH AND 6TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n41,#n47
$
$
$ UPPER LAYER (IN Z) COIL
$ OUTER MOST RADIUS
$ DETERMINE NODE NUMBERS
default coord 6
define parameter off 1200
define parameter k1 #off+1
define parameter k2 #off+2
define parameter k3 #off+3
define parameter k4 #off+4
define parameter k5 #off+5
define parameter k6 #off+6
define parameter k7 #off+7
define parameter k8 #off+8
define parameter k9 #off+9
define parameter k10 #off+10
define parameter k11 #off+11
define parameter k12 #off+12
define parameter k13 #off+13
define parameter k14 #off+14
define parameter k15 #off+15
define parameter k16 #off+16
define parameter k17 #off+17
define parameter k18 #off+18
define parameter k19 #off+19
define parameter k20 #off+20
define parameter k21 #off+21
define parameter k22 #off+22
define parameter k23 #off+23
define parameter k24 #off+24
define parameter k25 #off+25
define parameter k26 #off+26
define parameter k27 #off+27
define parameter k28 #off+28
define parameter k29 #off+29
define parameter k30 #off+30
define parameter k31 #off+31
define parameter k32 #off+32
define parameter k33 #off+33
define parameter k34 #off+34
define parameter k35 #off+35
define parameter k36 #off+36
define parameter k37 #off+37
define parameter k38 #off+38
define parameter k39 #off+39
define parameter k40 #off+40
define parameter k41 #off+41
define parameter k42 #off+42
define parameter k43 #off+43
define parameter k44 #off+44
define parameter k45 #off+45
define parameter k46 #off+46
define parameter k47 #off+47
define parameter k48 #off+48
define parameter k49 #off+49
define parameter k50 #off+50
define parameter k51 #off+51
node #k1,#r6,0,#z6
node #k2,#r6,90,#z6
node #k3,#r6,180,#z6
node #k4,0,0,#z6
element,quad,2,1,1,4,#k1,#k2,#k3,#k4
node,#k5,#r6,-90,#z6
node,#k6,#r6,#jog,#z6
elem,quad,2,1,1,4,#k3,#k5,#k6,#k4
$
$ 5TH RADIUS
node #k7,#r5,0,#z6
node #k8,#r5,90,#z6
node #k9,#r5,180,#z6
element,quad,2,1,1,4,#k7,#k8,#k9,#k4
node,#k10,#r5,-90,#z6
node,#k11,#r5,#jog,#z6
elem,quad,2,1,1,4,#k9,#k10,#k11,#k4
$
$ CONNECT 6TH AND 5TH RADIUS
elem,beam,4,1,1,2,#k6,#k7
$
$ 4TH RADIUS
node #k17,#r4,0,#z6
```

```
node #k18,#r4,90,#z6
node #k19,#r4,180,#z6
element,quad,2,1,1,4,#k17,#k18,#k19,#k4
node,#k20,#r4,-90,#z6
node,#k21,#r4,jog,#z6
elem,quad,2,1,1,4,#k19,#k20,#k21,#k4
$
$ CONNECT 5TH AND 4TH RADIUS
elem,beam,4,1,1,2,#k11,#k17
$
$ 3RD RADIUS
node #k27,#r3,0,#z6
node #k28,#r3,90,#z6
node #k29,#r3,180,#z6
element,quad,2,1,1,4,#k27,#k28,#k29,#k4
node,#k30,#r3,-90,#z6
node,#k31,#r3,jog,#z6
elem,quad,2,1,1,4,#k29,#k30,#k31,#k4
$
$ CONNECT 4TH AND 3TH RADIUS
elem,beam,4,1,1,2,#k21,#k27
$
$ 2ND RADIUS
node #k37,#r2,0,#z6
node #k38,#r2,90,#z6
node #k39,#r2,180,#z6
element,quad,2,1,1,4,#k37,#k38,#k39,#k4
node,#k40,#r2,-90,#z6
node,#k41,#r2,#jog,#z6
elem,quad,2,1,1,4,#k39,#k40,#k41,#k4
$
$ CONNECT 3RD AND 2ND RADIUS
elem,beam,4,1,1,2,#k31,#k37
$
$ 1ST RADIUS
node #k47,#r1,0,#z6
node #k48,#r1,90,#z6
node #k49,#r1,180,#z6
element,quad,2,1,1,4,#k47,#k48,#k49,#k4
node,#k50,#r1,-90,#z6
node,#k51,#r1,#adv,#z6
elem,quad,2,1,1,4,#k49,#k50,#k51,#k4
$
$ CONNECT 2ND AND 1ST RADIUS
elem,beam,4,1,1,2,#k41,#k47
$
$
$ LOWER TO UPPER LAYER CONNECTION
elem,beam,4,1,1,2,#n51,#k1
$
$
$$$$$$$$$$$$
$ SECOND TO THIRD COIL PAIR
CONNECTION
define parameter xx #k51-100
elem,beam,4,1,1,2,#xx,#n1
$$$$$$$$$
$
$$$$$$$$$$$$$$$$$$$$$$$$
$ THIRD COIL PAIR
$$$$$$$$$$$$$$$$$$$$$$$$
$ INNER RADIUS
$ DETERMINE NODE NUMBERS
default coord 7
define parameter off 300
define parameter n1 #off+1
define parameter n2 #off+2
define parameter n3 #off+3
define parameter n4 #off+4
define parameter n5 #off+5
define parameter n6 #off+6
define parameter n7 #off+7
define parameter n8 #off+8
define parameter n9 #off+9
define parameter n10 #off+10
define parameter n11 #off+11
define parameter n12 #off+12
define parameter n13 #off+13
define parameter n14 #off+14
define parameter n15 #off+15
define parameter n16 #off+16
define parameter n17 #off+17
define parameter n18 #off+18
define parameter n19 #off+19
define parameter n20 #off+20
define parameter n21 #off+21
define parameter n22 #off+22
define parameter n23 #off+23
define parameter n24 #off+24
define parameter n25 #off+25
define parameter n26 #off+26
define parameter n27 #off+27
define parameter n28 #off+28
define parameter n29 #off+29
define parameter n30 #off+30
define parameter n31 #off+31
define parameter n32 #off+32
define parameter n33 #off+33
define parameter n34 #off+34
define parameter n35 #off+35
define parameter n36 #off+36
define parameter n37 #off+37
define parameter n38 #off+38
define parameter n39 #off+39
define parameter n40 #off+40
define parameter n41 #off+41
define parameter n42 #off+42
define parameter n43 #off+43
define parameter n44 #off+44
define parameter n45 #off+45
define parameter n46 #off+46
define parameter n47 #off+47
define parameter n48 #off+48
define parameter n49 #off+49
define parameter n50 #off+50
define parameter n51 #off+51
node #n1,#r1,0,#z7
node #n2,#r1,90,#z7
node #n3,#r1,180,#z7
node #n4,0,0,#z7
element,quad,2,1,1,4,#n1,#n2,#n3,#n4
node,#n5,#r1,-90,#z7
node,#n6,#r1,#jog,#z7
elem,quad,2,1,1,4,#n3,#n5,#n6,#n4
$
$ 2ND RADIUS
node #n7,#r2,0,#z7
node #n8,#r2,90,#z7
node #n9,#r2,180,#z7
element,quad,2,1,1,4,#n7,#n8,#n9,#n4
node,#n10,#r2,-90,#z7
node,#n11,#r2,#jog,#z7
elem,quad,2,1,1,4,#n9,#n10,#n11,#n4
$
$ CONNECT 1ST AND 2ND RADIUS
$ lower layer
elem,beam,4,1,1,2,#n6,#n7
$
$ 3RD RADIUS
node #n17,#r3,0,#z7
node #n18,#r3,90,#z7
node #n19,#r3,180,#z7
element,quad,2,1,1,4,#n17,#n18,#n19,#n4
node,#n20,#r3,-90,#z7
node,#n21,#r3,#jog,#z7
elem,quad,2,1,1,4,#n19,#n20,#n21,#n4
$
$ CONNECT 2ND AND 3RD RADIUS
$ lower layer
elem,beam,4,1,1,2,#n11,#n17
$
$ 4TH RADIUS
node #n27,#r4,0,#z7
node #n28,#r4,90,#z7
node #n29,#r4,180,#z7
element,quad,2,1,1,4,#n27,#n28,#n29,#n4
node,#n30,#r4,-90,#z7
node,#n31,#r4,#jog,#z7
elem,quad,2,1,1,4,#n29,#n30,#n31,#n4
$
$ CONNECT 3RD AND 4TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n21,#n27
$
$ 5TH RADIUS
node #n37,#r5,0,#z7
node #n38,#r5,90,#z7
node #n39,#r5,180,#z7
element,quad,2,1,1,4,#n37,#n38,#n39,#n4
node,#n40,#r5,-90,#z7
node,#n41,#r5,#jog,#z7
elem,quad,2,1,1,4,#n39,#n40,#n41,#n4
$
$ CONNECT 4TH AND 5TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n31,#n37
$
$ 6TH RADIUS
node #n47,#r6,0,#z7
node #n48,#r6,90,#z7
node #n49,#r6,180,#z7
element,quad,2,1,1,4,#n47,#n48,#n49,#n4
node,#n50,#r6,-90,#z7
node,#n51,#r6,#adv,#z7
elem,quad,2,1,1,4,#n49,#n50,#n51,#n4
$
$ CONNECT 5TH AND 6TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n41,#n47
$
$
$ UPPER LAYER (IN Z) COIL
$ OUTER MOST RADIUS
$ DETERMINE NODE NUMBERS
default coord 8
define parameter off 1300
define parameter k1 #off+1
define parameter k2 #off+2
define parameter k3 #off+3
define parameter k4 #off+4
define parameter k5 #off+5
define parameter k6 #off+6
define parameter k7 #off+7
define parameter k8 #off+8
define parameter k9 #off+9
define parameter k10 #off+10
define parameter k11 #off+11
define parameter k12 #off+12
define parameter k13 #off+13
define parameter k14 #off+14
define parameter k15 #off+15
define parameter k16 #off+16
define parameter k17 #off+17
define parameter k18 #off+18
define parameter k19 #off+19
define parameter k20 #off+20
define parameter k21 #off+21
define parameter k22 #off+22
define parameter k23 #off+23
define parameter k24 #off+24
define parameter k25 #off+25
define parameter k26 #off+26
define parameter k27 #off+27
define parameter k28 #off+28
define parameter k29 #off+29
define parameter k30 #off+30
define parameter k31 #off+31
define parameter k32 #off+32
define parameter k33 #off+33
define parameter k34 #off+34
define parameter k35 #off+35
define parameter k36 #off+36
define parameter k37 #off+37
define parameter k38 #off+38
define parameter k39 #off+39
define parameter k40 #off+40
define parameter k41 #off+41
define parameter k42 #off+42
define parameter k43 #off+43
define parameter k44 #off+44
define parameter k45 #off+45
define parameter k46 #off+46
define parameter k47 #off+47
define parameter k48 #off+48
define parameter k49 #off+49
define parameter k50 #off+50
define parameter k51 #off+51
node #k1,#r6,0,#z8
node #k2,#r6,90,#z8
node #k3,#r6,180,#z8
node #k4,0,0,#z8
element,quad,2,1,1,4,#k1,#k2,#k3,#k4
node,#k5,#r6,-90,#z8
node,#k6,#r6,#jog,#z8
elem,quad,2,1,1,4,#k3,#k5,#k6,#k4
$
$ 5TH RADIUS
node #k7,#r5,0,#z8
node #k8,#r5,90,#z8
node #k9,#r5,180,#z8
element,quad,2,1,1,4,#k7,#k8,#k9,#k4
node,#k10,#r5,-90,#z8
node,#k11,#r5,#jog,#z8
elem,quad,2,1,1,4,#k9,#k10,#k11,#k4
$
$ CONNECT 6TH AND 5TH RADIUS
elem,beam,4,1,1,2,#k6,#k7
$
$ 4TH RADIUS
node #k17,#r4,0,#z8
```

```
node #k18,#r4,90,#z8
node #k19,#r4,180,#z8
element,quad,2,1,1,4,#k17,#k18,#k19,#k4
node,#k20,#r4,-90,#z8
node,#k21,#r4,#jog,#z8
elem,quad,2,1,1,4,#k19,#k20,#k21,#k4
$
$ CONNECT 5TH AND 4TH RADIUS
elem,beam,4,1,1,2,#k11,#k17
$
$ 3RD RADIUS
node #k27,#r3,0,#z8
node #k28,#r3,90,#z8
node #k29,#r3,180,#z8
element,quad,2,1,1,4,#k27,#k28,#k29,#k4
node,#k30,#r3,-90,#z8
node,#k31,#r3,#jog,#z8
elem,quad,2,1,1,4,#k29,#k30,#k31,#k4
$
$ CONNECT 4TH AND 3TH RADIUS
elem,beam,4,1,1,2,#k21,#k27
$
$ 2ND RADIUS
node #k37,#r2,0,#z8
node #k38,#r2,90,#z8
node #k39,#r2,180,#z8
element,quad,2,1,1,4,#k37,#k38,#k39,#k4
node,#k40,#r2,-90,#z8
node,#k41,#r2,#jog,#z8
elem,quad,2,1,1,4,#k39,#k40,#k41,#k4
$
$ CONNECT 3RD AND 2ND RADIUS
elem,beam,4,1,1,2,#k31,#k37
$
$ 1ST RADIUS
node #k47,#r1,0,#z8
node #k48,#r1,90,#z8
node #k49,#r1,180,#z8
element,quad,2,1,1,4,#k47,#k48,#k49,#k4
node,#k50,#r1,-90,#z8
node,#k51,#r1,#adv,#z8
elem,quad,2,1,1,4,#k49,#k50,#k51,#k4
$
$ CONNECT 2ND AND 1ST RADIUS
elem,beam,4,1,1,2,#k41,#k47
$
$
$ LOWER TO UPPER LAYER CONNECTION
elem,beam,4,1,1,2,#n51,#k1
$
$
$$$$$$$$$$$$
$ THIRD TO FOURTH COIL PAIR
CONNECTION
define parameter xx #k51-100
elem,beam,4,1,1,2,#xx,#n1
$$$$$$$$$
$
$
$$$$$$$$$$$$$$$$$$$$$$
$ FIFTH COIL PAIR
$$$$$$$$$$$$$$$$$$$$$$
$ INNER RADIUS
$ DETERMINE NODE NUMBERS
default coord 9
define parameter off 400
define parameter n1 #off+1
define parameter n2 #off+2
define parameter n3 #off+3
define parameter n4 #off+4
define parameter n5 #off+5
define parameter n6 #off+6
define parameter n7 #off+7
define parameter n8 #off+8
define parameter n9 #off+9
define parameter n10 #off+10
define parameter n11 #off+11
define parameter n12 #off+12
define parameter n13 #off+13
define parameter n14 #off+14
define parameter n15 #off+15
define parameter n16 #off+16
define parameter n17 #off+17
define parameter n18 #off+18
define parameter n19 #off+19
define parameter n20 #off+20
define parameter n21 #off+21
define parameter n22 #off+22
define parameter n23 #off+23
define parameter n24 #off+24
define parameter n25 #off+25
define parameter n26 #off+26
define parameter n27 #off+27
define parameter n28 #off+28
define parameter n29 #off+29
define parameter n30 #off+30
define parameter n31 #off+31
define parameter n32 #off+32
define parameter n33 #off+33
define parameter n34 #off+34
define parameter n35 #off+35
define parameter n36 #off+36
define parameter n37 #off+37
define parameter n38 #off+38
define parameter n39 #off+39
define parameter n40 #off+40
define parameter n41 #off+41
define parameter n42 #off+42
define parameter n43 #off+43
define parameter n44 #off+44
define parameter n45 #off+45
define parameter n46 #off+46
define parameter n47 #off+47
define parameter n48 #off+48
define parameter n49 #off+49
define parameter n50 #off+50
define parameter n51 #off+51
node #n1,#r1,0,#z9
node #n2,#r1,90,#z9
node #n3,#r1,180,#z9
node #n4,0,0,#z9
element,quad,2,1,1,4,#n1,#n2,#n3,#n4
node,#n5,#r1,-90,#z9
node,#n6,#r1,#jog,#z9
elem,quad,2,1,1,4,#n3,#n5,#n6,#n4
$
$ 2ND RADIUS
node #n7,#r2,0,#z9
node #n8,#r2,90,#z9
node #n9,#r2,180,#z9
element,quad,2,1,1,4,#n7,#n8,#n9,#n4
node,#n10,#r2,-90,#z9
node,#n11,#r2,#jog,#z9
elem,quad,2,1,1,4,#n9,#n10,#n11,#n4
$
$ CONNECT 1ST AND 2ND RADIUS
$ lower layer
elem,beam,4,1,1,2,#n6,#n7
$
$ 3RD RADIUS
node #n17,#r3,0,#z9
node #n18,#r3,90,#z9
node #n19,#r3,180,#z9
element,quad,2,1,1,4,#n17,#n18,#n19,#n4
node,#n20,#r3,-90,#z9
node,#n21,#r3,#jog,#z9
elem,quad,2,1,1,4,#n19,#n20,#n21,#n4
$
$ CONNECT 2ND AND 3RD RADIUS
$ lower layer
elem,beam,4,1,1,2,#n11,#n17
$
$ 4TH RADIUS
node #n27,#r4,0,#z9
node #n28,#r4,90,#z9
node #n29,#r4,180,#z9
element,quad,2,1,1,4,#n27,#n28,#n29,#n4
node,#n30,#r4,-90,#z9
node,#n31,#r4,#jog,#z9
elem,quad,2,1,1,4,#n29,#n30,#n31,#n4
$
$ CONNECT 3RD AND 4TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n21,#n27
$
$ 5TH RADIUS
node #n37,#r5,0,#z9
node #n38,#r5,90,#z9
node #n39,#r5,180,#z9
element,quad,2,1,1,4,#n37,#n38,#n39,#n4
node,#n40,#r5,-90,#z9
node,#n41,#r5,#jog,#z9
elem,quad,2,1,1,4,#n39,#n40,#n41,#n4
$
$ CONNECT 4TH AND 5TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n31,#n37
$
$ 6TH RADIUS
node #n47,#r6,0,#z9
node #n48,#r6,90,#z9
node #n49,#r6,180,#z9
element,quad,2,1,1,4,#n47,#n48,#n49,#n4
node,#n50,#r6,-90,#z9
node,#n51,#r6,#adv,#z9
elem,quad,2,1,1,4,#n49,#n50,#n51,#n4
$
$ CONNECT 5TH AND 6TH RADIUS
$ lower layer
elem,beam,4,1,1,2,#n41,#n47
$
$
$ UPPER LAYER (IN Z) COIL
$ OUTER MOST RADIUS
$ DETERMINE NODE NUMBERS
default coord 10
define parameter off 1400
define parameter k1 #off+1
define parameter k2 #off+2
define parameter k3 #off+3
define parameter k4 #off+4
define parameter k5 #off+5
define parameter k6 #off+6
define parameter k7 #off+7
define parameter k8 #off+8
define parameter k9 #off+9
define parameter k10 #off+10
define parameter k11 #off+11
define parameter k12 #off+12
define parameter k13 #off+13
define parameter k14 #off+14
define parameter k15 #off+15
define parameter k16 #off+16
define parameter k17 #off+17
define parameter k18 #off+18
define parameter k19 #off+19
define parameter k20 #off+20
define parameter k21 #off+21
define parameter k22 #off+22
define parameter k23 #off+23
define parameter k24 #off+24
define parameter k25 #off+25
define parameter k26 #off+26
define parameter k27 #off+27
define parameter k28 #off+28
define parameter k29 #off+29
define parameter k30 #off+30
define parameter k31 #off+31
define parameter k32 #off+32
define parameter k33 #off+33
define parameter k34 #off+34
define parameter k35 #off+35
define parameter k36 #off+36
define parameter k37 #off+37
define parameter k38 #off+38
define parameter k39 #off+39
define parameter k40 #off+40
define parameter k41 #off+41
define parameter k42 #off+42
define parameter k43 #off+43
define parameter k44 #off+44
define parameter k45 #off+45
define parameter k46 #off+46
define parameter k47 #off+47
define parameter k48 #off+48
define parameter k49 #off+49
define parameter k50 #off+50
define parameter k51 #off+51
node #k1,#r6,0,#z10
node #k2,#r6,90,#z10
node #k3,#r6,180,#z10
node #k4,0,0,#z10
element,quad,2,1,1,4,#k1,#k2,#k3,#k4
node,#k5,#r6,-90,#z10
node,#k6,#r6,#jog,#z10
elem,quad,2,1,1,4,#k3,#k5,#k6,#k4
$
$ 5TH RADIUS
node #k7,#r5,0,#z10
node #k8,#r5,90,#z10
node #k9,#r5,180,#z10
element,quad,2,1,1,4,#k7,#k8,#k9,#k4
node,#k10,#r5,-90,#z10
node,#k11,#r5,#jog,#z10
elem,quad,2,1,1,4,#k9,#k10,#k11,#k4
$
$ CONNECT 6TH AND 5TH RADIUS
elem,beam,4,1,1,2,#k6,#k7
$
$ 4TH RADIUS
```

```
node #k17,#r4,0,#z10
node #k18,#r4,90,#z10
node #k19,#r4,180,#z10
element,quad,2,1,1,4,#k17,#k18,#k19,#k4
node,#k20,#r4,-90,#z10
node,#k21,#r4,#jog,#z10
elem,quad,2,1,1,4,#k19,#k20,#k21,#k4
$
$ CONNECT 5TH AND 4TH RADIUS
elem,beam,4,1,1,2,#k11,#k17
$
$ 3RD RADIUS
node #k27,#r3,0,#z10
node #k28,#r3,90,#z10
node #k29,#r3,180,#z10
element,quad,2,1,1,4,#k27,#k28,#k29,#k4
node,#k30,#r3,-90,#z10
node,#k31,#r3,#jog,#z10
elem,quad,2,1,1,4,#k29,#k30,#k31,#k4
$
$ CONNECT 4TH AND 3TH RADIUS
elem,beam,4,1,1,2,#k21,#k27
$
$ 2ND RADIUS
node #k37,#r2,0,#z10
node #k38,#r2,90,#z10
node #k39,#r2,180,#z10
element,quad,2,1,1,4,#k37,#k38,#k39,#k4
node,#k40,#r2,-90,#z10
node,#k41,#r2,#jog,#z10
elem,quad,2,1,1,4,#k39,#k40,#k41,#k4
$
$ CONNECT 3RD AND 2ND RADIUS
elem,beam,4,1,1,2,#k31,#k37
$
$ 1ST RADIUS
node #k47,#r1,0,#z10
node #k48,#r1,90,#z10
node #k49,#r1,180,#z10
element,quad,2,1,1,4,#k47,#k48,#k49,#k4
node,#k50,#r1,-90,#z10
$node,#k51,#r1,#adv,#z10
node,#k51,#r1,0,#z10
elem,quad,2,1,1,4,#k49,#k50,#k51,#k4
define parameter nend #k51
$
$ CONNECT 2ND AND 1ST RADIUS
elem,beam,4,1,1,2,#k41,#k47
$
$
$ LOWER TO UPPER LAYER CONNECTION
elem,beam,4,1,1,2,#n51,#k1
$
$
$$$$$$$$$$$$
$ FOURTH TO FIFTH COIL PAIR
CONNECTION
define parameter xx #k51-100
elem,beam,4,1,1,2,#xx,#n1
$$$$$$$$$
$
$ RETURN LEAD to CLOSE PATH
$ use Helix element
define parameter k52 #off+52
define parameter k53 #off+53
define parameter k54 #off+54
define parameter k55 #off+55
define parameter k56 #off+56
define parameter k57 #off+57
define parameter k58 #off+58
define parameter ag1 -#adv
node,#k52,#r1,#ag1,#z9
define parameter ag2 -2*#adv
node,#k53,#r1,#ag2,#z8
define parameter ag3 -3*#adv
node,#k54,#r1,#ag3,#z7
define parameter ag4 -4*#adv
node,#k55,#r1,#ag4,#z6
define parameter ag5 -5*#adv
node,#k56,#r1,#ag5,#z5
define parameter ag6 -6*#adv
node,#k57,#r1,#ag6,#z4
node,#k58,0,0,#z7
elem,quad,3,1,2,8,#nend,#k53,#k55,#k57,#k52,#k
54,#k56,#K58
define parameter k59 #off+59
define parameter k60 #off+60
define parameter k61 #off+61
define parameter k62 #off+62
define parameter k63 #off+63
define parameter k64 #off+64
define parameter ag7 -7*#adv
node,#k59,#r1,#ag7,#z3
define parameter ag8 -8*#adv
define parameter ag9 -9*#adv
node,#k60,#r1,#ag8,#z2
define parameter zm1 0.5*#z3+0.5*#z4
define parameter am1 0.5*#ag6+0.5*#ag7
node,#k61,#r1,#am1,#zm1
define parameter zm2 0.5*#z2+0.5*#z3
define parameter am2 0.5*#ag7+0.5*#ag8
node,#k62,#r1,#am2,#zm2
define parameter zm3 0.5*#z1+0.5*#z2
define parameter am3 0.5*#ag8+0.5*#ag9
node,#k63,#r1,#am3,#zm3
node,#k64,0,0,#zm2
elem,quad,3,1,3,8,#k57,#k59,#k60,#nst,#k61,#k62
,#k63,#k64
$elem,beam,4,1,1,2,#nend,#nst
$
$
$ OBSERVATION POINTS
default node start 10000
default coord 1
point p1 225 0
point p2 225 90
point p3 225 180
point p4 225 270
point p0 0 0
arc a1 p1 p2 p0 32
arc a2 p2 p3 p0 32
arc a3 p3 p4 p0 32
arc a4 p4 p1 p0 32
node name on
```

Appendix L - Location of points on the "Dee-shaped" surface

The following is a listing of the coordinates which define the "dee-shaped" plasma surface. The points are spaced in a 32 by 32 array of equal increments of toroidal angle ϕ and poloidal angle "little theta", θ.

Biot Savart Evaluation Points

Toroidal angle (rad)	node	x (cm)	y(cm)	z(cm)
0	10001	275.000000	000.000000	000.000000
0	10002	271.691016	000.000000	-021.804845
0	10003	263.295562	000.000000	-040.864956
0	10004	252.410520	000.000000	-056.398569
0	10005	240.726323	000.000000	-068.731391
0	10006	229.072167	000.000000	-078.266533
0	10007	217.870158	000.000000	-085.145402
0	10008	207.430722	000.000000	-089.165158
0	10009	198.123363	000.000000	-089.787775
0	10010	190.413416	000.000000	-086.397358
0	10011	184.641195	000.000000	-078.950546
0	10012	180.712567	000.000000	-068.346127
0	10013	178.187850	000.000000	-055.831750
0	10014	176.611296	000.000000	-042.338335
0	10015	175.664167	000.000000	-028.385311
0	10016	175.158810	000.000000	-014.230221
0	10017	175.000000	000.000000	000.000000
0	10018	175.158810	000.000000	014.230227
0	10019	175.664168	000.000000	028.385318
0	10020	176.611296	000.000000	042.338336
0	10021	178.187850	000.000000	055.831750
0	10022	180.712567	000.000000	068.346127
0	10023	184.641195	000.000000	078.950546
0	10024	190.413415	000.000000	086.397358
0	10025	198.123362	000.000000	089.787775
0	10026	207.430722	000.000000	089.165158
0	10027	217.870158	000.000000	085.145402
0	10028	229.072166	000.000000	078.266533
0	10029	240.726323	000.000000	068.731390
0	10030	252.410520	000.000000	056.398570
0	10031	263.295562	000.000000	040.864956
0	10032	271.691016	000.000000	021.804844
0.19635	10033	269.715952	053.649838	000.000000
0.19635	10034	266.470550	053.004288	-021.804845
0.19635	10035	258.236412	051.366416	-040.864956
0.19635	10036	247.560523	049.242850	-056.398569
0.19635	10037	236.100835	046.963376	-068.731391
0.19635	10038	224.670609	044.689763	-078.266533
0.19635	10039	213.683844	042.504359	-085.145402
0.19635	10040	203.444999	040.467726	-089.165158
0.19635	10041	194.316478	038.651951	-089.787775
0.19635	10042	186.754675	037.147815	-086.397358
0.19635	10043	181.093366	036.021710	-078.950546
0.19635	10044	177.240226	035.255273	-068.346127
0.19635	10045	174.764020	034.762725	-055.831750
0.19635	10046	173.217759	034.455155	-042.338335
0.19635	10047	172.288830	034.270379	-028.385311
0.19635	10048	171.793183	034.171789	-014.230221
0.19635	10049	171.637424	034.140606	000.000000
0.19635	10050	171.793183	034.171789	014.230227
0.19635	10051	172.288830	034.270379	028.385318
0.19635	10052	173.217760	034.455155	042.338336
0.19635	10053	174.764020	034.762725	055.831750
0.19635	10054	177.240226	035.255273	068.346127
0.19635	10055	181.093366	036.021710	078.950546
0.19635	10056	186.754675	037.147814	086.397358
0.19635	10057	194.316478	038.651951	089.787775
0.19635	10058	203.444999	040.467726	089.165158
0.19635	10059	213.683844	042.504359	085.145402
0.19635	10060	224.670609	044.689763	078.266533
0.19635	10061	236.100835	046.963376	068.731390
0.19635	10062	247.560522	049.242850	056.398570
0.19635	10063	258.236412	051.366416	040.864956
0.19635	10064	266.470550	053.004288	021.804844
0.392699	10065	254.066871	105.237944	000.000000
0.392699	10066	251.009769	103.971651	-021.804845
0.392699	10067	243.253381	100.758849	-040.864956
0.392699	10068	233.196913	096.593324	-056.398569
0.392699	10069	222.402123	092.121976	-068.731391
0.392699	10070	211.635086	087.662123	-078.266533
0.392699	10071	201.285780	083.375300	-085.145402
0.392699	10072	191.640999	079.380301	-089.165158
0.392699	10073	183.042120	075.818528	-089.787775
0.392699	10074	175.919057	072.868059	-086.397358
0.392699	10075	170.586221	070.659126	-078.950548
0.392699	10076	166.956842	069.155705	-068.346127
0.392699	10077	164.624108	068.189538	-055.831750
0.392699	10078	163.167562	067.586217	-042.338335
0.392699	10079	162.292529	067.223766	-028.385311
0.392699	10080	161.825640	067.030375	-014.230221
0.392699	10081	161.678918	066.969601	000.000000
0.392699	10082	161.825640	067.030375	014.230227
0.392699	10083	162.292529	067.223767	028.385318
0.392699	10084	163.167562	067.586217	042.338336
0.392699	10085	164.624107	068.189538	055.831750
0.392699	10086	166.956642	069.155705	068.346127
0.392699	10087	170.586221	070.659126	078.950546
0.392699	10088	175.919057	072.868059	086.397358
0.392699	10089	183.042119	075.818528	089.787775
0.392699	10090	191.640998	079.380300	089.165158
0.392699	10091	201.285780	083.375300	085.145402
0.392699	10092	211.635086	087.662123	078.266533
0.392699	10093	222.402123	092.121976	068.731390
0.392699	10094	233.196913	096.593324	056.398570
0.392699	10095	243.253381	100.758849	040.864956
0.392699	10096	251.009769	103.971651	021.804844
0.589049	10097	228.654143	152.781814	000.000000
0.589049	10098	225.902824	150.943441	-021.804845
0.589049	10099	218.922259	146.279177	-040.864956
0.589049	10100	209.871677	140.231771	-056.398569
0.589049	10101	200.156623	133.740379	-068.731391
0.589049	10102	190.466546	127.265677	-078.266533
0.589049	10103	181.152416	121.042174	-085.145402
0.589049	10104	172.472342	115.242334	-089.165158
0.589049	10105	164.733556	110.071443	-089.787775
0.589049	10106	158.322969	105.788026	-086.397358
0.589049	10107	153.523543	102.581152	-078.950546
0.589049	10108	150.257008	100.398523	-068.346127
0.589049	10109	148.157783	098.995865	-055.831750
0.589049	10110	146.846926	098.119979	-042.338335
0.589049	10111	146.059417	097.593782	-028.385311
0.589049	10112	145.639228	097.313021	-014.230221
0.589049	10113	145.507182	097.224791	000.000000
0.589049	10114	145.639228	097.313021	014.230227
0.589049	10115	146.059418	097.593783	028.385318
0.589049	10116	146.846926	098.119979	042.338336
0.589049	10117	148.157783	098.995865	055.831750
0.589049	10118	150.257008	100.398523	068.346127
0.589049	10119	153.523543	102.581151	078.950546
0.589049	10120	158.322969	105.788025	086.397358
0.589049	10121	164.733555	110.071442	089.787775
0.589049	10122	172.472342	115.242334	089.165158
0.589049	10123	181.152416	121.042174	085.145402
0.589049	10124	190.466545	127.265677	078.266533
0.589049	10125	200.156623	133.740379	068.731390
0.589049	10126	209.871677	140.231771	056.398570
0.589049	10127	218.922259	146.279177	040.864956
0.589049	10128	225.902824	150.943441	021.804844
0.785398	10129	194.454365	194.454365	000.000000
0.785398	10130	192.114560	192.114560	-021.804845
0.785398	10131	186.178078	186.178077	-040.864956
0.785398	10132	178.481191	178.481190	-056.398569
0.785398	10133	170.219216	170.219216	-068.731391
0.785398	10134	161.978483	161.978482	-078.266533
0.785398	10135	154.057466	154.057466	-085.145402
0.785398	10136	146.675670	146.675670	-089.165158
0.785398	10137	140.094373	140.094373	-089.787775
0.785398	10138	134.642618	134.642617	-086.397358
0.785398	10139	130.561041	130.561041	-078.950546
0.785398	10140	127.783082	127.783082	-068.346127
0.785398	10141	125.997837	125.997837	-055.831750
0.785398	10142	124.883045	124.883045	-042.338335
0.785398	10143	124.213324	124.213324	-028.385311
0.785398	10144	123.855983	123.855982	-014.230221
0.785398	10145	123.743687	123.743687	000.000000
0.785398	10146	123.855983	123.855982	014.230227
0.785398	10147	124.213324	124.213324	028.385318
0.785398	10148	124.883045	124.883045	042.338336
0.785398	10149	125.997837	125.997837	055.831750
0.785398	10150	127.783082	127.783082	068.346127
0.785398	10151	130.561041	130.561041	078.950546

0.785398	10152	134.642617	134.642617	086.397358
0.785398	10153	140.094373	140.094373	089.787775
0.785398	10154	146.675670	146.675670	089.165158
0.785398	10155	154.057466	154.057466	085.145402
0.785398	10156	161.978482	161.978482	078.266533
0.785398	10157	170.219216	170.219216	068.731390
0.785398	10158	178.481190	178.481190	056.398570
0.785398	10159	186.178078	186.178077	040.864956
0.785398	10160	192.114560	192.114560	021.804844
0.981748	10161	152.781814	228.654143	000.000000
0.981748	10162	150.943441	225.902824	-021.804845
0.981748	10163	146.279177	218.922259	-040.864956
0.981748	10164	140.231772	209.871677	-056.398569
0.981748	10165	133.740380	200.156623	-068.731391
0.981748	10166	127.265677	190.466545	-078.266533
0.981748	10167	121.042175	181.152416	-085.145402
0.981748	10168	115.242335	172.472342	-089.165158
0.981748	10169	110.071443	164.733555	-089.787775
0.981748	10170	105.788026	158.322969	-086.397358
0.981748	10171	102.581152	153.523543	-078.950546
0.981748	10172	100.398523	150.257008	-068.346127
0.981748	10173	098.995865	148.157782	-055.831750
0.981748	10174	098.119979	146.846926	-042.338335
0.981748	10175	097.593783	146.059417	-028.385311
0.981748	10176	097.313021	145.639228	-014.230221
0.981748	10177	097.224791	145.507182	000.000000
0.981748	10178	097.313021	145.639228	014.230227
0.981748	10179	097.593783	146.059417	028.385318
0.981748	10180	098.119979	146.846926	042.338336
0.981748	10181	098.995865	148.157782	055.831750
0.981748	10182	100.398523	150.257008	068.346127
0.981748	10183	102.581152	153.523542	078.950546
0.981748	10184	105.788026	158.322969	086.397358
0.981748	10185	110.071443	164.733555	089.787775
0.981748	10186	115.242335	172.472342	089.165158
0.981748	10187	121.042175	181.152416	085.145402
0.981748	10188	127.265677	190.466545	078.266533
0.981748	10189	133.740380	200.156623	068.731390
0.981748	10190	140.231772	209.871677	056.398570
0.981748	10191	146.279177	218.922259	040.864956
0.981748	10192	150.943442	225.902824	021.804844
1.178097	10193	105.237944	254.066871	000.000000
1.178097	10194	103.971651	251.009769	-021.804845
1.178097	10195	100.758850	243.253381	-040.864956
1.178097	10196	096.593324	233.196913	-056.398569
1.178097	10197	092.121976	222.402123	-068.731391
1.178097	10198	087.662123	211.635086	-078.266533
1.178097	10199	083.375300	201.285780	-085.145402
1.178097	10200	079.380301	191.640998	-089.165158
1.178097	10201	075.818529	183.042120	-089.787775
1.178097	10202	072.868060	175.919057	-086.397358
1.178097	10203	070.659126	170.586221	-078.950546
1.178097	10204	069.155706	166.956642	-068.346127
1.178097	10205	068.189538	164.624107	-055.831750
1.178097	10206	067.586217	163.167561	-042.338335
1.178097	10207	067.223767	162.292529	-028.385311
1.178097	10208	067.030375	161.825640	-014.230221
1.178097	10209	066.969601	161.678918	000.000000
1.178097	10210	067.030375	161.825640	014.230227
1.178097	10211	067.223767	162.292529	028.385318
1.178097	10212	067.586217	163.167562	042.338336
1.178097	10213	068.189538	164.624107	055.831750
1.178097	10214	069.155706	166.956642	068.346127
1.178097	10215	070.659126	170.586221	078.950546
1.178097	10216	072.868060	175.919057	086.397358
1.178097	10217	075.818529	183.042119	089.787775
1.178097	10218	079.380301	191.640998	089.165158
1.178097	10219	083.375300	201.285779	085.145402
1.178097	10220	087.662123	211.635086	078.266533
1.178097	10221	092.121976	222.402123	068.731390
1.178097	10222	096.593324	233.196913	056.398570
1.178097	10223	100.758850	243.253381	040.864956
1.178097	10224	103.971651	251.009769	021.804844
1.374447	10225	053.649839	269.715952	000.000000
1.374447	10226	053.004288	266.470550	-021.804845
1.374447	10227	051.366416	258.236412	-040.864956
1.374447	10228	049.242850	247.560523	-056.398569
1.374447	10229	046.963376	236.100835	-068.731391
1.374447	10230	044.689763	224.670609	-078.266533
1.374447	10231	042.504360	213.683844	-085.145402
1.374447	10232	040.467727	203.444999	-089.165158
1.374447	10233	038.651951	194.316478	-089.787775
1.374447	10234	037.147815	186.754675	-086.397358
1.374447	10235	036.021710	181.093366	-078.950546
1.374447	10236	035.255273	177.240226	-068.346127
1.374447	10237	034.762725	174.764020	-055.831750
1.374447	10238	034.455155	173.217759	-042.338335
1.374447	10239	034.270379	172.288830	-028.385311
1.374447	10240	034.171789	171.793183	-014.230221
1.374447	10241	034.140807	171.637424	000.000000
1.374447	10242	034.171789	171.793183	014.230227
1.374447	10243	034.270379	172.288830	028.385318
1.374447	10244	034.455155	173.217759	042.338336
1.374447	10245	034.762725	174.764020	055.831750
1.374447	10246	035.255273	177.240226	068.346127
1.374447	10247	036.021710	181.093366	078.950546
1.374447	10248	037.147815	186.754675	086.397358
1.374447	10249	038.651951	194.316477	089.787775
1.374447	10250	040.467727	203.444998	089.165158
1.374447	10251	042.504360	213.683844	085.145402
1.374447	10252	044.689763	224.670609	078.266533
1.374447	10253	046.963376	236.100835	068.731390
1.374447	10254	049.242850	247.560522	056.398570
1.374447	10255	051.366416	258.236412	040.864956
1.374447	10256	053.004288	266.470550	021.804844
1.570796	10257	000.000000	275.000000	000.000000
1.570796	10258	000.000000	271.691016	-021.804845
1.570796	10259	000.000000	263.295562	-040.864956
1.570796	10260	000.000000	252.410520	-056.398569
1.570796	10261	000.000000	240.726323	-068.731391
1.570796	10262	000.000000	229.072167	-078.266533
1.570796	10263	000.000000	217.870158	-085.145402
1.570796	10264	000.000000	207.430722	-089.165158
1.570796	10265	000.000000	198.123363	-089.787775
1.570796	10266	000.000000	190.413416	-086.397358
1.570796	10267	000.000000	184.641195	-078.950546
1.570796	10268	000.000000	180.712567	-068.346127
1.570796	10269	000.000000	178.187850	-055.831750
1.570796	10270	000.000000	176.611296	-042.338335
1.570796	10271	000.000000	175.664167	-028.385311
1.570796	10272	000.000000	175.158810	-014.230221
1.570796	10273	000.000000	175.000000	000.000000
1.570796	10274	000.000000	175.158810	014.230227
1.570796	10275	000.000000	175.664168	028.385318
1.570796	10276	000.000000	176.611296	042.338336
1.570796	10277	000.000000	178.187850	055.831750
1.570796	10278	000.000000	180.712567	068.346127
1.570796	10279	000.000000	184.641195	078.950546
1.570796	10280	000.000000	190.413415	086.397358
1.570796	10281	000.000000	198.123362	089.787775
1.570796	10282	000.000000	207.430722	089.165158
1.570796	10283	000.000000	217.870158	085.145402
1.570796	10284	000.000000	229.072166	078.266533
1.570796	10285	000.000000	240.726323	068.731390
1.570796	10286	000.000000	252.410520	056.398570
1.570796	10287	000.000000	263.295562	040.864956
1.570796	10288	000.000000	271.691016	021.804844
1.767146	10289	-053.649838	269.715952	000.000000
1.767146	10290	-053.004287	266.470550	-021.804845
1.767146	10291	-051.366416	258.236412	-040.864956
1.767146	10292	-049.242849	247.560523	-056.398569
1.767146	10293	-046.963375	236.100835	-068.731391
1.767146	10294	-044.689762	224.670609	-078.266533
1.767146	10295	-042.504359	213.683844	-085.145402
1.767146	10296	-040.467726	203.444999	-089.165158
1.767146	10297	-038.651950	194.316478	-089.787775
1.767146	10298	-037.147814	186.754675	-086.397358
1.767146	10299	-036.021710	181.093366	-078.950546
1.767146	10300	-035.255273	177.240226	-068.346127
1.767146	10301	-034.762725	174.764020	-055.831750
1.767146	10302	-034.455154	173.217759	-042.338335
1.767146	10303	-034.270379	172.288830	-028.385311
1.767146	10304	-034.171788	171.793183	-014.230221
1.767146	10305	-034.140806	171.637424	000.000000
1.767146	10306	-034.171788	171.793183	014.230227
1.767146	10307	-034.270379	172.288830	028.385318
1.767146	10308	-034.455154	173.217760	042.338336
1.767146	10309	-034.762725	174.764020	055.831750
1.767146	10310	-035.255273	177.240226	068.346127
1.767146	10311	-036.021710	181.093366	078.950546
1.767146	10312	-037.147814	186.754675	086.397358
1.767146	10313	-038.651950	194.316478	089.787775
1.767146	10314	-040.467726	203.444999	089.165158
1.767146	10315	-042.504359	213.683844	085.145402
1.767146	10316	-044.689762	224.670609	078.266533
1.767146	10317	-046.963375	236.100835	068.731390
1.767146	10318	-049.242849	247.560523	056.398570
1.767146	10319	-051.366415	258.236412	040.864956
1.767146	10320	-053.004287	266.470550	021.804844
1.963495	10321	-105.237943	254.066872	000.000000
1.963495	10322	-103.971650	251.009769	-021.804845
1.963495	10323	-100.758849	243.253381	-040.864956
1.963495	10324	-096.593324	233.196913	-056.398569
1.963495	10325	-092.121975	222.402123	-068.731391
1.963495	10326	-087.662122	211.635086	-078.266533
1.963495	10327	-083.375299	201.285780	-085.145402
1.963495	10328	-079.380300	191.640999	-089.165158
1.963495	10329	-075.818528	183.042120	-089.787775
1.963495	10330	-072.868059	175.919058	-086.397358
1.963495	10331	-070.659126	170.586221	-078.950546
1.963495	10332	-069.155705	166.956642	-068.346127
1.963495	10333	-068.189538	164.624108	-055.831750
1.963495	10334	-067.586217	163.167562	-042.338335
1.963495	10335	-067.223766	162.292529	-028.385311
1.963495	10336	-067.030374	161.825640	-014.230221
1.963495	10337	-066.969600	161.678918	000.000000

1.963495	10338	-067.030374	161.825640	014.230227
1.963495	10339	-067.223766	162.292529	028.385318
1.963495	10340	-067.586217	163.167562	042.338336
1.963495	10341	-068.189538	164.624108	055.831750
1.963495	10342	-069.155705	166.956642	068.346127
1.963495	10343	-070.659126	170.586221	078.950546
1.963495	10344	-072.868059	175.919057	086.397358
1.963495	10345	-075.818528	183.042120	089.787775
1.963495	10346	-079.380300	191.640998	089.165158
1.963495	10347	-083.375299	201.285780	085.145402
1.963495	10348	-087.662122	211.635086	078.266533
1.963495	10349	-092.121975	222.402123	068.731390
1.963495	10350	-096.593324	233.196913	056.398570
1.963495	10351	-100.758849	243.253381	040.864956
1.963495	10352	-103.971650	251.009769	021.804844
2.159845	10353	-152.781814	228.654144	000.000000
2.159845	10354	-150.943441	225.902824	-021.804845
2.159845	10355	-146.279176	218.922260	-040.864956
2.159845	10356	-140.231771	209.871678	-056.398569
2.159845	10357	-133.740379	200.156623	-068.731391
2.159845	10358	-127.265676	190.466546	-078.266533
2.159845	10359	-121.042174	181.152416	-085.145402
2.159845	10360	-115.242334	172.472342	-089.165158
2.159845	10361	-110.071442	164.733556	-089.787775
2.159845	10362	-105.788025	158.322969	-086.397358
2.159845	10363	-102.581151	153.523543	-078.950546
2.159845	10364	-100.398523	150.257009	-068.346127
2.159845	10365	-098.995865	148.157783	-055.831750
2.159845	10366	-098.119978	146.846926	-042.338335
2.159845	10367	-097.593782	146.059417	-028.385311
2.159845	10368	-097.313021	145.639228	-014.230221
2.159845	10369	-097.224790	145.507182	000.000000
2.159845	10370	-097.313021	145.639228	014.230227
2.159845	10371	-097.593782	146.059418	028.385318
2.159845	10372	-098.119979	146.846926	042.338336
2.159845	10373	-098.995865	148.157783	055.831750
2.159845	10374	-100.398523	150.257008	068.346127
2.159845	10375	-102.581151	153.523543	078.950546
2.159845	10376	-105.788025	158.322969	086.397358
2.159845	10377	-110.071442	164.733556	089.787775
2.159845	10378	-115.242334	172.472342	089.165158
2.159845	10379	-121.042174	181.152416	085.145402
2.159845	10380	-127.265676	190.466546	078.266533
2.159845	10381	-133.740379	200.156623	068.731390
2.159845	10382	-140.231771	209.871677	056.398570
2.159845	10383	-146.279176	218.922259	040.864956
2.159845	10384	-150.943441	225.902824	021.804844
2.356194	10385	-194.454364	194.454365	000.000000
2.356194	10386	-192.114560	192.114561	-021.804845
2.356194	10387	-186.178077	186.178078	-040.864956
2.356194	10388	-178.481190	178.481191	-056.398569
2.356194	10389	-170.219215	170.219216	-068.731391
2.356194	10390	-161.978482	161.978483	-078.266533
2.356194	10391	-154.057466	154.057467	-085.145402
2.356194	10392	-146.675670	146.675671	-089.165158
2.356194	10393	-140.094373	140.094374	-089.787775
2.356194	10394	-134.642617	134.642618	-086.397358
2.356194	10395	-130.561041	130.561041	-078.950546
2.356194	10396	-127.783081	127.783082	-068.346127
2.356194	10397	-125.997837	125.997837	-055.831750
2.356194	10398	-124.883045	124.883045	-042.338335
2.356194	10399	-124.213324	124.213324	-028.385311
2.356194	10400	-123.855982	123.855983	-014.230221
2.356194	10401	-123.743686	123.743687	000.000000
2.356194	10402	-123.855982	123.855983	014.230227
2.356194	10403	-124.213324	124.213325	028.385318
2.356194	10404	-124.883045	124.883045	042.338336
2.356194	10405	-125.997837	125.997837	055.831750
2.356194	10406	-127.783081	127.783082	068.346127
2.356194	10407	-130.561041	130.561041	078.950546
2.356194	10408	-134.642617	134.642618	086.397358
2.356194	10409	-140.094373	140.094373	089.787775
2.356194	10410	-146.675670	146.675670	089.165158
2.356194	10411	-154.057466	154.057466	085.145402
2.356194	10412	-161.978482	161.978483	078.266533
2.356194	10413	-170.219215	170.219216	068.731390
2.356194	10414	-178.481190	178.481191	056.398570
2.356194	10415	-186.178077	186.178078	040.864956
2.356194	10416	-192.114560	192.114561	021.804844
2.552544	10417	-228.654143	152.781815	000.000000
2.552544	10418	-225.902824	150.943442	-021.804845
2.552544	10419	-218.922259	146.279178	-040.864956
2.552544	10420	-209.871677	140.231772	-056.398569
2.552544	10421	-200.156622	133.740380	-068.731391
2.552544	10422	-190.466545	127.265678	-078.266533
2.552544	10423	-181.152416	121.042175	-085.145402
2.552544	10424	-172.472342	115.242335	-089.165158
2.552544	10425	-164.733555	110.071443	-089.787775
2.552544	10426	-158.322969	105.788026	-086.397358
2.552544	10427	-153.523542	102.581152	-078.950546
2.552544	10428	-150.257008	100.398524	-068.346127
2.552544	10429	-148.157782	098.995866	-055.831750
2.552544	10430	-146.846925	098.119979	-042.338335
2.552544	10431	-146.059417	097.593783	-028.385311
2.552544	10432	-145.639228	097.313021	-014.230221
2.552544	10433	-145.507182	097.224791	000.000000
2.552544	10434	-145.639228	097.313022	014.230227
2.552544	10435	-146.059417	097.593783	028.385318
2.552544	10436	-146.846926	098.119979	042.338336
2.552544	10437	-148.157782	098.995866	055.831750
2.552544	10438	-150.257008	100.398524	068.346127
2.552544	10439	-153.523542	102.581152	078.950546
2.552544	10440	-158.322968	105.788026	086.397358
2.552544	10441	-164.733555	110.071443	089.787775
2.552544	10442	-172.472341	115.242335	089.165158
2.552544	10443	-181.152415	121.042175	085.145402
2.552544	10444	-190.466545	127.265677	078.266533
2.552544	10445	-200.156622	133.740380	068.731390
2.552544	10446	-209.871677	140.231772	056.398570
2.552544	10447	-218.922258	146.279177	040.864956
2.552544	10448	-225.902824	150.943442	021.804844
2.748894	10449	-254.066871	105.237945	000.000000
2.748894	10450	-251.009769	103.971651	-021.804845
2.748894	10451	-243.253381	100.758850	-040.864956
2.748894	10452	-233.196913	096.593325	-056.398569
2.748894	10453	-222.402123	092.121976	-068.731391
2.748894	10454	-211.635086	087.662124	-078.266533
2.748894	10455	-201.285780	083.375301	-085.145402
2.748894	10456	-191.640998	079.380301	-089.165158
2.748894	10457	-183.042119	075.818529	-089.787775
2.748894	10458	-175.919057	072.868060	-086.397358
2.748894	10459	-170.586221	070.659127	-078.950546
2.748894	10460	-166.956642	069.155706	-068.346127
2.748894	10461	-164.624107	068.189539	-055.831750
2.748894	10462	-163.167561	067.586217	-042.338335
2.748894	10463	-162.292529	067.223767	-028.385311
2.748894	10464	-161.825639	067.030375	-014.230221
2.748894	10465	-161.678918	066.969601	000.000000
2.748894	10466	-161.825640	067.030375	014.230227
2.748894	10467	-162.292529	067.223767	028.385318
2.748894	10468	-163.167561	067.586217	042.338336
2.748894	10469	-164.624107	068.189539	055.831750
2.748894	10470	-166.956642	069.155706	068.346127
2.748894	10471	-170.586220	070.659127	078.950546
2.748894	10472	-175.919057	072.868060	086.397358
2.748894	10473	-183.042119	075.818529	089.787775
2.748894	10474	-191.640998	079.380301	089.165158
2.748894	10475	-201.285779	083.375300	085.145402
2.748894	10476	-211.635086	087.662124	078.266533
2.748894	10477	-222.402123	092.121976	068.731390
2.748894	10478	-233.196913	096.593325	056.398570
2.748894	10479	-243.253380	100.758850	040.864956
2.748894	10480	-251.009769	103.971651	021.804844
2.945243	10481	-269.715952	053.649839	000.000000
2.945243	10482	-266.470549	053.004289	-021.804845
2.945243	10483	-258.236412	051.366417	-040.864956
2.945243	10484	-247.560522	049.242850	-056.398569
2.945243	10485	-236.100834	046.963377	-068.731391
2.945243	10486	-224.670609	044.689763	-078.266533
2.945243	10487	-213.683844	042.504360	-085.145402
2.945243	10488	-203.444999	040.467727	-089.165158
2.945243	10489	-194.316478	038.651951	-089.787775
2.945243	10490	-186.754675	037.147815	-086.397358
2.945243	10491	-181.093366	036.021711	-078.950546
2.945243	10492	-177.240226	035.255274	-068.346127
2.945243	10493	-174.764020	034.762726	-055.831750
2.945243	10494	-173.217759	034.455155	-042.338335
2.945243	10495	-172.288830	034.270380	-028.385311
2.945243	10496	-171.793183	034.171789	-014.230221
2.945243	10497	-171.637424	034.140807	000.000000
2.945243	10498	-171.793183	034.171789	014.230227
2.945243	10499	-172.288830	034.270380	028.385318
2.945243	10500	-173.217759	034.455155	042.338336
2.945243	10501	-174.764020	034.762726	055.831750
2.945243	10502	-177.240226	035.255274	068.346127
2.945243	10503	-181.093366	036.021711	078.950546
2.945243	10504	-186.754675	037.147815	086.397358
2.945243	10505	-194.316477	038.651951	089.787775
2.945243	10506	-203.444998	040.467727	089.165158
2.945243	10507	-213.683844	042.504360	085.145402
2.945243	10508	-224.670609	044.689763	078.266533
2.945243	10509	-236.100835	046.963377	068.731390
2.945243	10510	-247.560522	049.242850	056.398570
2.945243	10511	-258.236412	051.366417	040.864956
2.945243	10512	-266.470550	053.004289	021.804844
3.141593	10513	-275.000000	000.000001	000.000000
3.141593	10514	-271.691016	000.000001	-021.804845
3.141593	10515	-263.295562	000.000001	-040.864956
3.141593	10516	-252.410520	000.000001	-056.398569
3.141593	10517	-240.726323	000.000001	-068.731391
3.141593	10518	-229.072167	000.000001	-078.266533
3.141593	10519	-217.870158	000.000001	-085.145402
3.141593	10520	-207.430722	000.000001	-089.165158
3.141593	10521	-198.123363	000.000001	-089.787775
3.141593	10522	-190.413416	000.000001	-086.397358
3.141593	10523	-184.641195	000.000001	-078.950546

3.141593	10524	-180.712567	000.000001	-068.346127
3.141593	10525	-178.187850	000.000001	-055.831750
3.141593	10526	-176.611296	000.000001	-042.338335
3.141593	10527	-175.664167	000.000001	-028.385311
3.141593	10528	-175.158810	000.000001	-014.230221
3.141593	10529	-175.000000	000.000001	000.000000
3.141593	10530	-175.158810	000.000001	014.230227
3.141593	10531	-175.664168	000.000001	028.385318
3.141593	10532	-176.611296	000.000001	042.338336
3.141593	10533	-178.187850	000.000001	055.831750
3.141593	10534	-180.712567	000.000001	068.346127
3.141593	10535	-184.641195	000.000001	078.950546
3.141593	10536	-190.413415	000.000001	086.397358
3.141593	10537	-198.123362	000.000001	089.787775
3.141593	10538	-207.430722	000.000001	089.165158
3.141593	10539	-217.870158	000.000001	085.145402
3.141593	10540	-229.072166	000.000001	078.266533
3.141593	10541	-240.726323	000.000001	068.731390
3.141593	10542	-252.410520	000.000001	056.398570
3.141593	10543	-263.295562	000.000001	040.864956
3.141593	10544	-271.691016	000.000001	021.804844
3.337942	10545	-269.715952	-053.649838	000.000000
3.337942	10546	-266.470550	-053.004287	-021.804845
3.337942	10547	-258.236412	-051.366415	-040.864956
3.337942	10548	-247.560523	-049.242849	-056.398569
3.337942	10549	-236.100835	-046.963375	-068.731391
3.337942	10550	-224.670609	-044.689762	-078.266533
3.337942	10551	-213.683844	-042.504359	-085.145402
3.337942	10552	-203.444999	-040.467726	-089.165158
3.337942	10553	-194.316478	-038.651950	-089.787775
3.337942	10554	-186.754675	-037.147814	-086.397358
3.337942	10555	-181.093366	-036.021709	-078.950546
3.337942	10556	-177.240226	-035.255272	-068.346127
3.337942	10557	-174.764020	-034.762724	-055.831750
3.337942	10558	-173.217760	-034.455154	-042.338335
3.337942	10559	-172.288830	-034.270378	-028.385311
3.337942	10560	-171.793183	-034.171788	-014.230221
3.337942	10561	-171.637424	-034.140806	000.000000
3.337942	10562	-171.793183	-034.171788	014.230227
3.337942	10563	-172.288830	-034.270378	028.385318
3.337942	10564	-173.217760	-034.455154	042.338336
3.337942	10565	-174.764020	-034.762724	055.831750
3.337942	10566	-177.240226	-035.255272	068.346127
3.337942	10567	-181.093366	-036.021709	078.950546
3.337942	10568	-186.754675	-037.147814	086.397358
3.337942	10569	-194.316478	-038.651950	089.787775
3.337942	10570	-203.444999	-040.467726	089.165158
3.337942	10571	-213.683844	-042.504358	085.145402
3.337942	10572	-224.670609	-044.689762	078.266533
3.337942	10573	-236.100835	-046.963375	068.731390
3.337942	10574	-247.560523	-049.242849	056.398570
3.337942	10575	-258.236412	-051.366415	040.864956
3.337942	10576	-266.470550	-053.004287	021.804844
3.534292	10577	-254.066872	-105.237943	000.000000
3.534292	10578	-251.009770	-103.971650	-021.804845
3.534292	10579	-243.253381	-100.758849	-040.864956
3.534292	10580	-233.196914	-096.593323	-056.398569
3.534292	10581	-222.402124	-092.121975	-068.731391
3.534292	10582	-211.635087	-087.662122	-078.266533
3.534292	10583	-201.285780	-083.375299	-085.145402
3.534292	10584	-191.640999	-079.380300	-089.165158
3.534292	10585	-183.042120	-075.818528	-089.787775
3.534292	10586	-175.919058	-072.868059	-086.397358
3.534292	10587	-170.586221	-070.659126	-078.950546
3.534292	10588	-166.956643	-069.155705	-068.346127
3.534292	10589	-164.624108	-068.189537	-055.831750
3.534292	10590	-163.167562	-067.586216	-042.338335
3.534292	10591	-162.292529	-067.223766	-028.385311
3.534292	10592	-161.825640	-067.030374	-014.230221
3.534292	10593	-161.678918	-066.969600	000.000000
3.534292	10594	-161.825640	-067.030374	014.230227
3.534292	10595	-162.292529	-067.223766	028.385318
3.534292	10596	-163.167562	-067.586216	042.338336
3.534292	10597	-164.624108	-068.189537	055.831750
3.534292	10598	-166.956642	-069.155705	068.346127
3.534292	10599	-170.586221	-070.659125	078.950546
3.534292	10600	-175.919058	-072.868059	086.397358
3.534292	10601	-183.042120	-075.818528	089.787775
3.534292	10602	-191.640999	-079.380300	089.165158
3.534292	10603	-201.285780	-083.375299	085.145402
3.534292	10604	-211.635086	-087.662122	078.266533
3.534292	10605	-222.402124	-092.121975	068.731390
3.534292	10606	-233.196913	-096.593323	056.398570
3.534292	10607	-243.253381	-100.758848	040.864956
3.534292	10608	-251.009770	-103.971650	021.804844
3.730641	10609	-228.654144	-152.781813	000.000000
3.730641	10610	-225.902825	-150.943440	-021.804845
3.730641	10611	-218.922260	-146.279176	-040.864956
3.730641	10612	-209.871678	-140.231771	-056.398569
3.730641	10613	-200.156623	-133.740379	-068.731391
3.730641	10614	-190.466546	-127.265676	-078.266533
3.730641	10615	-181.152416	-121.042174	-085.145402
3.730641	10616	-172.472342	-115.242334	-089.165158
3.730641	10617	-164.733556	-110.071442	-089.787775
3.730641	10618	-158.322969	-105.788025	-086.397358
3.730641	10619	-153.523543	-102.581151	-078.950546
3.730641	10620	-150.257009	-100.398523	-068.346127
3.730641	10621	-148.157783	-098.995865	-055.831750
3.730641	10622	-146.846926	-098.119978	-042.338335
3.730641	10623	-146.059418	-097.593782	-028.385311
3.730641	10624	-145.639228	-097.313020	-014.230221
3.730641	10625	-145.507183	-097.224790	000.000000
3.730641	10626	-145.639229	-097.313020	014.230227
3.730641	10627	-146.059418	-097.593782	028.385318
3.730641	10628	-146.846926	-098.119978	042.338336
3.730641	10629	-148.157783	-098.995865	055.831750
3.730641	10630	-150.257009	-100.398522	068.346127
3.730641	10631	-153.523543	-102.581151	078.950546
3.730641	10632	-158.322969	-105.788025	086.397358
3.730641	10633	-164.733556	-110.071442	089.787775
3.730641	10634	-172.472342	-115.242334	089.165158
3.730641	10635	-181.152416	-121.042174	085.145402
3.730641	10636	-190.466546	-127.265676	078.266533
3.730641	10637	-200.156623	-133.740379	068.731390
3.730641	10638	-209.871678	-140.231770	056.398570
3.730641	10639	-218.922260	-146.279176	040.864956
3.730641	10640	-225.902825	-150.943440	021.804844
3.926991	10641	-194.454366	-194.454364	000.000000
3.926991	10642	-192.114561	-192.114559	-021.804845
3.926991	10643	-186.178078	-186.178077	-040.864956
3.926991	10644	-178.481191	-178.481190	-056.398569
3.926991	10645	-170.219216	-170.219215	-068.731391
3.926991	10646	-161.978483	-161.978482	-078.266533
3.926991	10647	-154.057467	-154.057466	-085.145402
3.926991	10648	-146.675671	-146.675669	-089.165158
3.926991	10649	-140.094374	-140.094373	-089.787775
3.926991	10650	-134.642618	-134.642617	-086.397358
3.926991	10651	-130.561042	-130.561040	-078.950546
3.926991	10652	-127.783082	-127.783081	-068.346127
3.926991	10653	-125.997838	-125.997836	-055.831750
3.926991	10654	-124.883046	-124.883044	-042.338335
3.926991	10655	-124.213325	-124.213323	-028.385311
3.926991	10656	-123.855983	-123.855982	-014.230221
3.926991	10657	-123.743687	-123.743686	000.000000
3.926991	10658	-123.855983	-123.855982	014.230227
3.926991	10659	-124.213325	-124.213324	028.385318
3.926991	10660	-124.883046	-124.883044	042.338336
3.926991	10661	-125.997838	-125.997836	055.831750
3.926991	10662	-127.783082	-127.783081	068.346127
3.926991	10663	-130.561041	-130.561040	078.950546
3.926991	10664	-134.642618	-134.642617	086.397358
3.926991	10665	-140.094374	-140.094372	089.787775
3.926991	10666	-146.675671	-146.675669	089.165158
3.926991	10667	-154.057467	-154.057465	085.145402
3.926991	10668	-161.978483	-161.978481	078.266533
3.926991	10669	-170.219217	-170.219215	068.731390
3.926991	10670	-178.481191	-178.481189	056.398570
3.926991	10671	-186.178078	-186.178077	040.864956
3.926991	10672	-192.114561	-192.114559	021.804844
4.12334	10673	-152.781815	-228.654143	000.000000
4.12334	10674	-150.943442	-225.902823	-021.804845
4.12334	10675	-146.279178	-218.922258	-040.864956
4.12334	10676	-140.231772	-209.871677	-056.398569
4.12334	10677	-133.740381	-200.156622	-068.731391
4.12334	10678	-127.265678	-190.466545	-078.266533
4.12334	10679	-121.042175	-181.152415	-085.145402
4.12334	10680	-115.242335	-172.472341	-089.165158
4.12334	10681	-110.071444	-164.733555	-089.787775
4.12334	10682	-105.788026	-158.322968	-086.397358
4.12334	10683	-102.581152	-153.523542	-078.950546
4.12334	10684	-100.398524	-150.257008	-068.346127
4.12334	10685	-098.995866	-148.157782	-055.831750
4.12334	10686	-098.119980	-146.846925	-042.338335
4.12334	10687	-097.593783	-146.059417	-028.385311
4.12334	10688	-097.313022	-145.639228	-014.230221
4.12334	10689	-097.224791	-145.507182	000.000000
4.12334	10690	-097.313022	-145.639228	014.230227
4.12334	10691	-097.593783	-146.059417	028.385318
4.12334	10692	-098.119980	-146.846925	042.338336
4.12334	10693	-098.995866	-148.157782	055.831750
4.12334	10694	-100.398524	-150.257008	068.346127
4.12334	10695	-102.581152	-153.523542	078.950546
4.12334	10696	-105.788026	-158.322968	086.397358
4.12334	10697	-110.071443	-164.733555	089.787775
4.12334	10698	-115.242335	-172.472341	089.165158
4.12334	10699	-121.042175	-181.152415	085.145402
4.12334	10700	-127.265678	-190.466545	078.266533
4.12334	10701	-133.740381	-200.156622	068.731390
4.12334	10702	-140.231772	-209.871676	056.398570
4.12334	10703	-146.279178	-218.922258	040.864956
4.12334	10704	-150.943442	-225.902823	021.804844
4.31969	10705	-105.237945	-254.066871	000.000000
4.31969	10706	-103.971652	-251.009769	-021.804845
4.31969	10707	-100.758851	-243.253381	-040.864956
4.31969	10708	-096.593325	-233.196913	-056.398569
4.31969	10709	-092.121977	-222.402123	-068.731391

4.31969	10710	-067.662124	-211.635086	-078.266533
4.31969	10711	-083.375301	-201.285779	-085.145402
4.31969	10712	-079.380302	-191.640998	-089.165158
4.31969	10713	-075.818529	-183.042119	-089.787775
4.31969	10714	-072.868060	-175.919057	-086.397358
4.31969	10715	-070.659127	-170.586220	-078.950546
4.31969	10716	-069.155706	-166.956642	-068.346127
4.31969	10717	-068.189539	-164.624107	-055.831750
4.31969	10718	-067.586218	-163.167561	-042.338335
4.31969	10719	-067.223767	-162.292529	-028.385311
4.31969	10720	-067.030376	-161.825639	-014.230221
4.31969	10721	-066.969601	-161.678918	000.000000
4.31969	10722	-067.030376	-161.825640	014.230227
4.31969	10723	-067.223767	-162.292529	028.385318
4.31969	10724	-067.586218	-163.167561	042.338336
4.31969	10725	-068.189539	-164.624107	055.831750
4.31969	10726	-069.155706	-166.956642	068.346127
4.31969	10727	-070.659127	-170.586220	078.950546
4.31969	10728	-072.868060	-175.919057	086.397358
4.31969	10729	-075.818529	-183.042119	089.787775
4.31969	10730	-079.380302	-191.640998	089.165158
4.31969	10731	-083.375301	-201.285779	085.145402
4.31969	10732	-087.662124	-211.635086	078.266533
4.31969	10733	-092.121977	-222.402123	068.731390
4.31969	10734	-096.593325	-233.196913	056.398570
4.31969	10735	-100.758851	-243.253380	040.864956
4.31969	10736	-103.971652	-251.009769	021.804844
4.516039	10737	-053.649840	-269.715952	000.000000
4.516039	10738	-053.004289	-266.470549	-021.804845
4.516039	10739	-051.366417	-258.236412	-040.864956
4.516039	10740	-049.242851	-247.560522	-056.398569
4.516039	10741	-046.963377	-236.100834	-068.731391
4.516039	10742	-044.689764	-224.670609	-078.266533
4.516039	10743	-042.504360	-213.683844	-085.145402
4.516039	10744	-040.467727	-203.444999	-089.165158
4.516039	10745	-038.651952	-194.316478	-089.787775
4.516039	10746	-037.147816	-186.754675	-086.397358
4.516039	10747	-036.021711	-181.093366	-078.950546
4.516039	10748	-035.255274	-177.240226	-068.346127
4.516039	10749	-034.762726	-174.764020	-055.831750
4.516039	10750	-034.455155	-173.217759	-042.338335
4.516039	10751	-034.270380	-172.288830	-028.385311
4.516039	10752	-034.171790	-171.793183	-014.230221
4.516039	10753	-034.140607	-171.637424	000.000000
4.516039	10754	-034.171790	-171.793183	014.230227
4.516039	10755	-034.270380	-172.288830	028.385318
4.516039	10756	-034.455156	-173.217759	042.338336
4.516039	10757	-034.762726	-174.764020	055.831750
4.516039	10758	-035.255274	-177.240226	068.346127
4.516039	10759	-036.021711	-181.093366	078.950546
4.516039	10760	-037.147815	-186.754675	086.397358
4.516039	10761	-038.651952	-194.316477	089.787775
4.516039	10762	-040.467727	-203.444998	089.165158
4.516039	10763	-042.504360	-213.683844	085.145402
4.516039	10764	-044.689764	-224.670609	078.266533
4.516039	10765	-046.963377	-236.100834	068.731390
4.516039	10766	-049.242851	-247.560522	056.398570
4.516039	10767	-051.366417	-258.236411	040.864956
4.516039	10768	-053.004289	-266.470549	021.804844
4.712389	10769	-000.000001	-275.000000	000.000000
4.712389	10770	-000.000001	-271.691016	-021.804845
4.712389	10771	-000.000001	-263.295562	-040.864956
4.712389	10772	-000.000001	-252.410520	-056.398569
4.712389	10773	-000.000001	-240.726323	-068.731391
4.712389	10774	-000.000001	-229.072167	-078.266533
4.712389	10775	-000.000001	-217.870158	-085.145402
4.712389	10776	-000.000001	-207.430722	-089.165158
4.712389	10777	-000.000001	-198.123363	-089.787775
4.712389	10778	-000.000001	-190.413416	-086.397358
4.712389	10779	-000.000001	-184.641195	-078.950546
4.712389	10780	-000.000001	-180.712567	-068.346127
4.712389	10781	-000.000001	-178.187850	-055.831750
4.712389	10782	-000.000001	-176.611296	-042.338335
4.712389	10783	-000.000001	-175.664167	-028.385311
4.712389	10784	-000.000001	-175.158810	-014.230221
4.712389	10785	-000.000001	-175.000000	000.000000
4.712389	10786	-000.000001	-175.158810	014.230227
4.712389	10787	-000.000001	-175.664168	028.385318
4.712389	10788	-000.000001	-176.611296	042.338336
4.712389	10789	-000.000001	-178.187850	055.831750
4.712389	10790	-000.000001	-180.712567	068.346127
4.712389	10791	-000.000001	-184.641195	078.950546
4.712389	10792	-000.000001	-190.413415	086.397358
4.712389	10793	-000.000001	-198.123362	089.787775
4.712389	10794	-000.000001	-207.430722	089.165158
4.712389	10795	-000.000001	-217.870158	085.145402
4.712389	10796	-000.000001	-229.072166	078.266533
4.712389	10797	-000.000001	-240.726323	068.731390
4.712389	10798	-000.000001	-252.410520	056.398570
4.712389	10799	-000.000001	-263.295562	040.864956
4.712389	10800	-000.000001	-271.691016	021.804844
4.908739	10801	053.649837	-269.715952	000.000000
4.908739	10802	053.004286	-266.470550	-021.804845
4.908739	10803	051.366415	-258.236412	-040.864956
4.908739	10804	049.242848	-247.560523	-056.398569
4.908739	10805	046.963375	-236.100835	-068.731391
4.908739	10806	044.689761	-224.670609	-078.266533
4.908739	10807	042.504358	-213.683844	-085.145402
4.908739	10808	040.467725	-203.444999	-089.165158
4.908739	10809	038.651950	-194.316478	-089.787775
4.908739	10810	037.147814	-186.754675	-086.397358
4.908739	10811	036.021709	-181.093366	-078.950546
4.908739	10812	035.255272	-177.240226	-068.346127
4.908739	10813	034.762724	-174.764021	-055.831750
4.908739	10814	034.455154	-173.217760	-042.338335
4.908739	10815	034.270378	-172.288830	-028.385311
4.908739	10816	034.171788	-171.793183	-014.230221
4.908739	10817	034.140605	-171.637424	000.000000
4.908739	10818	034.171788	-171.793183	014.230227
4.908739	10819	034.270378	-172.288830	028.385318
4.908739	10820	034.455154	-173.217760	042.338336
4.908739	10821	034.762724	-174.764020	055.831750
4.908739	10822	035.255272	-177.240226	068.346127
4.908739	10823	036.021709	-181.093366	078.950548
4.908739	10824	037.147813	-186.754675	086.397358
4.908739	10825	038.651949	-194.316478	089.787775
4.908739	10826	040.467725	-203.444999	089.165158
4.908739	10827	042.504358	-213.683844	085.145402
4.908739	10828	044.689761	-224.670609	078.266533
4.908739	10829	046.963375	-236.100835	068.731390
4.908739	10830	049.242848	-247.560523	056.398570
4.908739	10831	051.366415	-258.236412	040.864956
4.908739	10832	053.004286	-266.470550	021.804844
5.105088	10833	105.237942	-254.066872	000.000000
5.105088	10834	103.971649	-251.009770	-021.804845
5.105088	10835	100.758848	-243.253382	-040.864956
5.105088	10836	096.593323	-233.196914	-056.398569
5.105088	10837	092.121974	-222.402124	-068.731391
5.105088	10838	087.662122	-211.635087	-078.266533
5.105088	10839	083.375299	-201.285780	-085.145402
5.105088	10840	079.380300	-191.640999	-089.165158
5.105088	10841	075.818527	-183.042120	-089.787775
5.105088	10842	072.868058	-175.919058	-086.397358
5.105088	10843	070.659125	-170.586221	-078.950546
5.105088	10844	069.155705	-166.956643	-068.346127
5.105088	10845	068.189537	-164.624108	-055.831750
5.105088	10846	067.586216	-163.167562	-042.338335
5.105088	10847	067.223766	-162.292529	-028.385311
5.105088	10848	067.030374	-161.825640	-014.230221
5.105088	10849	066.969600	-161.678919	000.000000
5.105088	10850	067.030374	-161.825640	014.230227
5.105088	10851	067.223766	-162.292530	028.385318
5.105088	10852	067.586216	-163.167562	042.338336
5.105088	10853	068.189537	-164.624108	055.831750
5.105088	10854	069.155705	-166.956643	068.346127
5.105088	10855	070.659125	-170.586221	078.950546
5.105088	10856	072.868058	-175.919058	086.397358
5.105088	10857	075.818527	-183.042120	089.787775
5.105088	10858	079.380299	-191.640999	089.165158
5.105088	10859	083.375299	-201.285780	085.145402
5.105088	10860	087.662122	-211.635086	078.266533
5.105088	10861	092.121974	-222.402124	068.731390
5.105088	10862	096.593323	-233.196914	056.398570
5.105088	10863	100.758848	-243.253381	040.864956
5.105088	10864	103.971649	-251.009770	021.804844
5.301438	10865	152.781813	-228.654144	000.000000
5.301438	10866	150.943440	-225.902825	-021.804845
5.301438	10867	146.279176	-218.922260	-040.864956
5.301438	10868	140.231770	-209.871678	-056.398569
5.301438	10869	133.740378	-200.156624	-068.731391
5.301438	10870	127.265676	-190.466546	-078.266533
5.301438	10871	121.042173	-181.152417	-085.145402
5.301438	10872	115.242334	-172.472343	-089.165158
5.301438	10873	110.071442	-164.733556	-089.787775
5.301438	10874	105.788025	-158.322970	-086.397358
5.301438	10875	102.581151	-153.523543	-078.950546
5.301438	10876	100.398522	-150.257009	-068.346127
5.301438	10877	098.995864	-148.157783	-055.831750
5.301438	10878	098.119978	-146.846926	-042.338335
5.301438	10879	097.593782	-146.059418	-028.385311
5.301438	10880	097.313020	-145.639229	-014.230221
5.301438	10881	097.224790	-145.507183	000.000000
5.301438	10882	097.313020	-145.639229	014.230227
5.301438	10883	097.593782	-146.059418	028.385318
5.301438	10884	098.119978	-146.846926	042.338336
5.301438	10885	098.995864	-148.157783	055.831750
5.301438	10886	100.398522	-150.257009	068.346127
5.301438	10887	102.581151	-153.523543	078.950546
5.301438	10888	105.788025	-158.322969	086.397358
5.301438	10889	110.071442	-164.733556	089.787775
5.301438	10890	115.242333	-172.472342	089.165158
5.301438	10891	121.042173	-181.152416	085.145402
5.301438	10892	127.265676	-190.466546	078.266533
5.301438	10893	133.740378	-200.156624	068.731390
5.301438	10894	140.231770	-209.871678	056.398570
5.301438	10895	146.279175	-218.922260	040.864956

5.301438	10896	150.943440	-225.902825	021.804844
5.497787	10897	194.454364	-194.454366	000.000000
5.497787	10898	192.114559	-192.114561	-021.804845
5.497787	10899	186.178076	-186.178079	-040.864956
5.497787	10900	178.481189	-178.481191	-056.398569
5.497787	10901	170.219215	-170.219217	-068.731391
5.497787	10902	161.978481	-161.978483	-078.266533
5.497787	10903	154.057465	-154.057467	-085.145402
5.497787	10904	146.675669	-146.675671	-089.165158
5.497787	10905	140.094372	-140.094374	-089.787775
5.497787	10906	134.642617	-134.642618	-086.397358
5.497787	10907	130.561040	-130.561042	-078.950546
5.497787	10908	127.783061	-127.783063	-068.346127
5.497787	10909	125.997836	-125.997838	-055.831750
5.497787	10910	124.883044	-124.883046	-042.338335
5.497787	10911	124.213323	-124.213325	-028.385311
5.497787	10912	123.855982	-123.855963	-014.230221
5.497787	10913	123.743686	-123.743687	000.000000
5.497787	10914	123.855982	-123.855963	014.230227
5.497787	10915	124.213323	-124.213325	028.385318
5.497787	10916	124.883044	-124.883046	042.338336
5.497787	10917	125.997836	-125.997838	055.831750
5.497787	10918	127.783081	-127.783063	068.346127
5.497787	10919	130.561040	-130.561042	078.950546
5.497787	10920	134.642616	-134.642618	086.397358
5.497787	10921	140.094372	-140.094374	089.787775
5.497787	10922	146.675669	-146.675671	089.165158
5.497787	10923	154.057465	-154.057467	085.145402
5.497787	10924	161.978481	-161.978483	078.266533
5.497787	10925	170.219215	-170.219217	068.731390
5.497787	10926	178.481189	-178.481191	056.398570
5.497787	10927	186.178076	-186.178079	040.864956
5.497787	10928	192.114559	-192.114561	021.804844
5.694137	10929	228.654142	-152.781816	000.000000
5.694137	10930	225.902823	-150.943443	-021.804845
5.694137	10931	218.922258	-146.279178	-040.864956
5.694137	10932	209.871676	-140.231773	-056.398569
5.694137	10933	200.156622	-133.740381	-068.731391
5.694137	10934	190.466545	-127.265678	-078.266533
5.694137	10935	181.152415	-121.042176	-085.145402
5.694137	10936	172.472341	-115.242336	-089.165158
5.694137	10937	164.733555	-110.071444	-089.787775
5.694137	10938	158.322968	-105.788027	-086.397358
5.694137	10939	153.523542	-102.581153	-078.950546
5.694137	10940	150.257008	-100.398524	-068.346127
5.694137	10941	148.157782	-098.995866	-055.831750
5.694137	10942	146.846925	-098.119980	-042.338335
5.694137	10943	146.059417	-097.593783	-028.385311
5.694137	10944	145.639227	-097.313022	-014.230221
5.694137	10945	145.507182	-097.224792	000.000000
5.694137	10946	145.639228	-097.313022	014.230227
5.694137	10947	146.059417	-097.593784	028.385318
5.694137	10948	146.846925	-098.119980	042.338336
5.694137	10949	148.157782	-098.995866	055.831750
5.694137	10950	150.257008	-100.398524	068.346127
5.694137	10951	153.523542	-102.581153	078.950546
5.694137	10952	158.322968	-105.788027	086.397358
5.694137	10953	164.733555	-110.071444	089.787775
5.694137	10954	172.472341	-115.242336	089.165158
5.694137	10955	181.152415	-121.042176	085.145402
5.694137	10956	190.466545	-127.265678	078.266533
5.694137	10957	200.156622	-133.740381	068.731390
5.694137	10958	209.871676	-140.231773	056.398570
5.694137	10959	218.922258	-146.279178	040.864956
5.694137	10960	225.902823	-150.943443	021.804844

5.890486	10961	254.066871	-105.237946	000.000000
5.890486	10962	251.009768	-103.971652	-021.804845
5.890486	10963	243.253380	-100.758851	-040.864956
5.890486	10964	233.196913	-096.593326	-056.398569
5.890486	10965	222.402123	-092.121977	-068.731391
5.890486	10966	211.635086	-087.662124	-078.266533
5.890486	10967	201.285779	-083.375301	-085.145402
5.890486	10968	191.640998	-079.380302	-089.165158
5.890486	10969	183.042119	-075.818530	-089.787775
5.890486	10970	175.919057	-072.868061	-086.397358
5.890486	10971	170.586220	-070.659127	-078.950546
5.890486	10972	166.956642	-069.155707	-068.346127
5.890486	10973	164.624107	-068.189539	-055.831750
5.890486	10974	163.167561	-067.586218	-042.338335
5.890486	10975	162.292528	-067.223768	-028.385311
5.890486	10976	161.825639	-067.030376	-014.230221
5.890486	10977	161.678918	-066.969602	000.000000
5.890486	10978	161.825639	-067.030376	014.230227
5.890486	10979	162.292529	-067.223768	028.385318
5.890486	10980	163.167561	-067.586218	042.338336
5.890486	10981	164.624107	-068.189539	055.831750
5.890486	10982	166.956642	-069.155707	068.346127
5.890486	10983	170.586220	-070.659127	078.950546
5.890486	10984	175.919057	-072.868061	086.397358
5.890486	10985	183.042119	-075.818530	089.787775
5.890486	10986	191.640998	-079.380302	089.165158
5.890486	10987	201.285779	-083.375301	085.145402
5.890486	10988	211.635085	-087.662124	078.266533
5.890486	10989	222.402123	-092.121977	068.731390
5.890486	10990	233.196912	-096.593326	056.398570
5.890486	10991	243.253380	-100.758851	040.864956
5.890486	10992	251.009769	-103.971652	021.804844
6.086836	10993	269.715952	-053.649840	000.000000
6.086836	10994	266.470549	-053.004290	-021.804845
6.086836	10995	258.236412	-051.366418	-040.864956
6.086836	10996	247.560522	-049.242851	-056.398569
6.086836	10997	236.100834	-046.963378	-068.731391
6.086836	10998	224.670609	-044.689764	-078.266533
6.086836	10999	213.683844	-042.504361	-085.145402
6.086836	11000	203.444999	-040.467728	-089.165158
6.086836	11001	194.316477	-038.651952	-089.787775
6.086836	11002	186.754675	-037.147816	-086.397358
6.086836	11003	181.093366	-036.021711	-078.950546
6.086836	11004	177.240226	-035.255274	-068.346127
6.086836	11005	174.764020	-034.762726	-055.831750
6.086836	11006	173.217759	-034.455156	-042.338335
6.086836	11007	172.288829	-034.270380	-028.385311
6.086836	11008	171.793183	-034.171790	-014.230221
6.086836	11009	171.637424	-034.140808	000.000000
6.086836	11010	171.793183	-034.171790	014.230227
6.086836	11011	172.288830	-034.270380	028.385318
6.086836	11012	173.217759	-034.455156	042.338336
6.086836	11013	174.764020	-034.762726	055.831750
6.086836	11014	177.240226	-035.255274	068.346127
6.086836	11015	181.093366	-036.021711	078.950546
6.086836	11016	186.754675	-037.147816	086.397358
6.086836	11017	194.316477	-038.651952	089.787775
6.086836	11018	203.444998	-040.467728	089.165158
6.086836	11019	213.683844	-042.504361	085.145402
6.086836	11020	224.670609	-044.689764	078.266533
6.086836	11021	236.100834	-046.963378	068.731390
6.086836	11022	247.560522	-049.242851	056.398570
6.086836	11023	258.236411	-051.366418	040.864956
6.086836	11024	266.470549	-053.004290	021.804844

Appendix M - Table of complex helical coefficients for four different PF3 designs

The following are the complex coefficients resulting from the Fourier analysis of the magnetic field normal to the "dee-shaped" surface. The coefficients have been normalized by 4 T and are expressed in parts per 10000. The results for both $n\phi+m\theta$ and $n\phi-m\theta$ are given for up to m=16 and n=6. Here ϕ corresponds to the toroidal direction and θ corresponds to the poloidal direction. The m and n indices (including sign) listed correspond to those from the actual two-dimensional fft. For example, the case of $4\phi-2\theta$ harmonics is listed as mode (4,-2). The data corresponding to negative mode numbers (i.e., -4,2 or $-4\phi+2\theta$) are repititious, since they are the conjugate of their corresponding positive modes (i.e., 4,-2). Therefore, they are not included in the tables which follow.

Table M.1a – Positive m and n (i.e.,left-handed, nϕ+mθ) helical Fourier coefficients for co-located PF3U spiral design with vertical return.

Normalize by 40,000 Gauss and express in parts per 10000

	n=0		n=1		n=2		n=3		n=4		n=5		n=6	
	real	imag	real	imag	real	imag	real	imag	real	imag	real	imag	real	imag
m=0	20.69902581	0	0.00205134	-0.0005756629	0.000679832	-0.005241628	3.81035E-08	-0.003749159	4.19761E-08	-0.002363119	-4.92773E-09	-0.001365666	2.43677E-08	-0.000746303
m=1	-87.22253325	-21.56306118	0.0043152366	0.005042827	0.0015273349	0.004376387	0.003714096	0.002905987	0.002108063	0.001628645	0.00114862	0.000875611	0.000613745	0.000449955
m=2	48.39616329	-12.43452479	-0.0005889393	0.003547993	-0.005479919	0.0029779222	-0.003712141	0.001676961	-0.002144544	0.000945421	-0.001174501	0.000502966	-0.000620747	0.000273897
m=3	6.561330567	19.65255284	-2.73254E-05	-0.005911284	-0.000354074	-0.004900006	-5.03795E-05	-0.003017457	1.07486E-05	-0.001757342	2.9988E-05	-0.000966892	1.69407E-05	-0.000522802
m=4	-14.07166423	-5.787433487	0.0039389997	0.001280554	0.003219776	0.000978353	0.001879614	0.000675208	0.001093141	0.000426883	0.000598482	0.000257524	0.000327449	0.000146742
m=5	1.101747392	-4.84355379	-0.0013957033	0.002130075	-0.001091135	0.001715321	-0.000689043	0.000974472	-0.000441379	0.00056215	-0.000264203	0.000303106	-0.000154147	0.00016471
m=6	4.575847249	2.794400785	-0.000971969	-0.001084379	-0.000813257	-0.000885426	-0.00046276	-0.000537284	-0.000257689	-0.000336256	-0.000133389	-0.000197891	-6.93012E-05	-0.000115748
m=7	-0.842687561	1.234740738	0.000723508	-0.000459015	0.000573934	-0.00036572	0.000344527	-0.000206206	0.000216464	-0.000109301	0.00012682	-5.27998E-05	7.40277E-05	-2.45765E-05
m=8	-1.819556019	-1.295356761	0.000224687	0.000460441	0.000184803	0.000372531	0.000104004	0.000222196	4.9646E-05	0.000135553	2.10443E-05	7.77507E-05	7.62737E-06	4.44893E-05
m=9	0.5606031	-0.405207161	-0.000279223	0.000122574	-0.000223769	9.24168E-05	-0.000135476	5.10437E-05	-8.2635E-05	2.30071E-05	-4.70188E-05	8.60674E-06	-2.6405E-05	2.01111E-06
m=10	0.754507941	0.598604769	-6.70051E-05	-0.000187675	-5.60679E-05	-0.000151034	-3.10203E-05	-9.08218E-05	-1.29068E-05	-5.37286E-05	-4.20705E-06	-2.98839E-05	-5.12842E-07	-1.63236E-05
m=11	-0.360274733	0.090882281	9.0000128417	-3.95958E-05	0.000101184	-2.91148E-05	6.09393E-05	-1.55056E-05	3.58668E-05	-6.37422E-06	1.97219E-05	-1.85408E-06	1.05873E-05	1.26572E-06
m=12	-0.303383764	-0.290860216	2.48864E-05	9.55454E-05	1.99238E-05	7.44367E-05	1.02373E-05	4.40402E-05	3.78347E-06	2.53977E-05	9.27447E-07	1.3741E-05	-1.41685E-07	7.26915E-06
m=13	0.190884424	0.006578009	-7.27094E-05	1.45047E-05	-5.46163E-05	9.28958E-06	-3.1945E-05	4.28888E-06	-1.83679E-05	1.48249E-06	-9.89991E-06	1.85899E-07	-5.21475E-06	-2.5095E-07
m=14	0.11473492	0.114197516	-7.96496E-06	-6.06668E-05	-5.81611E-06	-4.36394E-05	-2.49902E-06	-2.47681E-05	-7.07876E-07	-1.4113E-05	2.02881E-08	-7.53305E-06	2.57114E-07	-3.94771E-06
m=15	-0.060136802	-0.039477298	5.90296E-05	-4.42393E-06	3.83806E-05	-1.94482E-06	2.07437E-05	-5.81148E-07	1.17457E-05	-8.83159E-08	6.23654E-06	1.03858E-07	3.22851E-06	1.67223E-07
m=16	-0.066243111	0	-1.02413E-06	6.02892E-05	3.57607E-08	3.71734E-05	2.31006E-09	1.9384E-05	3.37891E-10	1.09648E-05	-9.78174E-09	5.81971E-06	2.4002E-08	3.00104E-06

Table M.1b – Negative m and positive n (i.e.,right-handed, nϕ-mθ) helical Fourier coefficients for co-located PF3U spiral design with vertical return.

Normalize by 40,000 Gauss and expressed in parts per 10000

	n=0		n=1		n=2		n=3		n=4		n=5		n=6	
	real	imag	real	imag	real	imag	real	imag	real	imag	real	imag	real	imag
m=-15	-0.060136802	0.039477298	-7.61037E-05	-2.86056E-06	-4.21762E-05	-1.62134E-06	-2.07572E-05	-5.8842E-07	-1.17574E-05	-8.84028E-08	-6.2461E-06	9.09883E-08	-3.25557E-06	1.71745E-07
m=-14	0.11473492	-0.114197516	1.83359E-05	-9.0927E-05	7.36772E-06	-5.0481E-05	2.52686E-06	-2.4751E-05	7.15938E-07	-1.41182E-05	-2.76709E-06	-7.5451E-06	-2.28436E-07	-3.95955E-06
m=-13	0.190884424	-0.006578009	0.000129676	2.49158E-05	6.7399E-05	1.15881E-05	3.19219E-05	4.26401E-06	1.83874E-05	1.48696E-06	9.91216E-06	1.94534E-07	5.21584E-06	-2.48955E-07
m=-12	-0.303383764	0.290860216	-6.56826E-05	0.000169074	-2.74229E-05	9.10733E-05	-1.01598E-05	4.40391E-05	-3.79813E-06	2.53979E-05	-9.28921E-07	1.37443E-05	1.45419E-07	7.26417E-06
m=-11	-0.360274733	-0.090882281	-0.000249262	-7.93631E-05	-0.000128794	-3.7687E-05	-6.09532E-05	-1.5482E-05	-3.58399E-05	-6.41207E-06	-1.97231E-05	-1.8646E-06	-1.0575E-05	2.9728E-06
m=-10	0.754507941	-0.598604769	0.000176967	-0.000349753	7.6658E-05	-0.00018835	3.10135E-05	-9.08352E-05	1.28985E-05	-5.36983E-05	4.22756E-06	-2.98804E-05	4.96996E-07	-1.8316E-05
m=-9	0.5606031	0.405207161	0.000549329	0.000236829	0.000288129	0.000116221	0.000135505	5.10396E-05	8.26514E-05	2.29968E-05	4.70087E-05	8.58805E-06	2.64081E-05	1.98716E-06
m=-8	-1.81956019	1.295356761	-0.000543228	0.000887501	-0.000247682	0.00047424	-0.000104023	0.000222223	-4.96504E-05	0.000135593	-2.10408E-05	7.77496E-05	-7.60983E-06	4.45001E-05
m=-7	-0.842687561	-1.234740738	-0.001423941	-0.000939928	-0.000749901	-0.000474171	-0.000344565	-0.000206253	-0.00021652	-0.000109319	-0.000126824	-5.27951E-05	-7.40353E-05	-2.458E-05
m=-6	4.575847249	-2.794400785	0.002311834	-0.002167449	0.001112219	-0.001153706	0.000462868	-0.000537332	0.00025771	-0.000336294	0.000133392	-0.000197883	6.92989E-05	-0.000115729
m=-5	1.101747392	4.84355379	0.002590516	0.004613142	0.00140711	0.002313871	0.000689046	0.00097463	0.000441402	0.000562183	0.000264203	0.000303116	0.000154137	0.000164691
m=-4	-14.07166423	5.787433487	-0.009226121	0.001767123	-0.004480994	0.00109205	-0.001879784	0.000675139	-0.001093177	0.000426881	-0.000598506	0.000257515	-0.000327444	0.000148747
m=-3	6.561330567	-19.65255284	0.003380428	-0.013496269	0.001152036	-0.006750713	5.05741E-05	-0.003017661	-1.07308E-05	-0.001757329	-2.99587E-05	-0.000966965	-1.69395E-05	-0.000522746
m=-2	48.39616329	12.43452479	0.014600041	0.012809808	0.007362295	0.005322248	0.003712272	0.001677277	0.002144484	0.000945424	0.00117459	0.00050305	0.000620662	0.000273848
m=-1	-87.22253325	21.56306118	-0.019289719	0.004206854	-0.008609056	0.003882831	-0.003714337	0.002905934	-0.002108115	0.0016288	-0.001148648	0.000875643	-0.000613732	0.000449916

Table M.2a – Positive m and n (i.e.,left-handed, nϕ+mθ) helical Fourier coefficients for co-located PF3U constant radius/jog design with vertical return.

Normalize by 40,000 Gauss and expressed in parts per 10000														
	n=0		n=1		n=2		n=3		n=4		n=5		n=6	
	real	imag	real	imag	real	imag	real	imag	real	imag	real	imag	real	imag
m=0	20.6936983	0	-0.002033338	-0.003940634	-0.00144888	-0.004318181	-0.000927113	-0.003334633	-0.000532911	-0.002169488	-0.000283302	-0.001280239	-0.000142312	-0.000711046
m=1	-87.19942128	-21.56152879	0.011480366	0.006710992	0.007406073	0.004761523	0.00430444	0.002786815	0.002386214	0.001510925	0.001283573	0.000787885	0.000674416	0.000402009
m=2	48.38382354	-12.42408849	-0.00813915	0.003155422	-0.006181327	0.002433544	-0.003903022	0.001625678	-0.002243233	0.000982558	-0.001219506	0.000556934	-0.000639772	0.000302359
m=3	6.556750314	19.64354832	-0.000668137	-0.005309203	-6.23737E-05	-0.004279124	8.23467E-05	-0.002865574	7.91864E-05	-0.001733601	5.06021E-05	-0.000983539	2.80443E-05	-0.000534186
m=4	-14.06520167	-5.786795303	0.003123141	0.000965489	0.002430905	0.000905859	0.001618117	0.00068163	0.000987842	0.000454003	0.000569595	0.000278701	0.000315163	0.000161415
m=5	1.100794484	-4.840568143	-0.000607903	0.001548461	-0.000706327	0.001192615	-0.000583411	0.000782	-0.000409706	0.000489427	-0.000261478	0.000266485	-0.00015657	0.000145598
m=6	4.574010776	2.793212185	-0.000914528	-0.000665285	-0.000640748	-0.000583269	-0.000384528	-0.000432852	-0.000212318	-0.000291901	-0.0001111	-0.000184033	-5.59141E-05	-0.000110339
m=7	-0.842015956	1.234072915	0.000351599	-0.000422468	0.000347016	-0.000304112	0.000266552	-0.000178333	0.000180334	-9.18169E-05	0.000112978	-4.27006E-05	6.72088E-05	-1.78896E-05
m=8	-1.819019637	-1.294842004	0.000314648	0.000313506	0.0001986	0.000255519	0.000103387	0.000177794	4.67493E-05	0.000113446	1.80637E-05	6.82862E-05	5.20166E-06	3.93435E-05
m=9	0.560310599	-0.405019835	-0.000171417	0.000139263	-0.000154552	9.56328E-05	-0.000110635	5.15308E-05	-7.01994E-05	2.27609E-05	-4.14206E-05	7.81691E-06	-2.32005E-05	1.27957E-06
m=10	0.754304039	0.598393437	-0.000118975	-0.000145732	-7.06976E-05	-0.000115528	-3.42131E-05	-7.71029E-05	-1.38804E-05	-4.67848E-05	-4.22475E-06	-2.66433E-05	-3.7366E-07	-1.44529E-05
m=11	-0.360129526	0.090820212	9.2179E-05	-4.40172E-05	7.72963E-05	-3.02306E-05	5.22896E-05	-1.58443E-05	3.15924E-05	-6.49362E-06	1.77342E-05	-1.78383E-06	9.43762E-06	8.92822E-08
m=12	-0.303303322	-0.290760641	4.49965E-05	7.37275E-05	2.48707E-05	5.76197E-05	1.11116E-05	3.76029E-05	3.96704E-06	2.22376E-05	8.80901E-07	1.22902E-05	-1.8649E-07	6.46234E-06
m=13	0.190812976	0.006594394	-4.90828E-05	1.26075E-05	-4.03059E-05	8.41986E-06	-2.66844E-05	4.0284E-06	-1.57681E-05	1.3127E-06	-8.69402E-06	7.32754E-06	-4.56939E-06	-3.18615E-07
m=14	0.114707248	0.114156827	-1.47652E-05	-3.67919E-05	-7.25878E-06	-2.96562E-05	-2.72066E-06	-1.95163E-05	-6.71892E-07	-1.15146E-05	9.05557E-06	-6.32628E-06	3.06985E-07	-3.32167E-06
m=15	-0.060114886	-0.039476051	2.54138E-05	-2.4055E-06	2.22549E-05	-1.71616E-06	1.49804E-05	-6.98688E-07	8.89428E-06	-9.38564E-06	4.89724E-06	1.30627E-07	2.56243E-06	1.98518E-07
m=16	-0.066229485	0	4.65266E-06	2.00514E-05	1.78524E-06	1.80973E-05	6.99231E-07	1.2443E-05	2.56696E-07	7.48773E-06	6.78262E-06	4.17949E-06	4.52798E-06	2.1922E-06

Table M.2b – Negative m and positive n (i.e.,right-handed, nϕ-mθ) helical Fourier coefficients for co-located PF3U constant radius/jog design with vertical return.

Normalize by 40,000 Gauss and expressed in parts per 10000														
	n=0		n=1		n=2		n=3		n=4		n=5		n=6	
	real	imag	real	imag	real	imag	real	imag	real	imag	real	imag	real	imag
m=-15	-0.060114886	0.039476051	-1.23277E-05	2.19116E-06	-1.52062E-05	1.5379E-06	-1.14851E-05	9.18223E-07	-7.21717E-06	5.81196E-07	-4.12096E-06	3.58701E-07	-2.22359E-06	2.74875E-07
m=-14	0.114707248	-0.114156827	-3.28981E-06	-1.49356E-05	-5.36506E-07	-1.72643E-05	-5.26497E-07	-1.29155E-05	-6.11275E-07	-8.1962E-06	-5.76634E-07	-4.74194E-06	-4.39219E-07	-2.59677E-06
m=-13	0.190812976	-0.006594394	6.15814E-06	-4.53264E-06	1.6948E-05	-2.0108E-06	1.48951E-05	-1.15532E-06	1.00817E-05	-9.22636E-07	6.01042E-06	-7.90765E-07	3.32724E-06	-5.98987E-07
m=-12	-0.303303322	0.290760641	6.35952E-06	2.13417E-05	-1.50495E-06	2.80231E-05	-9.84966E-07	2.1668E-05	6 3436E-08	1.40645E-05	5.88417E-07	8.27404E-06	6.36482E-07	4.5515E-06
m=-11	-0.360129526	-0.090820212	-4.95352E-06	7.23456E-06	-2.80399E-05	-7.33227E-07	-2.65815E-05	-1.58191E-06	-1.8553E-05	-5.26542E-07	-1.12839E-05	3.93939E-07	-6.28025E-06	7.18868E-07
m=-10	0.754304039	-0.598393437	-1.43087E-05	-3.77502E-05	9.08479E-06	-5.22998E-05	7.77748E-06	-4.12244E-05	3.34668E-06	-2.71298E-05	4.7885E-07	-1.62219E-05	-7.53859E-07	-9.02813E-06
m=-9	0.560310599	0.405019835	2.7311E-06	-2.05795E-06	4.95039E-05	1.62109E-05	5.02511E-05	1.25327E-05	3 65416E-05	5.39169E-06	2.3006E-05	7.08958E-07	1.33277E-05	-1.42623E-06
m=-8	-1.819019637	1.294842004	3.77658E-05	7.13592E-05	-2.44803E-05	0.000103628	-2.11404E-05	8.43123E-05	-8.63689E-06	5.81199E-05	-5.48776E-07	3.67283E-05	2.67026E-06	2.20081E-05
m=-7	-0.842015956	-1.234072915	-3.21767E-06	2.25326E-05	-0.000102245	-3.20916E-05	-0.000112927	-2.57485E-05	-8.95998E-05	-9.95733E-06	-6.18039E-05	2.57908E-07	-3.95313E-05	4.31659E-06
m=-6	4.574010776	-2.793212185	-0.000190409	-0.000144497	1.18847E-05	-0.000244309	3.62499E-05	-0.000223039	2.20507E-05	-0.000170319	8.8166E-06	-0.000117774	2.06381E-06	-7.61273E-05
m=-5	1.100794484	4.840568143	0.000154496	-0.000163596	0.000375313	7.42182E-05	0.000391215	0.000108258	0.000311612	8.72779E-05	0.000216296	5.99346E-05	0.00013778	3.84331E-05
m=-4	-14.06520167	5.786795303	0.000588296	0.000884867	-0.000186901	0.001001758	-0.000353449	0.000810617	-0.000312918	0.000564519	-0.000225921	0.000357162	-0.000147153	0.000210983
m=-3	6.556750314	-19.64354832	-0.001985345	2.44375E-06	-0.001898224	-0.001061984	-0.001190936	-0.001148749	-0.000726865	-0.000888115	-0.000405062	-0.000590141	-0.000211992	-0.000358834
m=-2	48.38382354	12.42408849	0.000719848	-0.003896275	0.002846217	-0.002167474	0.002561938	-0.000962363	0.001745016	-0.000358541	0.001049331	-0.000102557	0.00058817	-1.00882E-05
m=-1	-87.19942128	21.56152879	0.002280795	0.007412221	-0.000813347	0.006006568	-0.001265967	0.003732544	-0.001010617	0.00209971	-0.000668754	0.001120487	-0.00040292	0.000578032

Table M.3a – Positive m and n (i.e.,left-handed, nϕ+mθ) helical Fourier coefficients for uniformly clocked (-36 degs.) PF3U constant radius/jog design with vertical return.

Normalize by 40,000 Gauss and expressed in parts per 10000														
	n=0		n=1		n=2		n=3		n=4		n=5		n=6	
	real	Imag	real	Imag	real	Imag	real	Imag	real	Imag	real	Imag	real	Imag
m=0	20.34760894	0	0.001801668	0.047418265	0.000583011	0.022537566	0.000232819	0.010333746	0.000101217	0.004523441	0.001496449	-0.000163221	-2.89586E-05	0.000814585
m=1	-85.73752998	-21.19919282	-0.075286172	-0.066951153	-0.025370816	-0.022825543	-0.009632769	-0.008069824	-0.003765756	-0.002726266	-0.002816036	0.002466911	-0.000672788	-0.000631548
m=2	47.57039218	-12.21508513	0.06524823	-0.024735072	0.024051157	-0.00881544	0.009352081	-0.004002212	0.003418563	-0.002004358	-0.00031046	-0.004207435	0.000853207	-0.000152791
m=3	6.447993584	19.31194176	0.001878052	0.04925593	7.00757E-05	0.017879226	0.000264984	0.007310011	0.000533052	0.002994283	0.003126892	0.001718879	-0.000259583	0.000622357
m=4	-13.82844946	-5.68837305	-0.029239829	-0.010206304	-0.01067938	-0.003690835	-0.004550536	-0.001349417	-0.00208453	-0.000299633	-0.002160467	0.001338334	-0.000276778	-0.000357164
m=5	1.08113472	-4.759192754	0.007638406	-0.015397687	0.003139747	-0.005643258	0.001394774	-0.002470855	0.000537645	-0.001232122	-0.000185861	-0.001602429	0.000262664	-5.39377E-05
m=6	4.497469553	2.745719345	0.008011159	0.007122389	0.00292119	0.002646623	0.00126442	0.001151278	0.000648856	0.000506655	0.000934953	0.000223115	-2.67999E-05	0.000143759
m=7	-0.827514169	1.213538374	-0.004094317	0.003950871	-0.001640717	0.001458082	-0.000762229	0.000625887	-0.000367774	0.000320622	-0.000272156	0.000475032	-6.50442E-05	-3.48159E-05
m=8	-1.788673047	-1.272955743	-0.002508778	-0.003251697	-0.00086897	-0.001195561	-0.000340927	-0.00052166	-0.000159897	-0.000248853	-0.000231996	-0.000199123	2.1574E-05	-2.77296E-05
m=9	0.550809934	-0.398312548	0.001800967	-0.00125263	0.000717983	-0.00045211	0.000326332	-0.000179044	0.000157672	-8.11978E-05	0.000130024	-0.000117041	1.32573E-05	1.03144E-05
m=10	0.741724075	0.588308153	0.000900043	0.001456596	0.000299967	0.000535512	0.000108779	0.000227193	4.5027E-05	0.000104249	6.46631E-05	7.97198E-05	-4.16711E-06	8.43397E-06
m=11	-0.354055593	0.089333072	-0.00091801	0.00039599	-0.000353996	0.000145378	-0.000152859	5.69482E-05	-6.93005E-05	2.49264E-05	-5.27183E-05	3.92081E-05	-6.47283E-06	-2.01904E-06
m=12	-0.298250818	-0.285865458	-0.000337726	-0.000747009	-0.000107327	-0.000271778	-3.72667E-05	-0.000112079	-1.53896E-05	-4.90117E-05	-2.44585E-05	-3.57548E-05	1.33292E-06	-5.14809E-06
m=13	0.187599846	0.006464414	0.000507944	-0.00012125	0.000191987	-4.51244E-05	8.05079E-05	-1.81733E-05	3.51603E-05	-8.84162E-06	2.66665E-05	-1.5215E-05	4.03733E-06	1.21626E-06
m=14	0.112804007	0.112235401	0.000104804	0.000415834	3.31848E-05	0.000152506	1.19879E-05	6.26127E-05	5.96881E-06	2.69555E-05	8.32523E-06	2.02378E-05	-1.01158E-06	3.21057E-06
m=15	-0.059103409	-0.038800197	-0.000336998	2.41716E-05	-0.000126163	1.13846E-05	-5.19929E-05	5.92953E-06	-2.22638E-05	4.26939E-06	-1.64282E-05	3.37595E-06	-2.76613E-06	-8.6413E-07
m=16	-0.065135735	0	-7.55134E-06	-0.000318089	-5.41535E-06	-0.000118095	-4.07458E-06	-4.83816E-05	-3.93495E-06	-2.06182E-05	7.76019E-07	-1.38199E-05	7.32115E-07	-2.6756E-06

Table M.3b – Negative m and positive n (i.e.,right-handed, nϕ-mθ) helical Fourier coefficients for for uniformly clocked (-36 degs.) PF3U constant radius/jog design with vertical return.

Normalize by 40,000 Gauss and expressed in parts per 10000														
	n=0		n=1		n=2		n=3		n=4		n=5		n=6	
	real	Imag	real	Imag	real	Imag	real	Imag	real	Imag	real	Imag	real	Imag
m=-15	-0.059103409	0.038800197	0.000323288	6.60646E-06	0.000124057	-9.86351E-07	5.14547E-05	-3.06104E-06	2.1954E-05	-4.18414E-06	1.2452E-05	4.70573E-06	2.97746E-06	6.28826E-07
m=-14	0.112804007	-0.112235401	-7.96142E-05	0.000390583	-1.85451E-05	0.000148284	-1.49174E-06	6.13684E-05	3.94279E-06	2.609E-05	-8.79829E-06	1.22819E-05	-6.60839E-07	3.77376E-06
m=-13	0.187599846	-0.006464414	-0.000463296	-8.38244E-05	-0.000185581	-2.42373E-05	-7.90251E-05	-3.91455E-06	-3.38633E-05	4.24356E-06	-1.3317E-05	-1.45167E-05	-5.16919E-06	-9.01334E-07
m=-12	-0.298250818	0.285865458	0.00027748	-0.000598209	7.0081E-05	-0.000262664	1.62902E-05	-0.000109106	-2.69518E-06	-4.58671E-05	2.1925E-05	-1.64504E-05	1.60045E-06	-7.49256E-06
m=-11	-0.354055593	-0.089333072	0.000821646	0.000309971	0.000340211	0.000101671	0.000148509	2.72902E-05	6.39743E-05	-3.96013E-06	2.23809E-05	3.60144E-05	1.10868E-05	2.97804E-06
m=-10	0.741724075	-0.588308153	-0.000756478	0.001322314	-0.000234891	0.000514702	-6.29115E-05	0.000218812	3.40455E-06	9.46691E-05	-5.97449E-05	3.20119E-05	-6.02621E-06	1.69374E-05
m=-9	0.550809934	0.398312548	-0.001565748	-0.001029023	-0.000684927	-0.000337768	-0.000316626	-9.47016E-05	-0.000149877	1.00454E-05	-4.34261E-05	-0.000110304	-2.57283E-05	-1.23179E-05
m=-8	-1.788673047	1.272955743	0.002059805	-0.002892658	0.000667831	-0.001157684	0.000191293	-0.000522327	-4.61727E-06	-0.000263856	0.000200796	-3.97437E-05	2.54696E-05	-3.86682E-05
m=-7	-0.827514169	-1.213538374	0.00353407	0.003093895	0.001629363	0.001077405	0.000823356	0.000351734	0.0004743	3.77079E-05	-2.10221E-05	0.000360936	5.40082E-05	5.06714E-05
m=-6	4.497469553	-2.745719345	-0.006195619	0.006530036	-0.002269837	0.002805151	-0.000844282	0.001397598	-0.000257959	0.00084242	-0.00055912	-0.000238039	-9.55682E-05	6.90488E-05
m=-5	1.08113472	4.759192754	-0.007581456	-0.012125284	-0.003758038	-0.004649742	-0.002042576	-0.001949516	-0.001294469	-0.000861736	0.000704939	-0.000669524	-7.36404E-05	-0.000168147
m=-4	-13.82844946	5.68837305	0.023932149	-0.012267036	0.009816039	-0.005263063	0.004285844	-0.002601704	0.002141539	-0.001536569	0.000326834	0.001387251	0.000275931	-5.50607E-05
m=-3	6.447993584	-19.31194176	0.004619749	0.04337441	0.002576569	0.01750967	0.001332184	0.007842072	0.000730287	0.003907102	-0.001697388	-0.000715804	-2.68466E-05	0.000419455
m=-2	47.57039218	12.21508513	-0.062427332	-0.013751933	-0.025388325	-0.006025055	-0.010883175	-0.003005418	-0.00497789	-0.00161332	0.001766158	-0.000799733	-0.00054036	-0.00023794
m=-1	-85.73752998	21.19919282	0.065116638	-0.070682153	0.024279555	-0.02471893	0.009872104	-0.009167314	0.004337217	-0.00355692	-0.000882357	0.000956962	0.000585935	-0.000457016

Table M.4a – Positive m and n (i.e.,left-handed, nϕ+mθ) helical Fourier coefficients for uniformly clocked (-36 degs.) PF3U constant radius/jog design with helical compensation return.

Normalize by 40,000 Gauss and expressed in parts per 10000														
	n=0		n=1		n=2		n=3		n=4		n=5		n=6	
	real	imag	real	imag	real	imag	real	imag	real	imag	real	imag	real	imag
m=0	20.63738285	0	-0.000848284	0.001822122	-0 000904952	0 001001637	-0.000532979	0.000646832	-0.000230737	0.000382244	0.001373214	-0.001887502	-6.93357E-05	0.000107285
m=1	-86.94351098	-21.49905264	-0.004501456	0.000475201	-0 00070934	-0.000359787	-0 000220097	-0.000151481	-8.44644E-05	0.000168602	-0.001156365	0.003561876	-9.04736E-05	-0.000205081
m=2	48.23080224	-12.37544076	0.005322037	-0.007260288	0 001247106	-0.002077586	0.000256715	-0.000944449	-0.000205252	-0.000674127	-0.001756604	-0.00364882	0.000271692	7.75016E-05
m=3	6.540135138	19.57043217	0 002067596	0.007020448	0.000954973	0.002217685	0.000724198	0.000861636	0.000741694	0.000315747	0.003220338	0.00061155	-0.000219489	0.000163058
m=4	-14.01653821	-5.764392205	-0.005294399	-0.000662697	-0.001870247	-5.61346E-05	-0.000922062	0.000205724	-0.000565001	0.000391986	-0.001525455	0.00164887	-9.49687E-06	-0.000219835
m=5	1.091422768	-4.823361231	0.001757861	-0.002879862	0.000541556	-0.001143054	0.000143092	-0.000652099	-5.75276E-05	-0.000482189	-0.000465966	-0.001293931	0.000133747	7.21959E-05
m=6	4.560388651	2.781687554	0.00131922	0.001404614	0.000535726	0.000513647	0.000343245	0.000220013	0.000289533	8.08812E-05	0.000796143	2.39676E-05	-7.73811E-05	5.2065E-05
m=7	-0.837330061	1.230561183	-0.001034942	0.000531187	-0.000386266	0.000231872	-0.000187038	0.000161858	-0.000102152	0.000151181	-0.000148692	0.000415494	-7.69453E-06	-5.26147E-05
m=8	-1.814159004	-1.290043962	-0.000197537	-0.000585327	-7.92846E-05	-0.000235882	-6.2258E-05	-0.000124732	-6.74605E-05	-7.9687E-05	-0.000202616	-0.000125805	2.78034E-05	7.07189E-06
m=9	0.557968351	-0.404016521	0.000376111	-8.64709E-05	0.000144715	-3.60904E-05	7.62034E-05	-2.48529E-05	5.08416E-05	-2.79684E-05	6.59007E-05	-9.97481E-05	-6.9689E-06	1.31252E-05
m=10	0.752343964	0.596302697	3.36421E-05	0.000211041	1.09609E-05	8.60905E-05	8.18908E-06	4.35601E-05	1.0761E-05	2.69813E-05	5.37348E-05	4.95546E-05	-8.21437E-06	-3.43704E-06
m=11	-0.358818089	0.09064259	-0.000150094	2.16602E-05	-5.54176E-05	8.05984E-06	-2.67003E-05	7.58161E-06	-1.45344E-05	7.98868E-06	-3.10403E-05	3.37064E-05	3.31706E-06	-7.01808E-06
m=12	-0 302554074	-0.289768364	-7.63294E-06	-9.18844E-05	-2.28028E-06	-3.63377E-05	-4.88283E-06	-1.95191E-05	-5.57135E-06	-1.02485E-05	-2.23563E-05	-1.90446E-05	2.84963E-06	4.27954E-06
m=13	0.190149469	0.006512396	7.24396E-05	-9.52852E-06	2.62085E-05	-2.45633E-06	1.36219E-05	-2.89099E-06	7.64121E-06	-4.38985E-06	1.45915E-05	-1.62523E-05	-1.44396E-06	-1.41572E-06
m=14	0.114466759	0.113769802	2.62132E-06	5.19034E-05	1.15752E-07	1.95959E-05	1.64855E-06	8.63983E-06	3.74629E-06	6.59084E-06	9.24514E-06	1.30852E-05	7.57827E-07	1.95483E-06
m=15	-0.059914347	-0.039310835	-4.69586E-05	9.96988E-07	-1.76427E-05	1.36358E-06	-7.23434E-06	2.64514E-06	-5.94924E-06	2.96014E-06	-1.08735E-05	1.98221E-06	-1.30495E-06	-2.0484E-06
m=16	-0.066112443	0	4.22445E-06	-3.57291E-05	8.33031E-07	-1.72186E-05	-9.92063E-07	-8.60494E-06	-2.3895E-06	-4.73677E-06	1.97832E-06	-7.24547E-06	2.21799E-06	8.02165E-07

Table M.4b – Negative m and positive n (i.e.,right-handed, nϕ-mθ) helical Fourier coefficients for uniformly clocked (-36 degs.) PF3U constant radius/jog design with helical compensation return.

Normalize by 40,000 Gauss and expressed in parts per 10000														
	n=0		n=1		n=2		n=3		n=4		n=5		n=6	
	real	imag	real	imag	real	imag	real	imag	real	imag	real	imag	real	imag
m=-15	-0.059914347	0.039310835	3.81078E-05	2.98464E-06	1.58719E-05	2.88049E-06	8.31646E-06	1.57484E-06	4.32021E-06	-2.47327E-06	6.33618E-06	4.64655E-06	-4.26906E-07	1.33627E-06
m=-14	0.114466759	-0.113769802	-3.22519E-06	3 63349E-05	-1.52913E-06	1.20788E-05	-4.59119E-07	6.33644E-06	2.58675E-06	3.96356E-06	-9.95354E-06	4.91927E-06	-2.0458E-06	5.62545E-07
m=-13	0.190149469	-0.006512396	-5.90353E-05	-2.38404E-06	-1.89365E-05	2.18523E-06	-9.37709E-06	3.15205E-06	-4.38912E-06	4.31103E-06	-4.44384E-07	-1.56307E-05	-1.65974E-07	-2.17721E-06
m=-12	-0.302554074	0.289768364	1.25026E-05	-6.67739E-05	4.04553E-07	-2.58453E-05	-4.42397E-06	-1.34815E-05	-8.34022E-06	-6.09937E-06	1.95727E-05	1.68171E-06	1.18207E-06	-8.38287E-07
m=-11	-0.358818089	-0.09064259	0.000113763	1.31245E-05	4.30239E-05	2.83428E-06	2.13986E-05	-5.74301E-06	1.18885E-05	-1.46111E-05	4.49055E-07	3.18929E-05	2.33902E-06	1.83758E-06
m=-10	0.752343964	-0.596302697	-3.75901E-05	0.000132357	-9.78577E-06	5.15774E-05	6.56093E-06	2.82212E-05	2.34067E-05	1.88891E-05	-5.5229E-05	1.75438E-06	-4.14588E-06	3.96587E-06
m=-9	0.557968351	0.404016521	-0.000247406	-2.821E-05	-9.25251E-05	5.03752E-07	-4.95997E-05	1.63001E-05	-3.53057E-05	4.24592E-05	4.15706E-06	-0.000104221	-6.3504E-06	-1.04951E-05
m=-8	-1.814159004	1.290043962	0.000112186	-0.000366996	1.32247E-05	-0.000155626	-2.46186E-05	-9.24001E-05	-7.25263E-05	-7.6702E-05	0.000183624	4.06438E-05	2.30942E-05	-5.02998E-06
m=-7	-0 837330061	-1.230561183	0.000732314	0.000180714	0.000318681	3.65285E-05	0.000199699	-2.44513E-05	0.000185697	-9.62345E-05	-0.000151591	0.00031609	-5.55957E-06	3.85886E-05
m=-6	4.560388651	-2.781687554	-0.000716608	0.001129961	-0.000248337	0.000538127	-7.80284E-05	0.00037022	3.33712E-05	0.000374502	-0.000448448	-0.000449796	-5.18889E-05	-2.7943E-05
m=-5	1.091422768	4.823361231	-0.001761344	-0.001635857	-0.000625614	-0.000705324	-0.000579517	-0.000369322	-0.000601437	-0.000219996	0.001020244	-0.000402678	6.60978E-05	-5.4189E-05
m=-4	-14.01653821	5.764392205	0.004083584	-0.001604567	0.001793427	-0.000748622	0.001016904	-0.000562722	0.000763818	-0.000627662	-0.00025729	0.001779898	2.59199E-05	0.000106133
m=-3	6.540135138	-19.57043217	-0.000385805	0.006245897	-0.000947914	0.002839753	-0.000104369	0.001679177	0.000109906	0.001318072	-0.001943002	-0.001794657	-0.000116114	-2.92001E-05
m=-2	48.23080224	12.37544076	-0.006873854	-0.006083458	-0.002786223	-0.002823655	-0.001579882	-0.001469095	-0.001213386	-0.000878203	0.003269819	-0.000452591	5.88868E-05	-7.52625E-05
m=-1	-86.94351098	21.49905264	0.007790728	0.001297451	0.003654997	0.000508706	0.001932678	6.39167E-05	0.001175152	-0.00012286	-0.002167595	0.002244823	5.8061E-05	3.06113E-05

TPX PF Winding Pack Insulation Design

J.F. Roach, J.F. Lowry, T. D. Hordubay
D.C. Johnson, P.A. Sanger, R. J. Hillenbrand

STC Advanced Electromagnetic Systems Department

June 30, 1995

TPX 14-950814-WEC-FRoach-01

APPROVED:

P.A. Sanger
Westinghouse TPX Chief Scientist

APPROVED:

D. R. Potter
Westinghouse TPX Engineering Manager

Westinghouse Electric Corporation
Electronic Systems Group

401 East Hendy Avenue, Sunnyvale, California 94088-3499

CONTENTS

LIST OF FIGURES v

LIST OF TABLES v

ABSTRACT vi

1. CDR BASELINE DESIGN SUMMARY FOR PF MAGNET SYSTEMS 1-1

2. DEPARTURES AND ADDITIONS TO CDR BASELINE DESIGN 2-1

3. ELECTRICAL REQUIREMENTS AND ANALYSIS 3-1

3.1 COIL OPERATIONAL VOLTAGES 3-1

3.2 ELECTROSTATIC FIELD PLOTTING 3-4

3.3 DESIGN VOLTAGES 3-7

4. CPDR DESIGN BASELINE DESCRIPTIONS 4-1
4.1.1 Technical Assessments of Options 4-1
4.1.2 Insulation System 4-1
4.1.3 Coil Winding 4-8

4.2 DESIGN DESCRIPTION 4-11
4.2.1 Conduit Insulation 4-12
4.2.2 Corner Fillers 4-15
4.2.3 Transition Pieces 4-15
4.2.4 Helium Stub Insulation 4-16
4.2.5 Groundwall 4-18
4.2.6 Groundplane 4-18
4.2.7 Lead and Lead Spur Insulation 4-20
4.2.8 Joint Insulation 4-25
4.2.9 Impregnation System 4-26

5. SUMMARY AND CONCLUSIONS 5-1

6. REFERENCES 6-1

7. APPENDICES 7-1

Appendix 7.1 — Summary of Electrostatic Field Analyses for PF Winding Packs 7.1-1

Appendix 7.2 — Technical Assessment of TPX Electrical Insulation System Alternatives 7.2-1

Appendix 7.3 — Technical Assessment of TPX CS/PF Winding Options 7.3-1

LIST OF FIGURES

Figure 1.1 — CDR Baseline winding pack electrical insulation system for PF coils....1-3
Figure 3.1 — Insulation configuration models of PF coils for electrostatic field analyses....3-5
Figure 4.1 — Spiral winding approach with stacked transitions showing one coil layer only....4-11
Figure 4.2 — CS and PF5 insulated coil pack cross sections. (MARD Dwg.)....4-13
Figure 4.3 — Details of winding pack insulation in adjacent conductor corners showing void fill cross section. (STC Dwg.)....4-14
Figure 4.4 — Helium Stub Insulation Design. (MARD Dwg.)....4-17
Figure 4.5 — Groundwall Insulation Design....4-19
Figure 4.6 — Lead Insulation Design....4-21
Figure 4.7 — Lead Spur Design....4-22
Figure 4.8 — Termination Joint Insulation Design....4-24

LIST OF TABLES

Table 1.1 — Summary of CDR Baseline PF Winding Pack Nominal Dimensions....1-1
Table 3.1 — Maximum PF and TF Operating Voltages and Peaking Factors....3-2
Table 3.2 — Summary of Stresses and Field Enhancement Factors for PF Winding Pack Configurations Predicted for Maximum Voltage Drops of 10 kV Turn-to-Ground, 2 kV Layer-to-Layer....3-6
Table 3.3 — DC Design Voltages, Electric Stress, and Safety Margins for PF Coils....3-8
Table 4.1 — Summary Of TPX Candidate Insulation Systems (Dimensions In mm)....4-4
Table 4.2 — Summary Of Results Of Technical Assessment Of TPX Electrical Insulation System Alternatives....4-6
Table 4.3 — Summary of Technical Assessments for Winding Design Options....4-10

ABSTRACT

The CPDR winding pack design and for the TPX PF coils is presented in this report. The CDR Baseline winding pack design for the PF coils is reviewed, and recommended design changes/additions are summarized. Requirements for the electrical insulation system are discussed. PF system peak operational voltages are reviewed and design voltages derived, including peaking factors for non-uniform voltage distribution within coil packs, local electric field enhancements, and void stress. Results of electrostatic field analysis of local stresses within PF coils is reviewed and peak stress enhancement factors at conductor corners for layer-to-layer and coil turns-to-ground determined. The report focuses on the electrical insulation design of the winding pack, including helium stubs, groundwall, groundplane, leads and termination joints.

1. CDR BASELINE DESIGN SUMMARY FOR PF MAGNET SYSTEMS

The CDR Baseline design for the PF magnet systems winding packs is summarized in this section.

1. *TPX PF Winding Pack Dimensions and Construction*

The TPX PF coil winding pack dimensions (expressed at room temperature) are presented in Table 1.1 derived from the CDR drawing package. Table 1.1 gives the following parameters for each coil: the mean radius, R to the coil vertical centerline, the winding pack cross sectional height, H and width, W which include groundwall insulation, and the turns configuration, turns per layer, N,number of layers (pancakes) per coil, n, and total turns TURNS=nN. The winding packs for the upper, U and lower, L coils are mirror images. The nominal dimension of the insulated square conduit is 23.93 mm. The nominal groundwall insulation is 7.87 mm. Each PF coil is a spiral winding having effectively (n + 1.125) turns per cross sectional width.

Table 1.1 — Summary of CDR Baseline PF Winding Pack Nominal Dimensions

COIL	R	H	W	N	n	TURNS
-	mm	mm	mm	#	#	#
PF1 U,L	811	494	186	20	6	120
PF2 U,L	811	399	186	16	6	96
PF3 U,L	811	255	186	10	6	60
PF4 U,L	811	255	186	10	6	60
PF5 U,L	1215	399	234	16	8	128
PF6 U,L	3770	494	186	20	6	120
PF7 U,L	4310	351	186	14	6	84

The eight PF1-4 U,L coils comprise the CS central solenoid, and the six coils PF5-7 U,L the large poloidal field coils. The PF1-5 conductors are square Incoloy 908 CICC Nb_3Sn superconductors, and the winding packs are formed by the wind, react, insulate, and VPI process. The PF6-7 conductors are square 304 LN stainless steel CICC NbTi superconductors, and the winding packs are formed by the wind, insulate, and VPI process.

2. *Electrical Insulation System*

The CDR Baseline electical insulation scheme for the PF coil system is shown in Figure 1.1, taken from CDR package drawing TPX E-9414203, PF-7 Poloidal Field Coil, 06-28-94. The insulation system shown for the PF-7 coil is identical for all PF winding packs. The 22.30 mm (0.878") CICC conductors are first wrapped with 0.610 mm (0.024") dry glass. As each layer (pancake) is formed 0.406 mm (0.016") G11-CR or polyimide strips are inserted for turn-to-turn insulation barriers. After each layer winding is formed a 0.406 mm (0.016") G11-CR or polyimide sheet is placed on top and the next layer winding started on top of the layer-to-layer insulation barrier sheet.

The triangluar shaped void corners formed at the barrier strip and barrier sheet or groundwall insulation wrap are filled with cylindrically shapped glass roving as the barrier strips and sheets are inserted. The void spaces on the circumference of the winding pack resulting from the spiral winding and layer-to-layer transitions are filled with dielectric "blocks", assumed to be machined G11-CR or molded parts.

The total insulation build from turn-to-turn within a layer or from layer to layer is 1.626 mm (0.064"). After the coil turns are insulated, stacked, and barriers and void fillers inserted, a Kapton and dry glass ground wrap insulation is applied with a total build of 7.87 mm (0.031+/-0.06"). The configuration of the of Kapton film and dry glass tape groundwall insulation was not defined in the CDR drawing package. The coil is then impregnated with an epoxy resin system and vacuum-

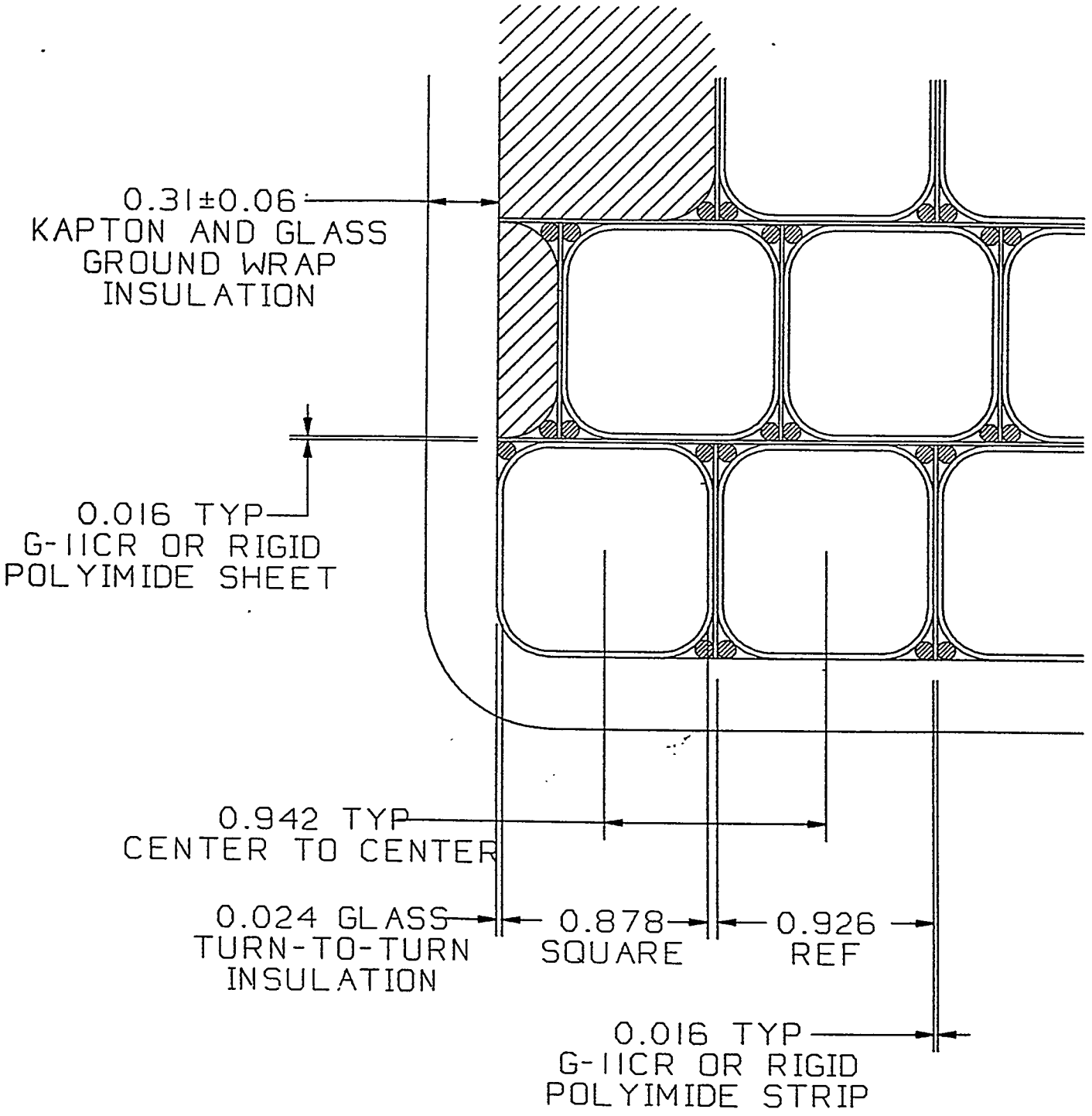


Figure 1.1 — CDR Baseline winding pack electrical insulation system for PF coils.

pressure-impregnated (VPI). A conducting groundplane is put on the surface of the groundwall insulation to complete the winding pack insulation system. The groundplane design was also undefinded in the CDR Baseline drawings.

3. *Leads, Terminations, Helium Stubs*

The start and finish leads of each coil are support as they turn away from the winding pack by lead spurs. The lead spurs are dielectric structures which support the leads against the winding pack and are assumed to be impregnated with the coil during the VPI process to bond and support the leads to against the winding pack body. The CDR drawing package did not detail the lead spurs and support structures.

The CDR package contained several design options for lead terminations and helium stubs.

The CDR package did not provide details of the electrical insulation system for the leads, terminations, helium stubs, and helium lines. The helium stub insultion was described as a dielectric molded boot which fits over the helium stub assembly and is cured in with the groundwall insulation.

2. DEPARTURES AND ADDITIONS TO CDR BASELINE DESIGN

The significant departures and additions to the CDR Baseline PF winding pack design are:

1. *Coil Electrical Insulation System*

The CDR Baseline coil insulation design is epoxy/glass, G11-CR insulation barriers, and corner glass roving with 1.626 mm insulation spacing between adjacent turns within or between layer (pancake) coils; the epoxy/glass insulation is bonded to the conductors resulting in a monolithically bonded winding pack structure.

The CPDR Baseline coil insulation design is the Kapton Slip option with three-dimensional (3-D) woven glass tape and preformed 3-D corner fillers. The Kapton is multilapped directly on the conductor without adhesives with a 3-D woven dry glass tape overwrap. The 3-D glass corner fillers are preformed to the corner void shape and maybe optionally tackified to form rigid filler elements. The interface between the conductor and Kapton insulation film is not bonded and represents a "slip" surface controlled by the effective interfacial friction factor between Kapton and conductor under operational temperature. The G11-CR barriers used in the CDR Baseline are eliminated in the CPDR design. The insulation spacing between turns and layers is 1.626 mm, identical to the CDR Baseline.

2. *Groundwall Insulation*

The CDR Baseline groundwall insulation is defined as interleaved Kapton and dry glass wraps with nominal total insulation thickness of 8 mm with a minimum allowable of 6.35 mm. The CDR drawings define the tolerance on the the

groundwall insulation build as 0.31+\-0.06 inches, that is 7.87 +\-1.52 mm. The groundwall Kapton/glass wrapping scheme is not defined in the CDR drawing package. The coil impregnation VPI process must penetrate the Kapton/glass wrap. The groundplane is not defined in the CDR drawing package and is assumed to be applied on the surface of the groundwall insulation after completion of VPI.

The CPDR Baseline groundwall insulation is defined as dry glass wraps only. The dry glass is wrapped first to a minimum dimension of 5.54 mm and then the groundplane screen applied. After the groundplane wrap is complete, including insulation break, additional dry glass is wrapped over the groundplane to achieve a final groundwall with imbedded groundplane thickness of 7.87 +1.52/-0. This places the groundplane a minimum of 6.35 mm from the conductor surface.

3. *Groundplane*

The CDR Baseline groundplane is defined as a conducting or semiconducting layer on the outside surface of the groundwall insulation wrap for containing the electric stress within the winding pack and control of the potential seen in the cryostat vacuum environment surrounding the winding pack structure. The groundplane is applied after the coils are VPI processed. The CDR Baseline did not detail the groundplane design, but the TPX Poloidal Field System Design Description (SDD), UCRL-AR-113939, March 12, 1993 suggested several alternatives such as semiconductive coatings ("paints") or tape films and metallic foil wraps.

The CPDR Baseline groundplane is lapped copper screen tape imbedded just below the outside surface of the groundwrap and impregnated during the coil VPI process. The screen void content is about 40% allowing for full impregnation of the winding pack. The screen covers the entire surface of the coil and and has one Kapton insulation break. The coil groundplane screen is interfaced and electrically connected to the groundplanes on the start and finsh leads and the helium stubs and

lines. The groundplane screens are, thus, fully impregnated within the groundwall insulation with a protective overwrap of epoxy/glass in a single VPI process.

4. *Helium Stub and Insulation*

The CDR Baseline helium stub design is a streamlined weldment assembly with a molded dielectric sleeve placed over the stub for electrical insulation.

The CPDR Baseline helium stub design is a three piece cylindrical "top hat" weldment with taper for strain relief. The electrical insulation is achieved using overlapping Kapton preforms around the conductor and stub with glass tape overwrap which are interfaced with the conductor Kapton wraps and 3-D glass tape overwarp. The coil groundwall glass wrap and groundplane screen is extended up the stub and terminated in a taperer for later interface with the helium line insulation applied after coil VPI.

5. *Lead Spurs and Lead Support*

The CDR Baseline lead spurs and lead support are G11-CR spurs and support structures impregnated within the groundwall insulation. There are no details of the lead spurs or lead supports structures in the CDR Baseline drawing package.

The CPDR Baseline lead spurs and lead support is (1) welded lead spurs, interlocked and insulated, fully bonded and impregnated within the groundwall insulation, and (2) G11-CR external lead support structures assembled on top of the grounwall insulation, laced with glass tape and impregnated during the coil VPI process.

6. *Insulation System for Leads and Terminations*

The CDR Baseline insulation system for leads and terminations was not defined in the CDR drawing package.

The CPDR Baseline insulation system for leads and terminations is driven by the assumption that all exposed high voltage surfaces in the cryostat vacuum environment shall be limite to a surface potential less than 160 V or that is Paschen minimum breakdown voltage for helium. This demands that all lead and termination surfaces be fully insulated and a groundplane applied to contain the local electric stress and keep surface potential to below the 160 V minimum. The full length of the leads for both CS and PF 5 coils will be wrapped with Kapton, glass tape, and groundplane screen up to the termination block and fully impregnated with the winding pack during the VPI process. The lead insulation is terminated short of the termination block and the Kapton, epoxy/glass, and groundplane screen terminated in tapered fashion for later interface with the final insulation of the termination joint assembly. The surface of the termination joint assembly is fitted with metallic caps to make a smooth joint assembly for insulation wrapping. The join assembly end are fitted with dielectric end blocks to provide a tapered surface to the leads, instrumentation buss, and helium lines for ease of insulating. Kapton is wrapped over the smoothed joint assembly and blended with the lead from the coil and the lead on the other side of the joint from the power supply buss. Prepreg glass tape is then wrapped over the Kapton and blended with the cured glass insulation from the coil and power supply leads. The groundplane screen is then applied over the joint and electrically connected with the leads on either side of the temination. Following a protective wrap of prepreg glass wrap the assembly is wrapped in heat shrink tape and cured.

7. *Insulation System for Helium Lines and Insulation Isolator Interfaces*

The CDR Baseline insulation system for helium lines and insulation isolator interfaces was not defined in the CDR drawing package.

The CPDR Baseline insulation system for helium lines and insulation isolator interfaces is driven by the same electrical constraints as the leads and termination joints discussed above. The helium line insulation proceedure is the same as that for the coil leads with blending of the Kapton, cured glass, and

groundplane at the helium stub, in this case. The interface with the helium isolator requires that the groundplane be extended over the isolator sufficient to shield the isolator surface stresses from vacuum breadown potentials. Since the insulation isolator electrical design does not presently have a coaxial confirguration, that is has a ground shield, it is unclear what impact extending the helium line groundplane over the helium isolator will have on the isolator insulation performance. Therefore, the interface with the isolator is TBD and will be addressed in Phase II.

3. ELECTRICAL REQUIREMENTS AND ANALYSIS

The reliability of the electrical insulation design of the PF winding packs is viewed as crucial to the success of the TPX system. The PF coil and lead insulation designs must be robust and have adequate safety margins against electrical failure under the vacuum environment of the cryostat and for the operational electrical, thermal, and mechanical cycles over the life of the magnet system. Since PF coil terminations will exceed 4000 V in the worst case, the PF coils are considered high voltage magnets. The winding pack turn-to-turn, layer-to-layer, and coil-to-groung insulation must support local structural loads with residual voltage withstand capability at the end of life. The vacuum environment demands that special insulation design attention be given to all high voltage surfaces . Degraded vacuum due to helium leaks from coolant lines could in principle result in low voltage breakdowns, approaching the helium Paschen breakdown minimum of 160 V. Therefore, groundwall insulation with conducting groundplanes is required over coil winding packs, their leads, terminations, and helium cooling lines in order to exclude high electrical stress from the external vacuum environment.

3.1 COIL OPERATIONAL VOLTAGES

The TPX PF operational voltages assumed for the electrical design of the PF coils were taken from published analyses by Radovinsky of MIT. Table 3.1 presents a summary of the peak operating voltages predicted by Radovinsky during 12 V and 20 V startups and HC scenario, Reference 1. Table 3.1 presents the peak terminal voltage, pancake-to-pancake, and turn-to-turn voltages for each of the PF coils for the two operating scenarios having the highest terminal voltage >1000 V. The peaking factors (Pk. F) in Table 3.1 give the ratio of peak local inductive voltages to

average voltage based on uniform distribution of terminal voltage throughout the winding. Also included are the peak TF voltages estimated for a fast dump leading to a 7500 V terminal voltage.

Table 3.1 — Maximum PF and TF Operating Voltages and Peaking Factors

COIL	SCENARIO	TERMINAL VOLTAGE	PANCAKE-PANCAKE		TURN-TURN	
		Volts	Volts	Pk. F	Volts	Pk. F
TF	Dump	7500	<312	-	<22	-
PF1	12 V Startup	3059	347	1.13	30	1.17
PF1	20 V Startup	2979	310	1.04	27	1.07
PF2	20 V Startup	2646	338	1.02	29	1.05
PF2	12 V Startup	1443	181	1.00	16	1.03
PF3	20 V Startup	1492	307	1.03	26	1.06
PF4	20 V Startup	1356	289	1.07	25	1.06
PF5	20 V Startup	4437	595	1.07	39	1.12
PF5	12 V Startup	2645	355	1.07	23	1.12
PF6	20 V Startup	2877	308	1.07	26	1.10
PF6	12 V Startup	2337	252	1.08	22	1.11
PF7	20 V Startup	4067	628	1.08	55	1.13
PF7	HC Normal	1327	197	1.04	17	1.06
	Maximum Operating Voltages, Vop	7500 TF 4437 PF	<312 TF 628 PF		<22 TF 55 PF	

The maximum system voltages for electrical design of the TF coils were assumed to be 7500 V terminal to ground, 312 V layer-to-layer, and 22 V turn-to-turn occuring during energy dump scenario. For the PF coils the maximum voltages are determined from operational scenarios for the PF5 and PF7 coils, all other PF coils having lower operational voltages under all scenarios. For electrical design of the PF coils then, the maximum terminal voltage is assumed to be 4437 V, occuring during the 20 V startup for PF5, and 628 V pancake-to-pancake, 55 V turn-to-turn occuring during the 20 V startup for PF7. Since the electrical insulation design for winding packs is expected to be common for both the PF and TF, the insulation

must be capable of sustaining the maximum operational voltages expect for either coil system. Therefore, the insulation design is predicated on 7500 V terminal-to-ground, 628 V pancake-to-pancake, and 55 V turn-to-turn under the worst operating scenarios of either coil system. This appoach clearly leads to conservative design for the TF coils for turn insulation and for the PF coils for groundwall and line lead insulation where the maximum terminal voltage is 4437 V compared to 7500 V for the TF terminals. The turn insulation requirement between the high voltage ends of adjacent pancake layers is 628 V, so that the turn-to-turn insulation is also to be designed for an operating voltage of the same value.

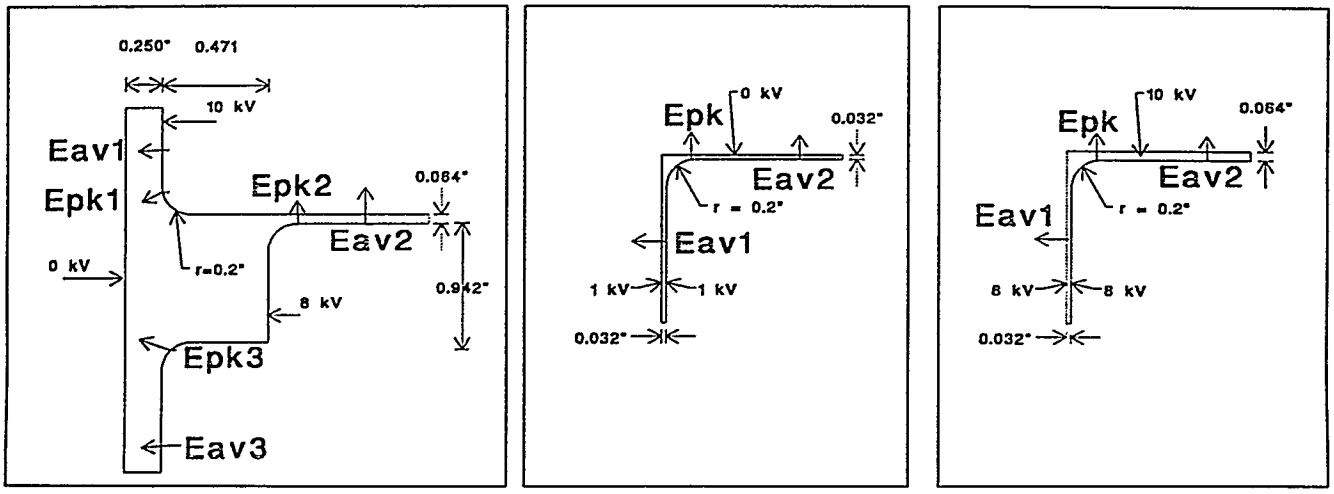
For the worst case voltages presented in Table 3.1, the maximum peaking factors for pancake-to-pancake and turn-to-turn voltage distributions are 1.13 and 1.17, respectively occuring for PF1 under 12 V startup. Therefore, the inductive voltage distributions in PF coils is nearly uniform for all worst case voltage coils. Additional peaking factors resulting from capacitance coupling turn-to-turn and turn-to-groundplane are not expected to be significant under normal operating conditions where the terminal voltage ramps are on the order of seconds; fault disruptions could lead to some peaking of voltage near the line lead turns, but was not calculated in the preliminary design phase.

The maximum system voltages for electrical design of the TF coils were assumed to be 7500 V terminal to ground, 312 V layer-to-layer, and 22 V turn-to-turn occuring during energy dump scenario. For the PF coils the maximum voltages are determined from operational scenarios for the PF5 and PF7 coils, all other PF coils having lower operational voltages under all scenarios. For electrical design of the PF coils then, the maximum terminal voltage is assumed to be 4437 V, occuring during the 20 V startup for PF5, and 628 V pancake-to-pancake, 55 V turn-to-turn occuring during the 20 V startup for PF7. Since the electrical insulation design for winding packs is expected to be common for both the PF and TF, the insulation must be capable of sustaining the maximum operational voltages expect for either coil system. Therefore, the insulation design is predicated on 7500 V terminal-to-

ground, 628 V pancake-to-pancake, and 55 V turn-to-turn under the worst operating scenarios of either coil system. This approach clearly leads to conservative design for the TF coils for turn insulation and for the PF coils for groundwall and line lead insulation where the maximum terminal voltage is 4437 V compared to 7500 V for TF. Since the turn insulation requirement between high voltage ends of adjacent pancake layers is 628 V the turn-to-turn insulation is also designed for the same voltage level, that is well in excess of the 55 V turn-to-turn maximum.

3.2 ELECTROSTATIC FIELD PLOTTING

Electrostatic field analyses were performed using the WEMAP code (Westinghouse proprietary) to calculate local peak electrical stresses within PF winding packs. Two dimensional models of turn-to-ground and layer-to-layer insulation configurations sufficient for electrostatic analysis are presented in Figure 3.1. Model 1 represents a turn-to-ground configuration for a PF spiral winding at the end of three adjacent layers of a spiral wind with a large 1/2 turn wide void filler, nominally 12.0 mm wide by 24 mm high. The left-hand wall is at ground potential and the groundwall insulation build is 6.35 mm. The upper layer is placed at 10 kV and the middle and lower layers at 8 kV, representing the layer transition region. In Model 1 the peak turn-to-ground potential drop is 10 kV and the layer-to-layer drop 2 kV. Model 2 represents a layer-to-layer configuration between four adjacent turn corners in the full cruciform shapped void region for a regimented winding pack, and shows only a lower right-hand turn. The model assumes quarter symmetry between the four turns with reflections of the displayed turn across both the vertical (with image having same potential sign) and horizontal (with image having opposite polarity sign) axes. Therefore, the lower two turns are at the same potential, arbitrarily 1 kV and the upper two turns are placed 2 kV away from the lower turns, the turn voltage drop in each layer assumed negligible compared to the layer-to-layer drop. Model 3 represents a layer-to-layer configuration in a spiral winding pack shown where the lower turns are at the same potential and the upper



Model 1	Model 2	Model 3
Turn-to-Ground for Spiral Winding Pack	Layer-to-Layer for Regimented Winding Pack	Layer-to-Layer for Spiral Winding Pack

Figure 3.1 — Insulation configuration models of PF coils for electrostatic field analyses.

turns are represented by a plane potential surface with a 2 kV potential drop from the lower turns. In this case the lower right-hand turn is reflected in the vertical axis with the imaged electrode having the same potential. Model 3 represents the worst case stress for conductor corners in a spiral winding pack when the void fill region is one half of the full void fill cruciform for a regimented winding pack. The turn-to-turn and/or layer-to-layer insulation builds between adjacent conductors for all the models shown in Figure 3.1 is 1.626 mm, and the radius of curvature of the conductors is 5.08 mm.

Table 3.2 presents a summary of the average, Eav and peak, Epk local stresses(kV/mm) in the corner regions of the electrostatic field models indicated in Figure 3.1 for each of the models. The local electric field enhancement factors defined as the ratio η_1 = Epk/Eav are also presented in Table 3.2. Models 1-3 assume a uniform relative dielectric constant of 5 for the glass/epoxy insulation.

Model 4 is the same as the Model 3 configuration except that 0.20 mm of Kapton is wrapped around the conduits, with total insulation thickness remaining constant. The relative dielectric constant of Kapton was assumed to be 3.5 so that the dielectric constant ratio across the Kapton/(glass/epoxy) boundary is 5/3.5=1.43. The predicted stresses scale with potential drop ΔV.

Table 3.2 — Summary of Stresses and Field Enhancement Factors for PF Winding Pack Configurations Predicted for Maximum Voltage Drops of 10 kV Turn-to-Ground, 2 kV Layer-to-Layer

MODEL	ΔV	Eav1	Eav2	Eav3	Epk1	Epk2	Epk3
	kV	kV/mm Turn-Gd	kV/mm Layer-Layer	kV/mm Turn-Gd	kV/mm Turn-Gd (Epk/Eav)	kV/mm Layer-Layer (Epk/Eav)	kV/mm Turn-Gd (Epk/Eav)
1 Groundwall	10,2,8 Gd, Layer, Gd	1.57	1.23	1.26	2.01 (η_1=1.28)	1.33 (η_1=1.08)	1.61 (η_1=1.28)
2 Regimented Winding Pack	2 Layer	0 Turn-Turn	1.23	NA	NA	1.28 (η_1=1.04)	NA
3 Spiral Winding Pack	2 Layer	0 Turn-Turn	1.23	NA	NA	1.33 (η_1=1.08)	NA
4 Spiral Winding With Kapton	2 Layer	0 Turn-Turn	1.23	NA	NA	1.97 (η_1=1.60)	NA

The electrostatic field analysis predicts maximum field enhancement factors of 1.28 at conductor corners for turns-to-ground, and 1.08 for conductor corners for layer-to-layer stress within the winding pack assuming uniform glass/epoxy insulation. With 0.20 mm of Kapton wrapped around conductors, as in the Kapton Slip insulation design, the conductor corner the maximum field enhancement factor is 1.60 as the result of condensation of equipotenial lines with the Kapton wrap due to its lower dielectric constant. Therefore, with Kapton barrier insulation on conductors the field enhancement is 1.60/1.08=1.48 times greater than for the CDR Baseline epoxy/glass insulation. Small triangular voids in Kapton lapped joints or pin hole voids in the Kapton film will have correspondingly higher stress than equivalent sized voids (about 0.05 mm) in epoxy/glass without the Kapton wrap. As a consequence, slightly higher partial discharge activity might be expected with the

Kapton Slip insulation system relative to the CDR Baseline assuming equivalent void size and density.

The electrostatic field analysis for Models 1,2, and 3 was originally presented at the MSIM#4 meeting, 03-02-95 in Sunnyvale, CA. VuGraphs of that presentation showing the electrostatic field plots generated are included in in Appendix 7.1 for reference.

3.3 DESIGN VOLTAGES

The following stategy was used to develop the design voltages and insulation design safety margins for PF winding packs. It is based upon power apparatus insulation design experience and insulation testing of large AC rotating machines with DC voltage, References 2 and 3. First the DC design voltage, Vdc for each insulation region of the PF winding packs is derived from

(1) $Vdc = 2Vpk + 1000$ Volts

where Vpk is the effective peak operating voltage for PF coils defined by

(2) $Vpk = \eta_1 \eta_2 Vop$

where Vop is the maximum operating voltage from Table 3.1, which includes a peaking factor for nonuniform voltage distribution peaking factors. In the case of turn-to-turn and layer-to-layer insulation, Vop is additionally multipled by the peaking factors to account for local electric field enhancements at conductor corners, η_1 and within voids η_2. For the groundwall insulation where the coil-to-ground stress is near uniform field, the peaking factors are assumed to be unity, that is $\eta_1 \eta_2 = 1$. The field enhancement factor η_1 is found in Table 3.2 based upon electrostatic field analyses. The local void field enhancement factor η_2 is dependent on the shape of the void and the relative dielectric constant of the insulation around the void. For small spherical voids η_2 approaches 1.5. For large planar voids, for example due to debonding and delaminations over life, η_2 approaches the local dielectric constant of

the bulk insulation, that is 5.0 for glass/epoxy and 3.5 for Kapton insulation regions, respectively.

The effective AC design voltage, Vac is determined from

(3) $Vac = Vdc/1.7$

where the factor 1.7 is the correlation factor found between DC and AC breakdown for power apparatus insulation failures. Equation 2 represents the equivalent AC voltage testing level. The AC design voltage given by Equation 2 was used for accelerated life testing of PF winding pack insulation components in the Insulation and Impregnation R&D program.

The design voltages for the PF winding packs are presented in Figure 3.3. The design voltages are based upon Equations 1-3 and the maximum system voltage requirements in Table 3.1. The overall stress enhancement peaking factor for turn-to-turn and layer-to-layer insulation is assumed to be 2.4 with η_1 =1.6 the maximum field enhancement in the Kapton wrap and η_2 =1.5 for small voids. The overall insulation design safety margin that is the ratio of the design voltage divided by the operating voltage is also given in Table 3.3.

Table 3.3 — DC Design Voltages, Electric Stress, and Safety Margins for PF Coils

INSULATION REGION	MAXIMUM OPERATING VOLTAGE	STRESS PEAKING FACTOR	DESIGN VOLTAGE		AVERAGE DESIGN STRESS	SAFETY MARGIN
	V		kVdc	kVrms	kV/mm	
Turn-Turn	55 PF	2.4	4	2.5	2.46	72.7
Layer-Layer	628 PF	2.4	4	2.5	2.46	6.4
Coil-Ground	7500 TF 4437 PF	1.0	16	10	2.52	3.6

The design voltages for turn-to-turn and layer-to-layer insulation are the same. The PF coil-to-ground insulation design voltage is based upon the maximum lead-to-ground voltage expected for the TF system, which is about 1.7 times that required for the worst PF coil. The average design stress is the design voltage divided by the insulation spacing for each insulation region where for both turn-to-

turn and layer-to-layer insulation the spacing is 1.626 mm and the minimum coil-to-groundplane insulation spacing is assumed to be 6.35 mm. In all cases the average design stress is nominally 2.5 kV/mm which is assumed to be the maximum allowable average stress in epoxy/glass regions of the insulation. In the case of lapped Kapton insulation on conductors with a minimum creep path of 50 mm between adjacent conductors, the practical allowable stress is assumed to be 800 V per 0.0254 mm (that is per mil of Kapton film) or 31.5 kV/mm. For three effective layers of 0.0254 Kapton per conductor wrap, the expected capability of the Kapton Slip insulation system is conservatively estimated at 4.8 kV, meeting the design voltage requirement without any insulation capability assumed for the epoxy/glass overwrap.

4. CPDR DESIGN BASELINE DESCRIPTIONS

4.1.1 Technical Assessments of Options

Technical assessments were performed for electrical insulation system and the coil winding design options and the details are found in Appendicies 8.2 TECHNICAL ASSESSMENT OF TPX ELECTRICAL INSULATION SYSTEM ALTERNATIVES and 8.3 TECHNICAL ASSESSMENT OF TPX CS/PF WINDING OPTIONS. Brief summaries of these technical assessments are presented in the following sections.

4.1.2 Insulation System

The CDR Baseline electrical insulation system for the TPX superconducting magnets consists of a dry, S2 fiberglass tape wrap over the CICC, the tape wrap being comprised of two layers of 0.1524 mm thick tape, each overlapped 50%, for a total glass tape thickness of 0.6096 mm (0.024 in.). A 0.2032 mm thick G11-CR barrier is used both turn-turn , barrier strips and layer-layer, barrier sheets, making the total baseline insulation "build" 0.8128 mm (0.032 in.) on each conductor surface. The corners are filled with glass roving to exclude large resin rich regions. The winding pack is vacuum-pressure-impregnated (VPI) using an appropriate resin system, thus creating a "monolithic" structure in which the conductor and all components of the electrical insulation system are mechanically bonded together. The CDR baseline insulation system relies on the G11-CR turn and layer barriers for ensuring no turn-turn and/or layer-layer shorts during fabrication, and protecting against electrical breakdown during transient magnet operating conditions.

A number of insulation system options were investigated to improve both reliability of insulation performance and manufacturablility. Some of the concerns with the CDR Baseline insulation are:

1. Insertion of the thin G10 (or G11) barrier material presents manufacturing problems. Insulation layer-to-layer barrier sheets must be cut and inserted in overlapping fashion to provide adequate creep path for layer-to-layer stresses.

2. The layer-layer barrier can be a large sheet covering an entire layer, but the turn-turn barrier can be only one conductor height, and there is no effective way to seal or assure bonding of the two orthogonal barrier strips, thus creating (at least locally) the possibility of small gaps or voids between the barriers. If micro-cracks also form in the glass-reinforced epoxy conductor wrap due to thermal and/or mechanical stress (a strong possibility), then the baseline insulation system is compromised by possible turn-turn breakdown paths.

3. Structural analyses indicate that local mechanical stresses in the insulation under operational cyclic thermal and mechanical loadings fail to meet TPX Structural Design Criteria. Through tension appears to be a problem between turns with potential for debonding of the glass/epoxy insulation from the conductor with potential for turn-to-turn cracks and electrical failure.

4. No insulation barrier is placed on the conductor surface so that any structural failure of the epoxy/glass insulation matrix may lead to direct turn-to-turn faults, and even layer-to-layer faults at the high voltage ends of adjacent pancake layers.

5. The glass roving strand and strand bundles will be difficult to insert in the corner voids of the windings. The thermal and mechanical properties of glass roving lead to weakened mechanical properties in conductor corneres with potential for mechanical cracks leading to ultimate electrical failure.

Details of the baseline and alternative insulation configurations considered are presented in Table 4.1. All the alternative systems are based on elimination of the G11-CR barrier sheets and strips and using Kapton film wraps over the CICC as the principle insulation barrier for prevention of intra-conductor shorts and electrical breakdown. The insulation system options employ several types of S2 glass tapes for overwrapping the Kapton, including prepreg options based upon the ITER preliminary insulation design approach. The option types investigated in the technical assessment were:

Option A	CDR Baseline
Option B	Kapton/Glass Interleaved
Option C	Kapton Slip
Option D	Kapton/Prepreg Interleaved
Option E	Kapton/3-D Shapes
Option F	Kapton/3-D Tape

Because of the widespread impact of these alternative electrical insulation systems and variations on coil performance, reliability, cost, and manufacturability, a technical assessment to evaluate the baseline and various alternative systems was performed and determine the best overall approach to the electrical insulation sytem. This assessment was performed by first selecting the various approaches, then choosing the evaluation criteria (manufacturability, operational performance, cost, schedule, and risk), selecting an appropriate weighting factor for each criterion, enumerating and tabulating the strengths and weaknesses of each alternative approach with respect to the evaluation criteria, establishing a numerical grade of 1 - 5 in each category (for each option considered), and finally, generating a total score for each alternative. The insulation options considered are summarized in Table 4.1 and presented in detail in along with the results of the technical assessments in Appendix 8.2

The summary results of the technical assessment are presented in tabular form in Table 4.2. For each option the strengths and weaknesses are tabulated. An overall grade is given, together with a separate grade for risk. The overall grade is based on consideration of the factors discussed earlier and an overall evaluation of the strengths and weaknesses. **Note that a high risk score denotes low risk.** The highest score was obtained by option C0, followed closely by C1. Option C0 also has a relatively low risk; C1 is considered to have a higher risk factor than C0 due to the fact that the use of adhesive on all Kapton surfaces represents an unknown factor, that is, it is not known whether this adhesive would actually bond the Kapton surfaces together over the full range of operating temperatures and mechanical loading, or whether the bonds would break easily, resulting in a slip-

Table 4.1 — Summary Of TPX Candidate Insulation Systems (Dimensions In mm)

INSULATION SYSTEM	DRY S2 GLASS	PREPREG S2 GLASS	KAPTON	BARRIERS		CORNER ROVING	INSULATION BUILD	
				Layer	Turn		Layer	Turn
A Baseline	2-50%, 0.1524	none	none	yes	yes	yes	1.626	1.626
B Kapton/Glass Interleaved	1-67%, 0.1778 1-butt, 0.1778	none	1-50%, 0.0508 on top of glass	no	no	yes	1.626	1.626
C Kapton Slip (Cured adhesive)	2-50%, 0.1778	none	2-50%, 0.0508 wrap on conduit, XMPI adhesive top side (1st layer) and both sides (2nd layer)	no	no	yes	1.626	1.626
C0 Kapton Slip (No adhesive)	2-50%, 0.1778	none	2-50%, 0.0508 wrap on conduit, no adhesive (slip plane)	no	no	yes	1.626	1.626
C1 Kapton on Conduit (Adhesive Kapton on conduit)	2-50%, 0.1778	none	2-50%, 0.0508 wrap on conduit, XMPI adhesive both sides	no	no	yes	1.626	1.626

Table 4.1 — Summary of TPX Candidate Insulation Systems (continued)

INSULATION SYSTEM	DRY S2 GLASS	PREPREG S2 GLASS	KAPTON	BARRIERS		CORNER ROVING	INSULATION BUILD	
				Layer	Turn		Layer	Turn
D Kapton/Prepreg Interleaved (Hybrid cure prepreg with VPI)	1-butt, 0.1778 on top of prepreg	1-67%, 0.1778 Prepreg cure with VPI	1-50%, 0.0508 on top of prepreg	no	no	yes	1.626	1.626
D1Kapton/Prepreg Interleaved (ITER approach, cure prepreg "in-line")	1-butt, 0.1778 on top of prepreg	1-67%, 0.1778 Prepreg cure "in-line"	1-50%, 0.0508 on top of prepreg	no	no	yes	1.626	1.626
E Kapton/3D Shapes (Cured adhesive)	3D woven preform, 0.6096 and/or 1.219 thick	none	same as "C"	no	no	no (3-D preform)	1.626	1.626
E1 Kapton/3D Shapes (Adhesive Kapton on conduit)	3D woven preform, 0.6096 and/or 1.219 mm thick	none	same as "C1"	no	no	no (3-D preform)	1.626	1.626
F Kapton/3D Tape (Cured adhesive)	3D woven tape, 0.3556 - 0.4318 thick, 1-50%	none	same as "C"	no	no	yes	1.626	1.626
F1 Kapton/3DTape (Adhesive Kapton on conduit)	3D woven tape, 0.3556 - 0.4318 thick, 1-50%	none	same as "C1"	no	no	yes	1.626	1.626

Table 4.2 — Summary Of Results Of Technical Assessment Of TPX Electrical Insulation System Alternatives

OPTION	SCORE	RISK	STRENGTHS	WEAKNESSES
A	3.27	3.5	Winding and curing process Low manufacturing risk Proven design	Manufacturability of barrier and barrier strips Mechanical performance Insulation performance
B	3.24	2.8	Conduit bond No barriers Kapton insulation	Mechanical performance Manufacturing risk Winding interleaved Kapton/Dry Glass
C	3.80	2.4	Sealed against VPI No barriers Kapton insulation	Mechanical performance Adhesive cure step
C0	3.82	3.3	Manufacturability, no adhesive cure No barriers Kapton insulation	Mechanical peformance Total slip of Kapton
C1	3.74	1.9	Sealed against VPI No barriers Kapton insulation	Mechanical performance Adhesive cure step

Table 4.2 — Summary Of Results Of Technical Assessment Of TPX Electrical Insulation System Alternatives (continued)

OPTION	SCORE	RISK	STRENGTHS	WEAKNESSES
D	3.03	2.8	Hybrid cure reduces processing Conduit bond No barrier Kapton insulation	Control of interleaved Kapon/Prepreg Winding "sticky" prepreg
D1	2.57	2.8	Inspectability of insulation Conduit bond Kapton insulation	Control of interleaved Kapton/Prepreg Winding "sticky" prepreg Local curing of prepreg Manufacturability risk
E	2.79	2.1	Mechanical performance Kapton insulation Corner bonding Sealed against VPI	Cost/Schedule risk Fabrication of 3-D shapes Tolerance of 3-D shapes, build Adhesive cure step
E1	2.73	1.9	Mechanical performance Kapton insulation Corner bonding Sealed against VPI	Cost/Schedule risk Fabrication of 3-D shapes Tolerance of 3-D shapes, build Adhesive cure step
F	3.45	2.6	Mechanical performance Manufacturability Kapton insulation Corner bonding	Cost/Schedule risk Fabrication of 3-D weave - thin tapes; Filler forms for production Adhesive cure step
F1	3.3	1.9	Mechanical performance Kapton insulation Corner bonding Sealed against VPI	Cost/Schedule risk Fabrication of 3-D weave - thin tapes; Filler forms for production Adhesive cure step

plane system. Also, there were no test results at this point in time to indicate whether the slip-plane approach would result in acceptable mechanical stresses within the coil. Options F and F1 also scored relatively high; however, both had somewhat higher risk because of the developmental aspects of the 3D woven fiberglass materials used.

This initial technical assessment served primarily as a starting point to guide continuing development of alternative insulation systems and mechanical analysis of the coil winding pack. As three-dimensional (3D) woven fiberglass products (tapes and corner fill preforms) were developed, they were tested in the 3x3 R&D program and validated during acceptance testing in the 5x5 program. On the basis of the 3.3 and 5x5 electrical and mechanical test results, and detailed structural analysis employing 3-D material properties, Option F without adhesive on the Kapton conductor wrap was adopted for the PDR winding pack insulation system as the best approach for meeting the TPX mechanical, thermal, and electrical load requirements over life cycle operation. Therefore, the PDR insulation system baseline system is:

1. 2-50%, 0.025 mm thick Kapton, Type HN (no adhesive) wraps on CICC.
2. 1-50%, 0.356 mm thick (thin) 3D S2 fiberglass tape overwrap of Kapton.
3. Tackified 3D S2 fiberglass woven preforms for conductor corner void fill.

4.1.3 Coil Winding

There are two basic alternatives for winding the conductor comprising the CS/PF coils: 1) a true spiral winding, in which each turn continuously spirals in or out one conductor width for each 360° rotation; or 2) a constant radius winding, in which each turn is wound at a fixed radius, and as the point of 360° rotation is approached, turns sharply in or out one conductor width to move to a new fixed radius for the next turn. The sharp bend of the conductor to a new fixed radius is referred to as a "jog." Displacement of conductor from one layer ("pancake") to the next is referred to as a "transition." In addition to the two basic winding methods, there are options in the way the jogs and transitions can be made. These alternative winding methods as well as the options for jogs and transitions will

impact the manufacturability and performance of the coils, principally magnetic field quality, Reference 4. The focus of the coil winding design assessment was on the CS and PF5 coil designs. The large PF6 and PF7 coils were not considered in the evaluation, and the CDR baseline constant radius winding approach is selected for these coils.

The winding options selected for technical assessment to determine the best overall approach to CS/PF coil winding are as follows, including a brief description of key features:

1. Spiral Winding

   Winding pack progressively increases/decreases for each turn when winding out/in for each pancake layer. "Clocked" pancake layer transition occurs after six full turns in a 45 degree arc on either the outside (odd to even layers) or inside (even to odd layers). Alternatively, the transitions may be stacked. Requires large tapered wedge spacers on both the ID and OD of each layer.

2. Constant Radius Winding

   Each turn wound at a constant radius up to the point where it jogs to the next turn at a new radius. Full turns are not possible due to the space required to make jogs. "Clocked" pancake layer transition occurs after six full turns in a 45 degree arc on either the outside (odd to even layers) or inside (even to odd layers). Alternatively, the transitions may be stacked. Requires fixed radii spacers to fill the OD on odd layers and ID on even layers with slight tapers at the pancake transitions. The jogging options evaluated for constant radius were:

   2A Linear jog

   The jog from turn to turn starts with a straight line tangent followed by a small minimum radius bend which smooths the straight section into the next turn. Does not have any reverse bends.

   2B "S" jog, nested

   The jog from turn to turn starts with a small reverse bend followed by another small bend to initiate the next turn. The bends can be sized to nest for all layers and to minimize transition area length.

   2C "S" jog, fixed radii, modified spacing

   The jog from turn to turn starts with a small fixed reverse bend followed by another small fixed bend to initiate the next turn. These

bends do not normally nest together between the turns. By offsetting each jog it is possible to use constant fixed radii for the jogs.

2D Double radius jog

This approach is similar to a linear transition but uses a very large radius tangent to a turn followed by a smaller radius to jog from turn to turn. The extremes for this type of jog degenerate to the linear jog for a large (infinite) radius or to a "modified" spiral for the other extreme. Does not have any reverse bends. Can be nested or have modified spacing.

The evaluation criteria for the technical assessment of the winding options were manufacturability, operational performance, cost, schedule, and risk. The strengths and weaknesses of each option were evaluated numerically by assigning a grade of 1 - 5 to each evaluation category, with 5 representing the best approach. The grades were summed without weighting factors to score each option. The results of the winding design technical assessment are presented in detail in Appendix 8.3. The option scores are summarized in Table 4.3.

Table 4.3 — Summary of Technical Assessments for Winding Design Options

Winding Type	Option Description	Score
Spiral	1 Continuous spiral, no turn-turn jogs	19.5
Constant Radius	2A Nested "S" turn-turn jogs	13.5
Constant Radius	2B "S" jog turn-turn with spacing modified to allow fixed radii	14.0
Constant Radius	2C Linear turn-turn jog	15.0
Constant Radius	2D Double radius turn-turn jog	13.5

Based upon the results in Table 4.3, the CDR baseline, spiral winding design concept, Option 1 was selected for the CS and PF5 coils, modified for nesting of inside and outside jogs. Figure 4.1 shows the selected spiral winding option for a typical pancake coil with minimum pancake joggle configuration. Each coil layer

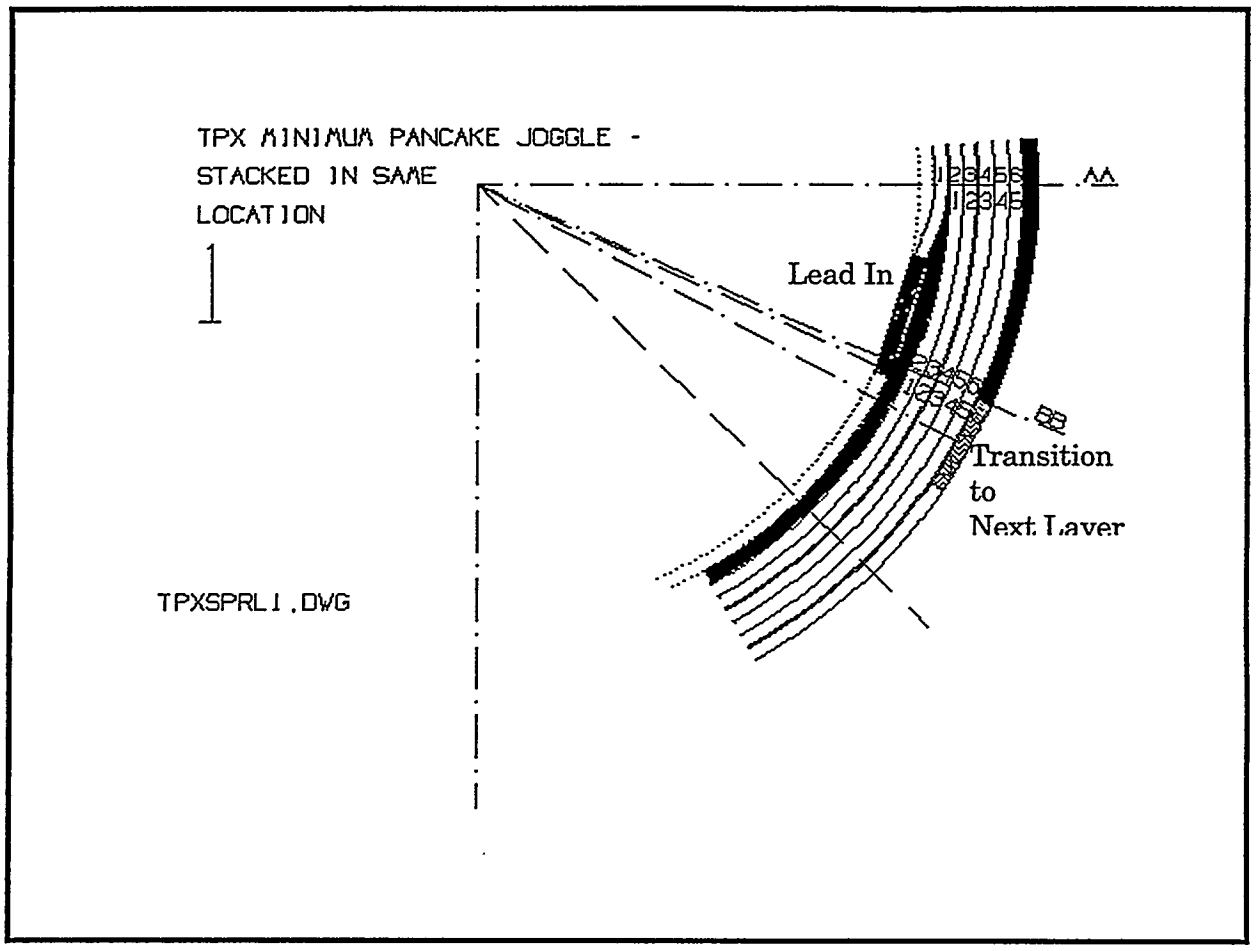


Figure 4.1 — Spiral winding approach with stacked transitions showing one coil layer only.

(pancake) within the winding pack is stacked such that all jogs are nested in the same location. The CS and PF5 winding packs are designed such that the nested jogs are located between the start and finish leads as they bend away from the coil.

4.2 DESIGN DESCRIPTION

This section presents an overview of the key design features of the CPDR baseline CS and PF5 winding pack designs. The supporting magnetic, mechanical,

and thermal analyses are found separately in References 4-7. Principle focus is placed on the electrical insulation design of winding pack components. The development of three-dimensional (3-D) woven fiberglass components for PF as well as TF winding pack electrical insulation systems is detailed in Reference 8. The winding pack electrical insulation design is further supported by the results of the Insulation and Impregnation R&D Program, References 9-12. The helium stub design is supported by the results of the Helium Stub Welding R&D Program, Reference 13.

The electrical insulation system for PF winding pack cross sections is shown in Figure 4.2. The details of the turn-to-turn and layer-to-layer insulation design at turn corners within winding layer is presented in Figure 4.3. The following sections discuss the CPDR designs for winding pack insulation and filler components, groundwall and groundplane, helium stub , lead and joint insulation.

4.2.1 Conduit Insulation

The CICC conductor surfaces are inspected and deburred as necessary, but are not sandblasted or roughed. The conductor surfaces are cleaned via a TBD process just before insulating. First two 50% (half-lapped) wraps of 25.4 mm wide, 0.0254 mm (0.001") Kapton, Type H or HN film barriers without adhesives are tightly wound in the same direction over the conduit. The second Kapton film barrier lap is registered relative to the inner first wrap such that the lapping joints of the second wrap are centered between the lapping joints of the inner wrap. The registering maximizes the creep path through the four layers of Kapton giving a nominal creep path of 38 mm. The Kapton wraps are overwrapped with one 50% wrap of 3-D dry S-2 glass tape nominally 25.4 mm wide and 0.356 mm (0.014") thick. The Kapton/3-D glass tape total conduit insulation build is 0.813 mm. The wrapped conduits are then assembled into the coil pack, eliminating the G11-CR turn barrier strips and layer barrier sheets used in the CDR Baseline, so that the

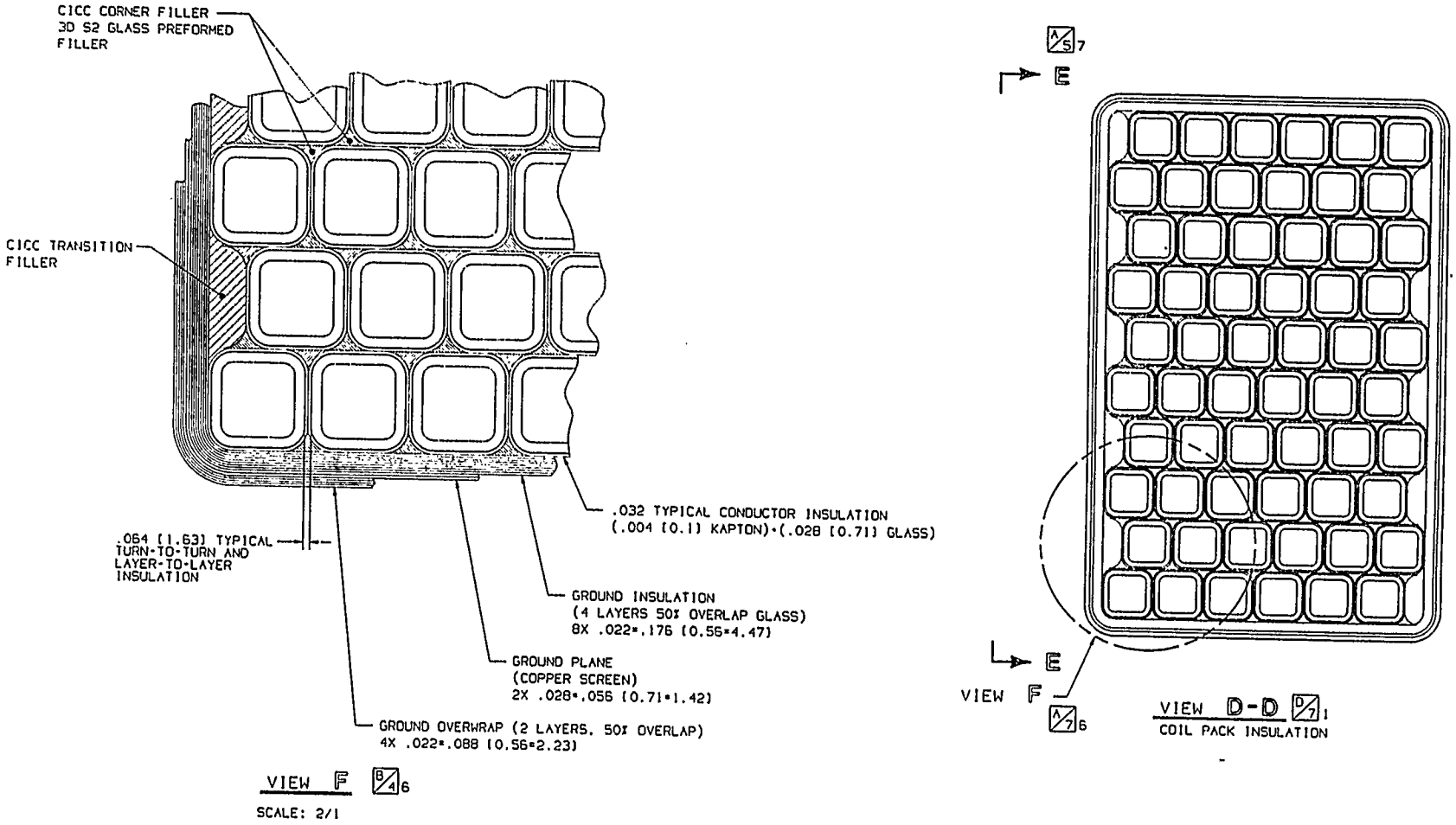


Figure 4.2 — CS and PF5 insulated coil pack cross sections. (MARD Dwg.)

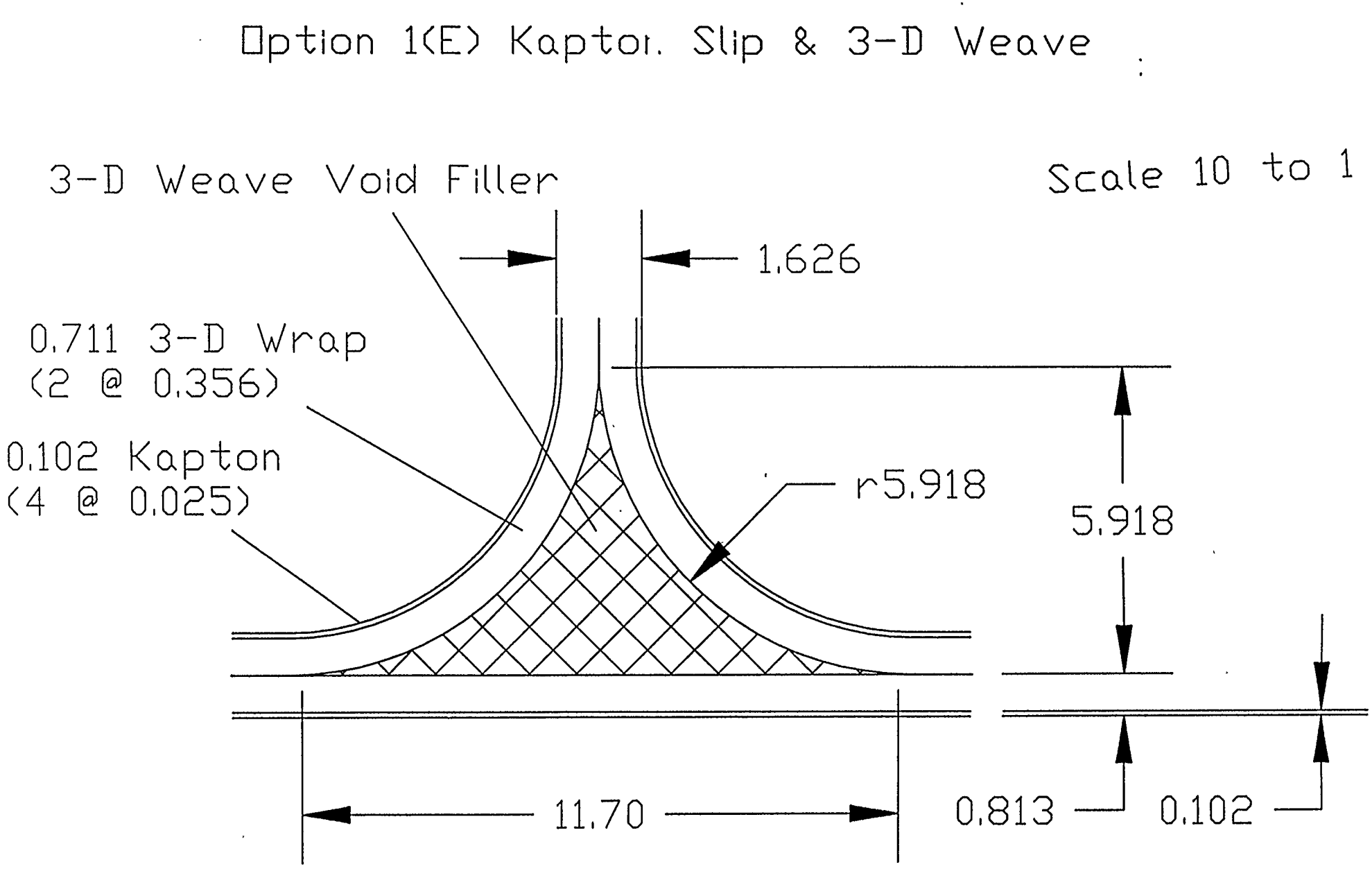


Figure 4.3 — Details of winding pack insulation in adjacent conductor corners showing void fill cross section. (STC Dwg.)

turn-to-turn and layer-to-layer insulation builds between bare metal conduit surfaces is 1.626 mm.

The double wrap of Kapton is designed to exclude penetration of the impregnating resin to the conduit/Kapton interface. The objective of the Kapton insulation design is to permit slip between the conduit and Kapton insulation. This is a major departure from the CDR Baseline which is designed to be a fully bonded winding pack and relies on G11-CR or polyimide barriers to prevent shorts and insulation failure between turns and layers. The structural behavior of the Kapton Slip CPDR design needs to be throughly analyzed and tested during Phase II to ensure that slip at the conduit is acceptible for the PF and TF systems under all operating and life cycle conditions.

4.2.2 Corner Fillers

The corner filler region is shown in Figure 4.2 as the cross hatched area. The corner filler is a formed dry S-2 glass, 3-D woven "rope" in the triangular shape of the corner void. The 3-D woven filler is manufactured dry, and may be optionally, "tackified" using a resin system compatible with the PF coil impregnating resin system. The tackified 3-D fillers are molded into the actual shape of the void region with thin feathered edges to penetrate into the three corners of the void, excluding as much resin-rich regions as possible. The dry or tackified 3-D corner fillers run continuously through the winding pack void with filler joints, if necessary (depending on manufacturable filler lengths) located only on the outside voids adjacent to the groundwall insulation. The 3-D fillers interface with the 3-D tape overwrap of the Kapton to form strong glass interfacial bonds upon VPI.

4.2.3 Transition Pieces

The void spaces in the winding pack generated by the spiral layer-to-layer turn ramps on both inside and outside coil pack radii are filled with dry S-2 glass 3-D weave laminates of 3-D tapes which are stitched together into bundles and

which allow laminate layers to be stripped away in a stepwise fashion to form the required void filler ramp shape. In addition to the transition fillers, small banana voids which may occur during winding due to turn forming tolerances. Such voids will be filled with tackified 3-D thin tapes which are sufficiently rigid for easy insertion into banana voids.

4.2.4 Helium Stub Insulation

The helium stub insulation configuration is presented in Figure 4.4. The helium stub design is described in detail in Reference 13. The CPDR stub design is a cylindrical structure welded on the with a conical stress relief section to the helium tubing welded on to the flat surface (12.09 mm width) of the conduit following piercing of the conduit wall and weld prep. The helium stubs are located on layer-to-layer transition turns so that there is a turn width gap between stubs which makes it easier to insulate the stubs. The helium stub electrical insulation design is presented in Figure 4.4 which shows a typical helium stub assembly on and inside radius transition turn. The stub is insulated by first applying two 102 mm wide, 0.051 mm thick molded (heat formed) Kapton "drapes" over the conduit and helium stub. The top drape has an integral molded Kapton "stove-pipe" which fits over the stub and its seam is place on the conduit surface opposite to the stub weldment. The second drape is fitted over the bottom seam of the first drape and is pulled over the top of the conduit on the stub weldment side. Additional overlapping Kapton pieces are put over the cylindirical stub sufaces as necessary to insure a minimum of 38 mm creep path from stub metal to the outside of the Kapton wrap. Following the Kapton drape assembly, additonal Kapton tape, two 50% laps of 0.025 mm film is wrapped around the stub and up the helium tube, forming a complete Kapton encasement of the stub assembly with 0.101 mm Kapton thickness and 38 mm minimum creep path everywhere.

After the Kapton turn/stub drapes and tape is applied, the conductor Kapton taping is continued with minimum overlapping of the Kapton drapes of 25 mm. The

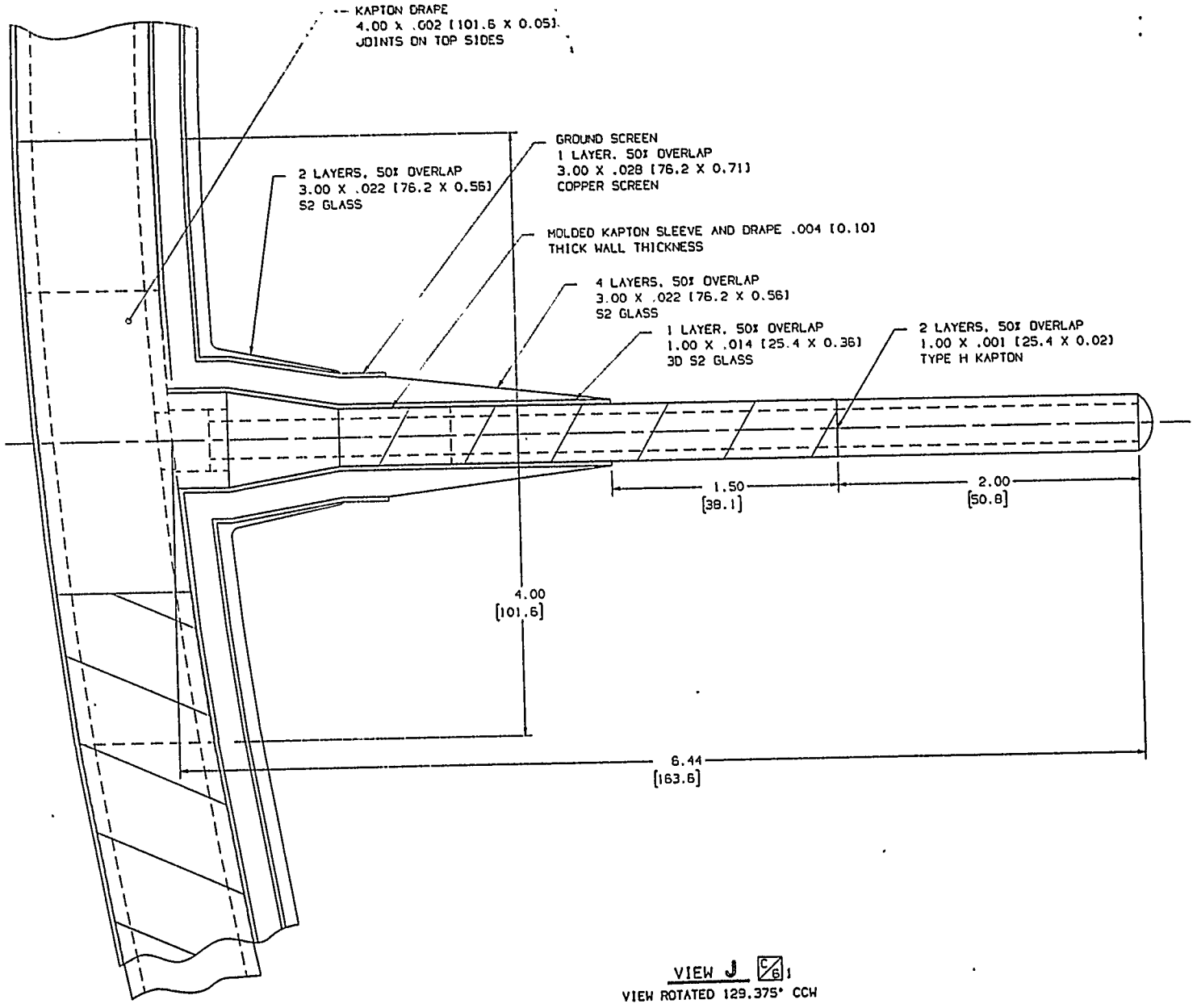


Figure 4.4~~A~~ Helium Stub Insulation Design. (MARD Dwg.)

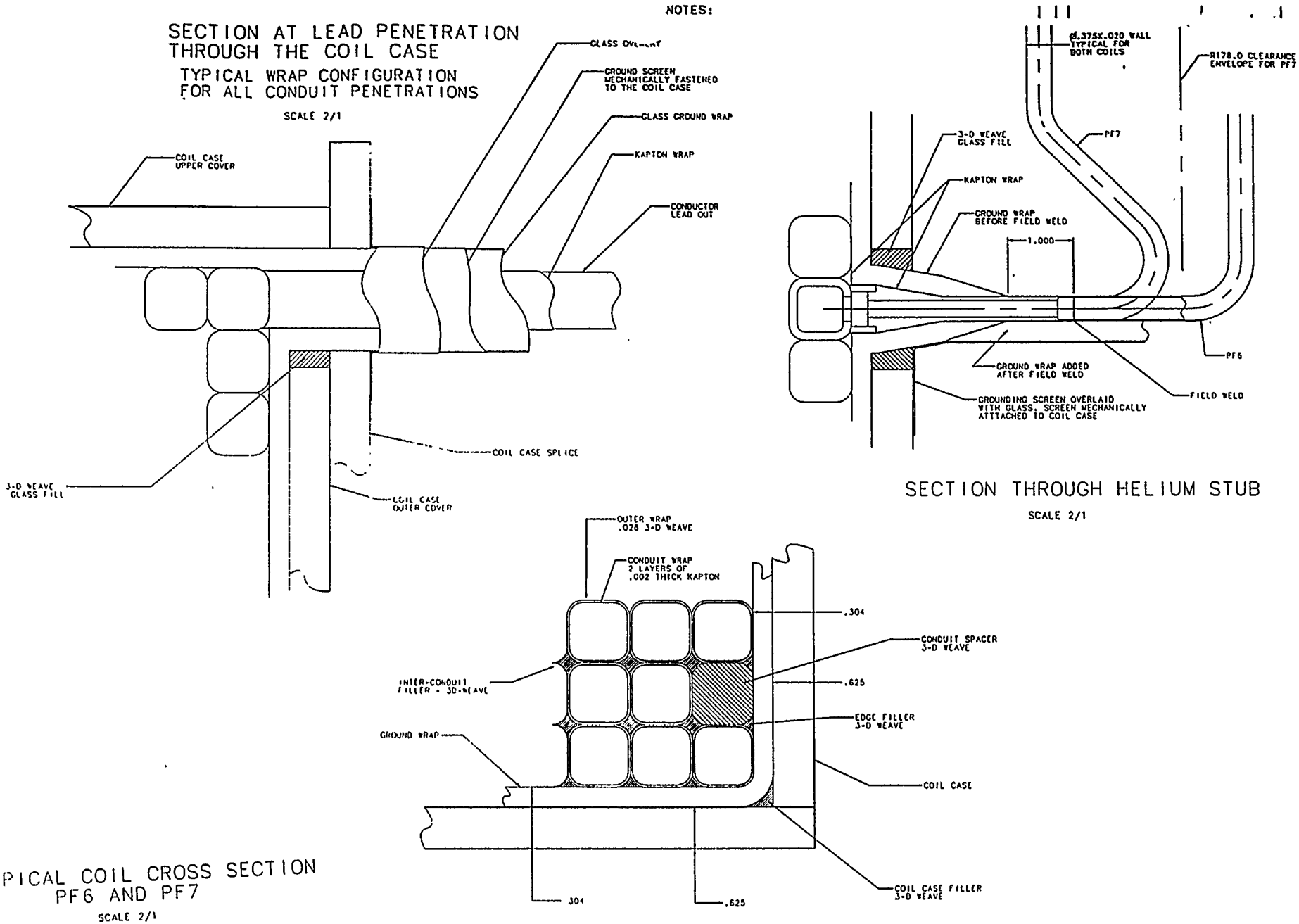


Figure 4.4β– Helium Stub Insulation Design. (MARD Dwg.)

3-D S-2 glass tape is then continued wrapping around the conduit and blending around the stub contour and up the stub assembly. Transitions fillers are inserted and the groundwall insulation with imbedded groundplane screen wrapped around the winding pack. The groundwrap glass taping is extended around and up the stub and terminated in a taper nominally 38 mm in length. The a groundscreen is then wrapped over the stub assembly so that it overlaps the winding pack groundscreen and electrical connectrion made. Finally, the protective glass overwrap is applied to the winding pack and blended over the stub assembly.

4.2.5 Groundwall

The groundwall insulation design is shown in Figures 4.1 and 4.5. The groundwrap is 76.2 mm wide, 0.56 mm thick S-2 dry glass tape with 50% overlapping (TBD weave type, ie plane or satin finish). First four layers of groundwrap are applied to a total nominal build of 4.47 mm, including wrapping of the helium stubs and leads to this same build. The groundplane screen is then wrapped over the winding pack, helium stub and lead assemblies. Following groundplane assembly, including insulation break, another 2 layers of groundwrap are applied over the groundplane as a protective jacket and to imbed the groundplane surface within the groundwall insulation wrapping. This final groundwrap also extends over the helium stub and lead assemblies.

4.2.6 Groundplane

The groundplane design employs 76.2 mm wide, 0.356 mm thick copper screening with 0.711 mm screen openings which is 50% lapped over the first grounwall insulation wrap. The screen will have finished edges to prevent local field enhancements at the groundplane surface. The groundplane screen has an insulation break located half way between the start and finish leads. The insulation break is made by inserting a 152 mm wide Kapton sheet with 114 mm

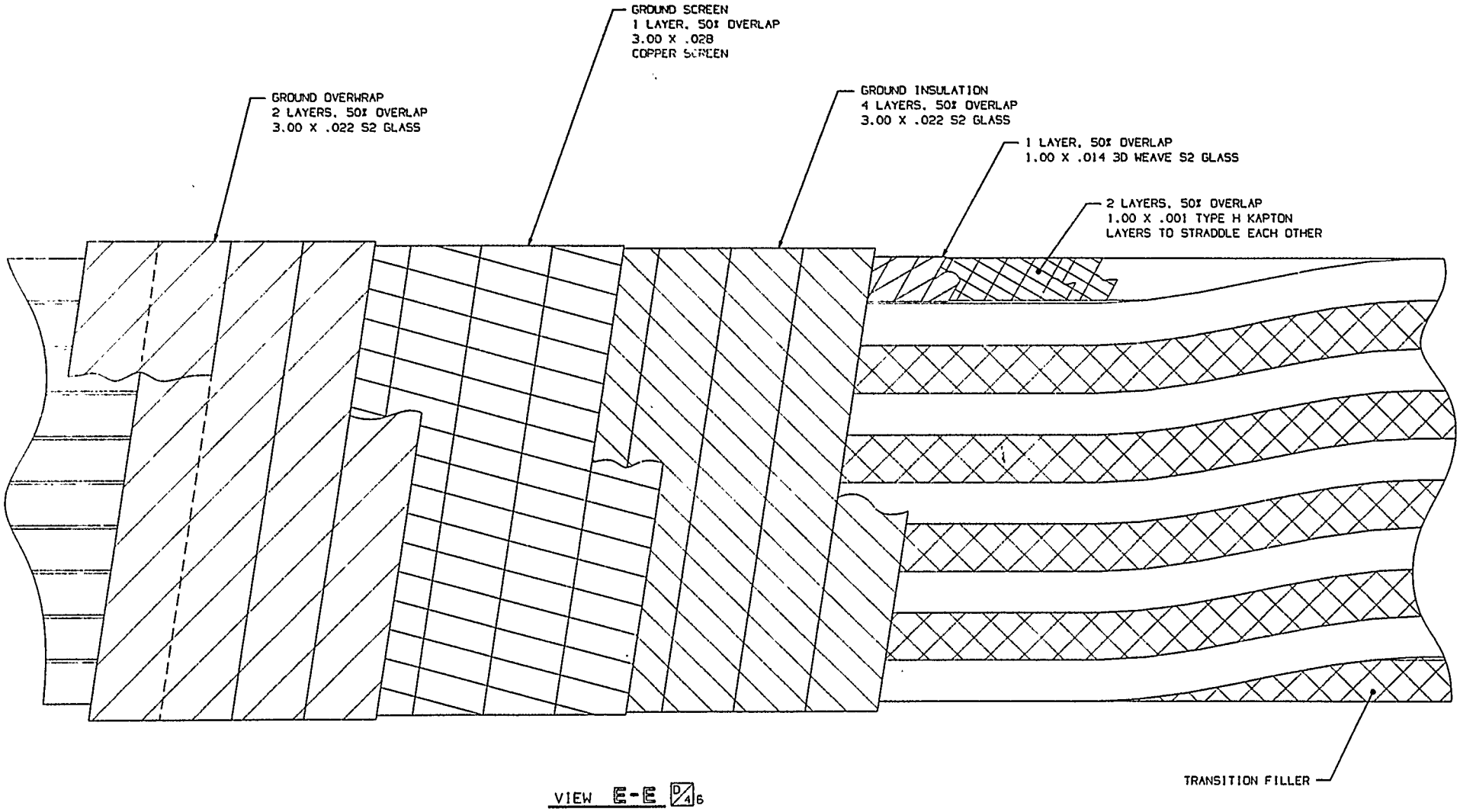


Figure 4.5 — Groundwall Insulation Design.

overlap of the terminated screen half and continuing the screen wrapping on the top of the Kapton insulation sheet beginning 38 mm from the Kapton sheet edge. The Kapton wrap is 2 overlapped sheets each 0.025 mm thick. The maximum insulation break capacitance is for the PF1 coils and is calculated to be

$$C_{break}=2\varepsilon\varepsilon_o T(H+W)/t = 0.065\ \mu F$$

where ε=3.5, T=76 mm, t=0.050 mm and H and W are taken from from Table 1-1 for PF1.

4.2.7 Lead and Lead Spur Insulation

The lead insulation design is shown in Figure 4.6. The leads are first insulated with Kapton, S-2 prepreg glass tape, and groundplane screen from about 200 mm below the VPI level line to the termination joint assembly. Two 50% layers of Kapton are overwrapped with 4-50% layers of 0.56 mm prepreg glass tape, 1-50% layer of 0.36 mm copper mesh screen, and finally a2-50% layers of 0.56 mm prepreg glass tape to protect the groundplane. The Kapton, prepreg tape, and copper screen are terminated in a telescope fashion on both ends for blending of the winding pack VPI insulation on one end and of the termination joint insulation on the other. The winding pack Kapton, S-2 dry glass, and copper screen wraps are blended with the tapered prepreg lead insulation by overlapping of the respective Kapton wraps, the prepreg and dry S-2 glass wraps, the groundplane screens and finally the prepreg and dry S-2 glass protective laps. The joint insulation must be completed in the field after connection of the power supply lead joints. The joint insulation is described in the next section.

The lead spur design is shown on Figure 4.7. The lead spur assembly consists of a welded "U" channel on the conduit wall at the end of the first lead turn and a welded mating spur bar on the conduit wall of the lead as it bends away from the coil. The lead mating spur bar and turn "U" channel weldments are interfaced via four pins, nomially 9.5 mm diameter.

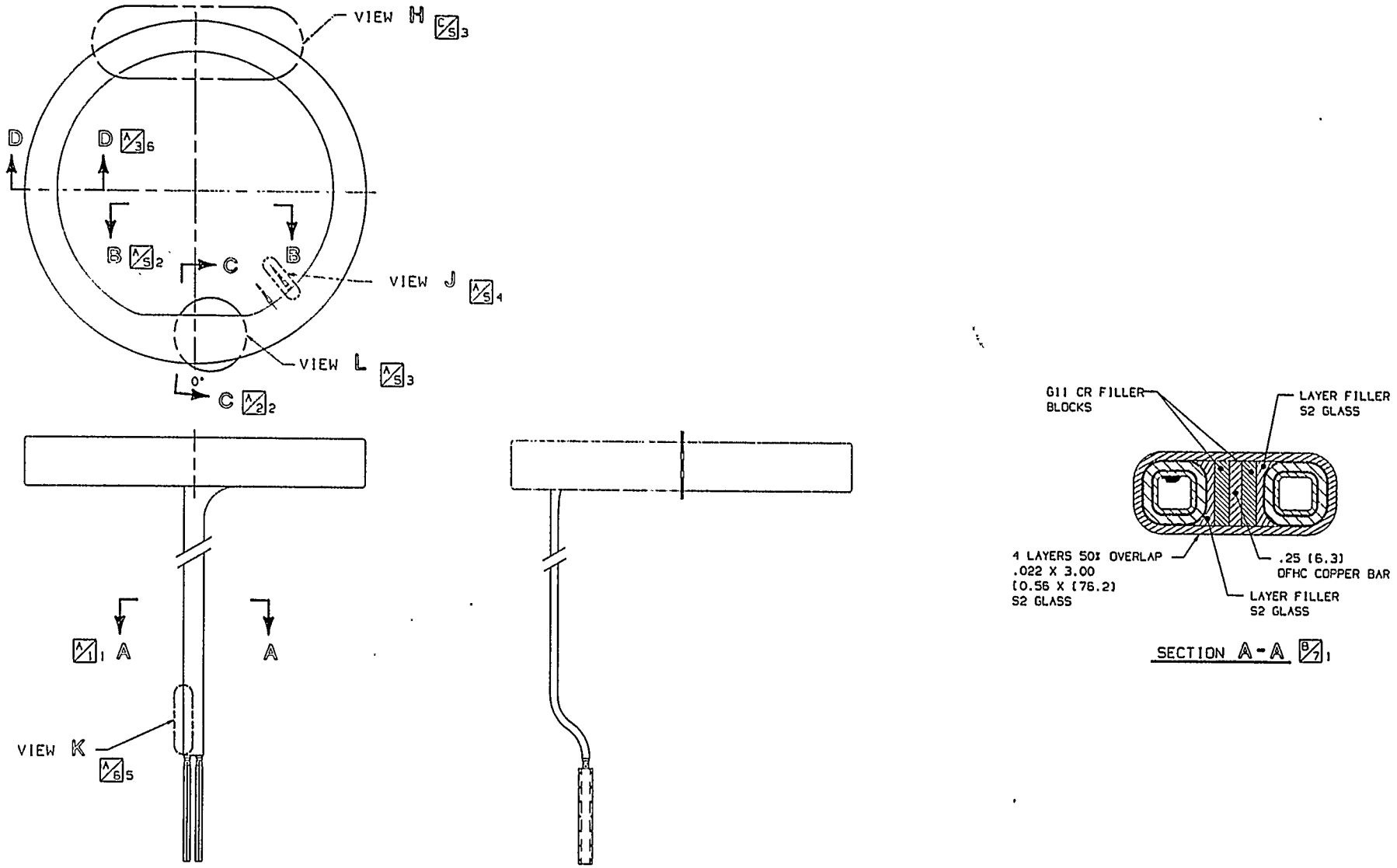


Figure 4.6A Lead Insulation Design.

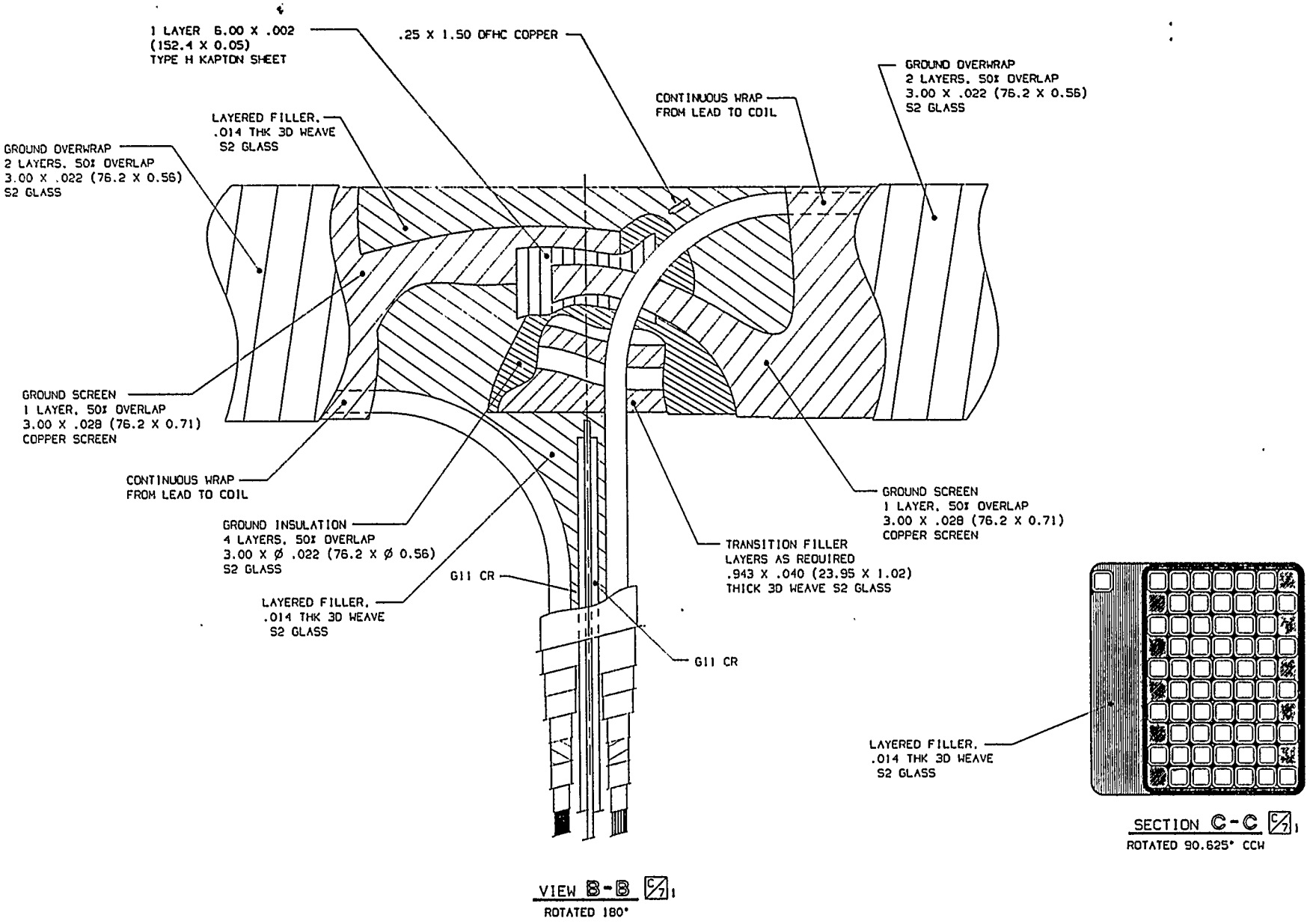


Figure 4.6B– Lead Insulation Design.

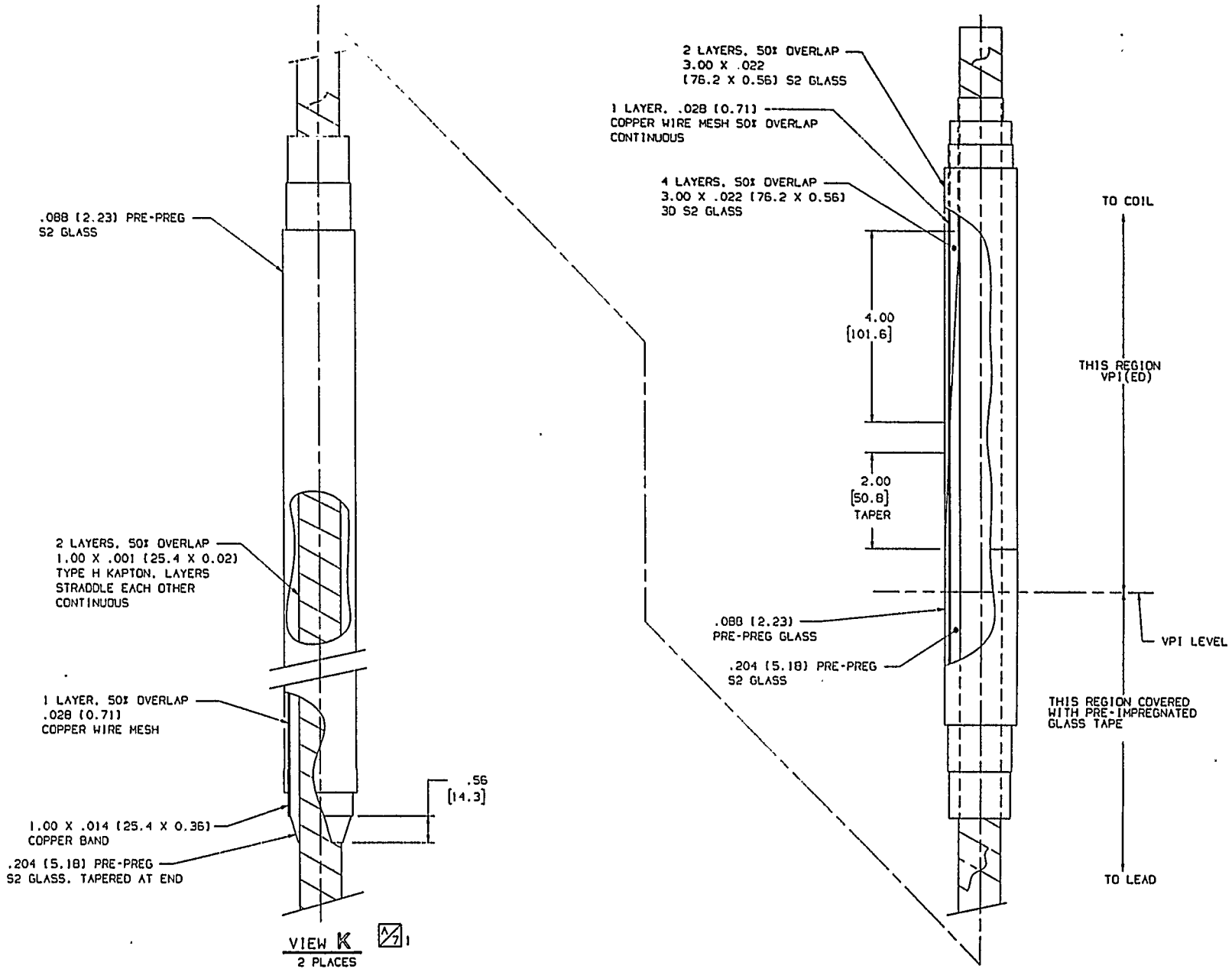


Figure 4.6 – Lead Insulation Design.

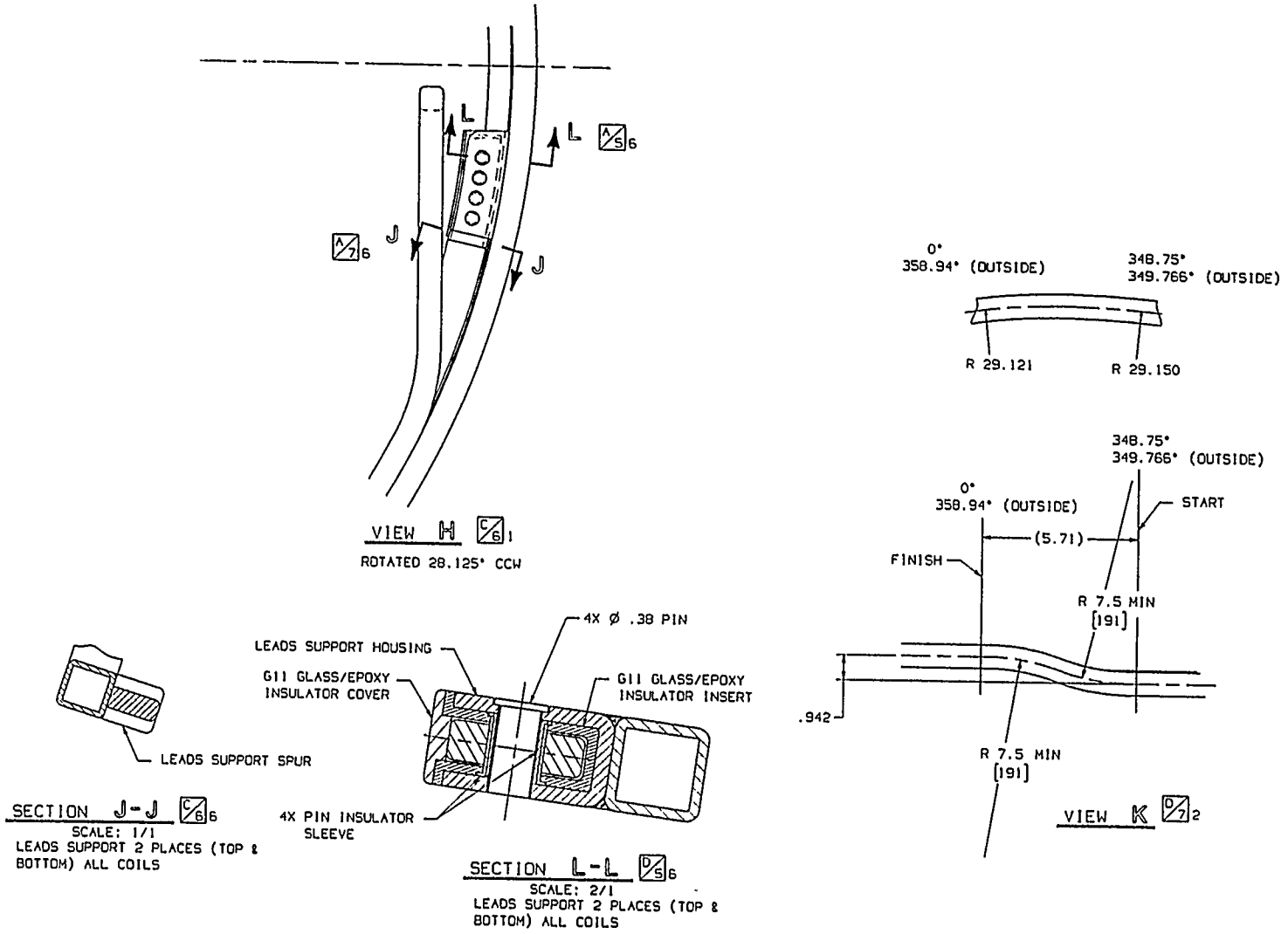


Figure 4.7A– Lead Spur Design.

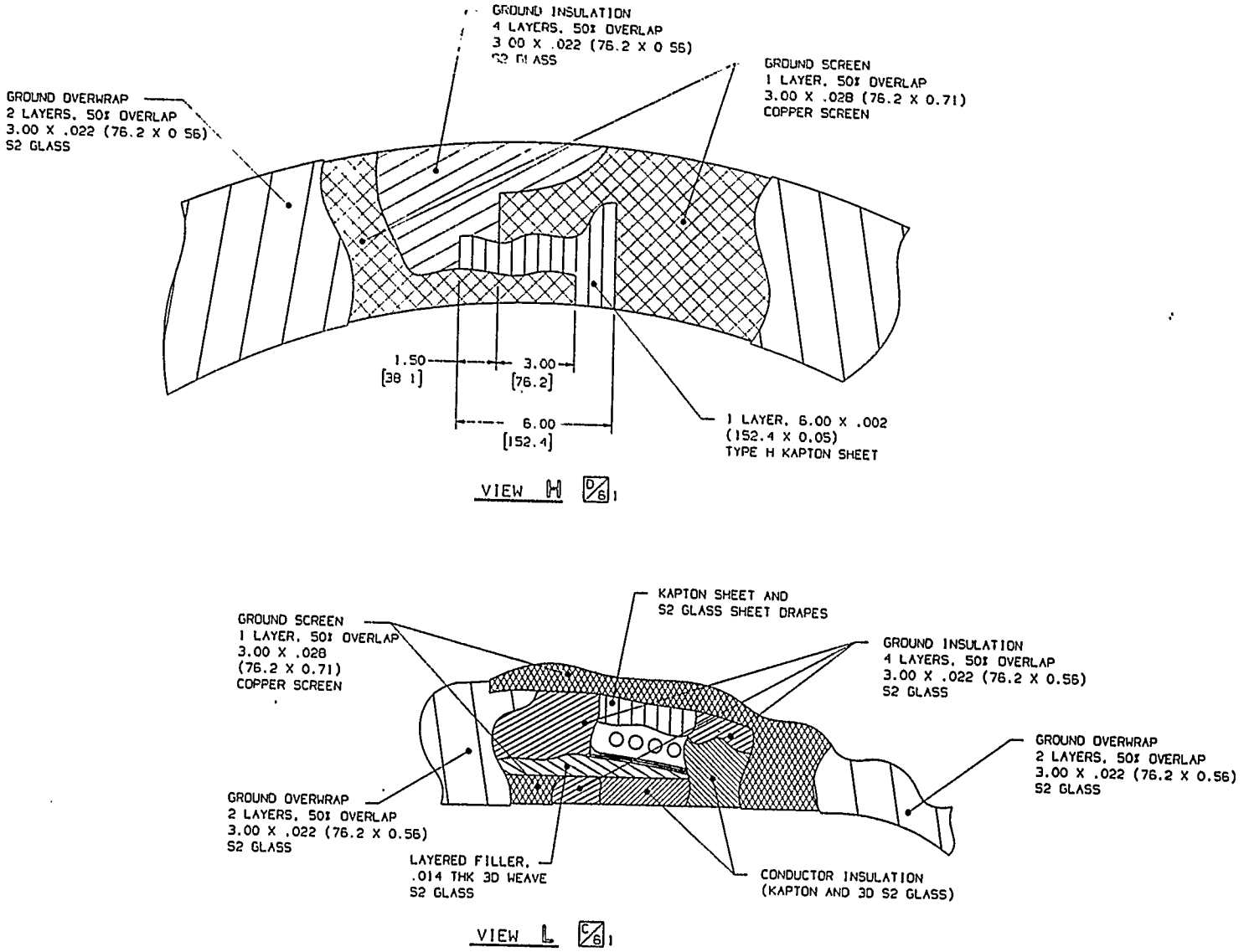


Figure 4.7B– Lead Spur Design.

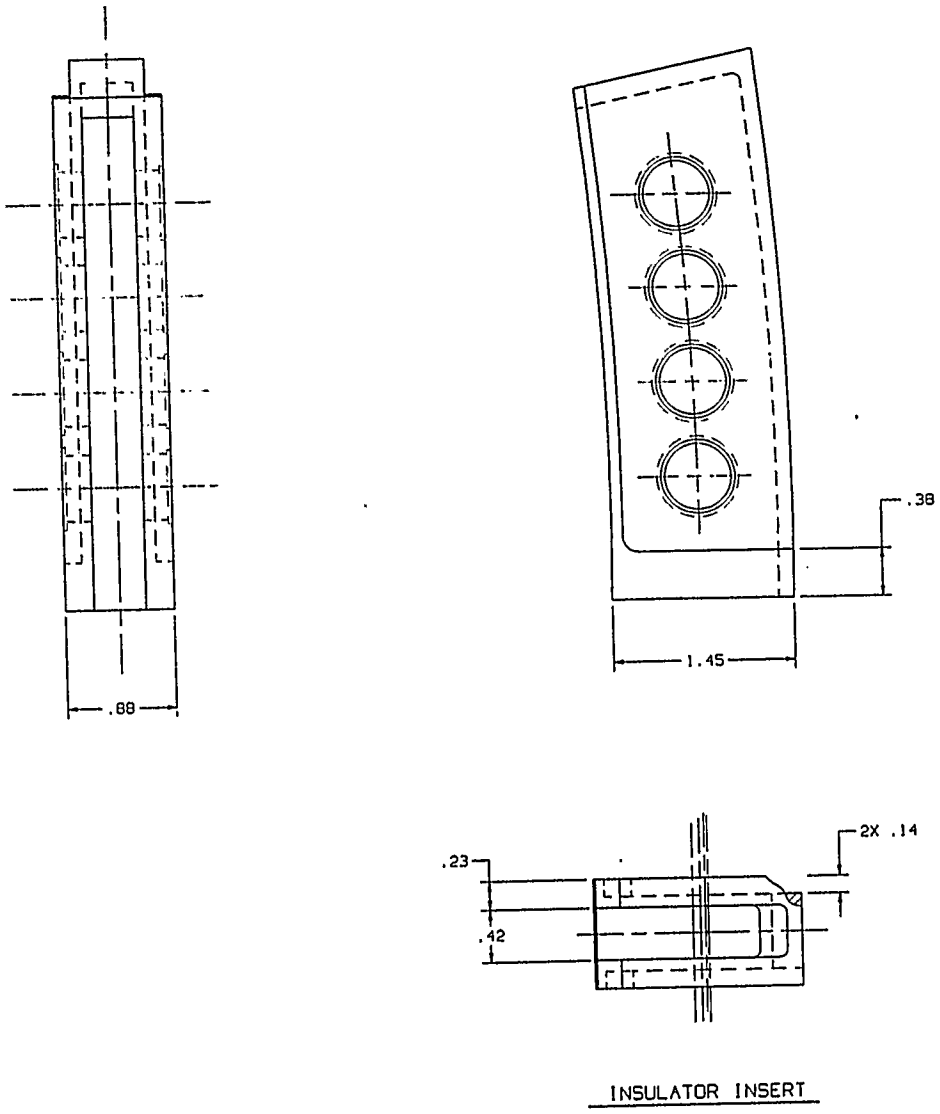


Figure 4.7C— Lead Spur Design.

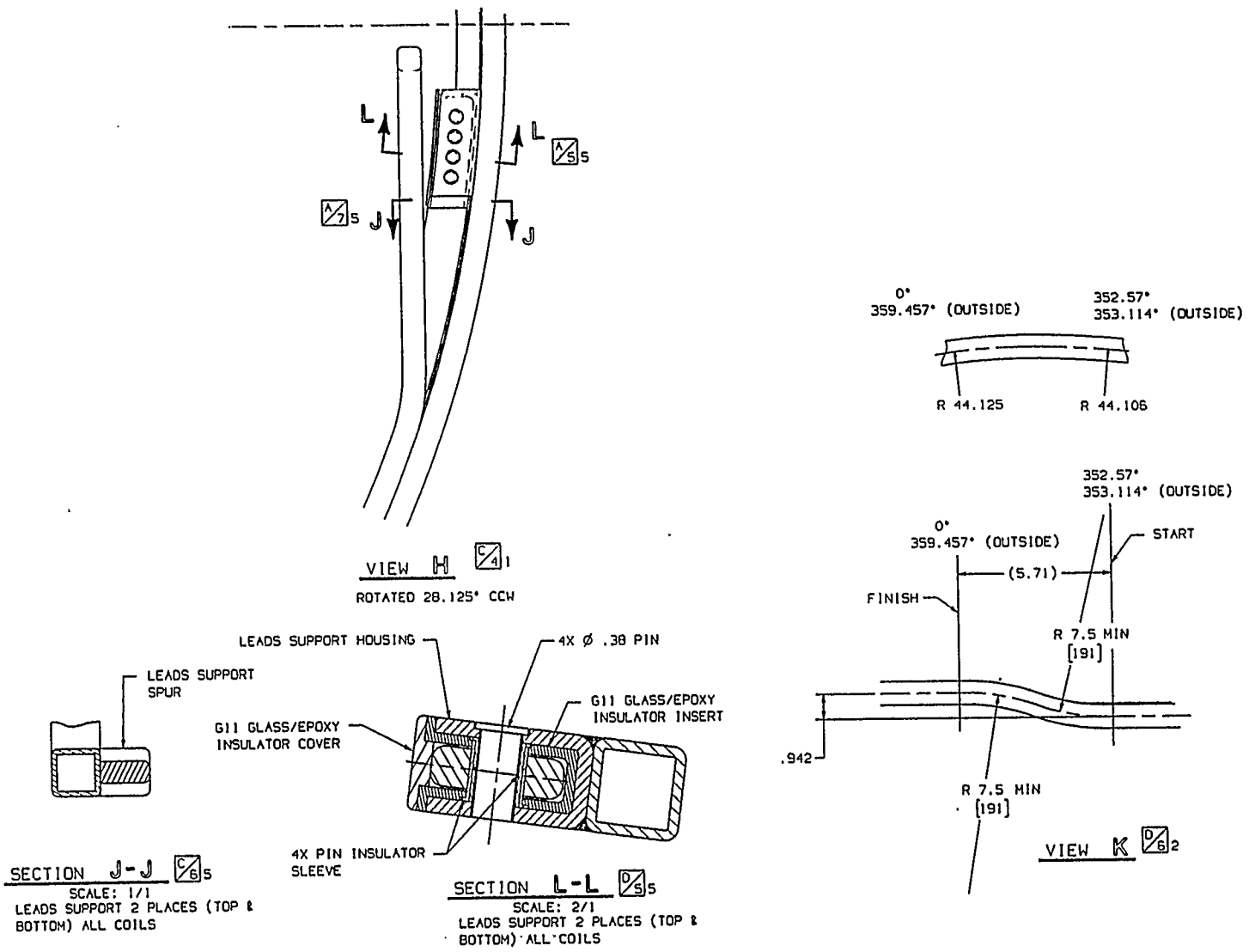


Figure 4.7D– Lead Spur Design.

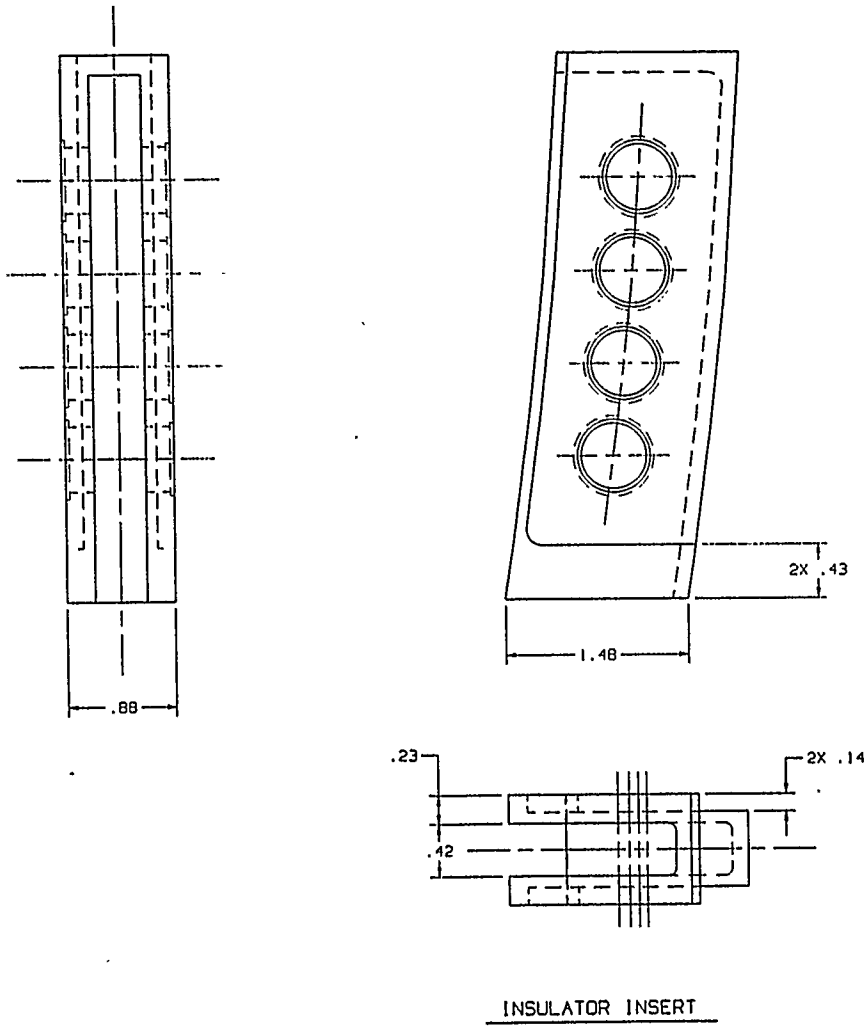


Figure 4.7E– Lead Spur Design.

Figure 4.8 describes the preliminary insulation concept for the welded lead spur assembly. The electrical insulation design of the lead spur is requires insulation of the two weldments for a peak turn-to-turn operating voltage of only 55 V maximum or nominally 1110 V using the 2 times operating plus 1000 V criteria. However, the lead spur assembly must be fully insulated for peak lead voltage to groundplane.

The turn-to-turn voltage insulation design is as follows. First the lead and lead turn are insulated with Kapton and 3-D glass wrap turn insulations which is broken the the regions of the "U" channel and mating spur bar weldments. The "U" channel is insulated with preformed polyimide "L" shapped pieces which cover the "U" channel and the exposed surfaces of the conduit left bare during the conductor insulation process. Alternately, the "U" channel may be insulated with G11-CR sheets for better mechanical performance. The "U" channel insulation pieces have preformed clearance holes for later installation of the support pins. The mating bar is then insulated with preformed polyimide or G11-CR pieces to cover the exposed metal surfaces. The preforms around the spur bar have preformed holes to accept the support pins. The holes in the spur bar are insulated with cylindrical sleeve bushings which are made of Vespel. The "U" channel and spur bar insulation pieces are then wrapped with additional Kapton tape to "lace" them in with the conductor Kapton and dry glass insulation, except for the interlocking spur bar and "U" channel areas.

The insulated spur bar is inserted in the insulated "U" channel and the supporting pins inserted and locked. Finally, the groundwall S-2 glass insulation is wrapped completely around the lead spur assembly. 3-D glass filler material is placed in the "V" knotch of the lead spur assembly to shape the groundplane smoothly around the complex shape of the lead spur assembly. The winding pack groundplane and glass protective wrap are then blended around the lead spur assembly and up the lead itself to complete the insulation and groundplane process.

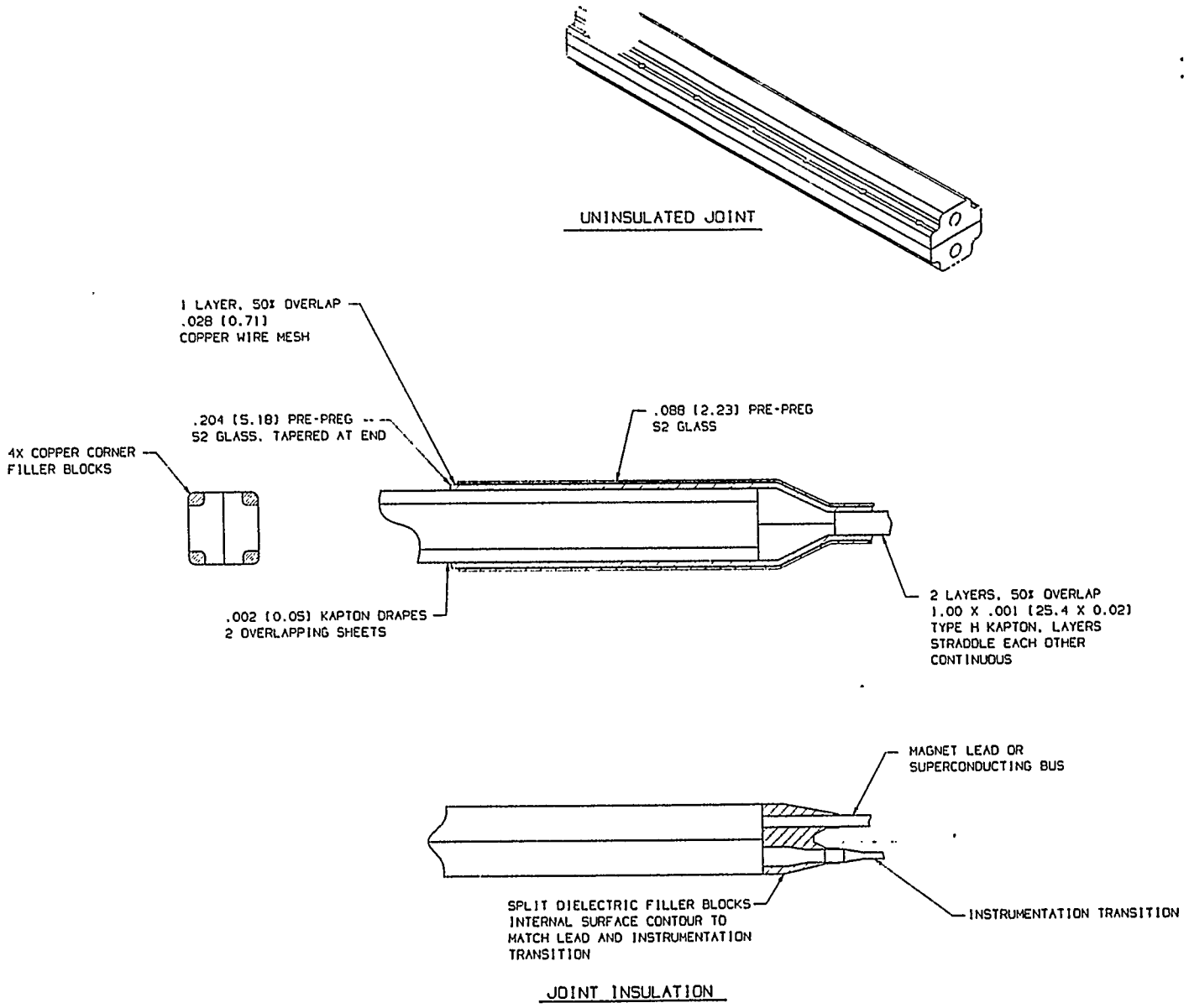


Figure 4.8 — Termination Joint Insulation Design.

Layered 3-D weave glass fillers are used to support the leads as they depart from the coil.

The coil leads are separated by G11-CR filler blocks and a 6.35 mm wide by 38.1 mm high copper bar. The lead assembly is wrapped with 2-50% layers of 0.556 mm thick S-2 glass tape to support the lead assembly. The copper bar serves as the current carrying ground under fault conditions, and is electrically connected to the copper ground fault conductor of the lead buss around the termination joint.

4.2.8 Joint Insulation

The termination joint insulation design is shown on Figure 4.8. The termination joint is assembled in the field joining the winding pack leads to the power supply buss leads. Metallic covers are placed over the termination joint housing to cover bolting hardware making the joint surface smooth and free of field enhancement edges. The ends of each joint are fitted with tapered dielectric end cap blocks which are adapted to accept the helium cooling lines and instrumentation buss. Kapton tape and fitted Kapton sheets are then placed over the metallic body and tapered dielectric end caps, and the Kapton blended with the telescoped Kapton insulation of the power supply and winding pack leads on either side of the joint. Following Kapton insulating, prepreg tape is wrapped over the joint and blended with the tapered prepreg tape over the power buss and winding pack leads. The groundplane screen is applied and connected to the groundplanes on the leads on either side of the joint, and a final protective layer of prepreg applied. The joint insulation is wrapped in shrink tape to apply some pressure to the prepreg insulation build. The joint prepreg insulation is cured via a "clam shell" type oven placed around the joint and extended over the leads on either side of the joint.

4.2.9 Impregnation System

The CPDR Baseline impregnation system for the winding packs is:

Resin	M1204	Shell 826
Hardener	M7231	Ciba-Geigy HY906
Accelerator	M7232	Ciba-Geigy DY062

The general VPI process steps are as follows:

Bake-out at 220 F for 1 hour.

Bake-out at 130 F for 8 hours.

Mix resin and hardener at 110 F and degas mix for 1 hour at or <700 microns.

Add hardener and degas again for 15 min.

Fill winding pack mold slowly until riser bulb is filled to TBD level.

Let filled mold under vacuum for TBD hours; add resin as necessary to maintain resin level.

Close off vacuum and apply 20 psi dry nitrogen pressure for TBD hours.

Add resin as necessary during the pressure soak.

Cure under pressure 4 hours at 175 F, then remove pressure and continure cure for 10 hours at 260 F. Mold cooldown and extraction of coil.

5. SUMMARY AND CONCLUSIONS

A major departure from the TPX CDR Baseline design for the PF magnet system is the electrical insulation system. The CPDR Baseline design for the conduit insulation is Kapton wrap directly on conduits with 3-D woven S-2 glass tape overwrap and 3-D woven shapped corner void fillers. Turn transition and/or joggle winding void spaces are filled with 3-D woven and stitched S-2 glass laminations which allows the spiral winding tapered voids to be packed. The groundwall insulation is build of dry glass wraps with imbedded groundplane copper screen having one insulation break. The winding pack is fully impregnated with Shell 826 resin system using a VPI process. The winding pack is not bonded to the conduits as in the CDR Baseline, and slip at the Kapton wrap/conduit wall interface is allowed. The structural performance of the CPDR winding pack design under operational thermal and mechanical loads is influenced by the slip conditions at the Kapton/conduit interace and by the 3-D material properties of the insulation matrix. Structural analysis, reported separately, has demonstrated that the CPDR winding pack design will meet the electrical, thermal, and mechanical performance criteria for the TPX system.

Preliminary electrical insulation designs have been generated for helium stubs, leads and lead spurs, and lead termination assemblies. The insulation design places a groundplane surface over all conponents of the magnet system in order to ensure that high voltage components as seen from the cryostat vacuum side will have surface potentials <160 V, based upon the Paschen breakdown minimum for helium. The requirement for integrated groundplane system over all high voltage components extends from the coils, leads, and helium lines to the ground sides of helium isolators and the groundplanes of the power supply leads to the other side of

the termination joints. This demands essentially a coaxial insulation system design with high reliability of the groundwall insulation system for prevent high voltage surfaces from electrical breakdown to the groundplane. The insulation system for these components must be throughly examined and tested in Phase II to demonstate that the insulation and structrual designs meet TPX operational requirements.

6. REFERENCES

1. A. L. Radovinsky, "Inductive Voltage in the TPX PF Coils During 12 V and 20 V Startups, and HC Scenario," 14-950214-MIT-ARadovinsky-01.

2. "IEEE Recommended Practice for Insulation Testing of Large AC Rotating Machinery with High Direct Voltage," ANSI/IEEE STD 95-1977.

3. NEMA Standards Publication No. MG 1-1993, MOTORS AND GENERATORS, Section I, General Standards Applying to All Machines, Part 3, High-Potential Tests, 1993.

4. M. P. Krefta, "Electromagnetic Analysis of TPX Poloidal Field Coils," WEC-STC Document No. 95-8TM4-TPXAC-R11, TPX Document No. 14-950630-WEC-MKrefta-01, June 30, 1995.

5. W. F. Hannan, J. Hillenbrand, and P. Sanger, "TPX PF1-4 Coil Pack Structural Analysis," WEC-STC Document No. 95-8TM4-TPXAC-R11, TPX Contract Document, August 14, 1995.

6. T. Kupiszewski, "Feasibility of Cooling the Superconducting Outer Ring Coils in the TPX Tokamak," WEC-STC Document No. 95-8TM4-TPXAC-R4, TPX Contract Document 14-950403-WEC-TKupiszewski, July 28, 1995.

7. O. R. Christianson, "Verification of Margin in PF2 & 5," WEC-STC Document No. 95-8TM4-TPXAC-R3, TPX Contract Document 14-950731-WEC-OChristianson-02.

8. J. F. Lowry, P. A. Sanger, and J. F. Roach, "Development of Three-Dimensional Woven Fiberglass Components for the TPX PF and TF Magnet Electrical Insulation Systems," WEC-STC Document No. 95-8TM4-TPXAC-R5, TPX Contract-Required Document, July 28, 1995.

9. J. F. Roach, W. M. Urban, and D. Hartman, "TPX Insulation and Impregnation R&D-1x2 Test Report," WEC-STC Document No. 95-8TM4-TPXAC-R2, TPX Document No. 14-950630-WEC-FRoach-01, August 2, 1995.

10. J. F. Roach, W. M. Urban, and D. Hartman, "TPX Insulation and Impregnation R&D-3x3 Test Report-Electrical Insulation," WEC-STC Document No. 95-8TM4-TPXAC-R5, TPX Document No. 14-950630-WEC-FRoach-02, August 10, 1995.

11. R. J. Hillenbrand, "3x3 Coil Test Program," WEC-STC Document No. 95-8TM4-TPXAC-R6, TPX Contract Document, August 2, 1995

12. P. A. Sanger, "TPX Magnet Insulation Large Scale Verification Test Program," WEC-STC Document No. 95-8TM4-TPXAC-R8, TPX Contract Document, August 15, 1995.

13. R. J. Hillenbrand, P. A. Sanger, G. Swartzback and W. Urban, "TPX Magnet Helium Stub Manufacturing R&D: Final Report," WEC-STC Document No. 95-8TM4-TPXAC-R9, TPX Contract Document, August 15, 1995.

7. APPENDICES

Appendix 7.1

SUMMARY OF ELECTROSTATIC FIELD ANALYSES FOR PF WINDING PACKS

The attached VuGraphs were presented at the MSIM #4 held at Sunnyvale, CA on March 2, 1995.

Page 7.1-2 presents Model-1: Turn-to Ground for Spiral Winding (PF) showing line of equal stress in kV/inch for 10 kV turn-to-ground and 2 kV layer-to-layer potential drops.

Pages 7.1-3 and 4 show expanded views of equal stess and equipotential plots, respectively, for Model 1.

Pages 7.1-5 and 6 present the equal stress and equipotential plots at the conductor corner, respectively, for Model 2: Layer-to-Layer in Regimented Pack (TF) for 2 kV layer-to-layer potential drop.

Pages 7.1-7 and 8 present the equal stress and equipotential plots at the conductor corner, respectively, for Model 3: Layer-to-Layer in Spiral Winding (PF) for 2 kV layer-to-layer potential drop.

Pages 7.1-9 presents the equipotential plot at the conductor corner for Model 4: Layer-to-Layer in Spiral Winding with Kapton on Conduit (PF) for 2 kV layer-to-layer potential drop. This is the same configuration as Model 3 except that Kapton is wrapped directly on the conduit with the layer-to-layer and turn-to-turn insulation spacing remaining constant at 1.626 mm (0.064"). For Model 4, the Kapton wrap around the conductor has a thickness of 0.203 mm (0.008") and the glass wrap overwrap 0.610 mm (0.024"). The PDR baseline insulation has 2-50% laps of 0.025 mm (0.001") Kapton for a thickness of 0.102 mm (0.004") or half that assumed for Model 4 analysis. The electric stress in the Kapton wrap is higher than that in the epoxy/glass overwrap by essentially the ratio of the dielectric constants, that is

ε(Epoxy/Glass) / ε(Kapton) = 5.0/3.5 = 1.42

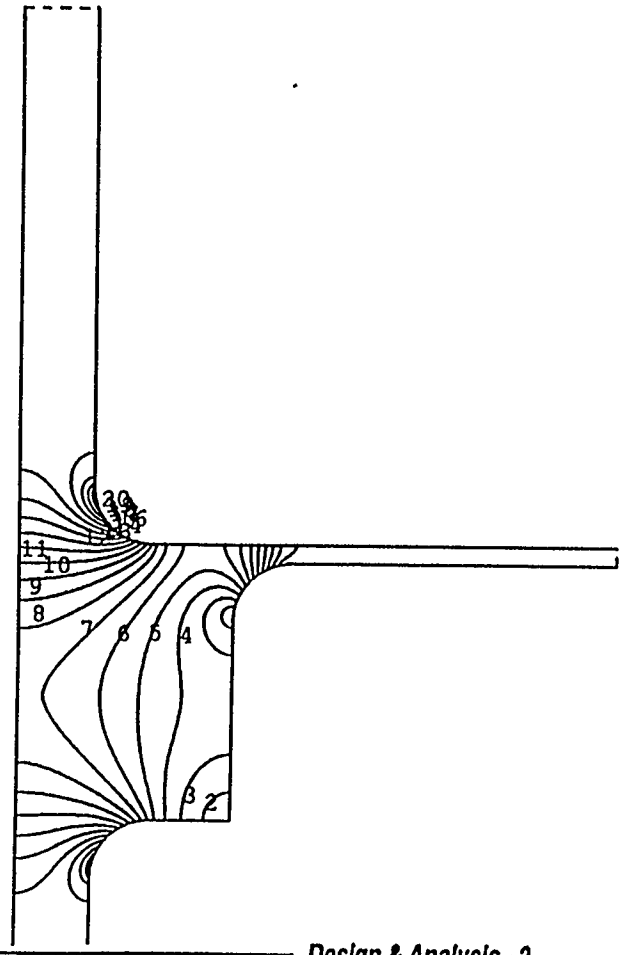
Since the Kapton layer is 25% of the total conductor insulation wrap, assumed for Model 4 and only 12.5% in the PDR baseline design, the peak stress within the Kapton insulation at the conductor surface is very close to 1.42 times the average electric stress, that is the layer-to-layer potential drop divided by the total insulation build of 1.626 mm. In the case of Model 4 for a potential drop of 2 kV the peak stress is estimated to be 1.42 x 2/1.626 = 1.72 kV/mm. The calculated peak stress is 1.97 kV/mm which is about 14.5 % higher and is due to the conductor corner curvature.

Model-1: Turn-to-Ground for Spiral Winding (PF)

Showing lines of equal electric stress, kV/inch (10 kV T-G; 2 kV L-L)

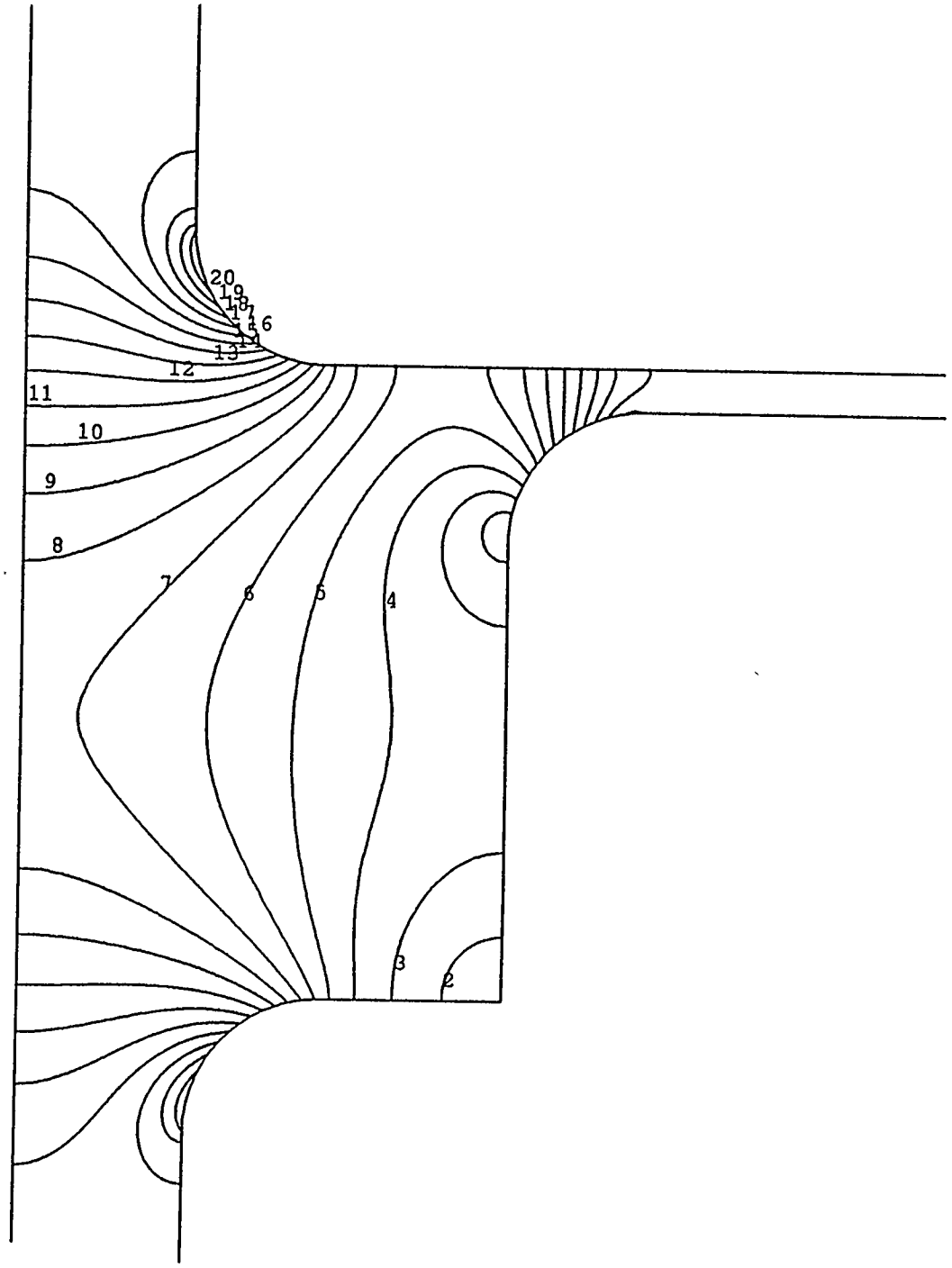
The Plotted Values are :

2.	0.2561E+04
3.	0.5121E+04
4.	0.7682E+04
5.	0.1024E+05
6.	0.1280E+05
7.	0.1536E+05
8.	0.1792E+05
9.	0.2048E+05
10.	0.2304E+05
11.	0.2560E+05
12.	0.2816E+05
13.	0.3073E+05
14.	0.3329E+05
15.	0.3585E+05
16.	0.3841E+05
17.	0.4097E+05
18.	0.4353E+05
19.	0.4609E+05
20.	0.4865E+05



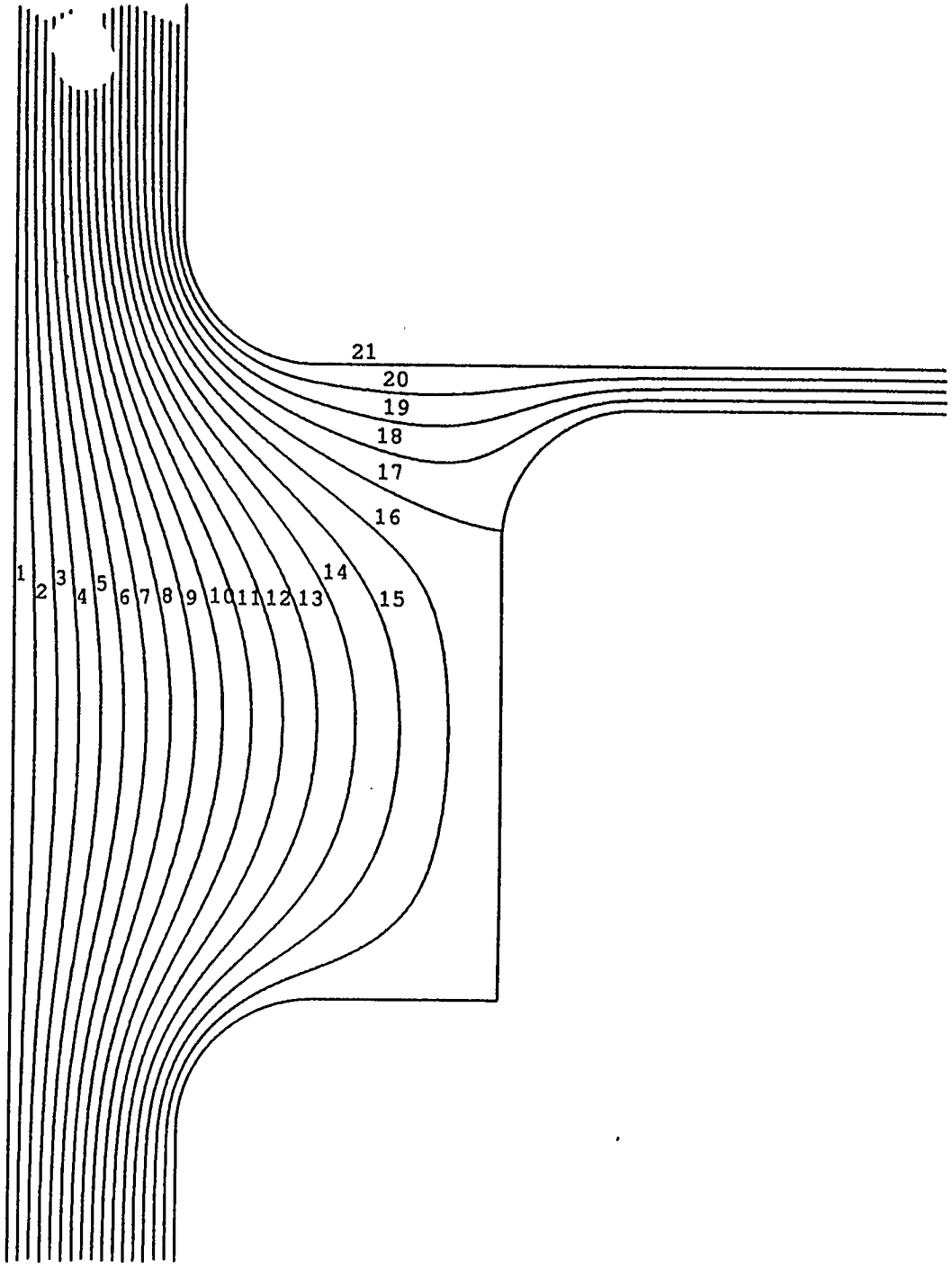
The ⁻ tted Values are :

2.	2561E+04
3.	5121E+04
4.	0.7682E+04
5.	0.1024E+05
6.	0.1280E+05
7.	0.1536E+05
8.	0.1792E+05
9.	0.2048E+05
10.	0.2304E+05
11.	0.2560E+05
12.	0.2816E+05
13.	0.3073E+05
14.	0.3329E+05
15.	0.3585E+05
16.	0.3841E+05
17.	0.4097E+05
18.	0.4353E+05
19.	0.4609E+05
20.	0.4865E+05



The 1 ed Values are :

1.	J00E+00
2.	0.5000E+03
3.	0.1000E+04
4.	0.1500E+04
5.	0.2000E+04
6.	0.2500E+04
7.	0.3000E+04
8.	0.3500E+04
9.	0.4000E+04
10.	0.4500E+04
11.	0.5000E+04
12.	0.5500E+04
13.	0.6000E+04
14.	0.6500E+04
15.	0.7000E+04
16.	0.7500E+04
17.	0.8000E+04
18.	0.8500E+04
19.	0.9000E+04
20.	0.9500E+04
21.	0.1000E+05



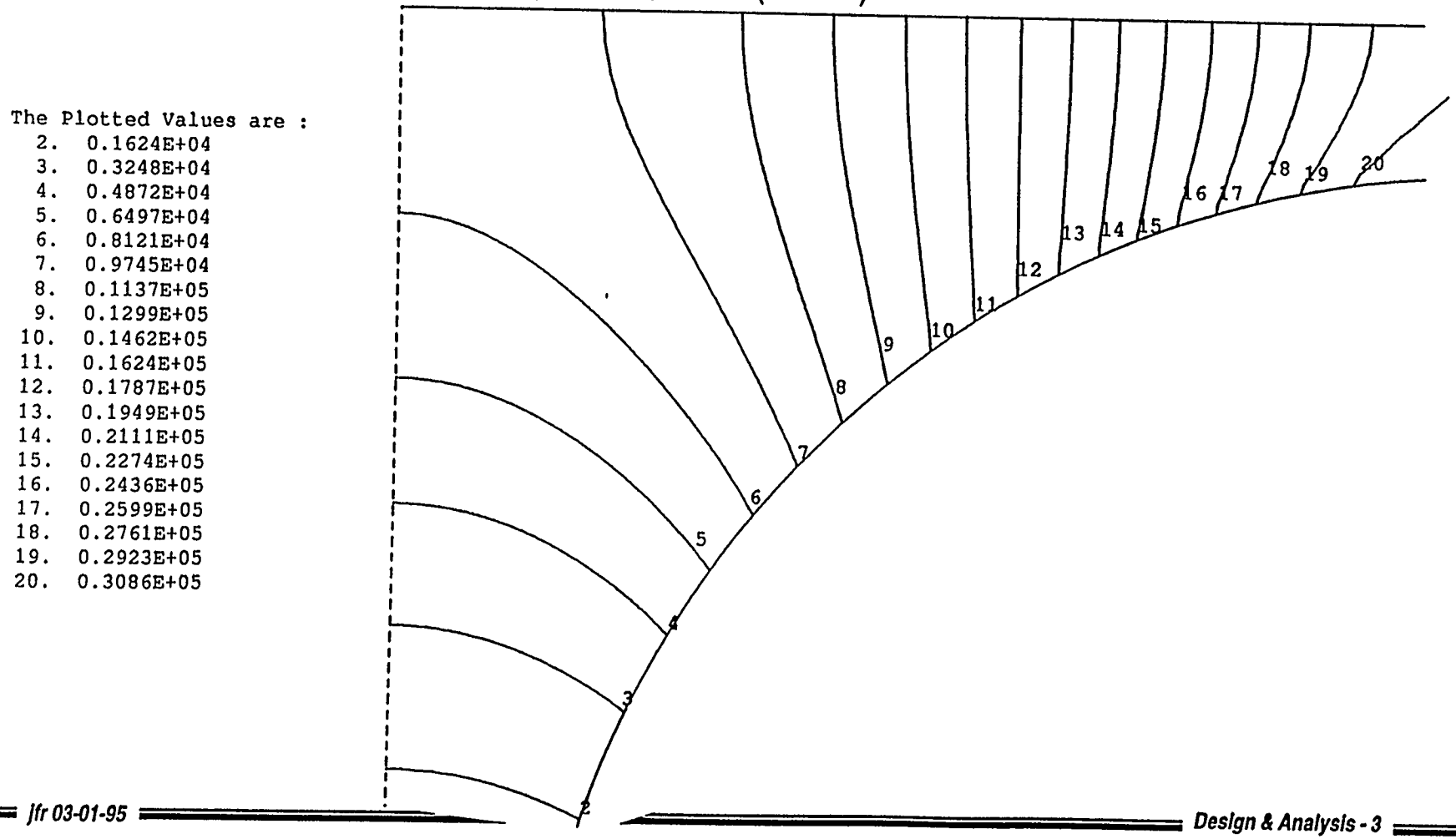
TPX

MARINE DIVISION

Winding Pack Design & Analysis

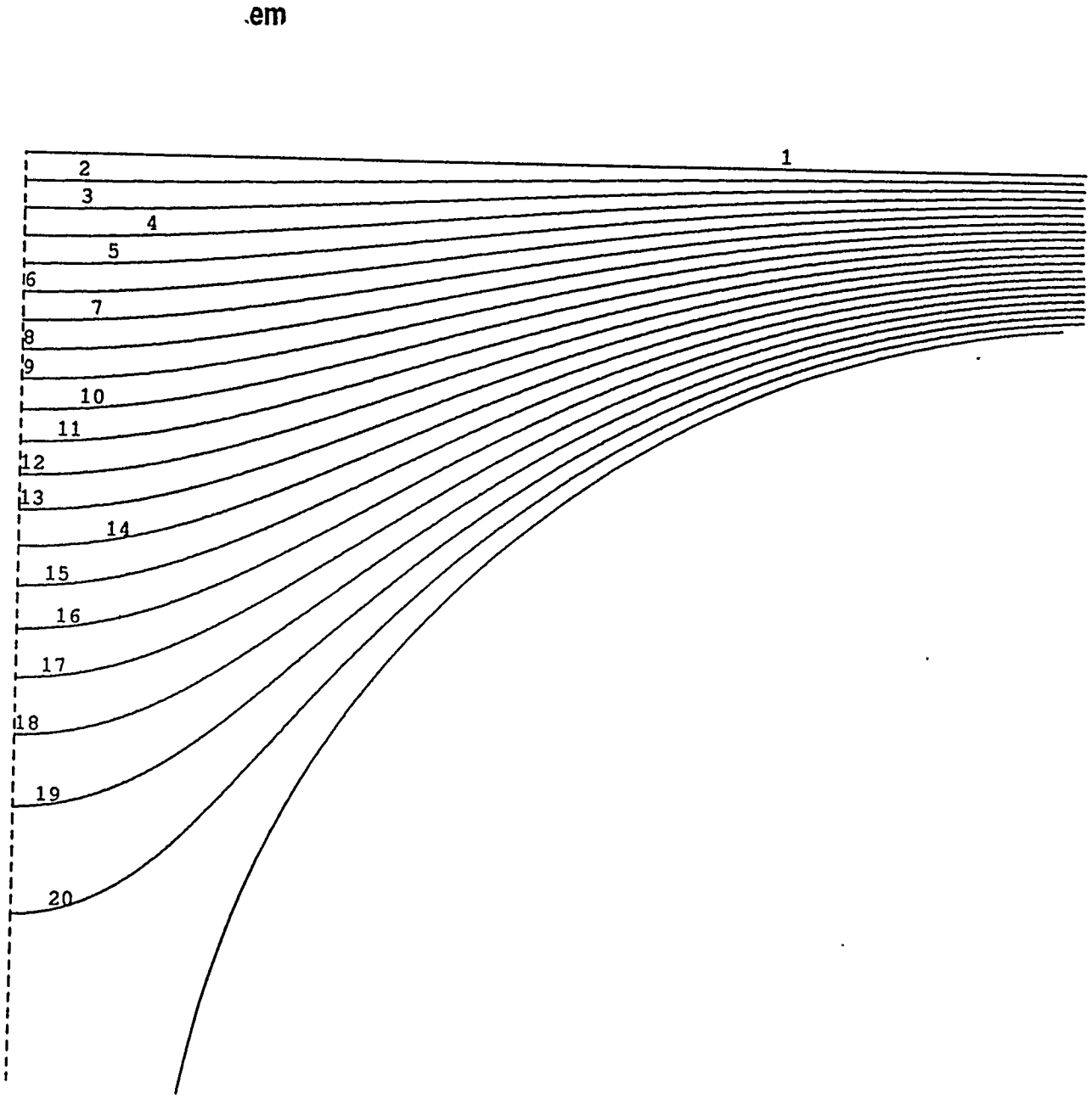
❑ Model-2: Layer-to-Layer in Regimented Pack (TF)

Showing lines of equal stress, kV/inch (2 kV L-L)

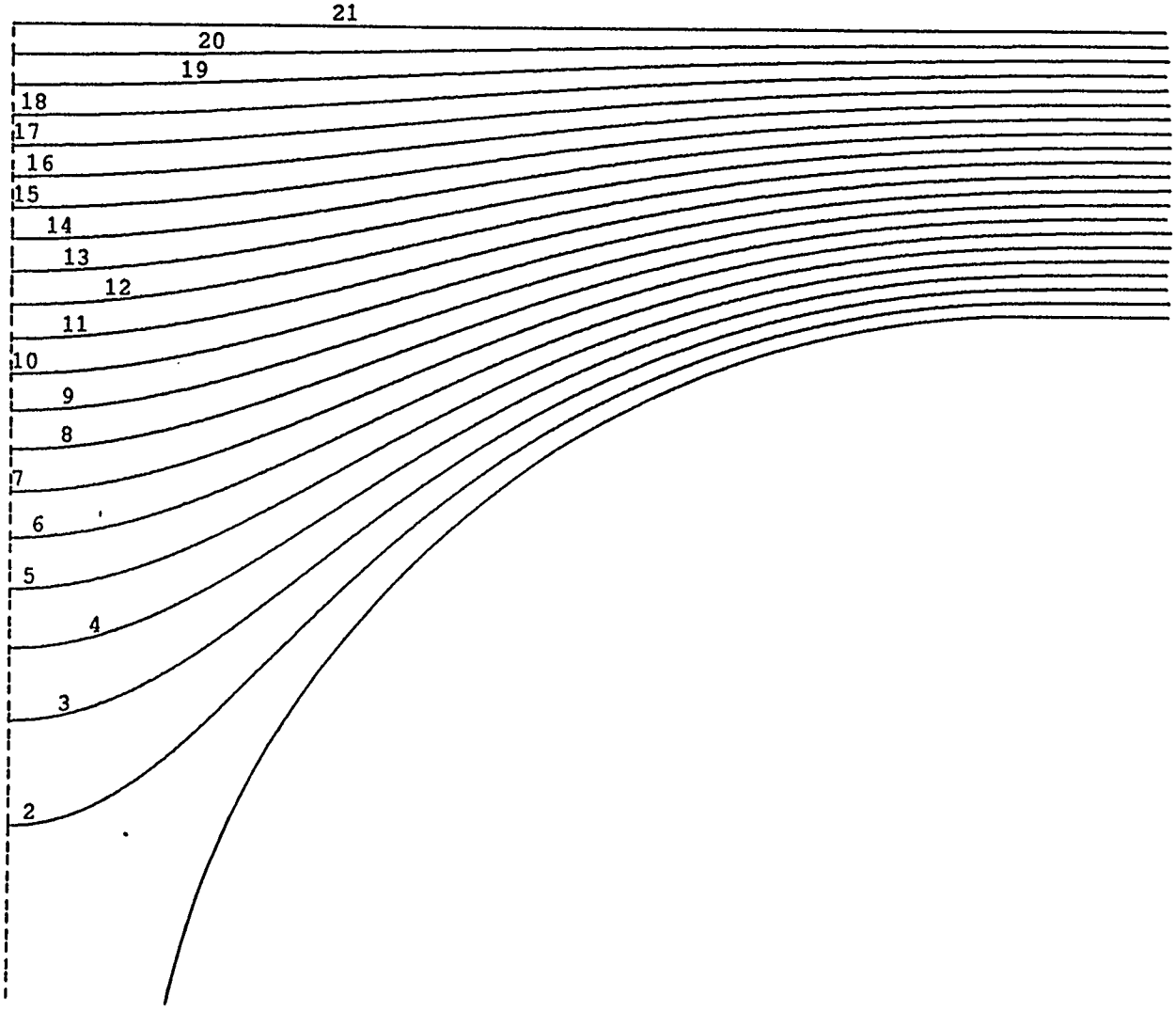


The plotted values are :

1.	0000E+00
2.	0000E+02
3.	0.1000E+03
4.	0.1500E+03
5.	0.2000E+03
6.	0.2500E+03
7.	0.3000E+03
8.	0.3500E+03
9.	0.4000E+03
10.	0.4500E+03
11.	0.5000E+03
12.	0.5500E+03
13.	0.6000E+03
14.	0.6500E+03
15.	0.7000E+03
16.	0.7500E+03
17.	0.8000E+03
18.	0.8500E+03
19.	0.9000E+03
20.	0.9500E+03



3.	?.8200E+04
4.	8300E+04
5.	3400E+04
6.	0.8500E+04
7.	0.8600E+04
8.	0.8700E+04
9.	0.8800E+04
10.	0.8900E+04
11.	0.9000E+04
12.	0.9100E+04
13.	0.9200E+04
14.	0.9300E+04
15.	0.9400E+04
16.	0.9500E+04
17.	0.9600E+04
18.	0.9700E+04
19.	0.9800E+04
20.	0.9900E+04
21.	0.1000E+05

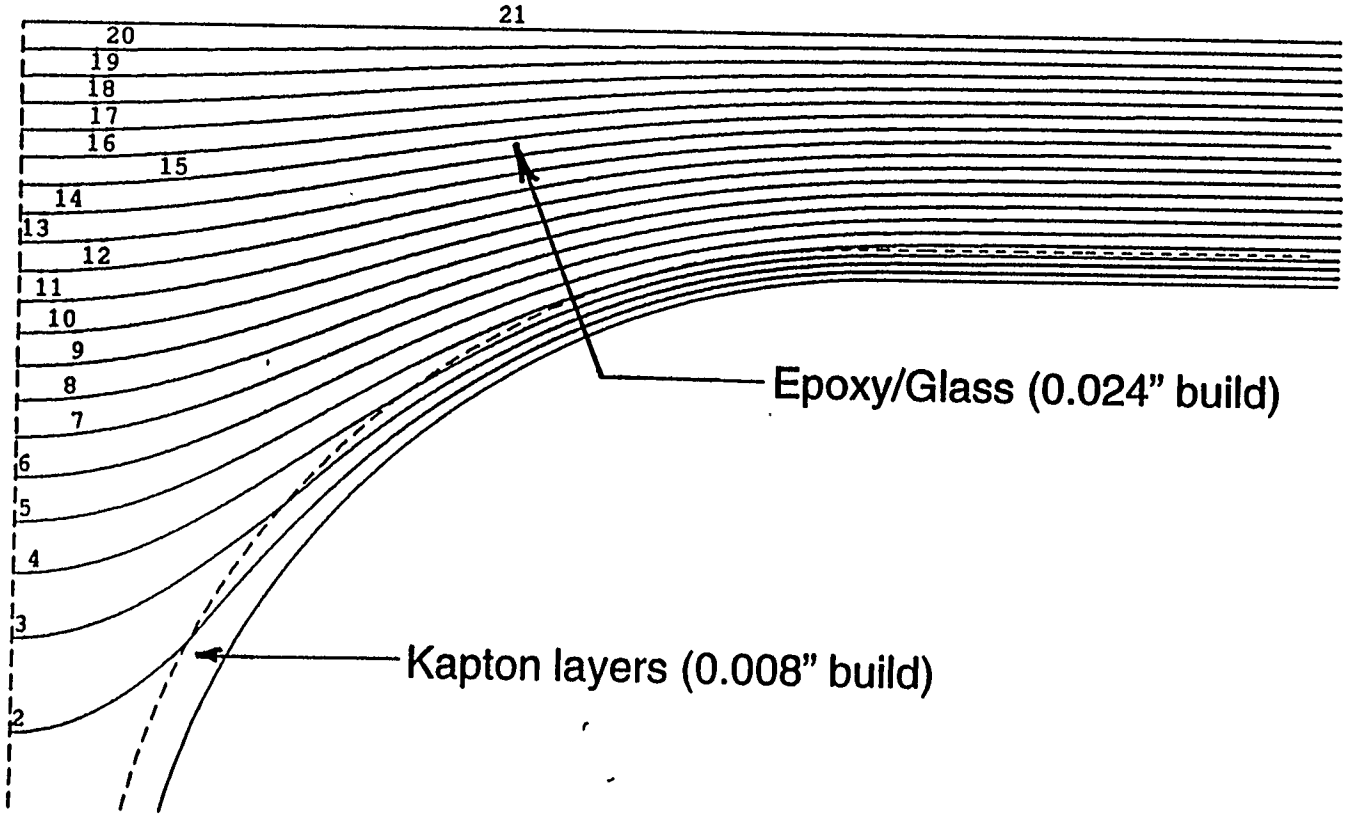


❑ Model-4: Layer-to-Layer Spiral Winding, Kapton on Conduit

Showing equipotential lines with stress enhancement in Kapton wrap (2 kV L-L)

The Plotted Values are :

2.	0.8100E+04
3.	0.8200E+04
4.	0.8300E+04
5.	0.8400E+04
6.	0.8500E+04
7.	0.8600E+04
8.	0.8700E+04
9.	0.8800E+04
10.	0.8900E+04
11.	0.9000E+04
12.	0.9100E+04
13.	0.9200E+04
14.	0.9300E+04
15.	0.9400E+04
16.	0.9500E+04
17.	0.9600E+04
18.	0.9700E+04
19.	0.9800E+04
20.	0.9900E+04
21.	0.1000E+05



Appendix 7.2

TECHNICAL ASSESSMENT OF TPX ELECTRICAL INSULATION SYSTEM ALTERNATIVES

The electrical insulation system for the TPX superconducting magnets impacts many critical areas: coil performance (mechanical, thermal, magnetic), reliability, cost, and manufacturability (which impacts both cost and schedule). Thus this system including its various components must be chosen very carefully with due consideration for all of the above factors.

The LLNL proposed baseline electrical insulation system for the TPX superconducting magnets consists of a dry, S2 fiberglass tape wrap over the CICC, the tape wrap being comprised of two layers of 0.1524 mm thick tape, each overlapped 50%, for a total glass tape thickness of 0.6096 mm (0.024 in.). A 0.2032 mm thick G10-CR or G11-CR barrier is used both turn-turn and layer-layer, making the total baseline insulation "build" 0.8128 mm (0.032 in.) on each conductor surface. The baseline system is vacuum-pressure-impregnated using an appropriate resin system (based on Shell 826 or CTD101K), thus creating a "monolithic" structure in which the conductor and all components of the electrical insulation system are mechnically bound together. The most important component of the baseline system from the point of view of preventing turn-turn and/or layer-layer electrical breakdown during certain transient magnet operating conditions is the G10 (G11) barrier system.

There are a large number of possible alternatives to the above baseline system, and there are several reasons for investigating certain alternative systems:

1. Insertion of the thin G10 (or G11) barrier material presents a significant manufacturing problem.
2. The layer-layer barrier can be a large sheet covering an entire layer, but the turn-turn barrier can be only one conductor height, and there is no effective way to seal or assure bonding of the two orthogonal barrier strips, thus creating (at

least locally) the possibility of small gaps or voids between the barriers. If micro-cracks also form in the glass-reinforced epoxy conductor wrap due to thermal and/or mechanical stress (a strong possibility), then the baseline insulation system is compromised by possible turn-turn breakdown paths.

All of the alternative systems are based on using a Kapton film dielectric wrapped over the CICC (conductor), generally in several layers, as the basic dielectric element for prevention of intra-conductor electrical breakdown. Various types of S2 glass tape systems have been proposed for overwrapping the Kapton, and there are also possible variations in the Kapton tape, including thickness, number of layers, and use of adhesive on one or more tape surfaces. Each alternative system minor variations to enhance reliability, manufacturability, or some other aspect of system performance, and some of these were considered in the technical assessment of insulation system options.

Because of the impact of alternative electrical insulation systems and variations may have on coil performance, reliability, cost, and manufacturability, a technical assessment study was conducted to evaluate the baseline and various alternative systems and to determine the best overall approach to the electrical insulation sytem. This assessment was performed by ranking the baseline and alternative insulation systems based on the evaluation criteria by establishing a weighted numerical grade of 1-5 for each evaluation criteria, and generating a total score for each alternative.

The numerical grade is interpreted as follows: a grade of "1" indicates that the insulation system just meets the technical requirements in that particular category, whereas an increasing grade, "2, 3, 4, or 5" indicates increasing strength or increasing degree of superior performance in that category. The principle strengths and weaknesses of each alternative approach with respect to the evaluation criteria were tabulated for ease of comparison.

To be selected as a viable alternative insulation system, the system had to meet all the technical requirements for the TPX magnet system. **It was not the**

objective of this study to eliminate those systems which could not filfill the basic TPX requirements, but rather to choose the superior system based on performance, manufacturability, low cost, and low risk. The options were selected based on input from and discussions among all team members. The detailed configurations of each the baseline and alternative insulation systems are presented below and are also found in the body of the text in Section 4, Table 4.1:

DESCRIPTION OF TPX CANDIDATE INSULATION SYSTEMS

A - Baseline (Dry Glass/Barriers)

CICC
S2 Glass Tape, Dry, 0.1524 mm (0.006 in.), 2 X 50% Laps
G10-CR Barriers, 0.2032 mm (0.008 in.), 2 Sheets, 100% Overlap L-L and T-T
Total Thickness = 4 X 0.1524 mm + 0.2032= 0.8128 mm (0.032 in.)
Corner roving filler TBD
VPI

B - Kapton Interleaved with Dry Glass/No Barriers

CICC
S2 Glass Tape, Dry, 0.1778 mm (0.007 in.), 67% Lap
Kapton Tape, 0.0508 mm (0.002 in.), 50% Lap
S2 Glass Tape, Dry, 0.1778 mm, Butt-Lap
Total Thickness = 4 X 0.1778 mm + 2 X 0.0508 mm = 0.8I28 mm (0.032 in.)
Corner roving filler TBD
VPI

C - Kapton on Conduit/Dry Glass/No Barriers

CICC
Kapton Tape, 0.0508 mm (0.002 in.), 2 X 50% Laps
[Kapton tape has XMPI (185 °C) adhesive, top side only of first layer and both sides of second layer, and is pre-pressed and cured "in-line."]
S2 Glass Tape, Dry, 0.1524 mm (0.006 in.), 2 X 50% Laps
Total Thickness = 4 X 0.1524 mm + 4 X 0.0508 mm = 0.8I28 mm (0.032 in.)
Corner roving filler TBD
VPI

Option C0
Same as C except Kapton tape has no adhesive (slip-plane); this option requires no in-line pre-press and cure.

Option C1
Same as C except Kapton tape has XMPI adhesive on both sides, both layers.

D - Kapton Interleaved with Pre-preg Glass/No Barriers

CICC
S2 Pre-preg. Glass Tape, 0.1778 mm (0.007 in.), 67% Lap
Kapton Tape, 0.0508 mm (0.002 in.), 50% Lap
S2 Glass Tape, Dry, 0.1778 mm, Butt-Lap
Total Thickness = 4 X 0.1778 mm + 2 X 0.0508 mm = 0.8I28 mm (0.032 in.)
Corner roving filler TBD
VPI/Pre-preg cure simultaneously

Option D1
Same as D except cure pre-preg "in-line" for inspectability (ITER approach).

E - Kapton on Conduit/3D Weave Preforms/No Barriers/No Roving

CICC
Kapton Tape, 0.0508 mm (0.002 in.), 2 X 50% Laps
[Kapton tape has XMPI (185 °C) adhesive, top side only of first layer and both sides of second layer, and is precured "in-line."]
3D Woven S2 Fiberglass Pre-forms ("L" or "U" or "T" shapes) for bulk of L-L and T-T structure in Lieu of Glass Tape, Barriers, and/or Roving
Total Thick. = 0.6096 mm (0.024 in.) + 4 X 0.0508 mm = 0.8128 mm (0.032 in.)

half of build
= 1.2192 mm (0.048 in.) + 8 X 0.0508 mm = 1.6256 mm (0.064 in.)
full build T-T and L-L

[Applicability of half-build or full-build thickness depends on shapes and dimensions of pre-forms.]
VPI

Option E1
Same as E except Kapton tape has XMPI adhesive on both sides, both layers.

F - Kapton on Conduit/3D Weave Tape/No Barriers

CICC

Kapton Tape, 0.0508 mm (0.002 in.), 2 X 50% Laps
[Kapton tape has XMPI (185 °C) adhesive, top side only of first layer and both sides of second layer, and is precured "in-line."]
3D Woven S2 Fiberglass Tape, Dry, 0.3556 - 0.4318 mm (0.014 - 0.017 in.), 1 X
50% Lap
Corner roving filler TBD
VPI

Option F1
Same as F except Kapton tape has XMPI adhesive on both sides, both layers.

Notes

1. TBD void fill options (for all insulation systems except option E)
   (Corners between turns, between turns and groundplane, at transition filler, at lead dielectric inserts, in "banana" voids)
   a) Twisted S-2 glass fiber roving conformable to void shape
   b) S-2 glass rope, braid, or wick (dry or pre-preg)/various woven configurations
   c) Flexible epoxy putty (Araldite) or 112P caulking
   d) "3D" S-2 glass "rope" (dry or pre-preg)
   e) Techniweave "gap filler"

2. Ground-wall insulation (same for all systems)
   a) Dry S-2 glass tape or 3D woven S-2 glass pre-form
   b) VP impregnated with coil
   c) Kapton wrap on outside

3. Transitions
   a) Dielectric, G11-CR, machined
   b) Dielectric, pre-formed (Grumman experience)
   c) Incoloy 908, machined and insulated
   d) "3D" woven S-2 glass structures
   e) 112P caulking
   f) Araldite

4. TBD Conducting groundplane

The evaluation criteria included 8 categories which are listed below. The elements of each criteria category which were considered in arriving at the numerical rating or score of 1-5 are also listed. The lists do not imply that technical, manufacturing, and/or cost data bases existed at the time of the performance of the technical assessment study. In many cases "best judgement" was used based on the team's past experience and present

knowledge of on going programs such as ITER. For some elements of each overall evaluation category no comparative judgement of the alternatives could be made and they were, therefore, given essentially the same score.

EVALUATION CRITERIA

1. Electrical Performance
   - 1.1 Electrical properties
     - 1.1.1 Punch-through resistance
     - 1.1.2 Dielectric strength
     - 1.1.3 Partial discharge characteristics
     - 1.1.4 Loss of dielectric strength during irradiation
   - 1.2 Insulation margin
     - 1.2.1 Turn-to-turn voltage withstand
     - 1.2.2 Layer-to-layer voltage withstand
     - 1.2.3 Turn-to-ground voltage withstand

2. Mechanical performance
   - 2.1 Mechanical margin
     - 2.1.1 Modulus
     - 2.1.2 Strength (compression, shear, tension, combinations)
   - 2.2 Tendency to crack on cooldown
   - 2.3 Tendency to crack on loading
   - 2.4 Bond strength (compression, shear, tension, combinations)
   - 2.5 Mechanical life cycles,
   - 2.6 Mechanical compatibility with other winding pack materials

3. Thermal performance
   - 3.1 Coefficient of thermal contraction match (α_x, α_y, α_z)
   - 3.2 Thermal conductivity (x, y, z)/heat transfer characteristics
   - 3.3 Thermal life cycles

4. Reliability
   - 4.1 Electrical
   - 4.2 Mechanical
   - 4.3 Thermal
   - 4.4 Radiation resistance
   - 4.5 Life cycle requirements/degradation factor for cycling

5. Manufacturability
   - 5.1 Conduit preparation for bond strength
   - 5.2 Winding process

5.2.1 Impact of raw material tolerances
5.2.2 Impact of assembly tolerances ("build")
5.2.3 Taping heads/multiple head requirements
5.2.4 Barrier insertion
5.2.5 Barrier bonding (barrier-to-barrier and barrier to impregnant)
5.3 Control of known void spaces
5.3.1 Void fill approach (T-T, L-L, others)
5.3.2 Void fraction
5.4 Accomodation of transitions/joggles
5.5 Thoroughness of VPI/curing process
5.6 Inspectability
5.7 Product availability
5.8 Tool cleaning
5.9 Shelf life, storage, cleanliness, and other handling problems

6. Cost
6.1 Cost of development
6.2 Cost of raw materials
6.3 Cost of tooling and equipment
6.4 Cost of labor

7. Schedule
7.1 Development time
7.2 Process cycle time
7.3 Material lead time

8. Risk (H/M/L)
8.1 Technical risk (H/M/L)
8.2 Schedule risk (H/M/L)
8.3 Cost risk (H/M/L)

RESULTS

A concurrent engineering team representing Westinghouse Marine Division, Westinghouse STC, Everson Electric, and Northrup-Grumman met on several occasions to discuss the various alternative insulation systems and score each one in the several categories listed. The summary results of the technical assessment are presented in tabular form. For each option the strengths and weaknesses are tabulated. An overall grade is given, together with a separate grade for risk. The

overall grade is based on consideration of the factors discussed earlier and an overall evaluation of the strengths and weaknesses. **Note that a high risk score denotes low risk.**

The results are summarized in the body of the text in Section 4 Table 4.2. The highest score was obtained by option C0, followed closely by C1. Option C0 also has a relatively low risk; C1 is considered to have a higher risk factor than C0 due to the fact that the use of adhesive on all Kapton surfaces represents an unknown factor, that is, it is not known whether this adhesive would actually bond the Kapton surfaces together over the full range of operating temperatures and mechanical loading, or whether the bonds would break easily, resulting in a slip-plane system. Also, there were no test results at this point in time to indicate whether the slip-plane approach would result in acceptable mechanical stresses within the coil. Options F and F1 also scored relatively high; however, both had somewhat higher risk because of the developmental aspects of the 3D woven fiberglass materials used.

This initial technical assessment served primarily as a starting point to guide continuing development of alternative insulation systems and mechanical analysis of the coil winding pack. As three-dimensional (3D) woven fiberglass products (tapes and corner fill preforms) were developed, used to fabricate models for electrical and mechanical testing, and subjected to mechanical analysis, it gradually became clear that the best approach to meeting overall TPX requirements was in the following type of system: Kapton tape overwrap on CICC; thin 3D S2 fiberglass tape overwrap of Kapton and CICC, and 3D S2 fiberglass woven preform for conductor corner void fill. This system is very similar to option F or F1, except that the Kapton tape is used without adhesive.

Appendix 7.3

TECHNICAL ASSESSMENT OF TPX CS/PF WINDING OPTIONS

There are two basic alternatives for winding the conductor comprising the CS/PF coils: 1) a true spiral winding, in which each turn continuously spirals in or out one conductor width for each 360° rotation; or 2) a constant radius winding, in which each turn is wound at a fixed radius, and as the point of 360° rotation is approached, turns sharply in or out one conductor width to move to a new fixed radius for the next turn. The sharp bend of the conductor to a new fixed radius is referred to as a "jog." Displacement of conductor from one layer ("pancake") to the next is referred to as a "transition."

In addition to the two basic alternative winding methods, there are many variations (options) in the way the jogs and transitions can be made. These alternative winding methods as well as the options for jogs and transitions impact the manufacturability of the coils (and hence the cost and schedule), and, in addition, will likely have other effects such as perturbations to magnetic field quality.

Layer-layer transitions can be "stacked" (located one over the other for the full coil height) or "clocked" (advanced or retarded relative to the actual turn completion point). Transitions introduce a component of coil current flowing along the coil axis, which can produce undesirable field harmonics. (Ideally, current should only flow in symmetrical, circular paths.) However, every transition in which current moves up from one layer to the next is somewhere balanced by a return lead in which current flows back down through the center of the coil. This geometric arrangement of "up" and "down" current components introduces field harmonics. One of the objectives of magnetic analysis is to find ways of arranging the jogs, transistions, and return leads so as to minimize their impact on field quality and yet allow for a manufacturable coil.

Because of the widespread impact of these coil winding methods and variations on coil manufacturability (which impacts cost, schedule, reliability, etc.) and coil performance (for example, magnetic field quality), we performed a technical assessment to determine the best overall approach to CS/PF coil winding. This assessment was performed by first selecting the various approaches, then choosing the evaluation criteria (manufacturability, operational performance, cost, schedule, and risk), enumerating and tabulating the strengths and weaknesses of each alternative approach with respect to the evaluation criteria, establishing a grade 0 - 5 in each category (for each option considered), with 5 being best, and, finally, generating a total score for each alternative.

A brief description of the basic winding alternatives and options for jogs and transitions selected for the technical assessment study is given in the text in Section 4.1.2. One approach to a manufacturable arrangement for transistions is to allow an angular region for each transition equal to 360° divided by the number of transistions (that is, the number of layers less one). For example, if there are eight layer-layer transitions, 360°/8 = 45°. Thus each transistion is made over an angular region (arc) of 45°, and the starting point of each transition is "clocked," that is, advanced (or retarded) 45° relative to the starting point of the previous transition. At the top of the coil, then, the total clocking is 360° for eight transitions, and the return lead passes through the coil and joins the input lead at about the same angular location.

An alternative approach is to make the transitions in as small an angular region as possible, and "stack" the transitions, one above the other. This arrangement also allows the return lead to join the input lead at about the same angular location. An analysis was performed to determine the relative merits of the two approaches in regard to perturbations to magnetic field quality. The analysis revealed that both approaches are workable, but that the "stacked" approach is more easily manufacturable; the "clocked" transistion approach requires the return lead to spiral down (or up) through the center of the coil in such a way that it exactly

compensates for the axial currents introduced at various angular locations by the clocked transistions.

The winding options considered in the technical assessment and the evaluation criteria used for scoring each option are listed below:

Winding Options

1. Spiral Winding
2. Constant Radius Winding
   - 2A Linear jog
   - 2B "S" jog, nested
   - 2C "S" jog, fixed radii, modified spacing
   - 2D Double radius jog

Evaluation Criteria

1. **Manufacturability**
   Considerations:
   Tooling - winding out
   Tooling - winding in
   Tooling - jogs
   Spacer insertion during winding (prior to reaction)
   Conductor insulation process
   Taping heads
   Barrier insertion (if used)
   Corner void fill
   Coil repacking
   Insertion of large gap fill
   Inspectability
   Safety considerations

2. **Operational Performance**
   Considerations:
   Mechanical
   Effects of hoop stresses
   "Clocking" of jogs/transistions
   Thermal
   Layer-layer heat transfer
   Magnetic
   Field harmonics due to radial current flow
   Effects of "clocking" of jogs/transitions

3. **Cost**
   Considerations:
   Cost of development
   Cost of tooling and equipment
   Cost of labor

4. **Schedule**
   Considerations:
   Development time
   Process cycle time

5. **Risk (H/M/L)**
   Considerations:
   Technical risk (H/M/L)
   Schedule risk (H/M/L)
   Cost risk (H/M/L)

RESULTS

The numerical scores of the technical assessment are presented in the text, Section 4, Table 4.3, and the following Tables summarize the strengths and weaknesses judged for each option, including the overall grade given in each category, and total score for the option. The continuous spiral winding method had the best score, resulting in the most easily manufacturable approach with lowest risk.

TPX CS/PF WINDING OPTIONS TRADE STUDY

Description of Option: Spiral winding; layer-layer transitions "clocked" or "stacked."

Evaluation Criteria	Grade	Strengths	Weaknesses
Manufacturability	4.5	1. No turn-turn jogs, hence no tooling required for jogs. Easier to insulate with automated taping heads. Also easier to install corner fill with no jogs. 2. Turns relatively easy to separate for insulating and reassembly. 3. Final turn complete before transition to next pancake (no fractional turns). However, this depends on "clocking" scheme. 4. No nesting of turn-turn jogs, hence more flexibility to absorb minor turn length deviations within the entire pancake. 5. Simpler algorithm required for roll former control.	1. Requires active control on tooling to generate constantly increasing (or decreasing) radius; this does not appear to be a problem. 2. or Requires approximation with two or more radii per turn. 3. Requires tapered gap fillers for ID and OD. 4. Conductor corner void fill choices limited since conductors do not "line up" vertically (layer-layer) 5. Each pancake (layer-layer) transition may add a fractional turn to coil (if "clocking" used); one or more turns (total) may be added to coil. Also, width of pancake may be increased by fractional turn; for example, if pancake is six full turns and clocking angle is 45 degrees, then 7-1/8 conductor widths are required for full pancake.
Operational Performance	5 5 5 Ave. 5	Mechanical: No jogs to perturb hoop stresses. Thermal: Lower peak conductor T, higher margin. Magnetic: Satisfactory provided that transitions are "stacked" and return lead is routed near "stacked" transitions. If transitions are "clocked," return lead must follow helical path along clocked transitions.	

Cost	5	1. No development costs for tooling for jogs. 2. No delays in winding process to install turn-turn jogs.	
Schedule	5	Minimal development time; winding process straightforward.	
Risk	L	1. Minimum number of operations being performed on conductor; hence, reduced risk of error, and reduced risk of conductor damage during processing. 2. Spiral winding algorithm already developed and functioning. Needs only to be modified for actual conductor cross section and turn count per layer. 3. Calculation of conductor length per 360 degrees is simpler (not complicated by additional bends associated with turn-turn jogs).	
Score	19.5		

TPX CS/PF WINDING OPTIONS TRADE STUDY

Description of Option: Constant radius winding; nested "S" turn-turn jogs; layer-layer transitions "clocked" or "stacked."

Evaluation Criteria	Grade	Strengths	Weaknesses
Manufacturability	3.5	1. Constant radius for each turn relatively simple to form and verify. 2. More options for conductor corner void fill since conductors "line up" vertically (layer-layer). 3. For six full turns, seven conductor widths required.	1. Can not make complete turn before jog to next turn. 2. Requires reverse bends. 3. Tooling/program changes required at each jog; change to small reverse radius, then small "normal" radius, then new radius of next turn. 4. Turns may "hang up" in jog area when separating for insulation and reassembly. 5. Accurate "nesting" required to avoid additional radial build.
Operational Performance	3 4 5 Ave. 4	Magnetic: Satisfactory provided that transitions are "stacked" and return lead is routed near "stacked" transitions. If transitions are "clocked," return lead must follow helical path along clocked transitions.	Mechanical: Jogs perturb hoop stresses; overall effect not yet known. Thermal: Higher peak conductor T, lower margin.
Cost	3		Increased tooling costs for reverse bends.
Schedule	3		Increased development time for tooling for reverse bends; longer winding time.
Risk	M		Increased risk associated with tooling development.
Score	13.5		

TPX CS/PF WINDING OPTIONS TRADE STUDY

Description of Option: Constant radius winding; "S" jog turn-turn with spacing modified to allow fixed radii; layer-layer transitions "clocked" or "stacked."

Evaluation Criteria	Grade	Strengths	Weaknesses
Manufacturability	4	1. Constant radius for each turn relatively simple to form and verify. 2. More options for conductor corner void fill since conductors "line up" vertically (layer-layer). 3. For six full turns, seven conductor widths required.	1. Can not make complete turn before jog to next turn. 2. Requires reverse bends. 3. Tooling/program changes required at each jog; change to small reverse radius, then small "normal" radius, then new radius of next turn. 4. Modified spacing reduces "hang-up" problems but requires longer jog region and generates small "banana" voids.
Operational Performance	3 4 5 Ave. 4	Magnetic: Satisfactory provided that transitions are "stacked" and return lead is routed near "stacked" transitions. If transitions are "clocked," return lead must follow helical path along clocked transitions.	Mechanical: Jogs perturb hoop stresses; overall effect not yet known. Thermal: Higher peak conductor T, lower margin.
Cost	3		Increased tooling costs for reverse bends.
Schedule	3		Increased development time for tooling for reverse bends; longer winding time.
Risk	M		Increased risk associated with tooling development.
Score	14		

TPX CS/PF WINDING OPTIONS TRADE STUDY

Description of Option: Constant radius winding; linear turn-turn jog; layer-layer transitions "clocked" or "stacked."			
Evaluation Criteria	**Grade**	**Strengths**	**Weaknesses**
Manufacturability	3	1 Constant radius for each turn relatively simple to form and verify. 2. No reverse bends. 3. Minimum angular region required for jogs. 4. More options for conductor corner void fill since conductors "line up" vertically (layer-layer). 5. For six full turns, seven conductor widths required.	1. Can not make complete turn before jog to next turn. 2. Tooling/program changes required at each jog; change to straight conductor, then small radius, then new radius of next turn. 3. Requires straightening conductor for jog. 4. Turns may "hang up" in jog area when separating for insulation and reassembly. 5. Accurate "nesting" required to avoid additional radial build.
Operational Performance	3 4 5 Ave. 4	 Magnetic: Satisfactory provided that transitions are "stacked" and return lead is routed near "stacked" transitions. If transitions are "clocked," return lead must follow helical path along clocked transitions.	Mechanical: Jogs perturb hoop stresses; overall effect not yet known. Thermal: Higher peak conductor T, lower margin.
Cost	4	Lower tooling development costs than for "S" jogs (no reverse bends) but higher compared to spiral winding.	
Schedule	4		Increased development time for tooling (compared to spiral winding); longer winding time.
Risk	M		Increased risk associated with tooling development.
Score	15		

TPX CS/PF WINDING OPTIONS TRADE STUDY

Description of Option: Constant radius winding; double radius turn-turn jog; layer-layer transitions "clocked" or "stacked."

Evaluation Criteria	Grade	Strengths	Weaknesses
Manufacturability	2.5	1 Constant radius for most of each turn - relatively simple to form and verify. 2. No reverse bends. 3. More options for conductor corner void fill since conductors "line up" vertically (layer-layer). 4. For six full turns, seven conductor widths required.	1. Can not make complete turn before jog to next turn. 2. Requires tooling/program changes at each jog; change to large radius, then small radius, then new radius of next turn. 3. Turns may "hang up" in jog area when separating for insulation and reassembling. 4. Accurate "nesting" required to avoid additional radial build.
Operational Performance	3 4 5 Ave. 4	 Magnetic: Satisfactory provided that transitions are "stacked" and return lead is routed near "stacked" transitions. If transitions are "clocked," return lead must follow helical path along clocked transitions.	Mechanical: Jogs perturb hoop stresses; overall effect not yet known. Thermal: Higher peak conductor T, lower margin.

Cost	4	Lower tooling development costs than for "S" jogs (no reverse bends) but higher compared to spiral winding.	
Schedule	3		Increased development time for tooling (compared to spiral winding and linear jog); longer winding time.
Risk	M		Increased risk associated with tooling development.
Score	13.5		

To: Distribution

Subject: PF Coil Dimensional Results Due to Thermal Contraction and Manufacturing Tolerances

Author: M. LaJeunesse, Westinghouse

References:

1. TPX-SPEC-14-0001, Rev 0, PF Magnet System Specification
2. TPX/MAG/SCHULT/95-005, Smeared Properties for Insulation as of 3/29/95

Introduction

Reference 1 specifies the coil current center locations at the operating temperature. In order to meet this requirement, the coil geometries and locations need to be specified at room temperature. The scope of this paper is to determine the PF coil dimensions at operating and room temperatures to support coil winding and insulating activities.

Requirements

Table 1 summarizes the requirements for each PF coil.

Table 1. Coil and Coil Current Center Requirements at Operating Temperature

Coil	TxP	Material	Rcc4 (meters)	Zcc4 (meters)
PF1U	6x20	Inco908	0.810	0.251
PF2U	6x16	Inco908	0.810	0.706
PF3U	6x10	Inco908	0.810	1.042
PF4U	6x10	Inco908	0.810	1.306
PF5U	8x16	Inco908	1.213	2.350
PF6U	6x20	316LN	3.758	2.144
PF7U	6x14	316LN	4.297	1.114

Assumptions

The following assumptions are made:

1. **Temperatures**
   Coil Operating Temperature 4 °K
   Room Temperature[1] 293 °K
2. **Nominal Conductor Dimensions**
   Conductor Size 0.022 meter (0.878 inch)
   Insulation Thickness 0.0008 meter (0.032 inch)
   Insulated Conductor Size 0.022 + 2*0.0008 = 0.024 meter (0.942 inch)
   Ground Wall Thickness 0.008 meter (0.312 inch)
   For the purposes of this study, the ground wall thickness is composed of all coil insulation wraps including the ground plane.
3. **Manufacturing Tolerances**
   The radial and pancake builds were developed through the Westinghouse Internally Funded Coil Program. These values represent the maximum allowable accumulation of tolerances that result from repaired anomalies such as banana gaps, as well as, size growth of conductor and insulation material.

---

[1] Room temperature defines the nominal temperature during magnet assembly and installation.

Total Radial Build	0.003 meter (0.12 inch)
Total Pancake Build	0.0015 meter (0.06 inch)

4. **Thermal Expansion/Contraction**

The coil coefficients of thermal contraction (αx, αy, and αz) are composites of the conductor and insulation properties. The coefficients for the insulation material differ in the three directions primarily due to differences in the insulation material's through thickness versus weave direction properties. See figure 1 for definition of each direction. These coefficients were developed in reference 2 and are summarized below:

Smeared Properties	**Inco908**	**316LN**
Radial, αx=	1.07E-05	1.33E-05
Axial, αy=	7.37E-06	9.89E-06
Circumferential, αz=	6.20E-06	9.88E-06

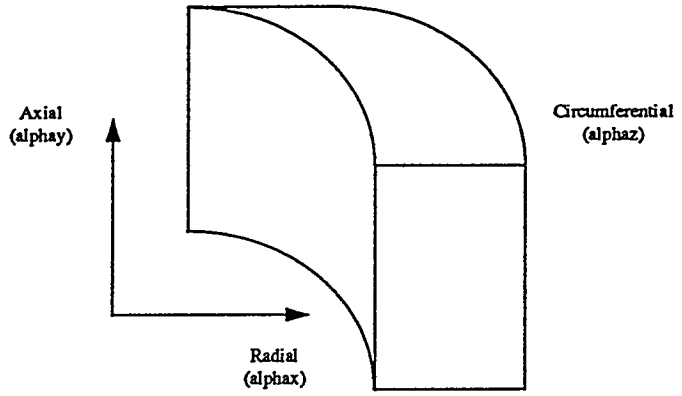


Figure 1. Directions of Typical Coil Cross Sectional Properties

Coil Dimensions

Overall coil dimensions are driven by the coil fabrication method. The PF1 through PF5 coils are spiral wound with transition areas occurring just prior to the end of the last turn of each layer (pancake). PF6 and PF7 are constant radius wound coils with transition areas occurring 3/4 of a turn prior to the end of the last turn of each layer. The following coil dimensions do not include lead or helium stub areas. All coil dimensions include ground wall, but do not include coil cases. The maximum radial width of each coil at room temperature is given by the following equation:

$$t293 = ((\text{Turns} + 1)*\text{Conductor Width}) + 2\,(\text{Groundwall}) + \text{Radial Build}$$

$$t293 = ((T + 1)*0.022) + 2\,(0.008) + 0.003 \qquad (1)$$

where, t293 is the radial width of the coil at 293 °K
T is the number of conductor turns at each layer

The maximum height of each coil at room temperature is given by the following equation:

$$h293 = (\text{Pancakes}*\text{ Conductor Width}) + 2\,(\text{Groundwall}) + \text{Pancake Build}$$

$$h293 = (P*0.022) + 2(0.008) + 0.0015 \qquad (2)$$

where, h293 is the height of the coil at 293 °K
P is the number of pancakes

The overall sizes of the coils at the operating temperature can be determined using the following equations:

$$t4 = t293(1 - (\alpha x)(\Delta T1)) \qquad (3)$$

$$h4 = h293(1 - (\alpha y)(\Delta T1)) \quad (4)$$

where, $\Delta T1 = 293 - 4 = 289\ °K$

Rcc and Zcc are specified in reference 1. These define the coil current center locations with respect to the TF vertical and midplane data. For the purposes of this study, it is assumed that the coil current center is coincident with the geometric center of the coil cross section. The following equations provide the room temperature radial coil dimensions and are developed from the operating temperature coil centers:

$$Rcc293 = Rcc4(1 + (\alpha z)(\Delta T1)) \quad (5)$$

$$Ric293 = Rcc293 - (t293)/2 \quad (6)$$

$$Roc293 = Rcc293 + (t293)/2 \quad (7)$$

The coil dimensions at the operating temperature can be determined using the following equations:

$$Ric4 = Rcc4 - (t4)/2 \quad (8)$$

$$Roc4 = Rcc4 + (t4)/2 \quad (9)$$

The coil dimensions at room temperature and operating temperature are provided in tables 2 and 3. Nominal dimensions do not include radial or pancake build manufacturing tolerances.

Table 2. Nominal PF Coil Geometry (meters) From CL of TF to Outside of Ground Wall at Room Temperature

Coil	t293	h293	Rcc293	Ric293	Roc293
PF1U	0.183	0.494	0.811	0.720	0.903
PF2U	0.183	0.399	0.811	0.720	0.903
PF3U	0.183	0.255	0.811	0.720	0.903
PF4U	0.183	0.255	0.811	0.720	0.903
PF5U	0.231	0.399	1.215	1.100	1.331
PF6U	0.183	0.494	3.769	3.677	3.860
PF7U	0.183	0.351	4.309	4.218	4.401

Table 3. Predicted PF Coil Geometry (meters) From CL of TF to Outside of Ground Wall at Room Temperature

Coil	t293	h293	Rcc293	Ric293	Roc293
PF1U	0.186	0.496	0.811	0.718	0.905
PF2U	0.186	0.400	0.811	0.718	0.905
PF3U	0.186	0.257	0.811	0.718	0.905
PF4U	0.186	0.257	0.811	0.718	0.905
PF5U	0.234	0.400	1.215	1.098	1.332
PF6U	0.186	0.496	3.769	3.676	3.862
PF7U	0.186	0.352	4.309	4.216	4.402

Coil Locations

The following summarizes the methodology used to determine the PF coil locations as provided in the following tables.

The vertical locations of each coil are dependent on the method of attachment to the TF structure. PF1 through PF4 are hung from the top of the TF structure and, thus, grow or shrink with respect to the top of the TF structure. The Zcc4 elevations shown in table 4 are with respect to the midplane of the TF structure at the operating temperature. These elevations are converted to a new reference plane located at the top surface of the PF4 Upper Coil (PF4U) and are represented by Ycc4. Note that Ycc is positive downward.

Room temperature locations (Ycc293) are developed using the appropriate αy for the coil. These are, then, transformed to Zcc293 elevations by the following equations:

$$Ycc4 = Htc4 - Zcc4 \quad (10)$$

$$Ycc293 = Ycc4(1 + (\alpha y)(\Delta T1))$$

$$= (Htc - Zcc4)(1 + (\alpha y)(\Delta T1)) \quad (11)$$

$$Zcc293 = Htc4(1 + (\alpha tf)(\Delta T1)) - Ycc293$$

$$= Htc4(1 + (\alpha tf)(\Delta T1)) - (Htc - Zcc4)(1 + (\alpha y)(\Delta T1))$$

$$= Htc4(\Delta T1)(\alpha tf - \alpha y) + Zcc4(1 + (\alpha y)(\Delta T1)) \quad (12)$$

where, Htc4 represents the distance from the midplane of the TF to the top of PF4 Upper Coil at operating temperature

αtf is the coefficient of thermal expansion of the TF structure

Table 4. PF1 Through PF4 Elevations (meters)

Coil	Zcc4	Ycc4	h4	h293	Ycc293	Zcc293	Ztc293	Zbc293
PF4U	1.306	0.128	0.256	0.257	0.128	1.310	1.438	1.182
PF3U	1.042	0.392	0.256	0.257	0.393	1.045	1.174	0.917
PF2U	0.706	0.728	0.399	0.400	0.730	0.709	0.909	0.509
PF1U	0.251	1.183	0.495	0.496	1.186	0.253	0.501	0.005
PF1L	-0.251	1.685	0.495	0.496	1.689	-0.250	-0.002	-0.498
PF2L	-0.706	2.140	0.399	0.400	2.145	-0.706	-0.506	-0.906
PF3L	-1.042	2.476	0.256	0.257	2.481	-1.043	-0.915	-1.171
PF4L	-1.306	2.740	0.256	0.257	2.746	-1.308	-1.179	-1.436

PF5 through PF7 are attached symmetrically about the TF structure midplane datum. The following equations are used to determine the PF5 through PF7 coil locations. The PF elevations (Z) are located with respect to the TF midplane and do not account for the thermal movement of the TF structure.

$$Zcc293 = Zcc4(1 + (\alpha y)(\Delta T1)) \quad (13)$$

$$Zbc293 = Zcc293 - (h293)/2 \quad (14)$$

$$Ztc293 = Zcc293 + (h293)/2 \quad (15)$$

$$Zbc4 = Zcc4 - (h4)/2 \quad (16)$$

$$Ztc4 = Zcc4 + (h4)/2 \quad (17)$$

Table 3. PF Coil Geometry (meters) From CL of TF to Outside of Ground Wall at Operating Temperature

Coil	Rcc4	Zcc4	t4	h4	Ric	Roc	Zbc	Ztc
PF5U	1.213	2.350	0.234	0.399	1.096	1.330	2.150	2.550
PF6U	3.758	2.144	0.186	0.494	3.665	3.851	1.897	2.391
PF7U	4.297	1.114	0.186	0.351	4.204	4.390	0.938	1.290

Table 5 defines the variables used in this paper.

Table 5. Legend

R c c X

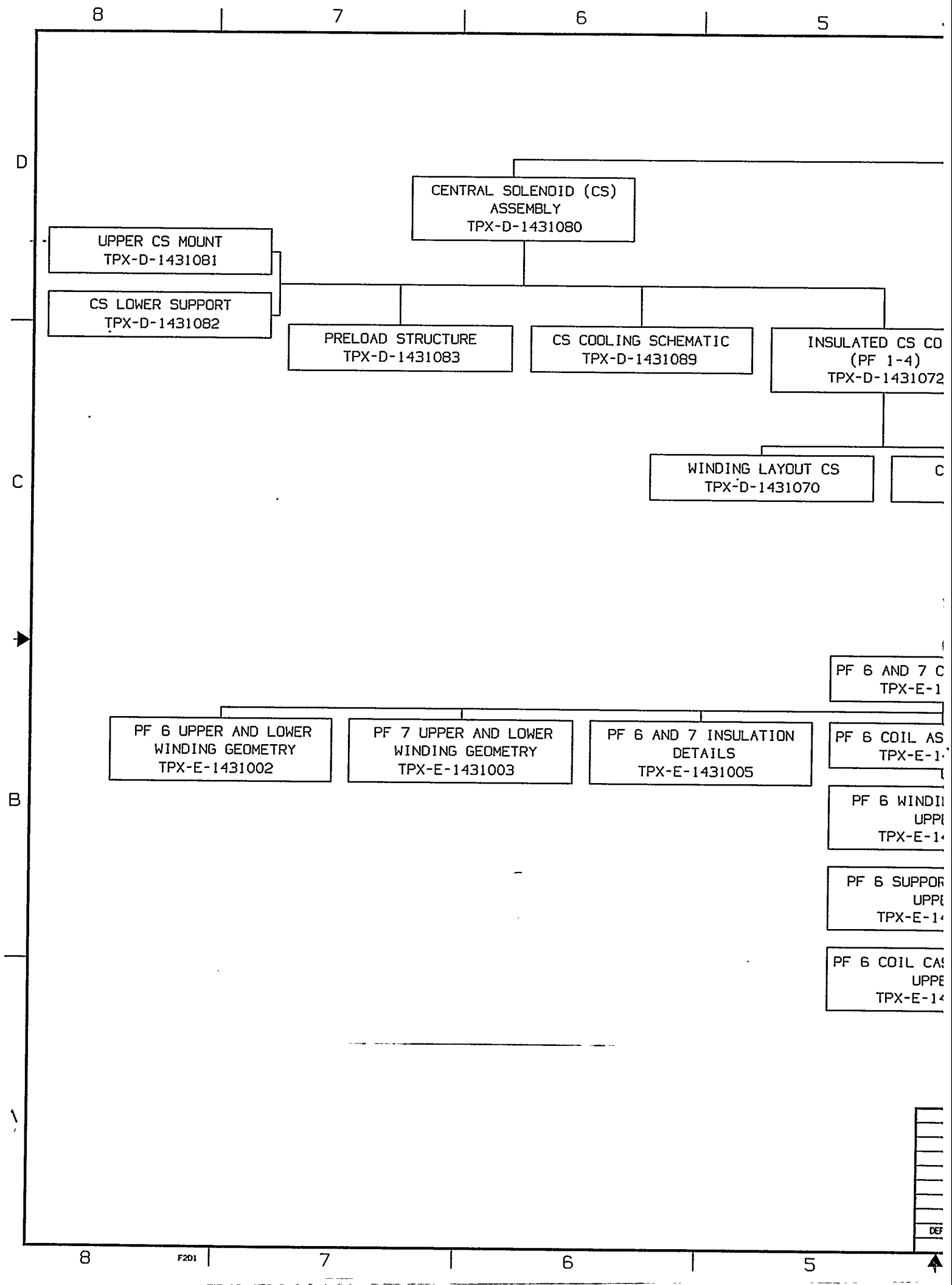
Temperature in °K
- 4 = operating temperature
- 293 = room temperature
- 326 = maximum installation temperature

Coil

Location of Measurement
- c = (geometric) center of coil
- i = inside radius
- o = outside radius
- t = top of coil
- b = bottom of coil

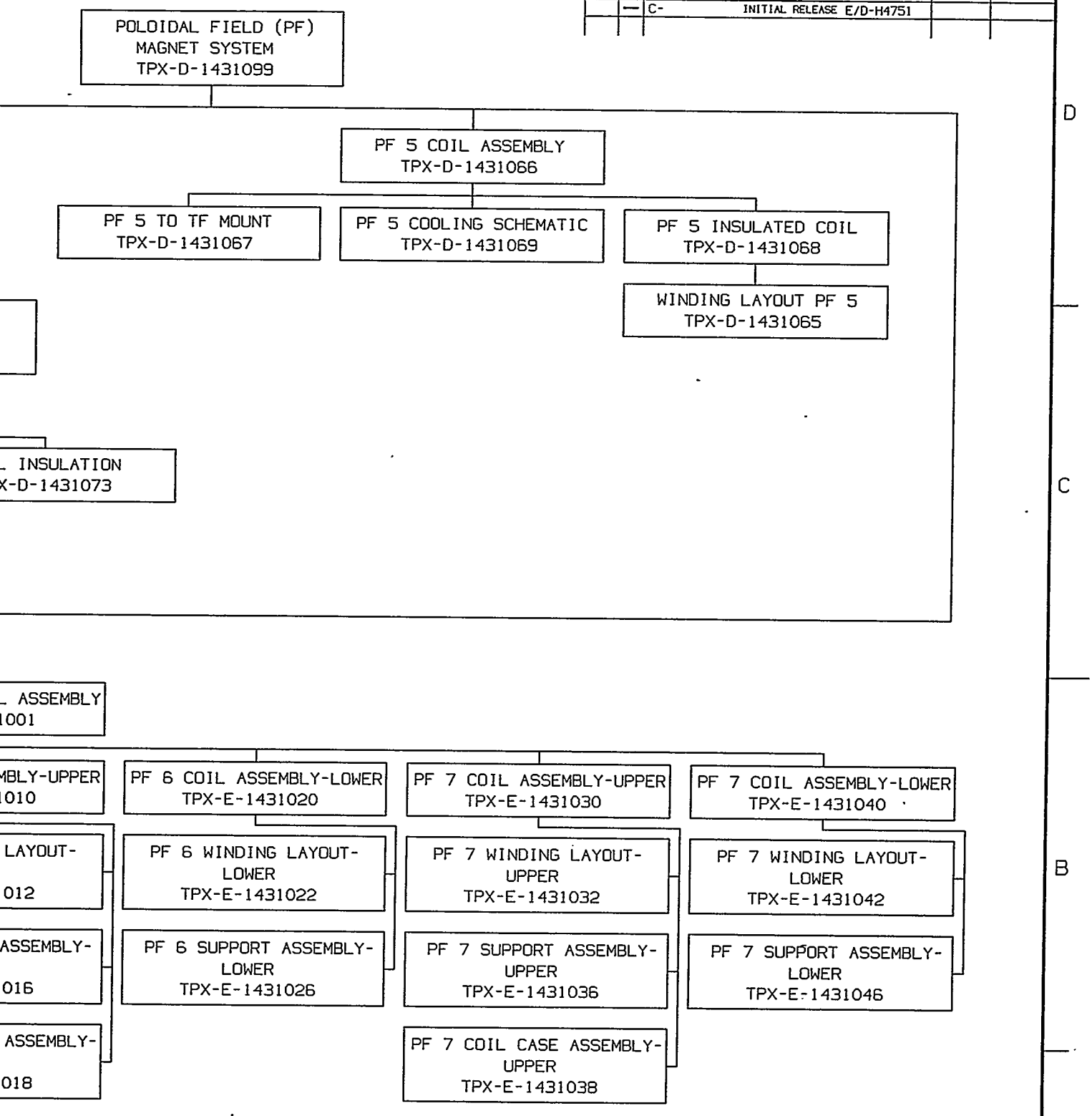
Type of Measurement
- R = radial dimension to center of coil cross section
- Z = vertical dimension to coil cross section
- t = thickness of coil in radial direction
- h = thickness of coil in vertical direction

Htc	**Height From TF Midplane to Top of PF4U Coil**
T x P	**Number of Turns x Number of Pancakes (layers)**


8
7
6
5
D
C
B
CENTRAL SOLENOID (CS) ASSEMBLY TPX-D-1431080
UPPER CS MOUNT TPX-D-1431081
CS LOWER SUPPORT TPX-D-1431082
PRELOAD STRUCTURE TPX-D-1431083
CS COOLING SCHEMATIC TPX-D-1431089
INSULATED CS CO (PF 1-4) TPX-D-1431072
WINDING LAYOUT CS TPX-D-1431070
C
PF 6 AND 7 C TPX-E-1
PF 6 UPPER AND LOWER WINDING GEOMETRY TPX-E-1431002
PF 7 UPPER AND LOWER WINDING GEOMETRY TPX-E-1431003
PF 6 AND 7 INSULATION DETAILS TPX-E-1431005
PF 6 COIL AS TPX-E-1
PF 6 WINDI UPP TPX-E-1
PF 6 SUPPOR UPP TPX-E-1
PF 6 COIL CA UPP TPX-E-1
8
F2D1
7
6
5

FSCH NO.	DWG NO.	SH
90099	A-15199	1

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



TPX-D-1431099.SH001.P00 DRAFT

SIGNED	DATE	DASH NO.	NEXT ASSY	USED ON
		NONE	NONE	TPX

LNL APPROVAL | APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± ---
3 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
DO NOT SCALE DRAWING

THIRD ANGLE PROJECTION

REF DWG:

CONTRACT: B254501

PREPARED	KAWASAKI	DATE 95-8-15
CHECKED		
ENGINEER		
APPROVED		

MARINE DIVISION
Westinghouse Electric Corporation
401 HENDY AVE. SUNNYVALE, CA. 94088

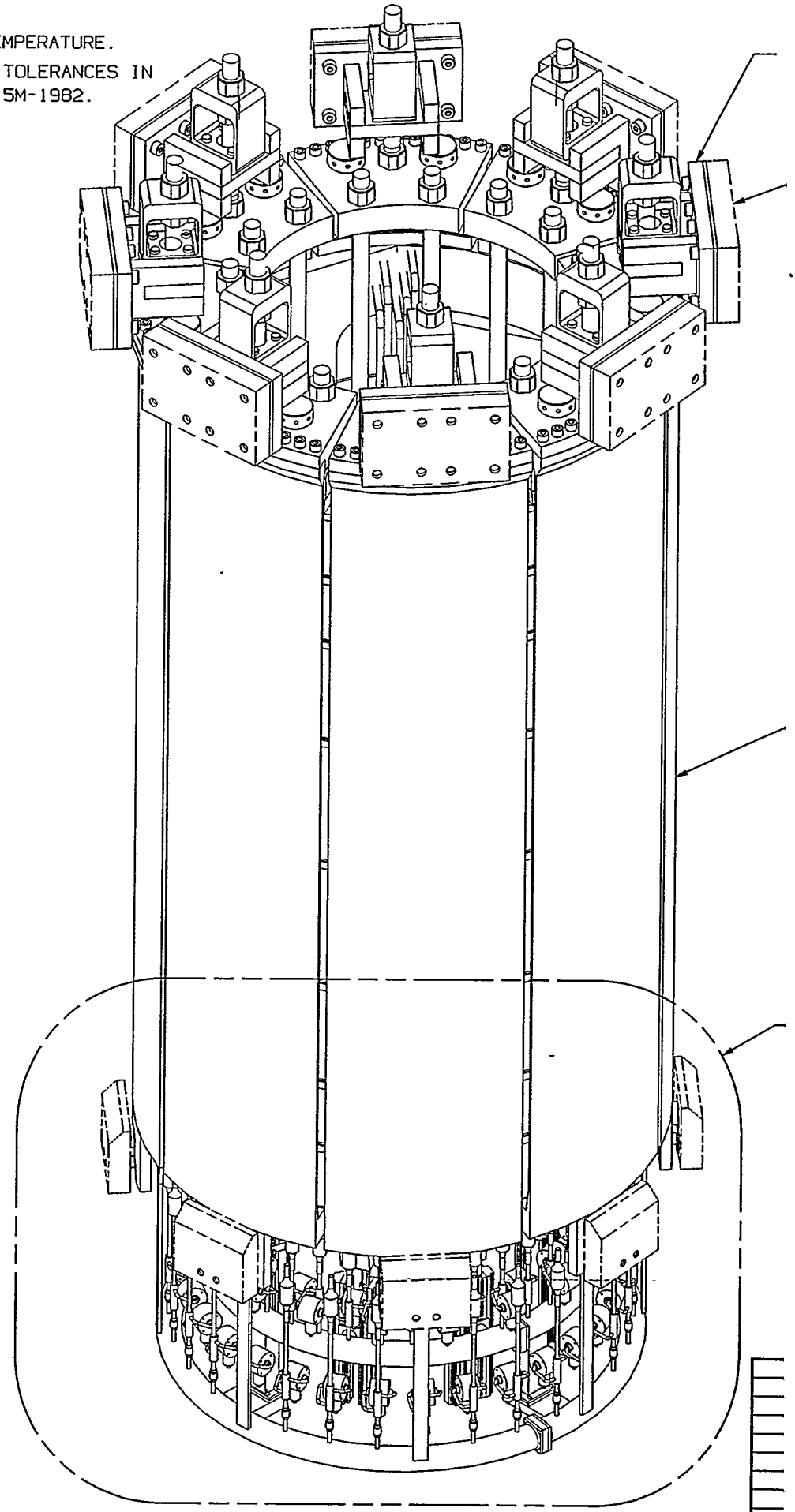
POLOIDAL FIELD (PF) MAGNET SYSTEM
DRAWING TREE

SIZE	FSCH NO.	DWG NO.
D	90099	A-15199

SCALE NONE | SHEET 1 OF 1

NOTES:

1. DIMENSIONS ARE AT ROOM TEMPERATURE.
2. INTERPRET DIMENSIONS AND TOLERANCES IN ACCORDANCE WITH ANSI Y14.5M-1982.



8 7 6 5

D C B A

8 F201 7 6 5

REV STATUS OF SHEETS			
SH 4	SH 3	SH 2	SH 1
-	-	-	-
-	-	SH 6	SH 5
-	-	-	-

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

PER CS MOUNT
X-D-1431081

UPPER CS INTERFACE
MOUNTING PAD
(PART OF TF STRUCTURE)

PRELOAD STRUCTURE
TPX-D-1431083

VIEW A A/5 2

TPX-D-1431080.SH001.P00 DRAFT

SIGNED	DATE	DASH NO.	NEXT ASSY	USED ON
		NONE	NONE	TPX

LLNL APPROVAL | APPLICATION

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± ---
3 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
DO NOT SCALE DRAWING

THIRD ANGLE PROJECTION

REF DWG:

CONTRACT: B254501

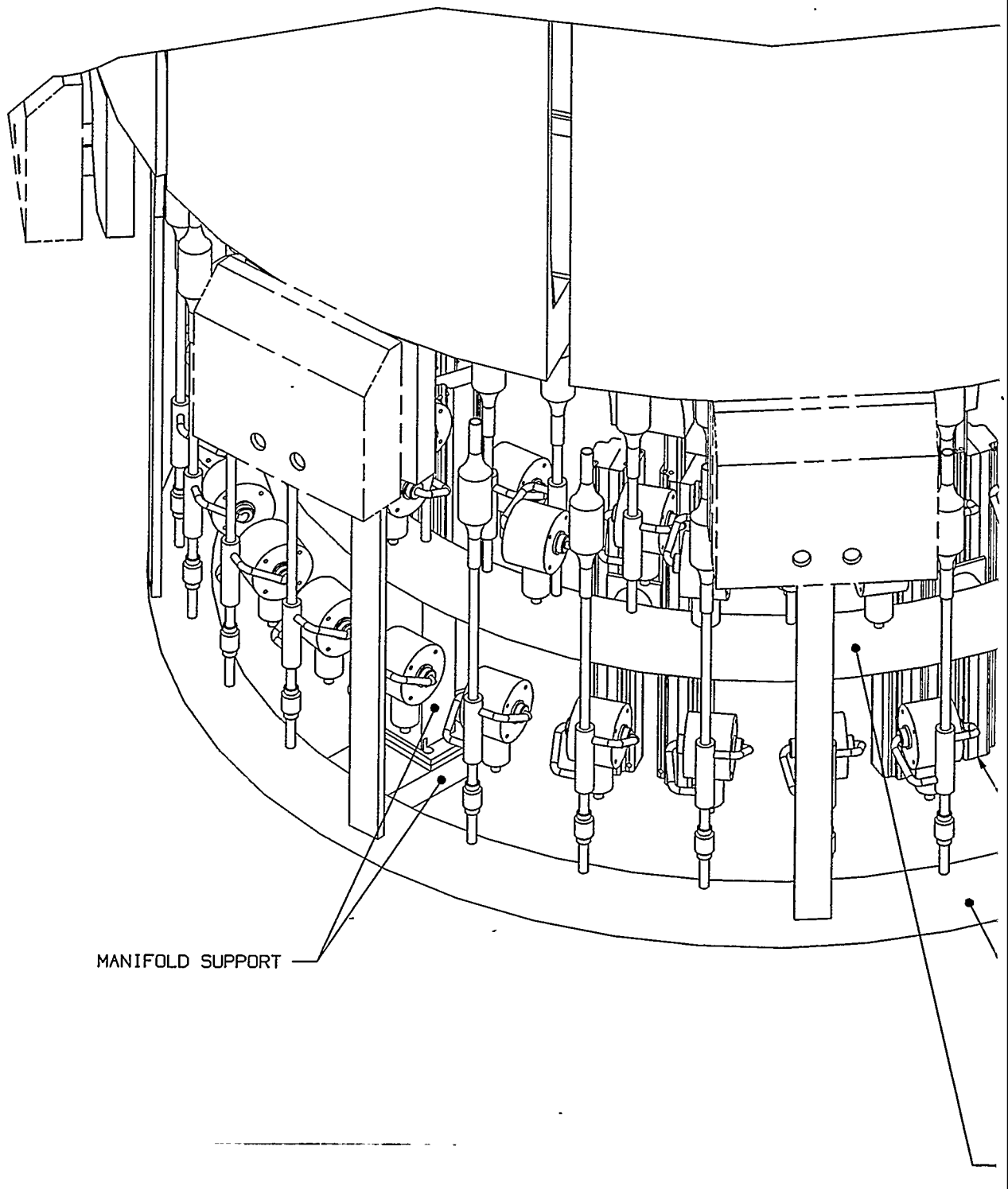
PREPARED KAWASAKI DATE DATE
CHECKED
DESIGNER
APPROVED

MARINE DIVISION
Westinghouse Electric Corporation
401 HENDY AVE. SUNNYVALE, CA. 94088

CS ASSEMBLY

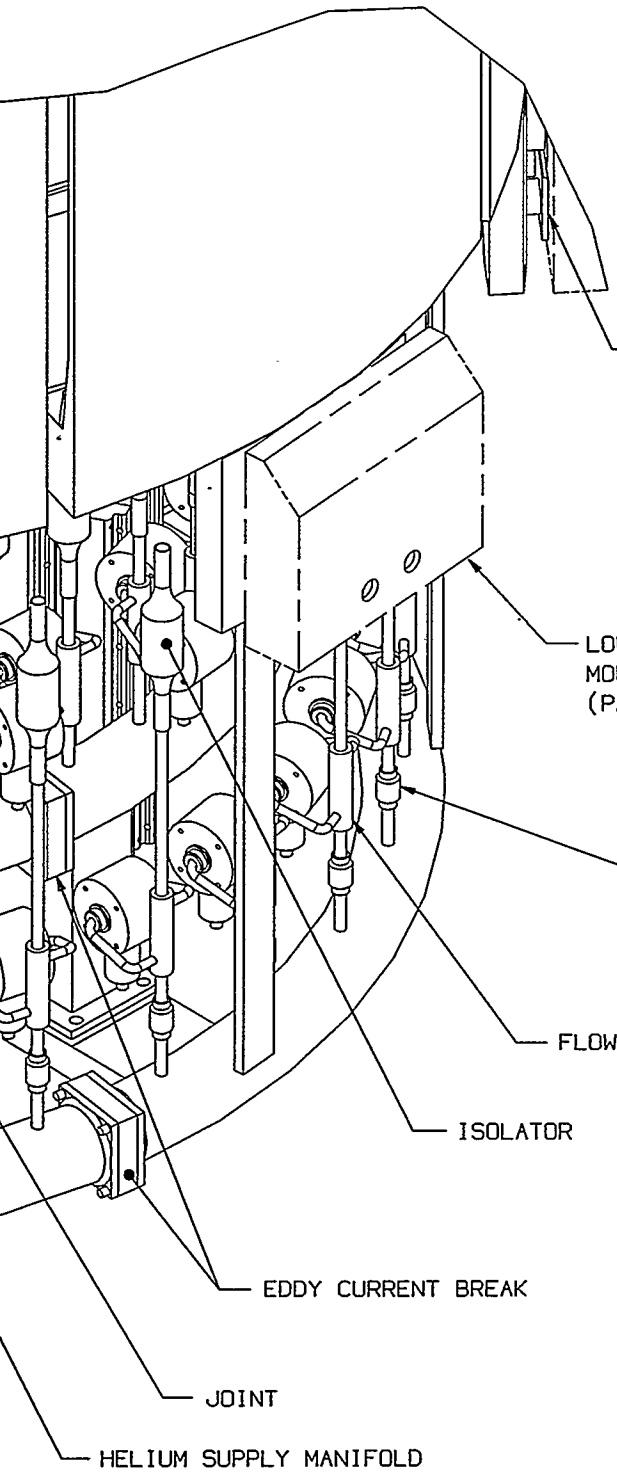
SIZE D | FSCH NO. 90099 | DWG NO. A-15180

SCALE NONE | SHEET 1 OF 6



VIEW A B/4 1

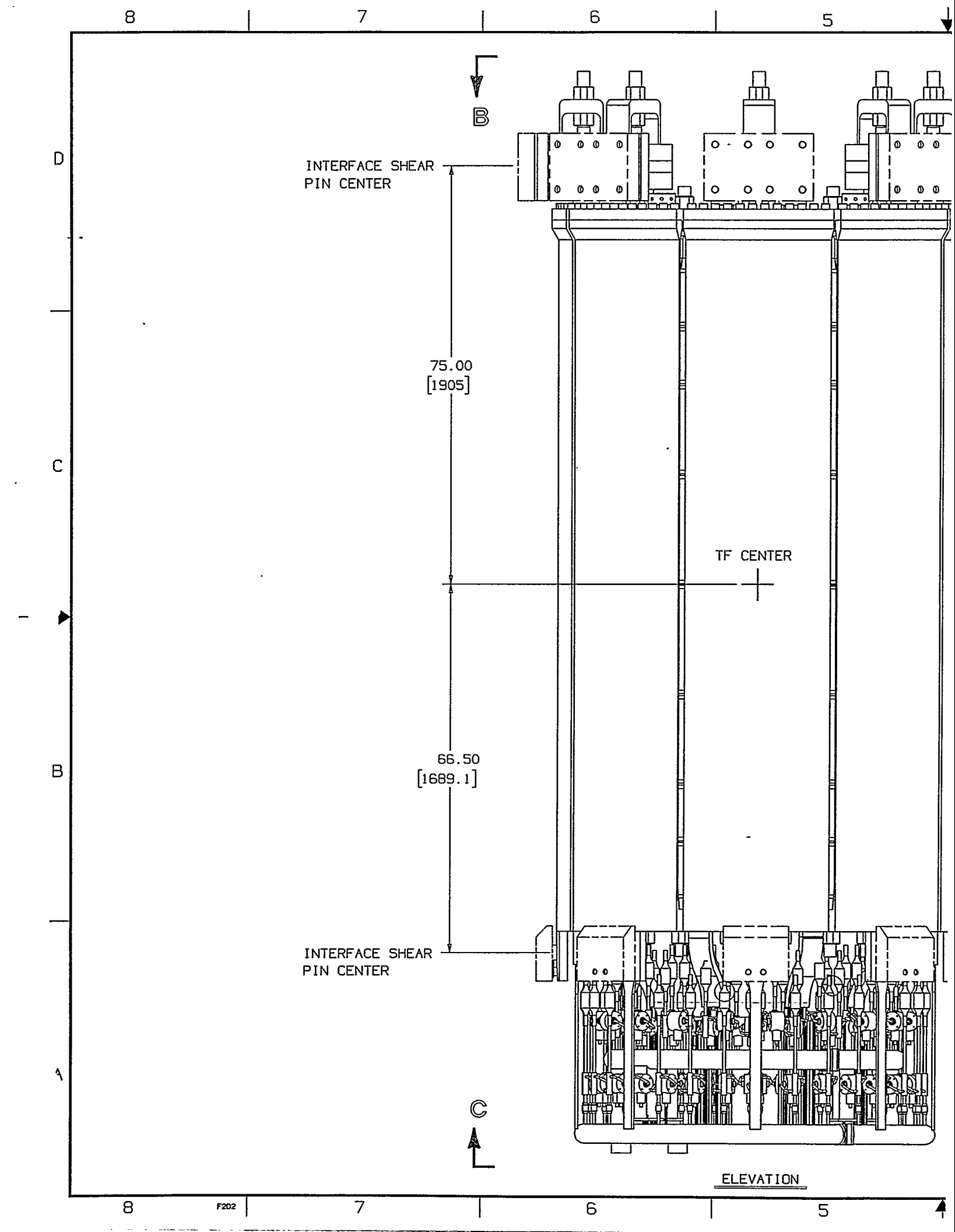
REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



NOTE: CS COOLING SCHEMATIC
SHOWN ON TPX-D-1431089.

TPX-D-1431080.SH002.P00 DRAFT

PREPARED KAWASAKI	DATE 95-8-14	SIZE D	FSCH NO. 90099	DWG NO. A-15180
CHECKED				
ENGINEER		SCALE NONE		SHEET 2


8
7
6
5
B
D
INTERFACE SHEAR
PIN CENTER
75.00
[1905]
C
TF CENTER
B
66.50
[1689.1]
INTERFACE SHEAR
PIN CENTER
A
C
ELEVATION
8
F202
7
6
5

FSCH NO. 90099 | DWG NO. A-15180 | SH 3

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

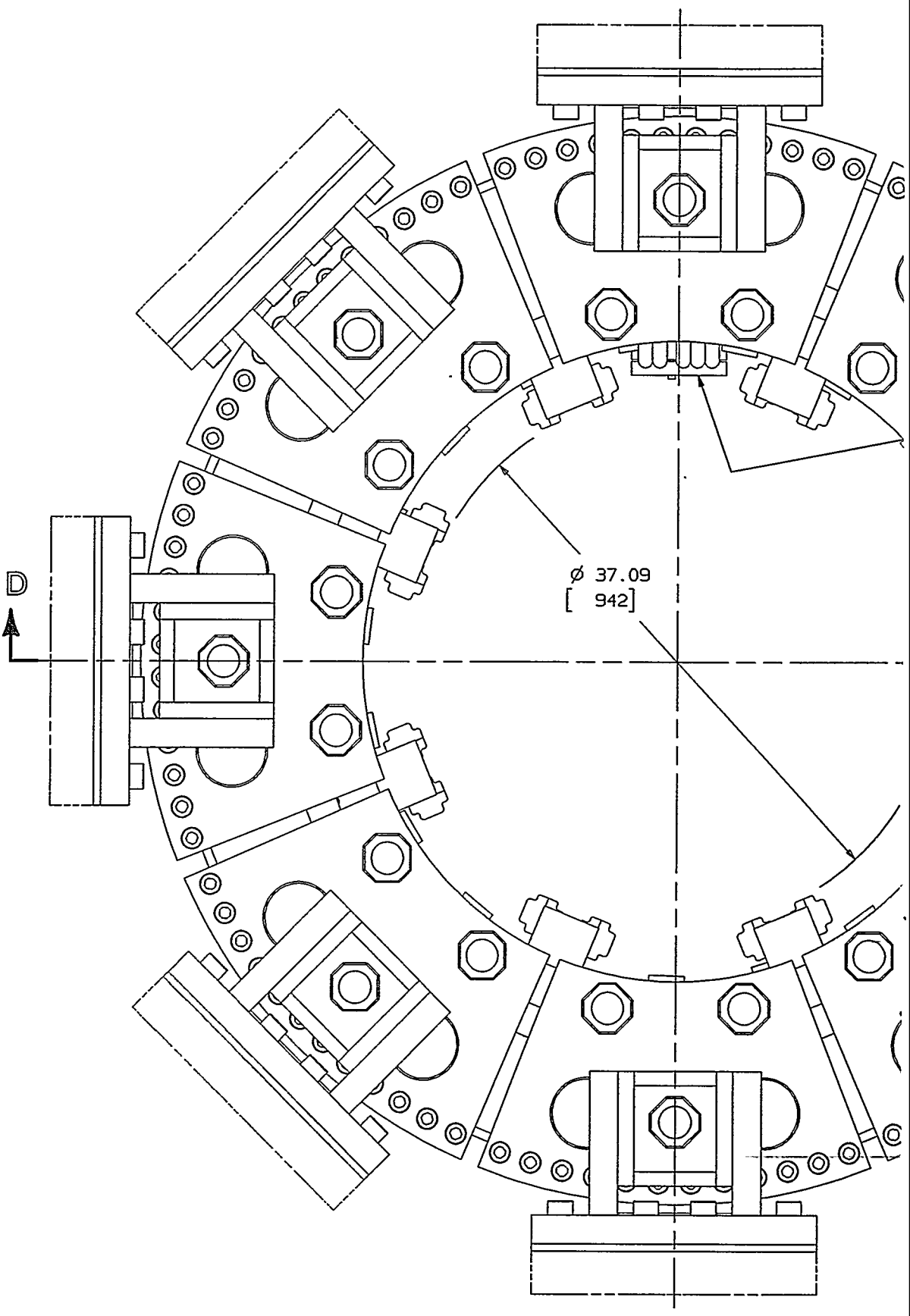
B A/5 4

C A/5 5

D C B A

TPX-D-1431080.SH003.P00 DRAFT

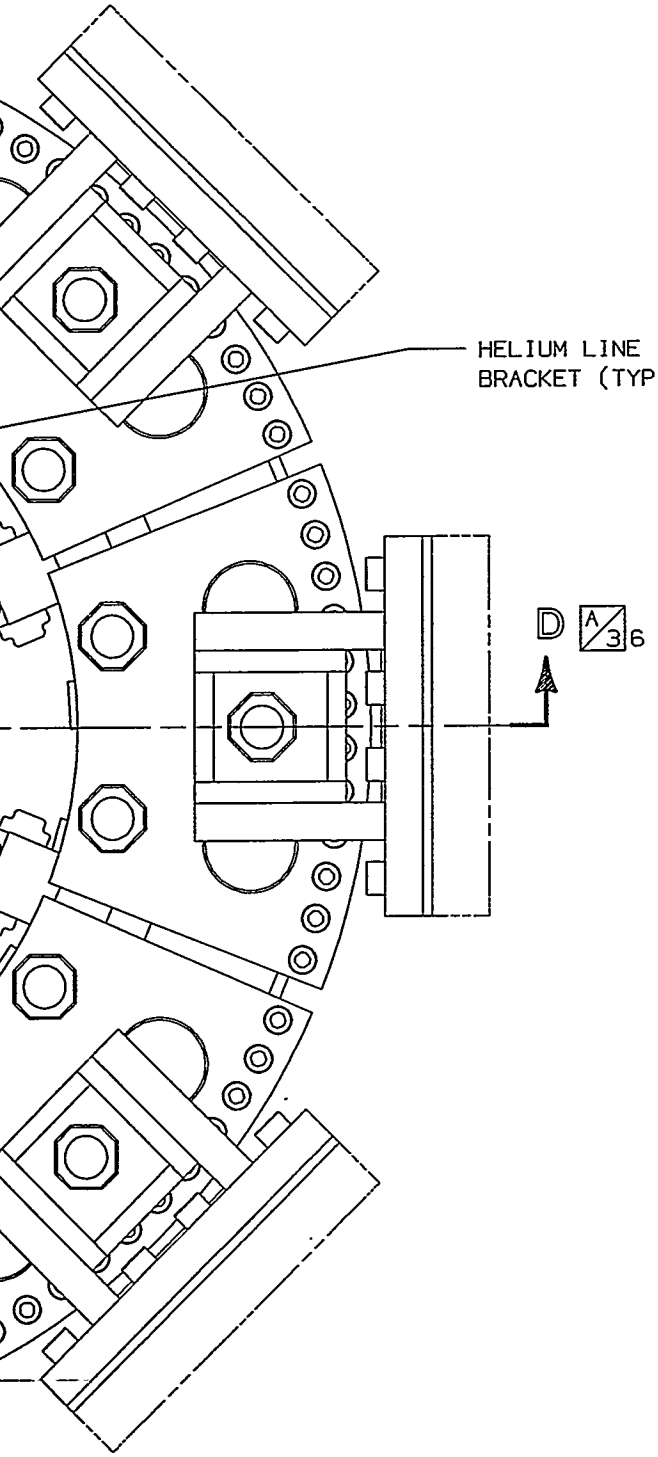
PREPARED KAWASAKI	DATE 95-8-14	SIZE D	FSCH NO. 90099	DWG NO. A-15180
CHECKED		SCALE 1/10		SHEET 3
ENGINEER				



VIEW B-B D/4 3

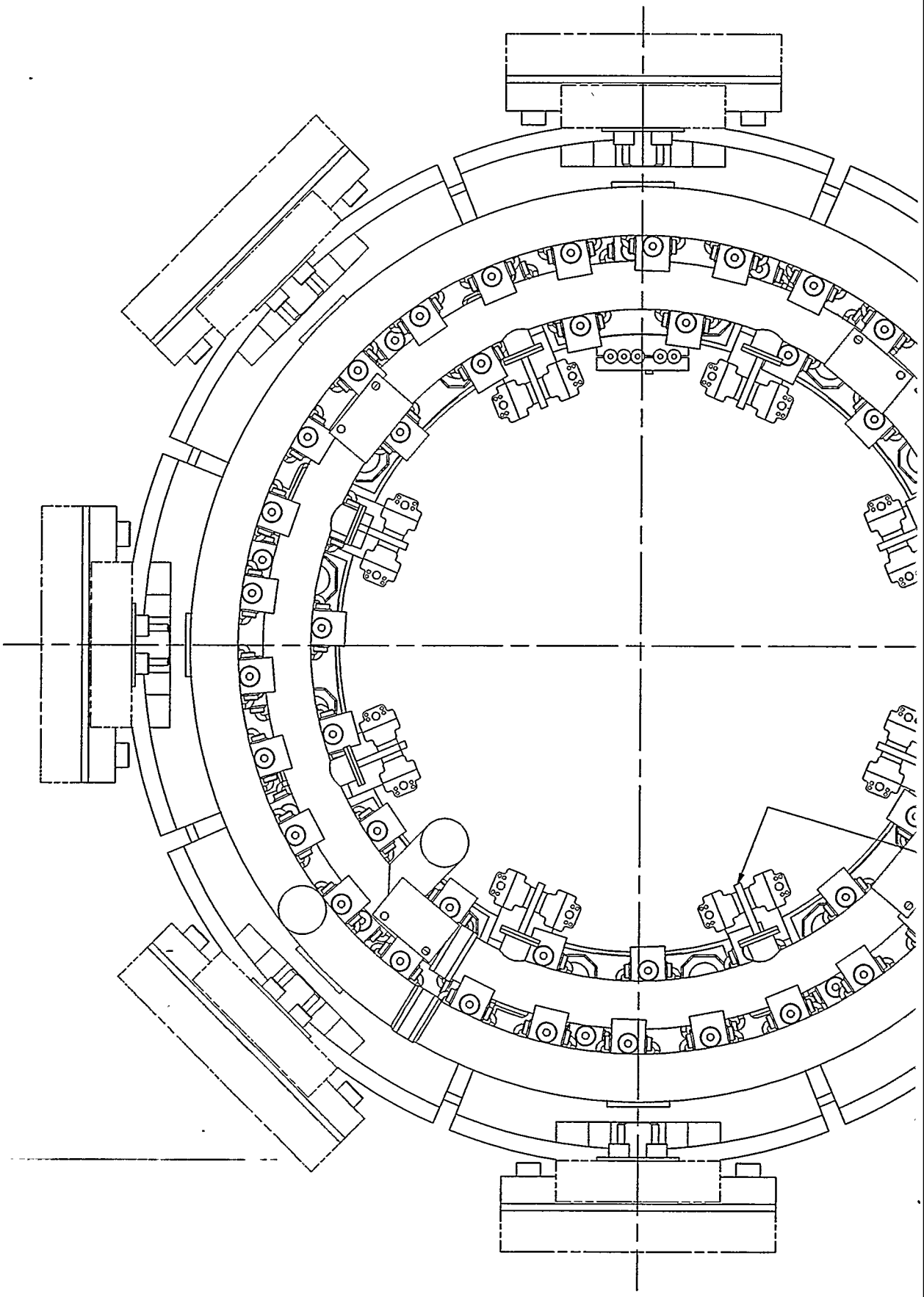
FSCH NO.	DWG NO.	SH
90099	A-15180	4

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



TPX-D-1431080.SH004.P00 DRAFT

PREPARED	DATE	SIZE	FSCH NO.	DWG NO.
KAWASAKI	95-8-14	D	90099	A-15180
CHECKED				
DESIGNER		SCALE 1/5		SHEET 4

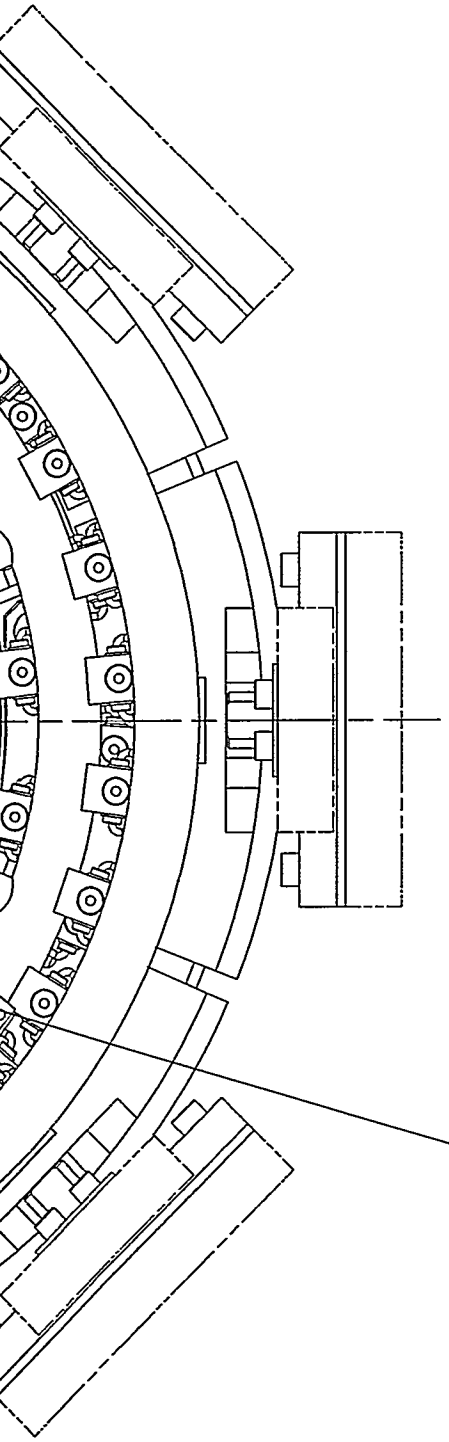


VIEW C-C A/4 3

FSCH NO.	DWG NO.	SH
90099	A-15180	5

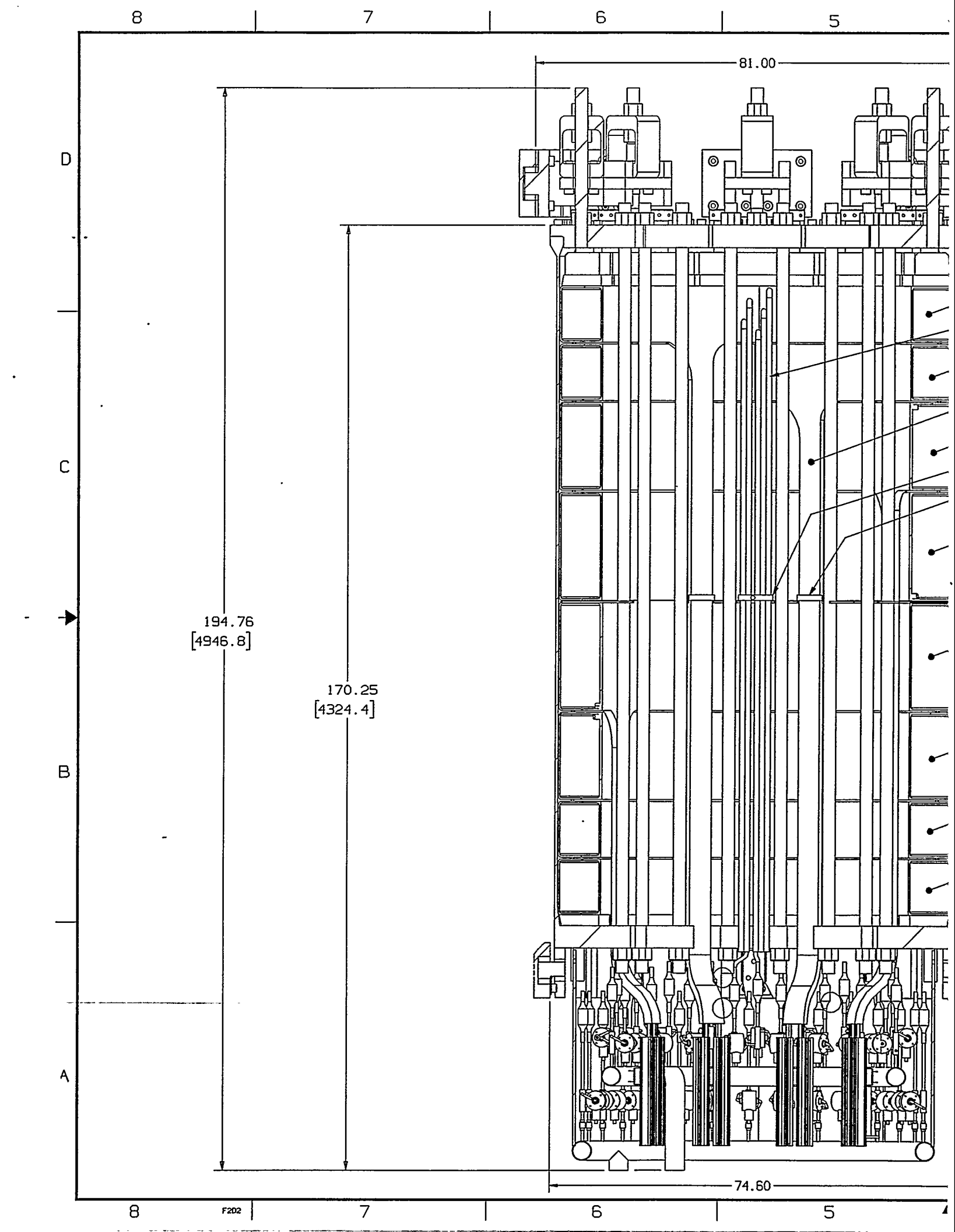
REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



TPX-D-1431080.SH005.P00 DRAFT

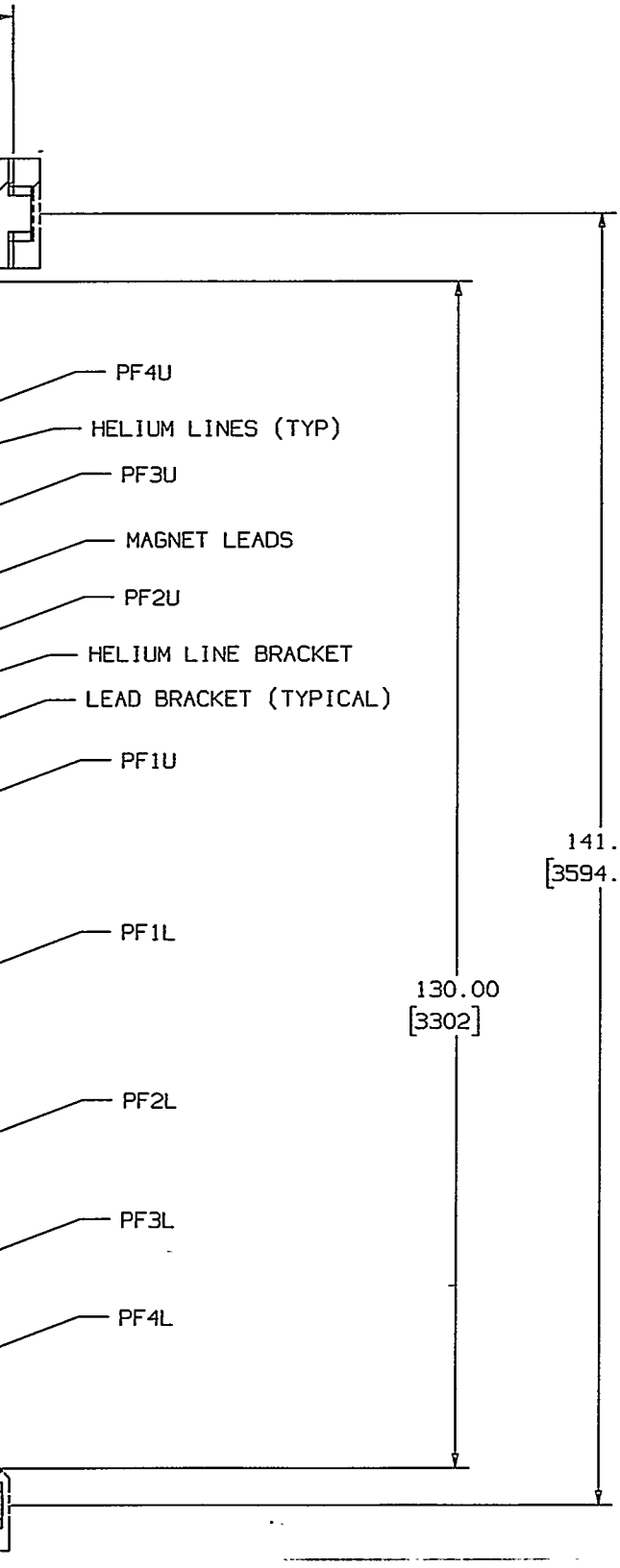
PREPARED KAWASAKI	DATE 95-8-14	SIZE D	FSCH NO. 90099	DWG NO. A-15180
CHECKED		SCALE NONE		SHEET 5
ENGINEER				


8
7
6
5
D
C
B
A
81.00
194.76
[4946.8]
170.25
[4324.4]
74.60
F202

FSCM NO.	DWG NO.	SH
90099	A-15180	6

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



NOTE: INTERFACE CS COILS
SHOWN ON TPX-D-1431072.

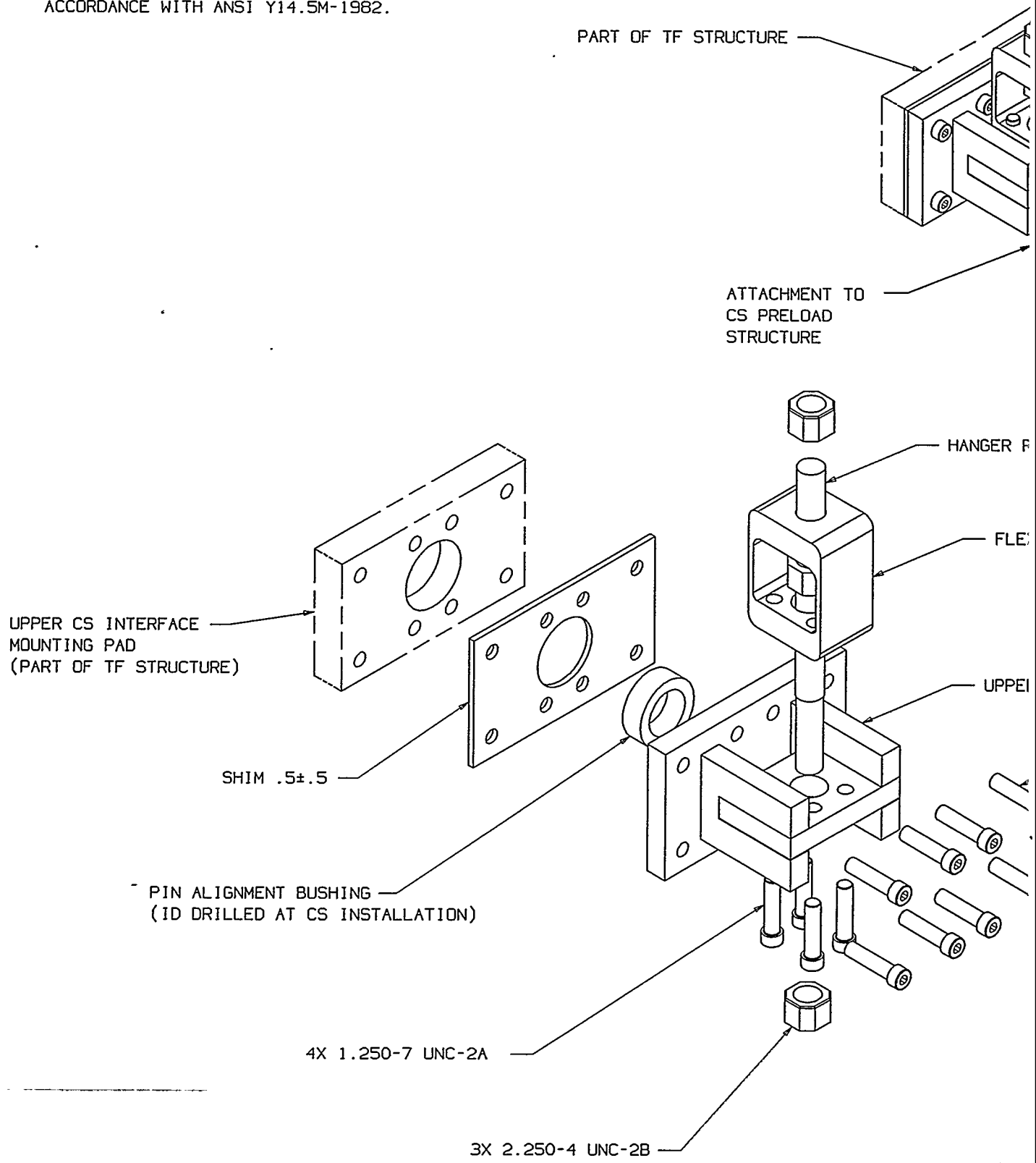
SECTION D-D C/3 4

TPX-D-1431080.SH006.P00 DRAFT

PREPARED KAWASAKI	DATE 95-8-14	SIZE D	FSCM NO. 90099	DWG NO. A-15180
CHECKED				
ENGINEER		SCALE NONE		SHEET 6

NOTES:

1. DIMENSIONS ARE AT ROOM TEMPERATURE.
2. INTERPRET DIMENSIONS AND TOLERANCES IN ACCORDANCE WITH ANSI Y14.5M-1982.

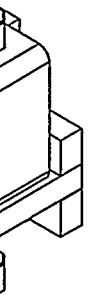


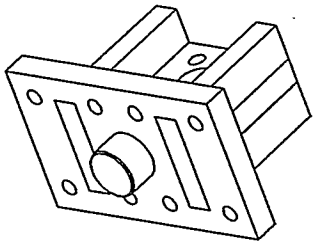
FSCH NO.	DWG NO.	SH
90099	A-15181	1

REV STATUS OF SHEETS		
SH 3	SH 2	SH 1
-	-	-

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		





OUNT

S SUPPORT MOUNT

8X 1.250-7 UNC-2A

TPX-D-1431081.SH001.P00 DRAFT

SIGNED	DATE	DASH NO.	NEXT ASSY	USED ON
		NONE	NONE	TPX

LLNL APPROVAL | APPLICATION

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± ---
3 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
DO NOT SCALE DRAWING

THIRD ANGLE PROJECTION

REF DWG:

CONTRACT: B254501

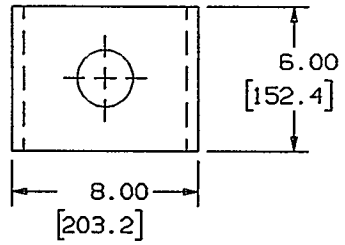
PREPARED	KAWASAKI	DATE DATE
CHECKED		
ENGINEER		
APPROVED		

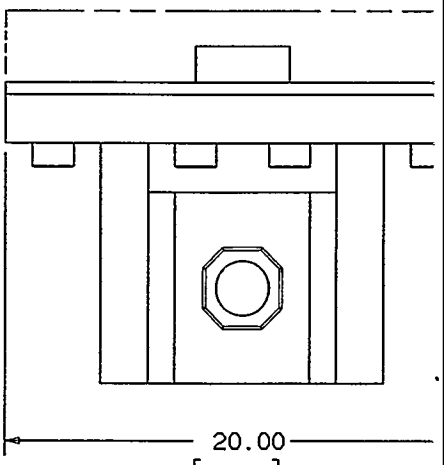
MARINE DIVISION
Westinghouse Electric Corporation
401 HENDY AVE. SUNNYVALE, CA. 94088

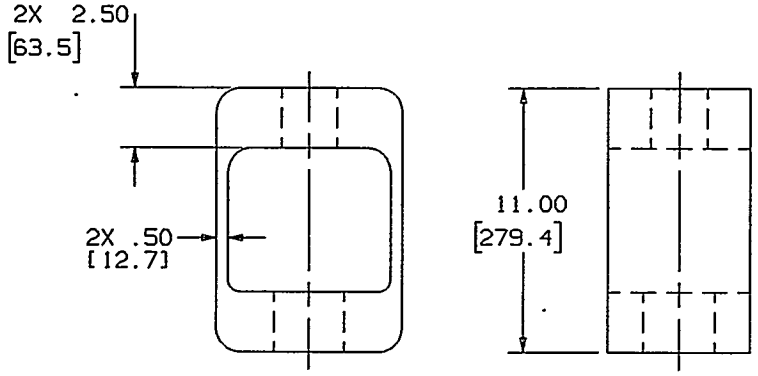
UPPER CS MOUNT

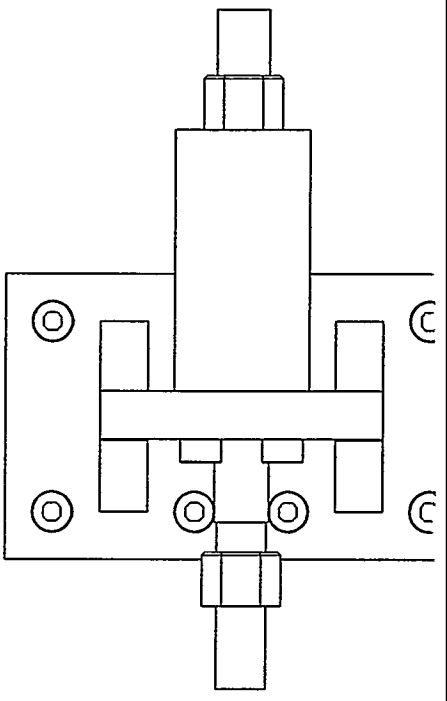
SIZE	FSCH NO.	DWG NO.
D	90099	A-15181

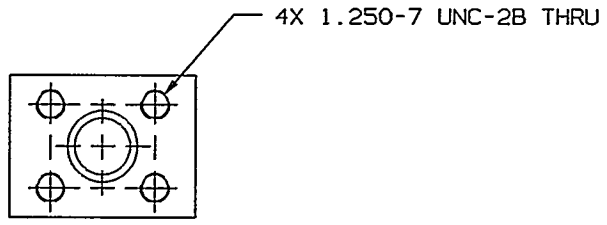
SCALE NONE | SHEET 1 OF 3


6.00
[152.4]
8.00
[203.2]

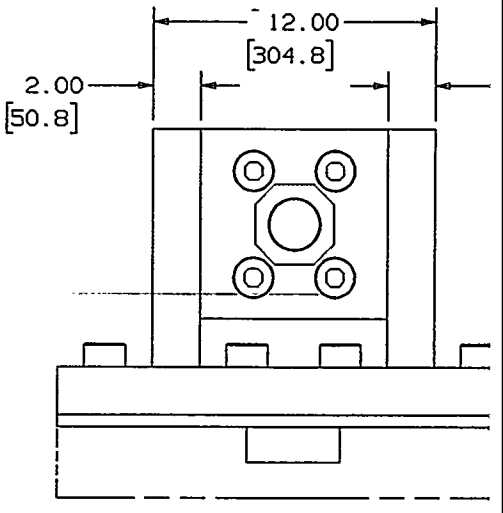

20.00
[508.0]


2X 2.50
[63.5]
2X .50
[12.7]
11.00
[279.4]



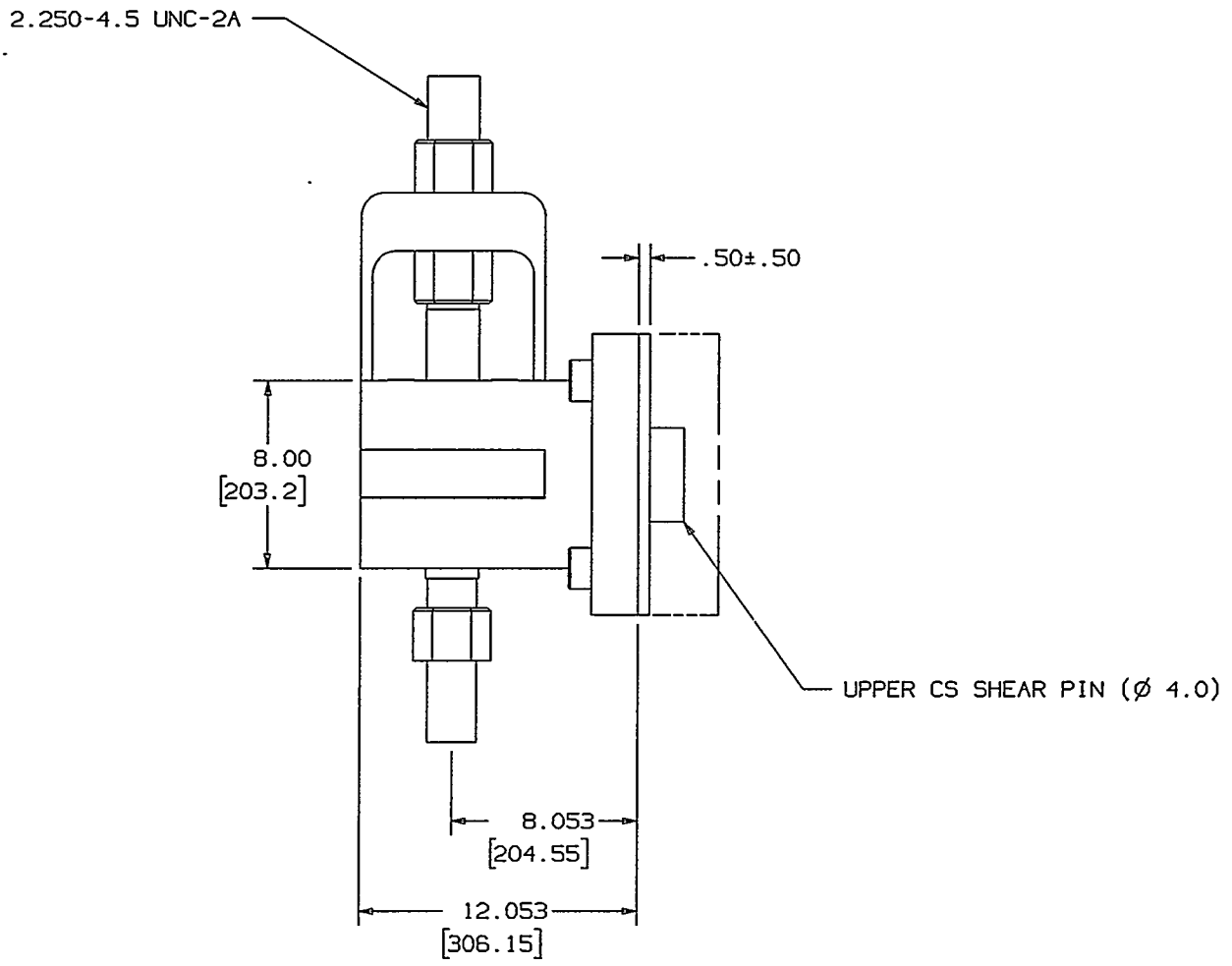

4X 1.250-7 UNC-2B THRU

FLEX MOUNT


12.00
[304.8]
2.00
[50.8]

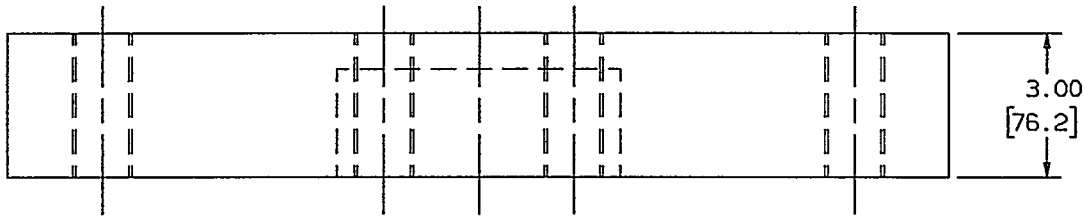
FSCH NO.	DWG NO.	SH
90099	A-15181	2

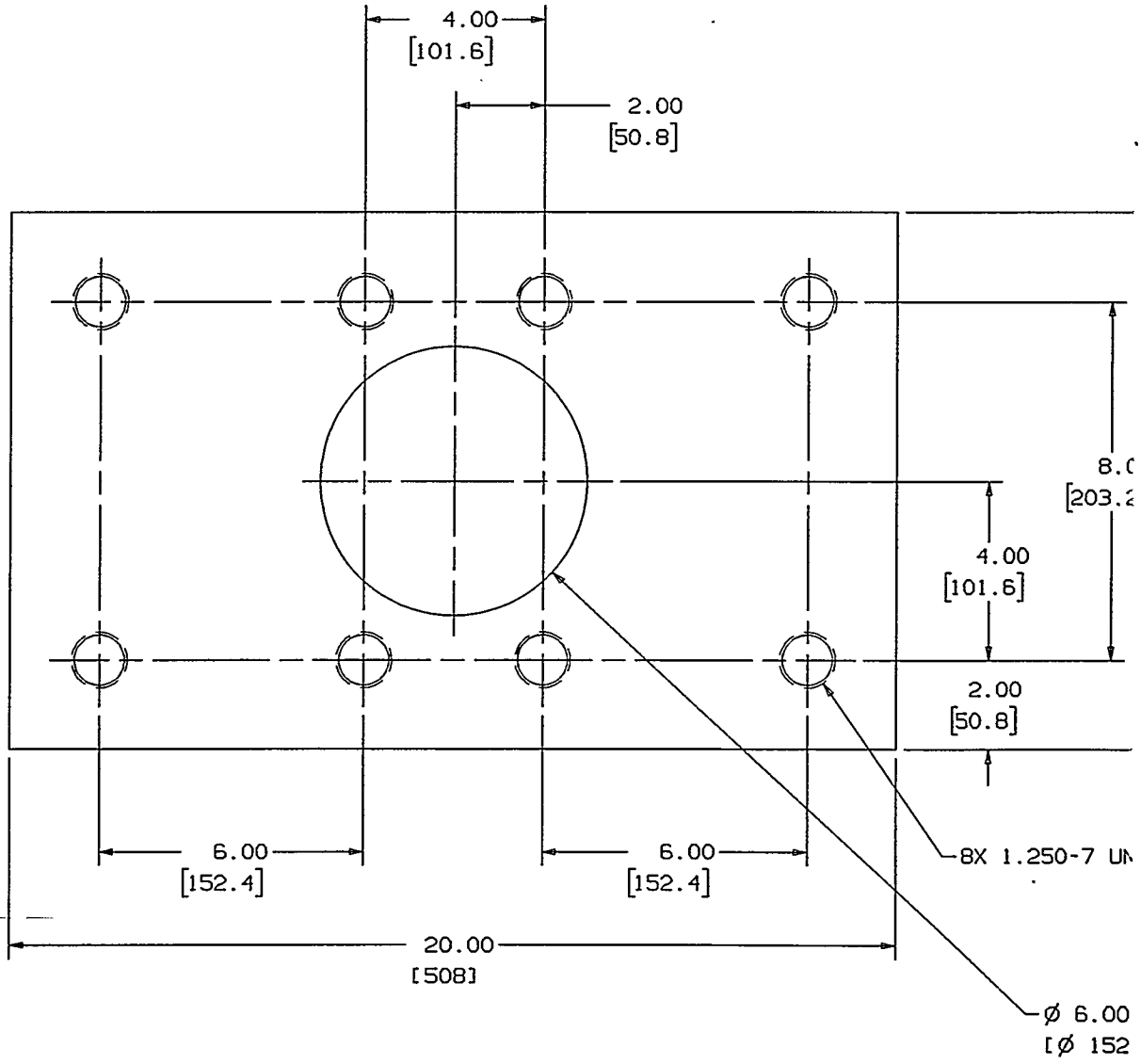
REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



TPX-D-1431081.SH002.P00 DRAFT

PREPARED	DATE	SIZE	FSCH NO.	DWG NO.
KAWASAKI	95-8-14	D	90099	A-15181
CHECKED		SCALE 1/4		SHEET 2
DESIGNER				





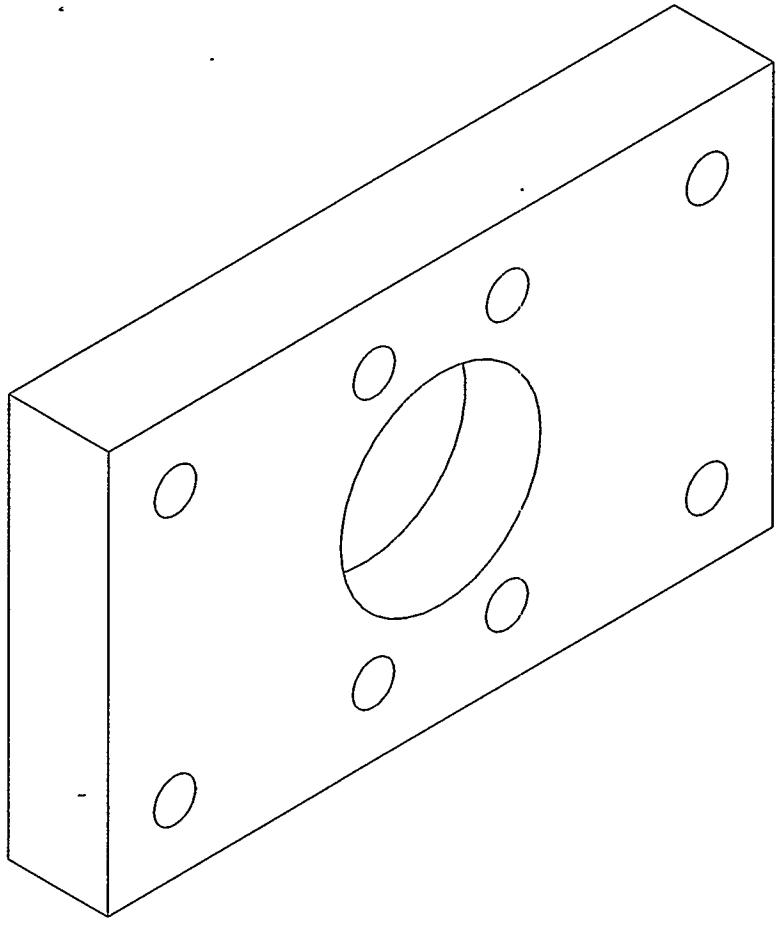
UPPER CS INTERFACE MOUNTING PAD

(PART OF TF STRUCTURE)

FSCH NO.	DWG NO.	SH
90099	A-15181	3

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



12.00
[304.8]

2B THRU

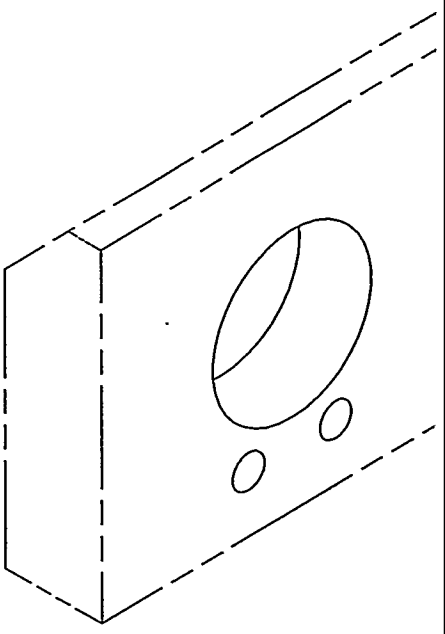
2.25
128.61

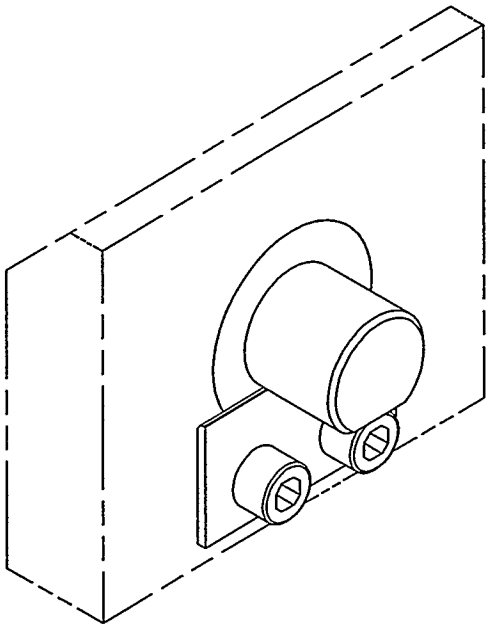
TPX-D-1431081.SH003.P00 DRAFT

PREPARED	DATE	SIZE	FSCH NO.	DWG NO.
KAWASAKI	95-8-14	D	90099	A-15181
CHECKED				
ENGINEER		SCALE 1/2		SHEET 3

NOTES:

1. DIMENSIONS ARE AT ROOM TEMPERATURE.
2. INTERPRET DIMENSIONS AND TOLERANCES IN ACCORDANCE WITH ANSI Y14.5M-1982.



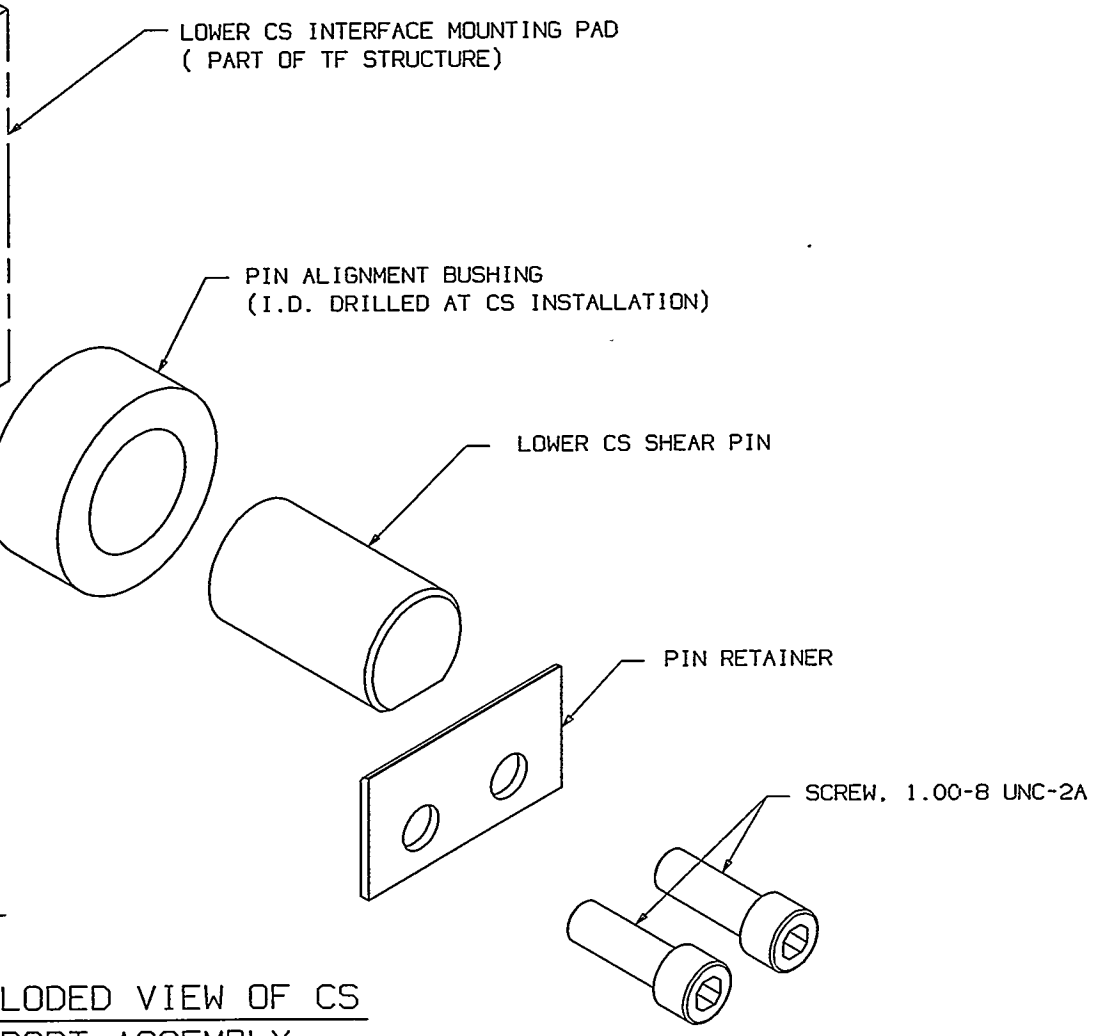


CS SUPPORT ASSEMBLED

FSCH NO.	DWG NO.	SH
90099	A-15182	1

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



LODED VIEW OF CS
PORT ASSEMBLY

TPX-D-1431082SH001.P00 DRAFT

PT	SIGNED	DATE	NONE DASH NO.	NONE NEXT ASSY	TPX USED ON
LLNL APPROVAL			APPLICATION		

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± ---
3 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION
REF DWG:

CONTRACT: B254501

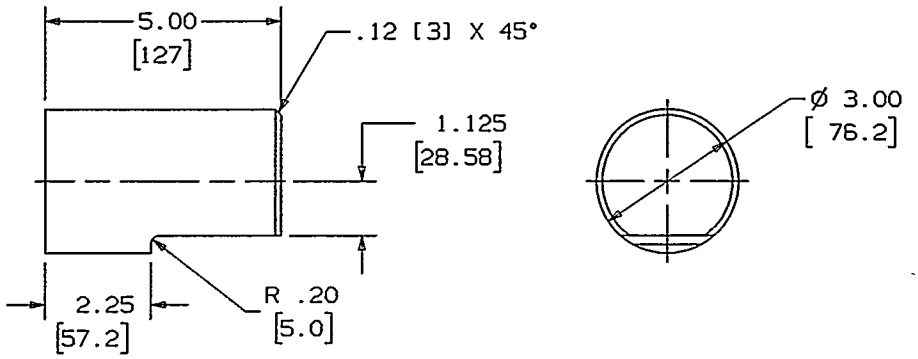
		DATE
PREPARED	L. UNDERWOOD	95-8-14
CHECKED		
ENGINEER		
APPROVED		

MARINE DIVISION
Westinghouse Electric Corporation
401 HENDY AVE. SUNNYVALE, CA. 94088

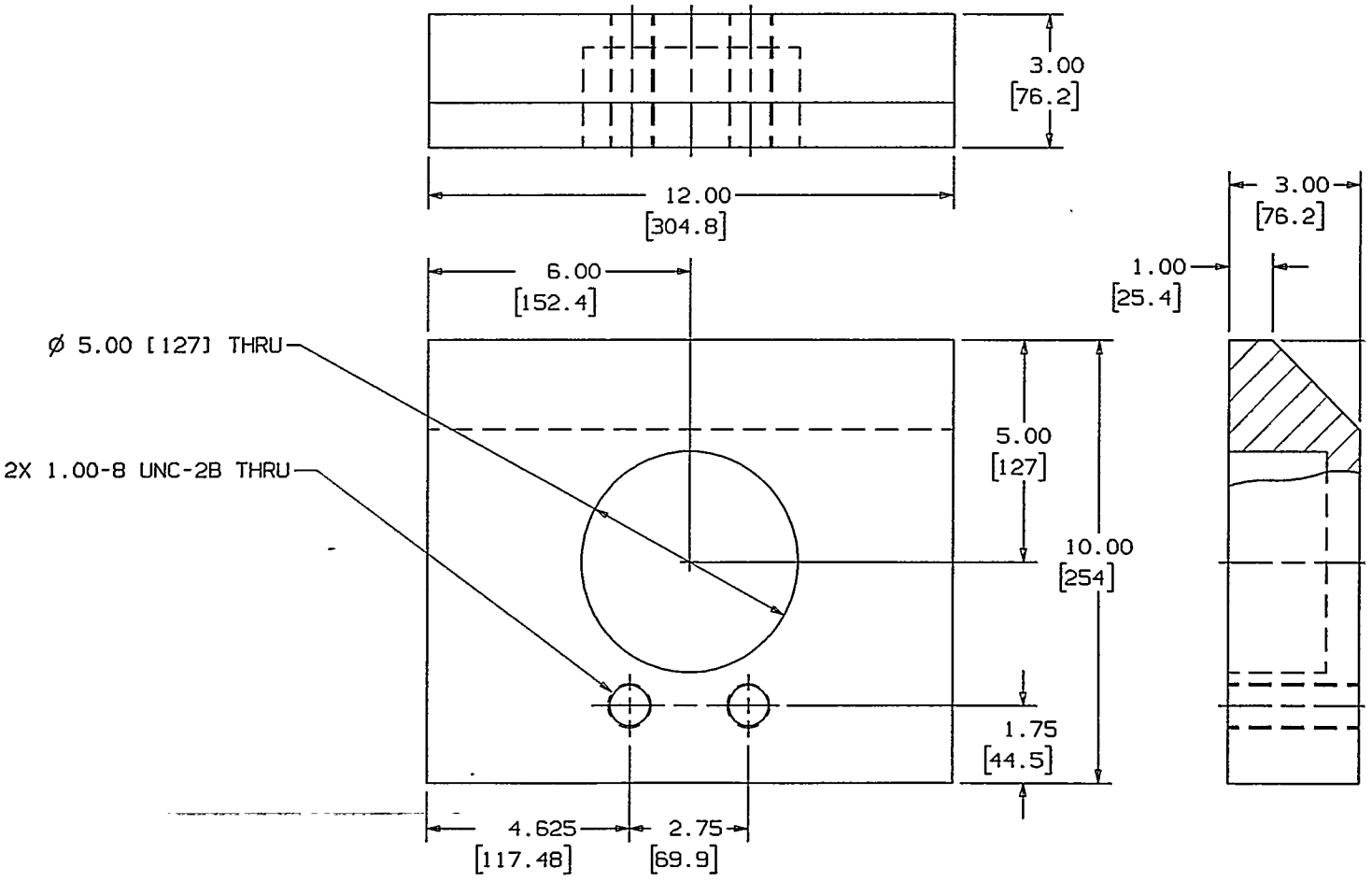
CENTRAL SOLENOID
LOWER SUPPORT

SIZE	FSCH NO.	DWG NO.
D	90099	A-15182

SCALE NONE SHEET 1 OF 2



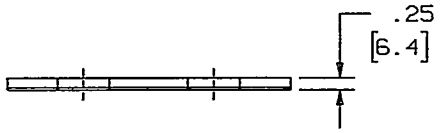
LOWER CS SHEAR PIN

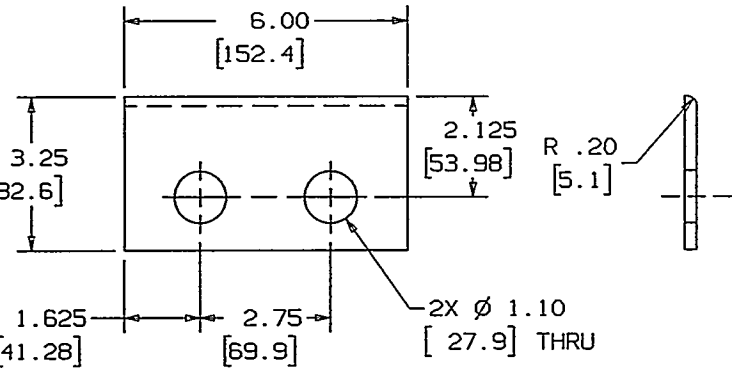


LOWER CS INTERFACE
MOUNTING PAD
(PART OF TF STRUCTURE)

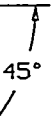
FSCM NO.	DWG NO.	SH
90099	A-15182	2

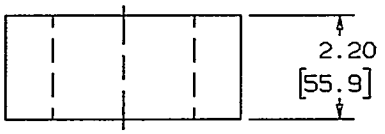
REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

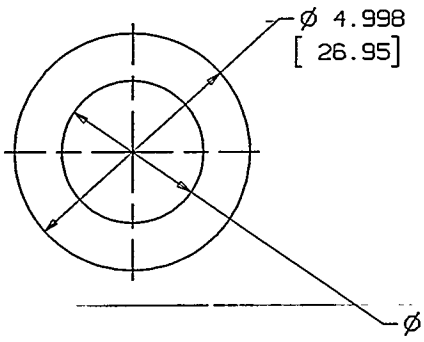




PIN RETAINER



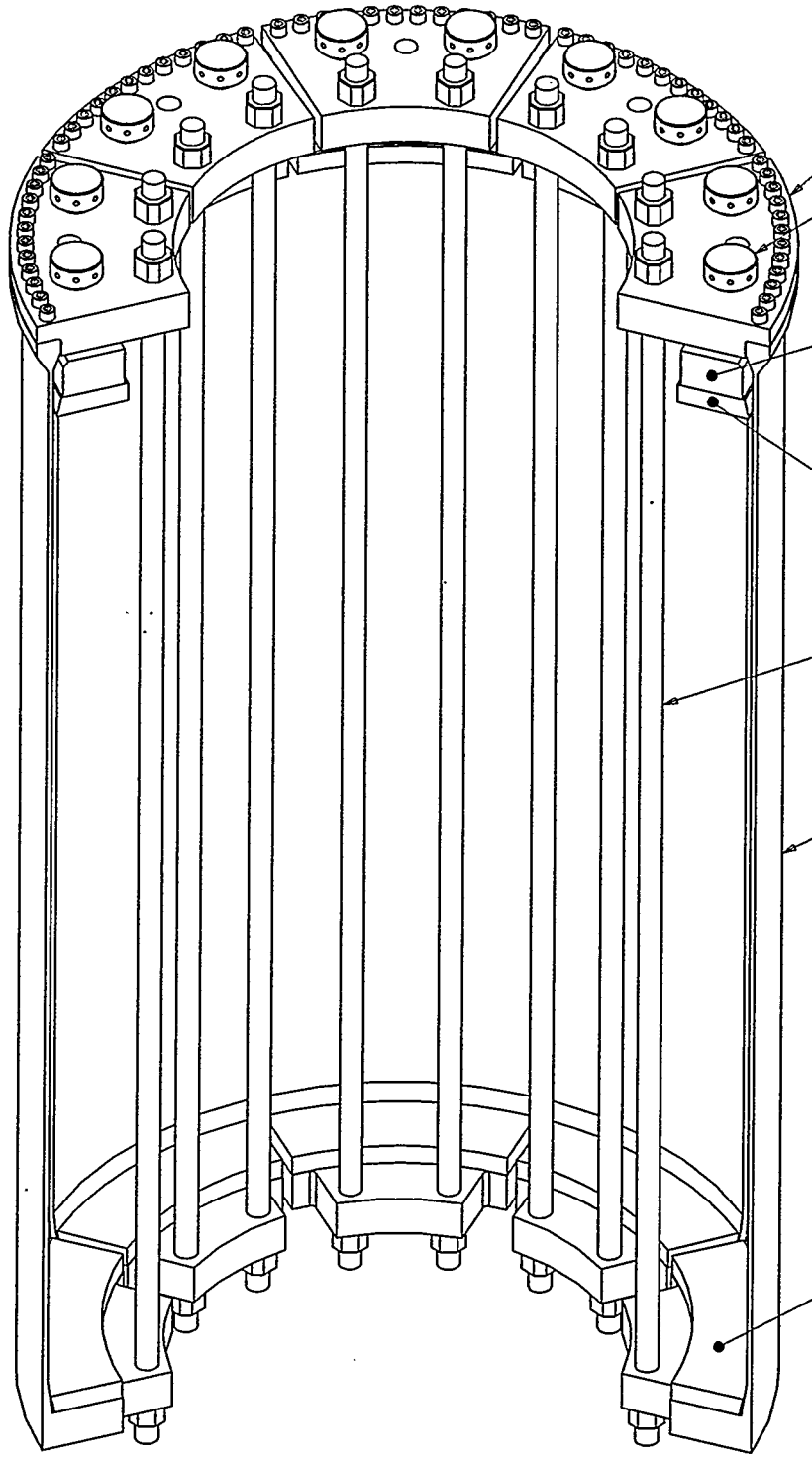




PIN ALIGNMENT BUSHING

TPX-D-1431082.SH002.P00 DRAFT

PREPARED	L.UNDERWOOD	DATE	95-08-14	SIZE	FSCM NO.	DWG NO.
CHECKED				D	90099	A-15182
ENGINEER				SCALE 1/2		SHEET 2


TOP
JACK
BEA
UPPER
TIE
OUTE
STRU

FSCH NO.	DWG NO.	SH
90099	A-15183	1

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

LATE

CREWS

NG PLATE

IM

OD

PRELOAD
URE

ER SHIM

TPX-D-1431083.SH001.P00 DRAFT

SIGNED	DATE	DASH NO.	NEXT ASSY	USED ON
		NONE	NONE	TPX
LLNL APPROVAL		APPLICATION		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± ---
3 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
DO NOT SCALE DRAWING

THIRD ANGLE PROJECTION

REF DWG:

CONTRACT: B254501

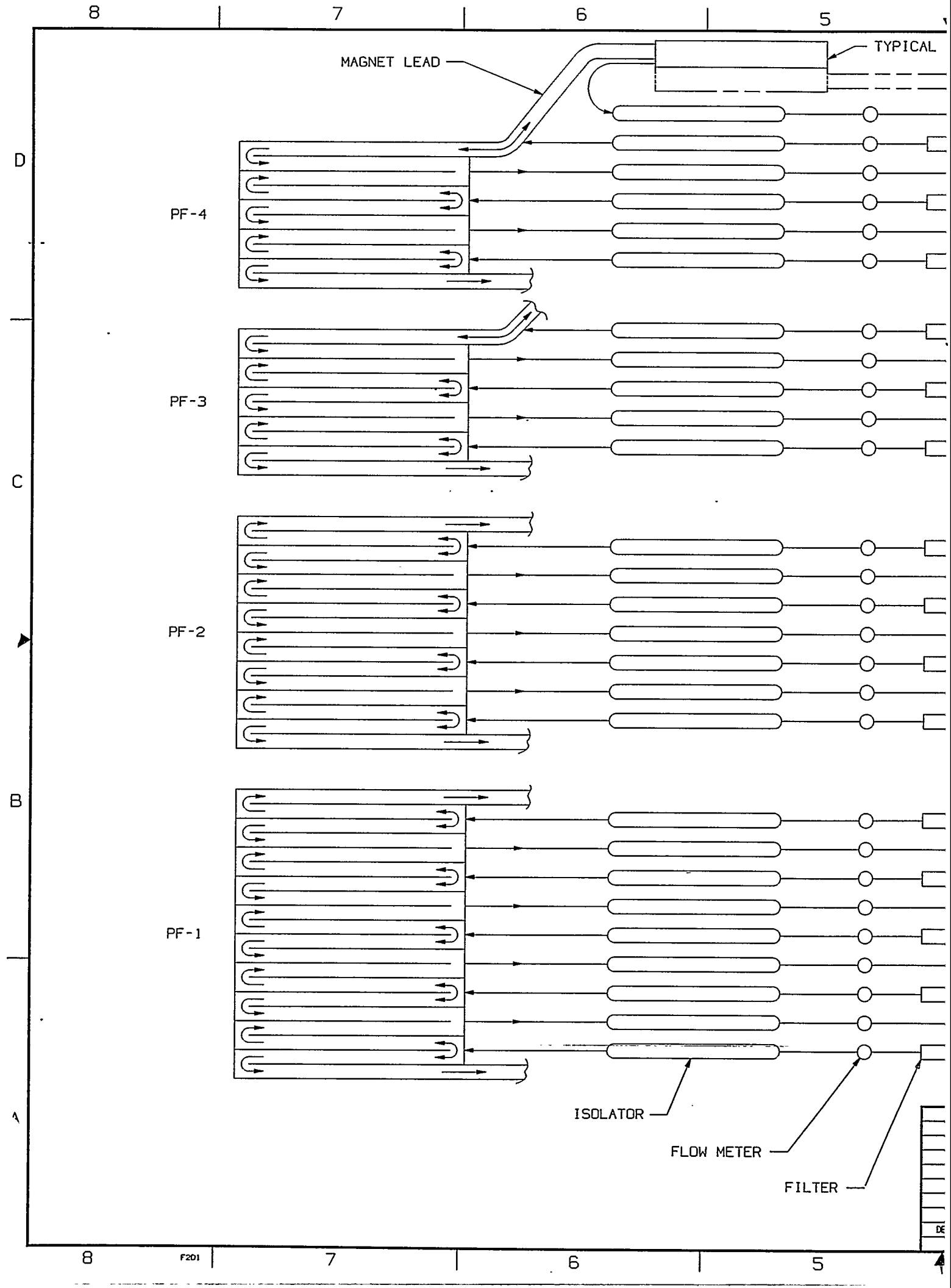
PREPARED	L. UNDERWOOD	DATE 95-08-16
CHECKED		
ENGINEER		
APPROVED		

MARINE DIVISION
Westinghouse Electric Corporation
401 HENDY AVE. SUNNYVALE, CA. 94088

CS PRELOAD STRUCTURE

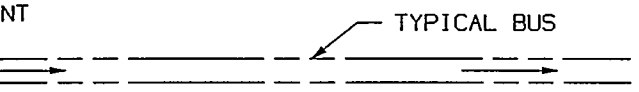
SIZE	FSCH NO.	DWG NO.
D	90099	A-15183

SCALE NONE SHEET 1 OF 1


8
7
6
5
MAGNET LEAD
TYPICAL
D
PF-4
PF-3
C
PF-2
B
PF-1
ISOLATOR
FLOW METER
FILTER
F201

FSCM NO.	DWG NO.	SH
90099	A-15189	1

NT



REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

SUPPLY

RETURN

NUMBER OF COMPONENTS			
COMPONENT	SUPPLY	RETURN	CS TOTAL
ISOLATORS	30	38	68
FLOW METERS	30	38	68
FILTERS	30	0	30

TPX-D-1431089.SH001.P00 DRAFT

SIGNED	DATE	DASH NO.	NEXT ASSY	USED ON
		NONE	NONE	TPX
LNL APPROVAL		APPLICATION		

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± ---
3 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
DO NOT SCALE DRAWING

THIRD ANGLE PROJECTION

REF DWG:

CONTRACT: B254501

		DATE
PREPARED	KAWASAKI	95-8-3
CHECKED		
ENGINEER		
APPROVED		

MARINE DIVISION
Westinghouse Electric Corporation
401 HENDY AVE. SUNNYVALE, CA. 94088

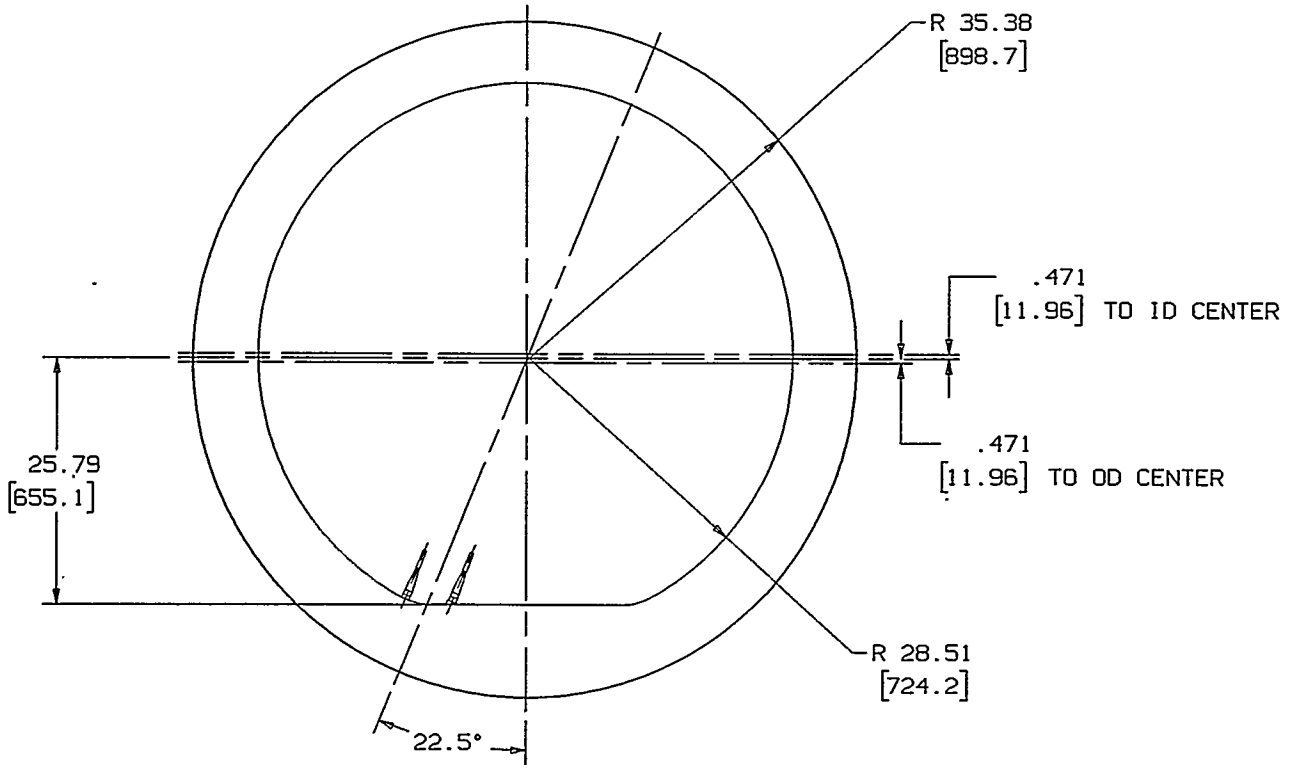
CS COOLING SCHEMATIC, DOUBLE-PANCAKE

SIZE	FSCM NO.	DWG NO.
D	90099	A-15189

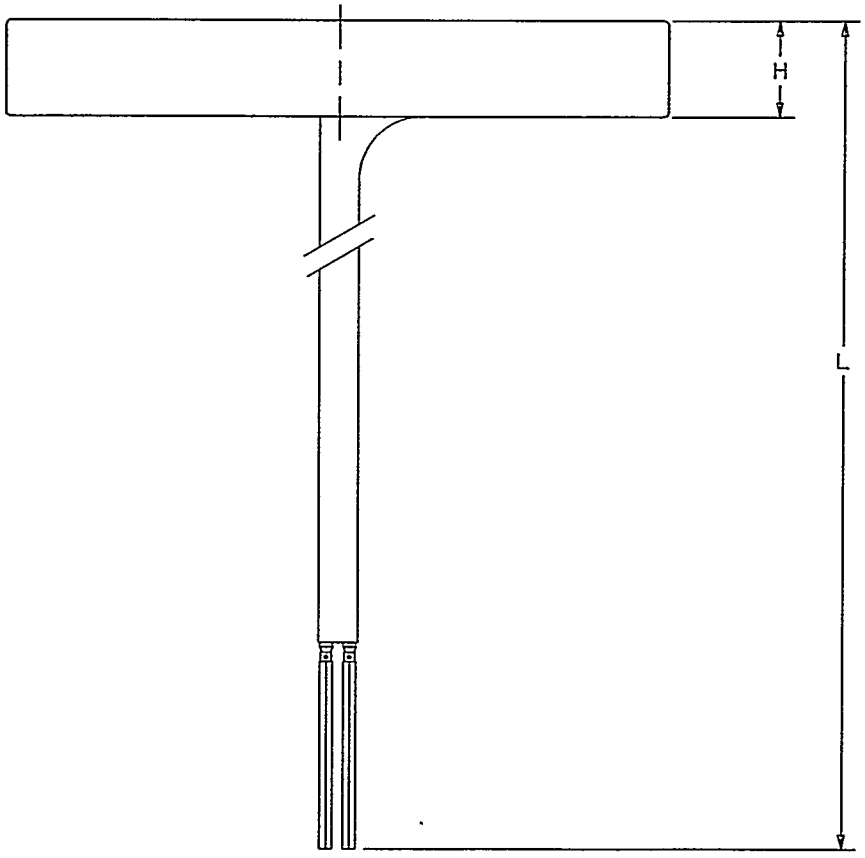
SCALE NONE | SHEET 1 OF 1

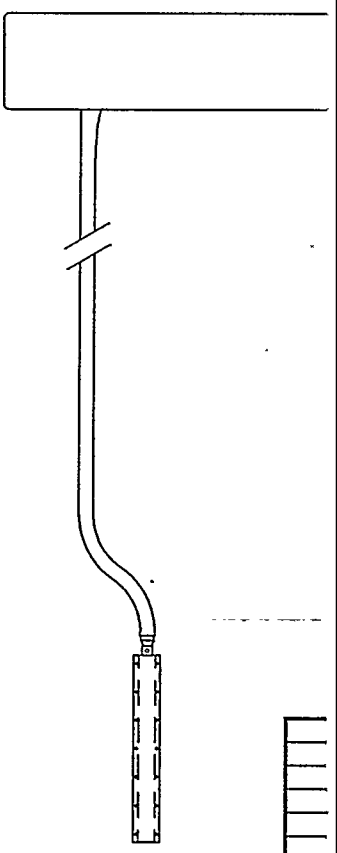
NOTES:

1. DIMENSIONS ARE AT ROOM TEMPERATURE.
2. INTERPRET DIMENSIONS AND TOLERANCES IN ACCORDANCE WITH ANSI Y14.5M-1982.



NOTE: W
I





FSCM NO.	DWG NO.	SH
90099	A-15172	1

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

COIL ENTITY	H	L
4 UPPER	10.10 [256.6]	155.00 [3937.0]
3 UPPER	10.10 [256.6]	144.58 [3672.3]
2 UPPER	15.76 [400.2]	134.15 [3407.4]
UPPER	19.52 [495.9]	118.09 [2999.5]
LOWER	19.52 [495.9]	98.28 [2496.3]
2 LOWER	15.76 [400.2]	78.45 [1992.6]
3 LOWER	10.10 [256.6]	62.36 [1583.9]
4 LOWER	10.10 [256.6]	51.95 [1319.5]

DING LAYOUT SHOWN ON TPX-D-1431070 (A-15170)
ULATION SHOWN ON TPX-D-1431073 (A-15173)

TPX-D-1431072.SH001.P00 DRAFT

		NONE	NONE	TPX
SIGNED	DATE	DASH NO.	NEXT ASSY	USED ON
LNL APPROVAL		APPLICATION		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± ---
3 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION
REF DWG:

CONTRACT: B254501

PREPARED	KAWASAKI	DATE 95-08-10
CHECKED		
ENGINEER		
APPROVED		

MARINE DIVISION
Westinghouse Electric Corporation
401 HENDY AVE. SUNNYVALE, CA. 94088

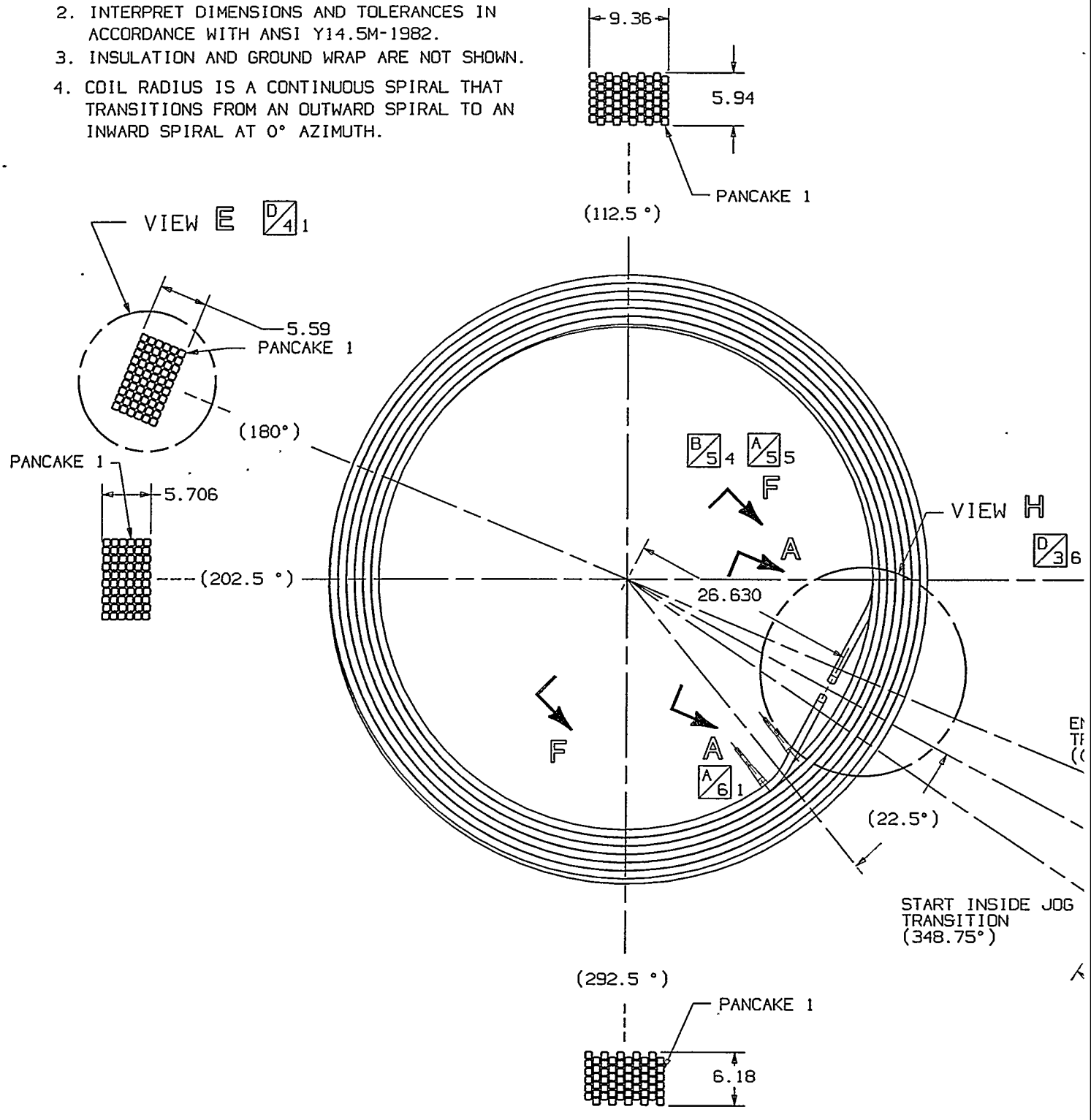
INSULATED CENTRAL SOLENOID
COIL (PF 1-4) - TPX

SIZE	FSCM NO.	DWG NO.
D	90099	A-15172

SCALE NONE SHEET 1 OF 1

NOTES:

1. DIMENSIONS ARE AT ROOM TEMPERATURE.
2. INTERPRET DIMENSIONS AND TOLERANCES IN ACCORDANCE WITH ANSI Y14.5M-1982.
3. INSULATION AND GROUND WRAP ARE NOT SHOWN.
4. COIL RADIUS IS A CONTINUOUS SPIRAL THAT TRANSITIONS FROM AN OUTWARD SPIRAL TO AN INWARD SPIRAL AT 0° AZIMUTH.



PLAN VIEW

PANCAKE LAYER 10 FOR PF3 & PF4 (UPPER & LOWER) SHOWN .
PANCAKE LAYER 16 FOR PF2 (UPPER & LOWER).
PANCAKE LAYER 20 FOR PF1 (UPPER & LOWER)

CCW WINDING

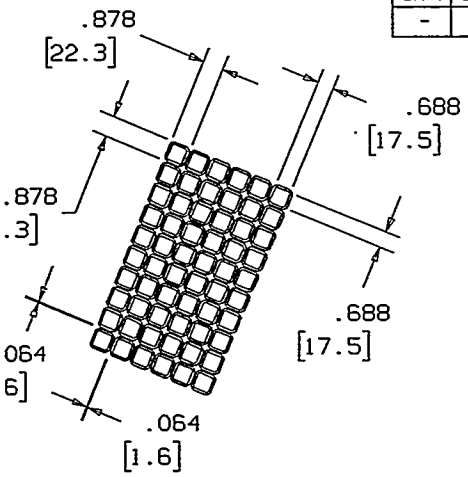
FSCH NO.	DWG NO.	SH
90099	A-15170	1

REV STATUS OF SHEETS

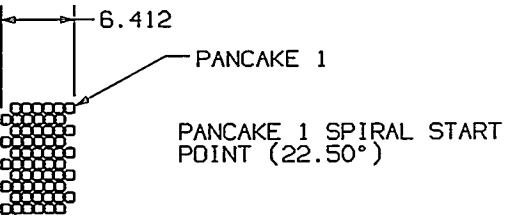
SH 7	SH 6	SH 5	SH 4	SH 3	SH 2	SH 1
-	-	-	-	-	-	-

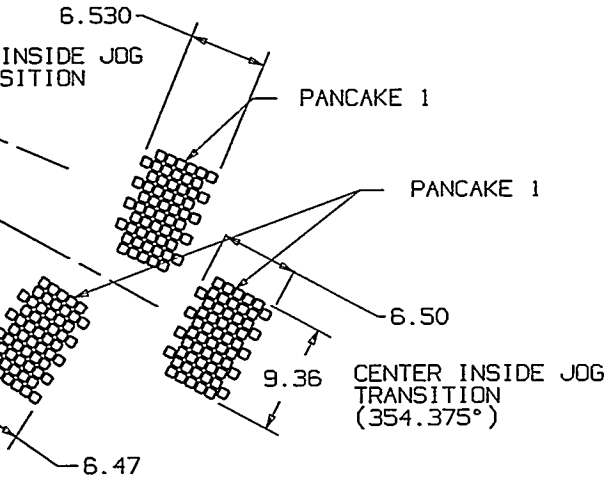
REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	----	C- INITIAL RELEASE E/D-H4751		



VIEW E D/8 1
SCALE: 1/4





TPX-D-1431070.SH001.P00 DRAFT

		NONE	NONE	TPX	
SIGNED	DATE	DASH NO.	NEXT ASSY	USED ON	
LLNL APPROVAL		APPLICATION			

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± ---
3 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION
REF DWG:

CONTRACT: B2S4501

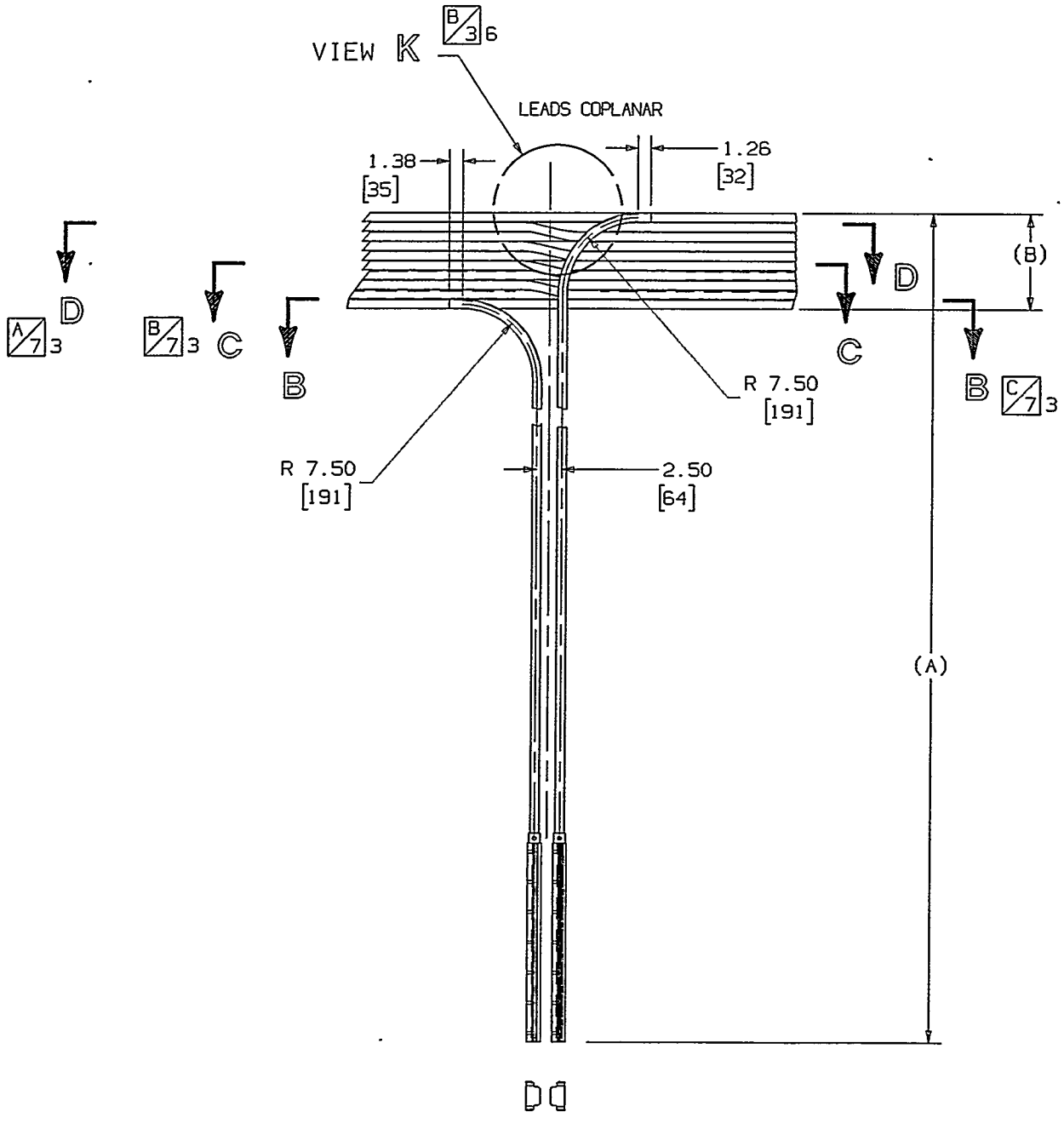
PREPARED	L. UNDERWOOD	DATE 95-8-01
CHECKED		
ENGINEER		
APPROVED		

MARINE DIVISION
Westinghouse Electric Corporation
401 HENDY AVE. SUNNYVALE, CA. 94088

WINDING LAYOUT
CENTRAL SOLENOID - TPX

SIZE	FSCH NO.	DWG NO.
D	90099	A-15170

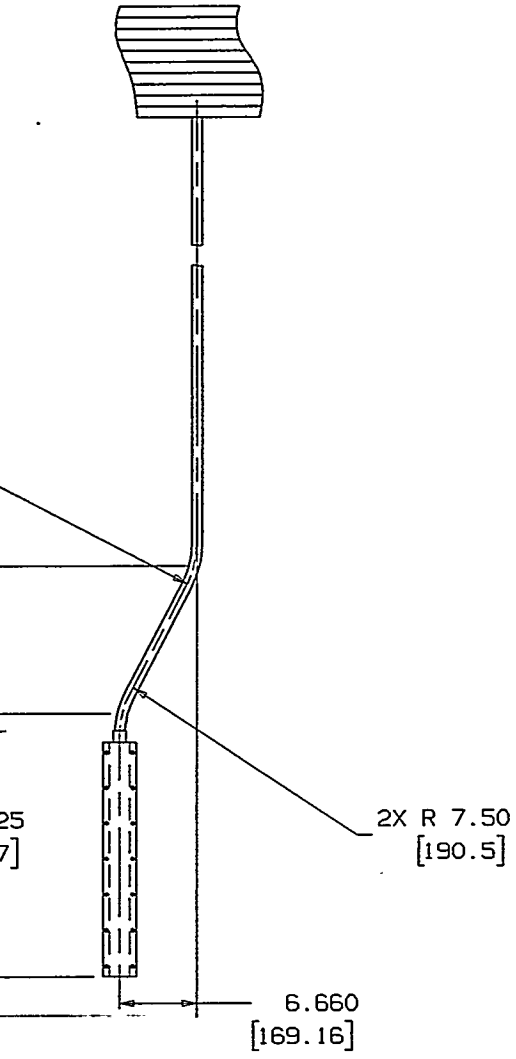
SCALE 1/8 & NOTED SHEET 1 OF 7



VIEW A-A B/6 1

ROTATED 118.125 CCW

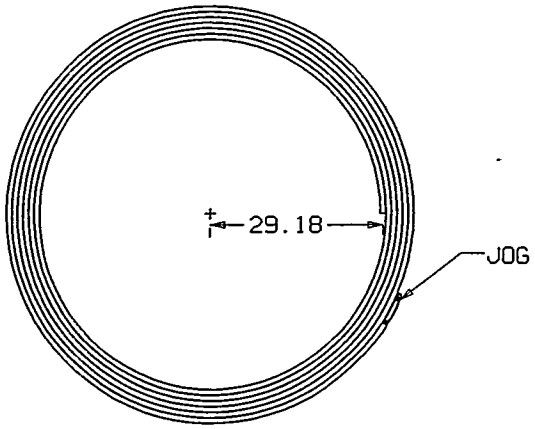
REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



COIL IDENTITY	NO. OF LAYERS	WINDING PACK HEIGHT (B)	OVERALL HEIGHT (A)
PF4 UPPER	10	9.36	154.63
PF3 UPPER	10	9.36	144.21
PF2 UPPER	16	15.00	133.77
PF1 UPPER	20	18.78	117.72
PF1 LOWER	20	18.78	97.91
PF2 LOWER	16	15.00	78.09
PF3 LOWER	10	9.36	61.99
PF4 LOWER	10	9.36	51.58

TPX-D-1431070.SH002.P00 DRAFT

PREPARED L. UNDERWOOD	DATE 05-8-02	SIZE D	FSCH NO. 90099	DWG NO. A-15170
CHECKED		SCALE 1/8		SHEET 2
DESIGNER				

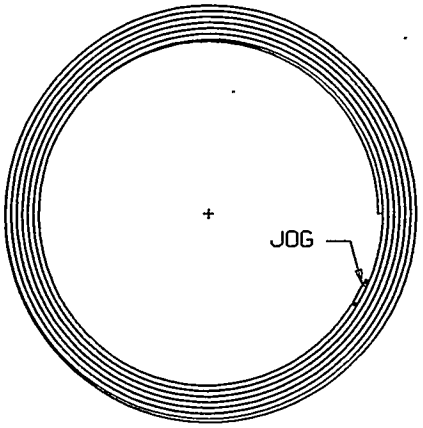


SECTION B-B [C/5]2

ROTATED 112.5° CW

PANCAKE LAYER 1 FOR PF1-4 (UPPERS & LOWERS)

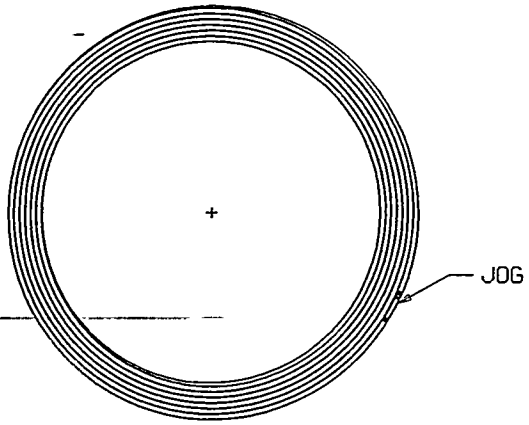
NOTE: COIL RADIUS IS /
SPIRAL TO AN INN



SECTION C-C [C/8]2

ROTATED 112.5° CW

PANCAKE LAYERS 2,4,6,8 FOR PF3 AND PF4 (UPPERS & LOWERS).
PANCAKE LAYERS 2,4,6,8,10,12,14 FOR PF2 (UPPERS & LOWERS).
PANCAKE LAYERS 2,4,6,8,10,12,14,16,18 FOR PF1 (UPPERS & LOWERS)



SECTION D-D [C/8]2

ROTATED 112.5° CW

PANCAKE LAYERS 3,5,7,9 FOR PF3 AND PF4 (UPPERS & LOWERS).
PANCAKE LAYERS 3,5,7,9,11,13,15 FOR PF2 (UPPERS & LOWERS).
PANCAKE LAYERS 3,5,7,9,11,13,15,17,19 FOR PF1 (UPPERS & LOWERS)

PANCAKE	START	
	AZIMUTH	RADIUS
1	22.50	29.180
2	358.98	34.770
3	0.00	29.121
4	358.98	34.770
5	0.00	29.121
6	358.98	34.770
7	0.00	29.121
8	358.98	34.770
9	0.00	29.121
10	358.98	34.770
11	0.00	29.121
12	358.98	34.770
13	0.00	29.121
14	358.98	34.770
15	0.00	29.121
16	358.98	34.770
17	0.00	29.121
18	358.98	34.770
19	0.00	29.121
20/LAST*	358.98	34.770

* DATA SHOWN IS FOR PF1. TH
AND PANCAKE 10 FOR PF3 AN

FSCH NO.	DWG NO.	SH
90099	A-15170	3

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

ONTINUOUS SPIRAL THAT TRANSITIONS FROM AN OUTWARD
D SPIRAL AT 0°.AZIMUTH

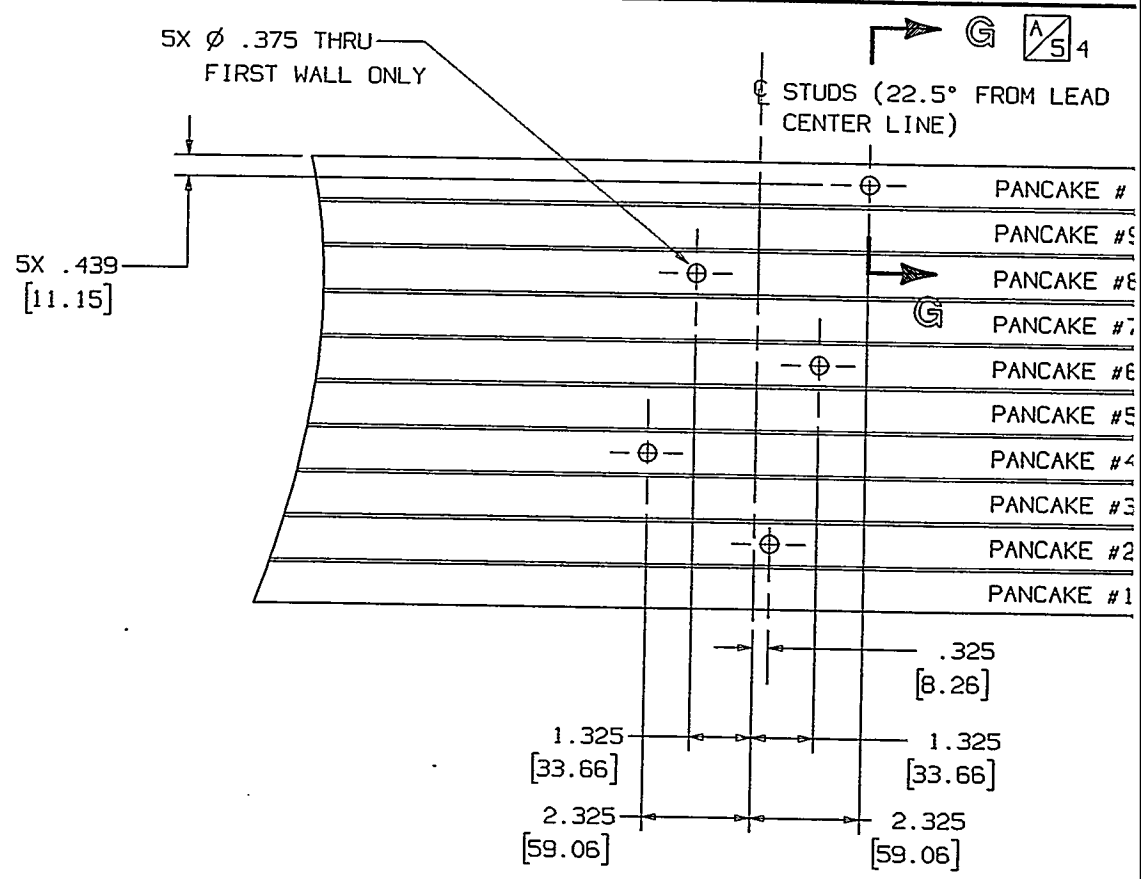
THROUGH P4 WINDING DATA

PIRAL TRANSITION		JOG START		JOG/PANCAKE END	
IMUTH	RADIUS	AZIMUTH	RADIUS	AZIMUTH	RADIUS
		349.77	34.746	358.98	34.770
0.00	34.773	348.75	29.136	360.00	29.121
		349.77	34.746	358.98	34.770
0.00	34.773	348.75	29.136	360.00	29.121
		349.77	34.746	358.98	34.770
0.00	34.773	348.75	29.136	360.00	29.121
		349.77	34.746	358.98	34.770
0.00	34.773	348.75	29.136	360.00	29.121
		349.77	34.746	358.98	34.770
0.00	34.773	348.75	29.136	360.00	29.121
		349.77	34.746	358.98	34.770
0.00	34.773	348.75	29.136	360.00	29.121
		349.77	34.746	358.98	34.770
0.00	34.773	348.75	29.136	360.00	29.121
		349.77	34.746	358.98	34.770
0.00	34.773	348.75	29.136	360.00	29.121
		349.77	34.746	358.98	34.770
0.00	34.773			326.25	29.209

LINE IS APPLICABLE TO PANCAKE 16 FOR PF2
PF4.

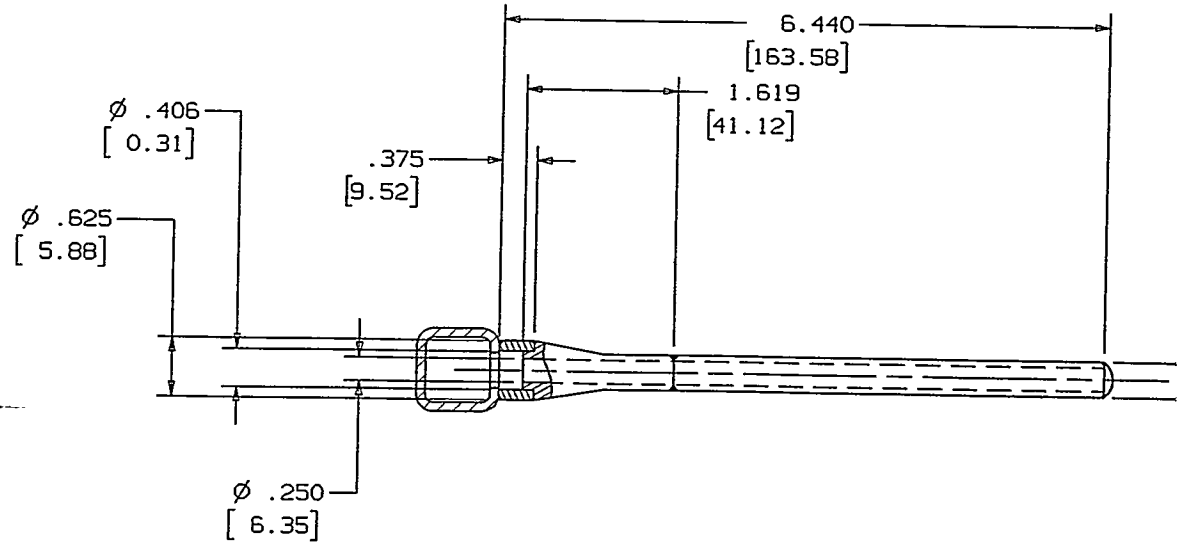
TPX-D-1431070.SH003.P00 DRAFT

PREPARED	DATE	SIZE	FSCH NO.	DWG NO.
L. UNDERWOOD	95-8-01	D	90099	A-15170
CHECKED		SCALE 1/16		SHEET 3
ENGINEER				



VIEW F-F C/6 1

ROTATED 140.25° CCW
PF3 & PF4 IDENTICAL

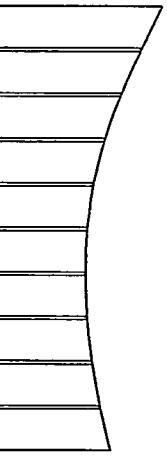


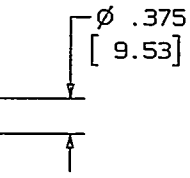
SECTION G-G D/5 4 D/4 5

SCALE: 1/1
HELIUM STUD 5 ON PF3 & PF4
7 ON PF2
9 ON PF1

FSCM NO.	DWG NO.	SH
90099	A-15170	4

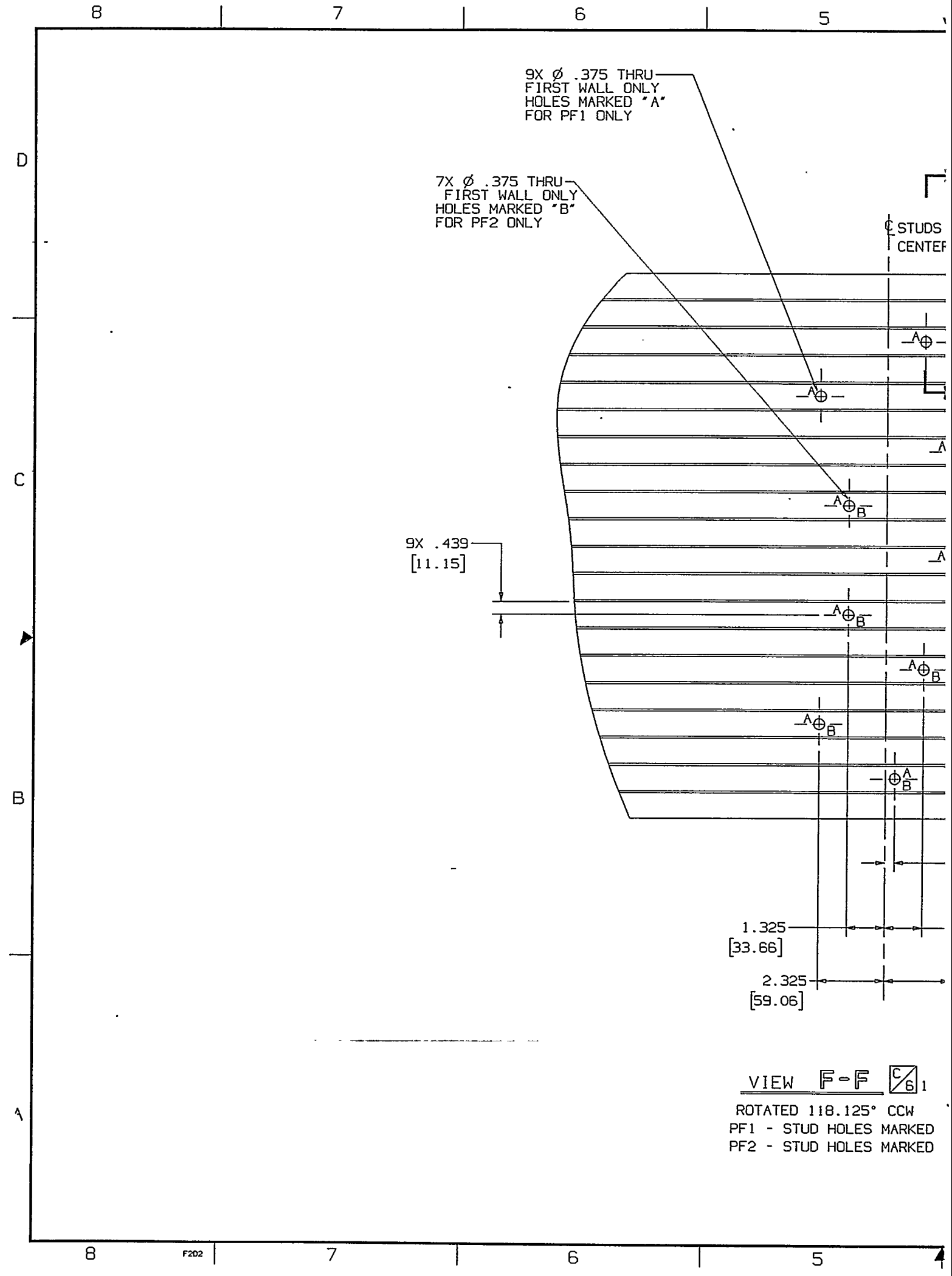
REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		





TPX-D-1431070.SH004.P00 DRAFT

PREPARED L. UNDERWOOD	DATE 95-8-01	SIZE D	FSCM NO. 90099	DWG NO. A-15170
CHECKED				
ENGINEER		SCALE 1/2 & NOTED		SHEET 4



VIEW F-F C/6 1

ROTATED 118.125° CCW
PF1 - STUD HOLES MARKED
PF2 - STUD HOLES MARKED

FSCH NO.	DWG NO.	SH
90099	A-15170	5

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

G C/6 4

2.5° FROM LEAD
INE)

PANCAKE #20
PANCAKE #19
PANCAKE #18
PANCAKE #17
PANCAKE #16
PANCAKE #15
PANCAKE #14
PANCAKE #13
PANCAKE #12
PANCAKE #11
PANCAKE #10
PANCAKE #9
PANCAKE #8
PANCAKE #7
PANCAKE #6
PANCAKE #5
PANCAKE #4
PANCAKE #3
PANCAKE #2
PANCAKE #1

— .325
[8.26]

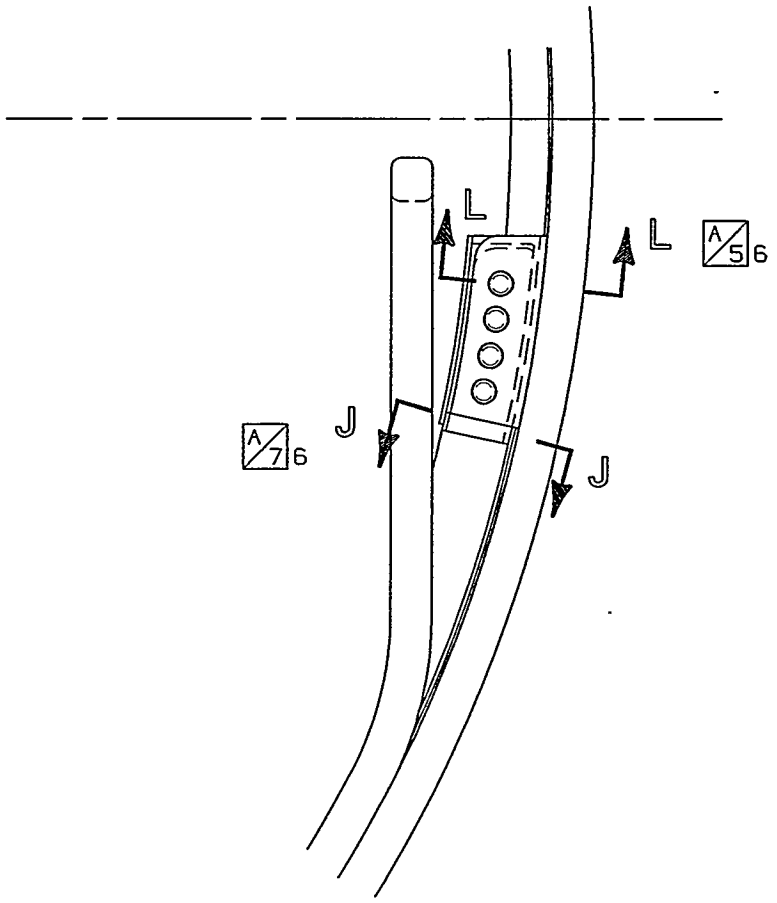
1.325
[33.66]

2.325
[59.06]

D C B A

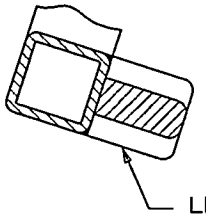
TPX-D-1431070.SH005.P00 DRAFT

PREPARED L. UNDERWOOD	DATE 95-8-01	SIZE D	FSCH NO. 90099	DWG NO. A-15170
CHECKED				
ENGINEER		SCALE 1/2		SHEET 5



VIEW H C/6 1

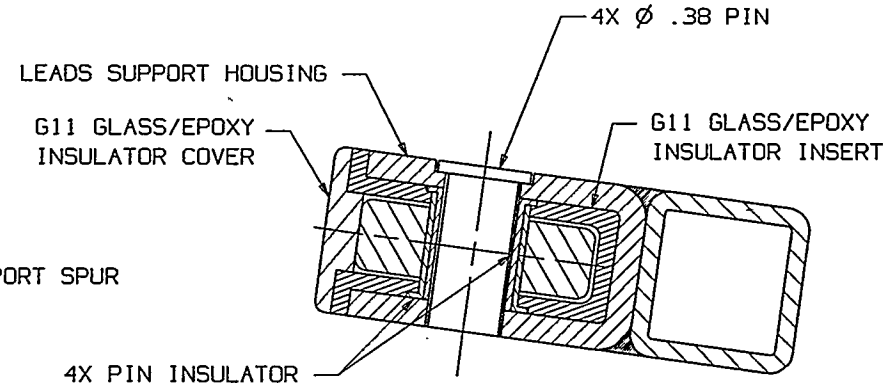
ROTATED 28.125° CCW



SECTION J-J C/6 6

SCALE: 1/1

LEADS SUPPORT 2 PLACES (TOP & BOTTOM) ALL COILS



SECTION L-L D/5 6

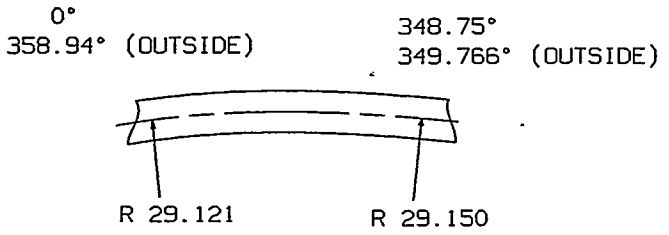
SCALE: 2/1

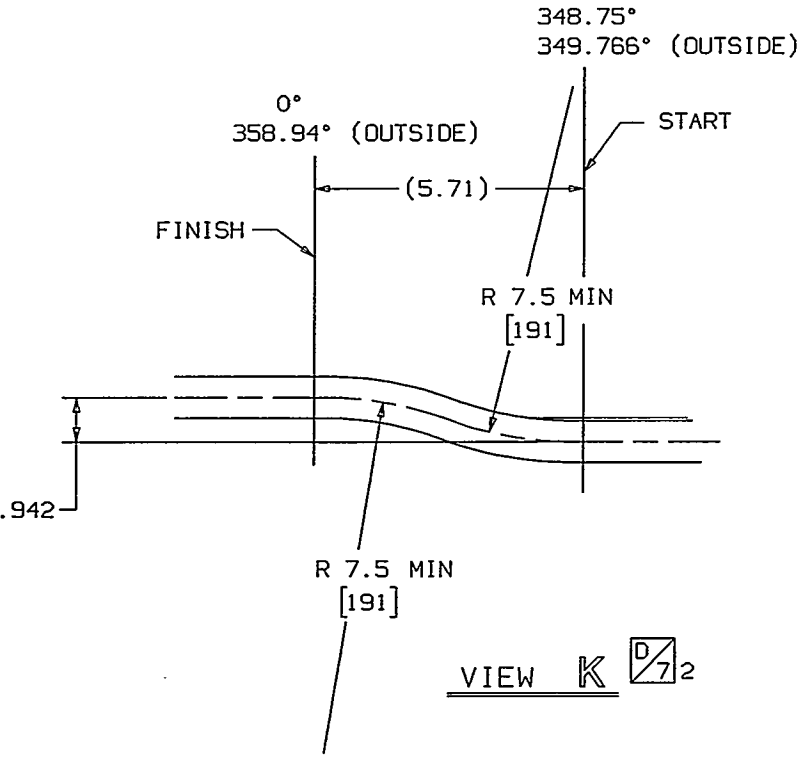
LEADS SUPPORT 2 PLACES (TOP & BOTTOM) ALL COILS

FSCH NO.	DWG NO.	SH
90099	A-15170	6

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

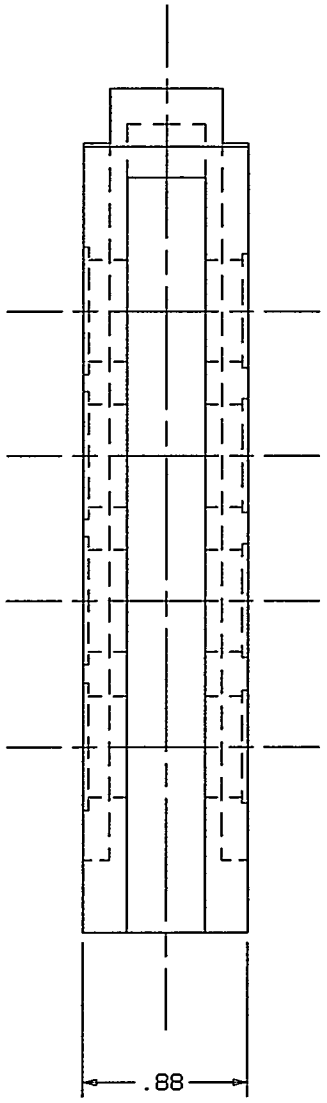


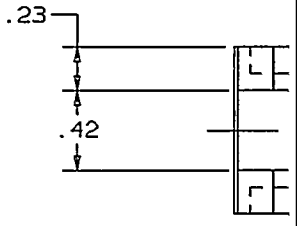


VIEW K D/7 2

TPX-D-1431070.SH006.P00 DRAFT

PREPARED	L. UNDERWOOD	DATE	95-8-01	SIZE	FSCH NO.	DWG NO.
CHECKED				D	90099	A-15170
ENGINEER				SCALE	1/2 & NOTED	SHEET 6



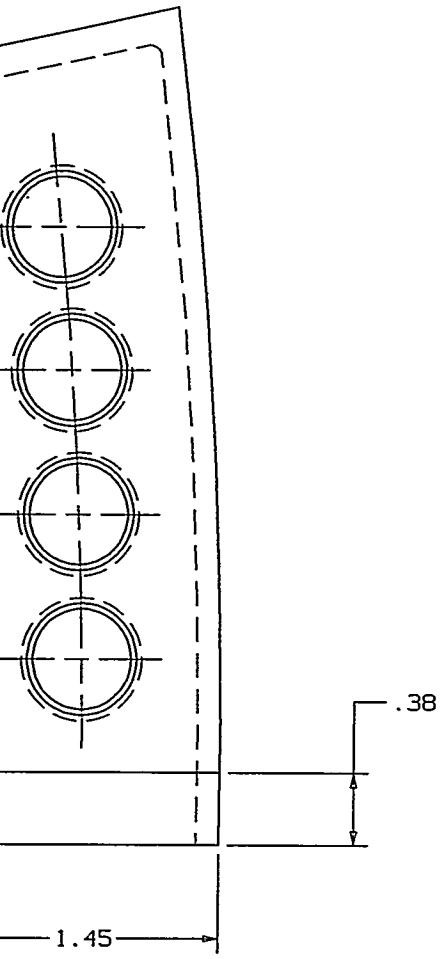


INS

F202

FSCH NO.	DWG NO.	SH
90099	A-15170	7

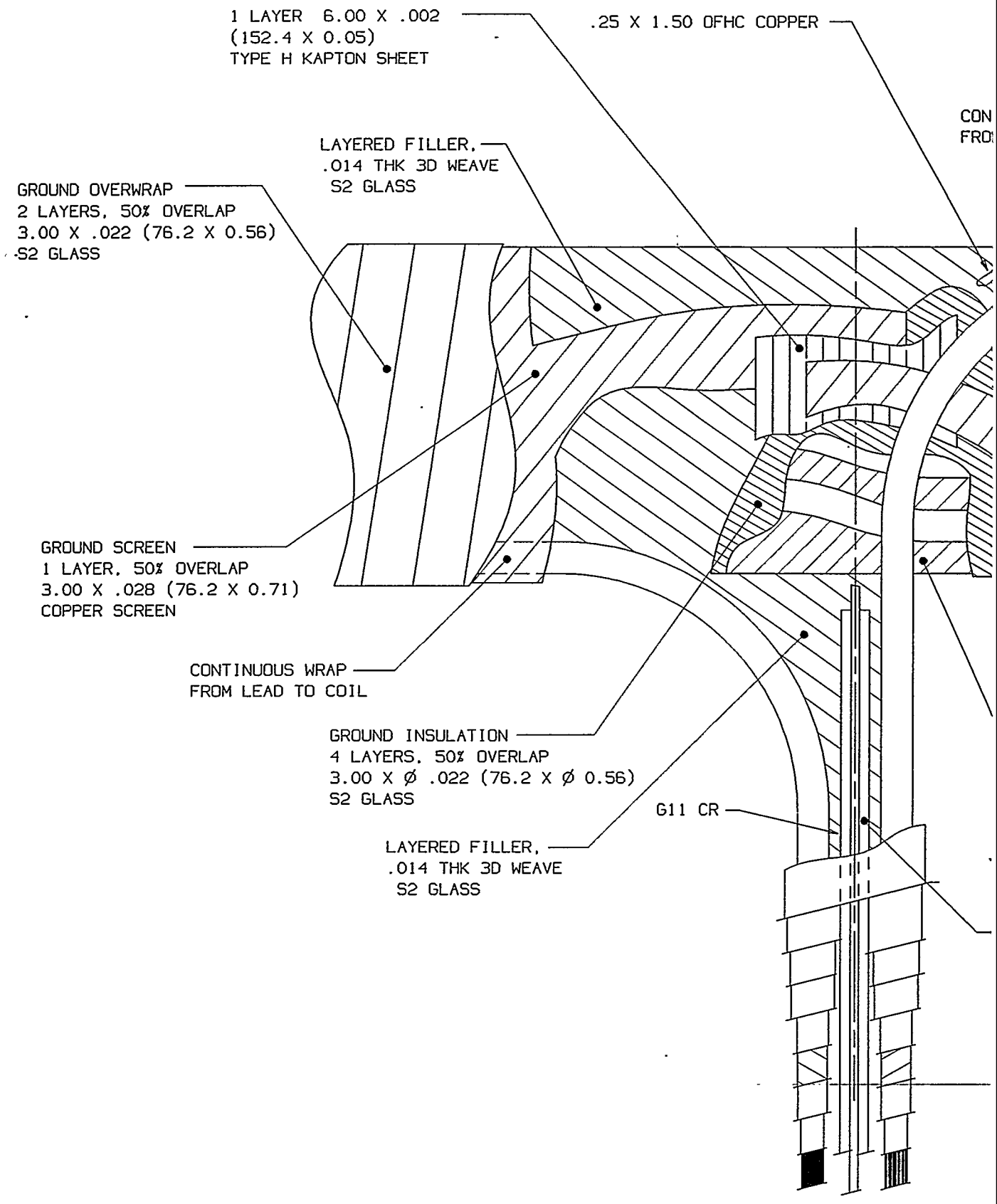
REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



FSCH NO.	DWG NO.	SH
90099	A-15173	1

REV STATUS OF SHEETS							
SH 8	SH 7	SH 6	SH 5	SH 4	SH 3	SH 2	SH 1
-	-	-	-	-	-	-	-

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



VIEW B-B C/7 1

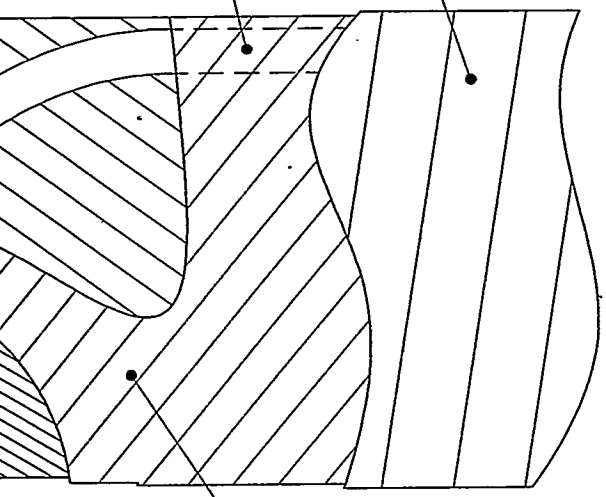
ROTATED 180°

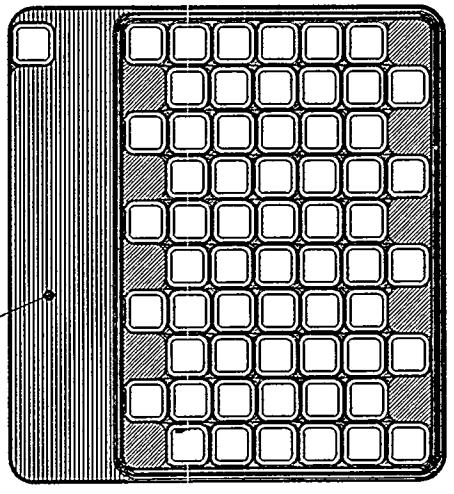
F202

FSCH NO.	DWG NO.	SH
90099	A-15173	2

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



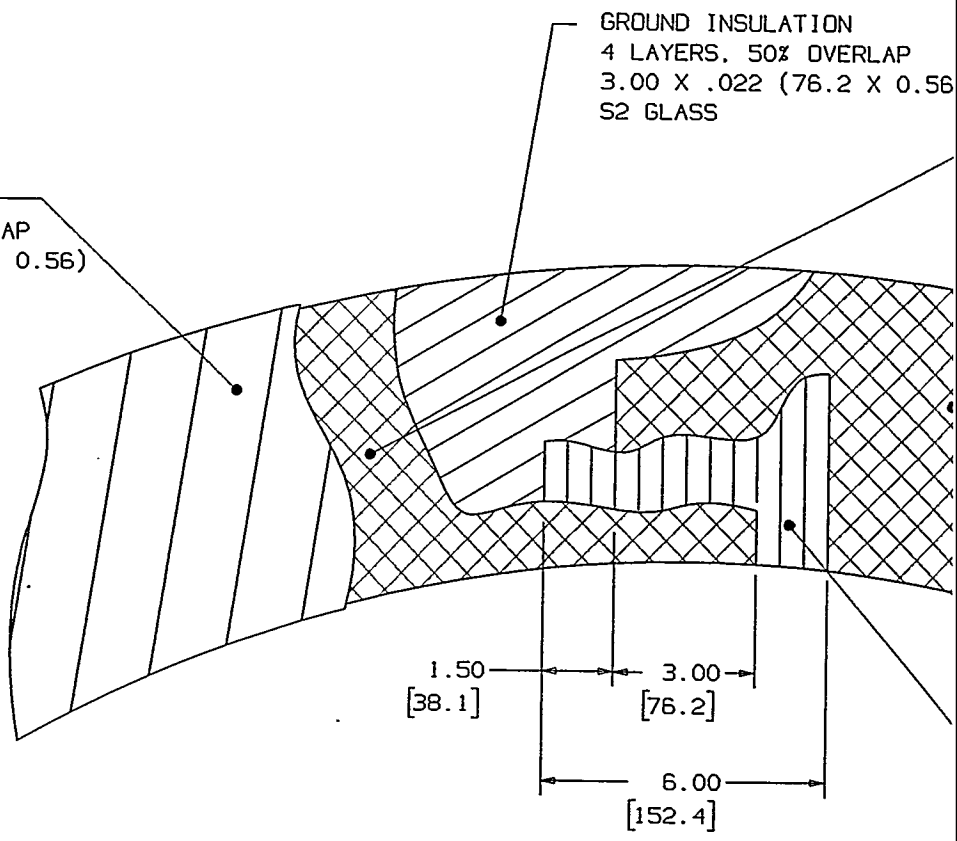


SECTION C-C C/7 1

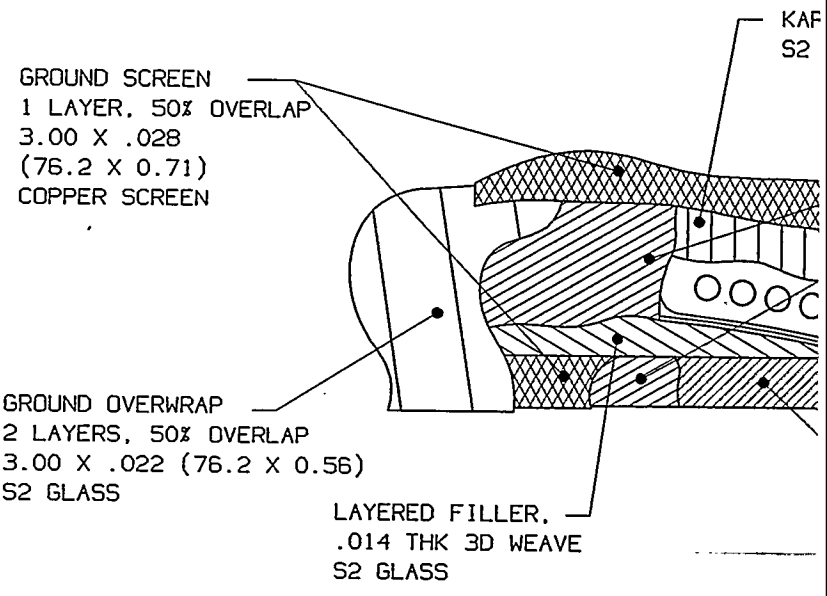
ROTATED 90.625° CCW

TPX-D-1431073.SH002.P00 DRAFT

PREPARED	KAWASAKI	DATE	95-8-1	SIZE	FSCH NO.	DWG NO.
CHECKED				D	90099	A-15173
ENGINEER				SCALE 1/2		SHEET 2



VIEW H D/6 1



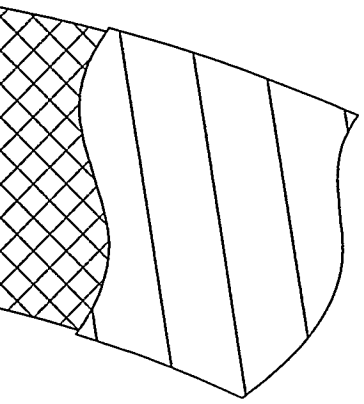
VIEW L C/6 1

FSCM NO.	DWG NO.	SH
90099	A-15173	3

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

GROUND SCREEN
1 LAYER, 50% OVERLAP
3.00 X .028 (76.2 X 0.71)
COPPER SCREEN



— 1 LAYER, 6.00 X .002
(152.4 X 0.05)
TYPE H KAPTON SHEET

N SHEET AND
ASS SHEET DRAPES

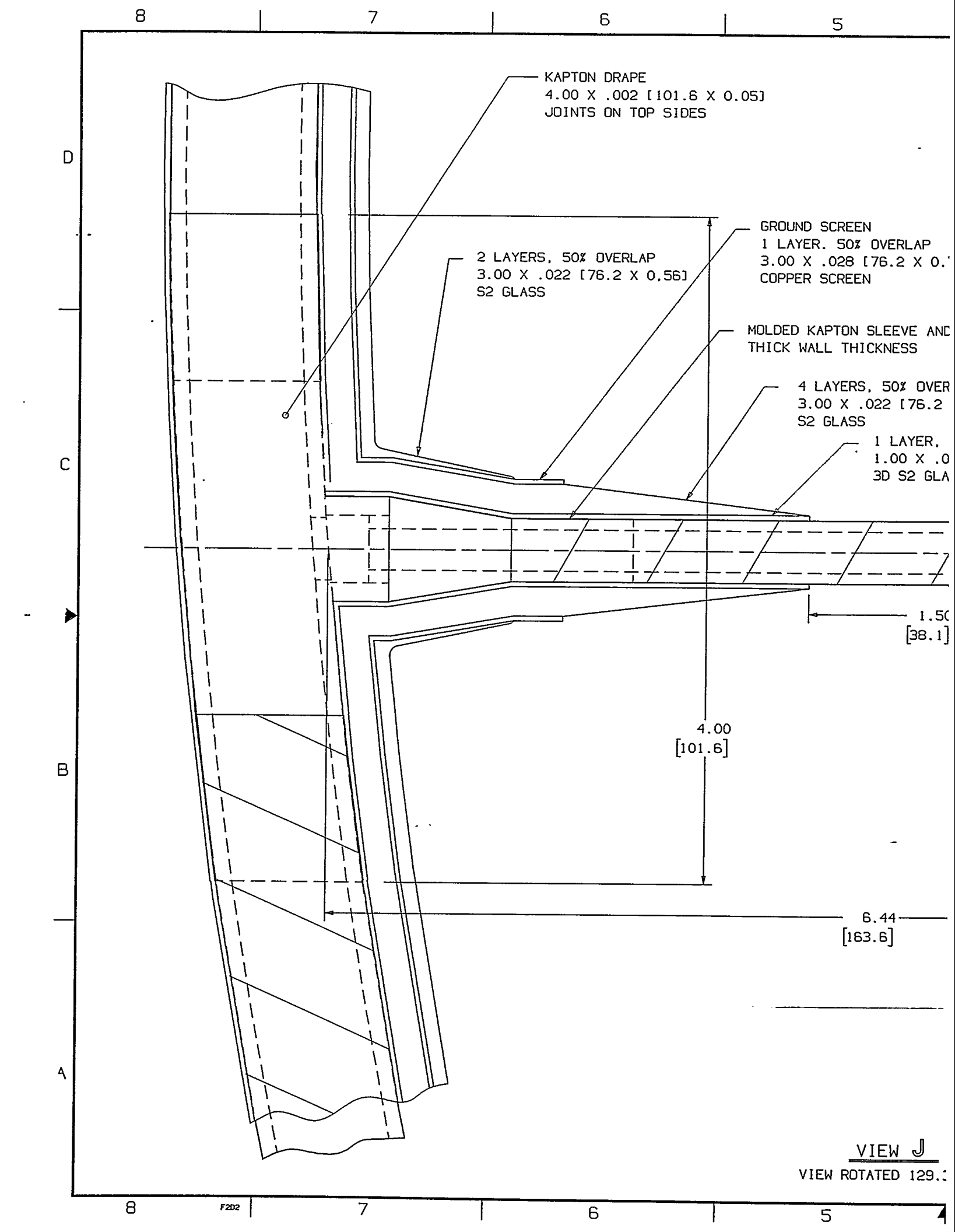
GROUND INSULATION
4 LAYERS, 50% OVERLAP
3.00 X .022 (76.2 X 0.56)
S2 GLASS

GROUND OVERWRAP
2 LAYERS, 50% OVERLAP
3.00 X .022 (76.2 X 0.56)
S2 GLASS

CONDUCTOR INSULATION
(KAPTON AND 3D S2 GLASS)

TPX-D-1431073.SH003.P00 DRAFT

PREPARED L. UNDERWOOD	DATE 95-08-10	SIZE D	FSCM NO. 90099	DWG NO. A-15173
CHECKED				
ENGINEER		SCALE 1/2		SHEET 3


KAPTON DRAPE
4.00 X .002 [101.6 X 0.05]
JOINTS ON TOP SIDES
GROUND SCREEN
1 LAYER. 50% OVERLAP
3.00 X .028 [76.2 X 0.
COPPER SCREEN
2 LAYERS, 50% OVERLAP
3.00 X .022 [76.2 X 0.56]
S2 GLASS
MOLDED KAPTON SLEEVE ANC
THICK WALL THICKNESS
4 LAYERS, 50% OVER
3.00 X .022 [76.2
S2 GLASS
1 LAYER,
1.00 X .0
3D S2 GLA
1.5(
[38.1]
4.00
[101.6]
6.44
[163.6]
VIEW J
VIEW ROTATED 129.
8
7
6
5
D
C
B
A
F2D2

FSCH NO.	DWG NO.	SH
90099	A-15173	4

REVISIONS

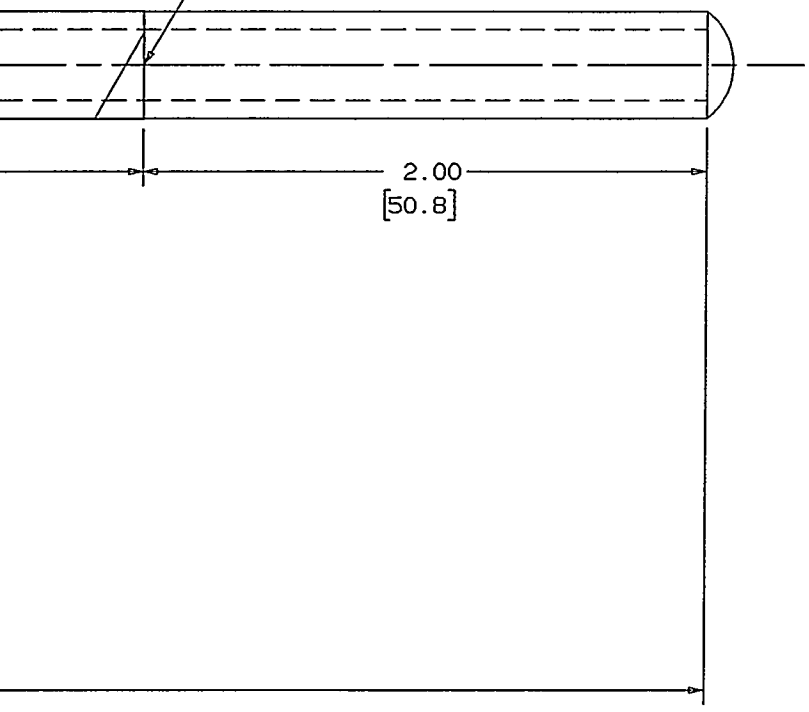
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

RAPE .004 [0.10]

P
0.56]

% OVERLAP
[25.4 X 0.36]

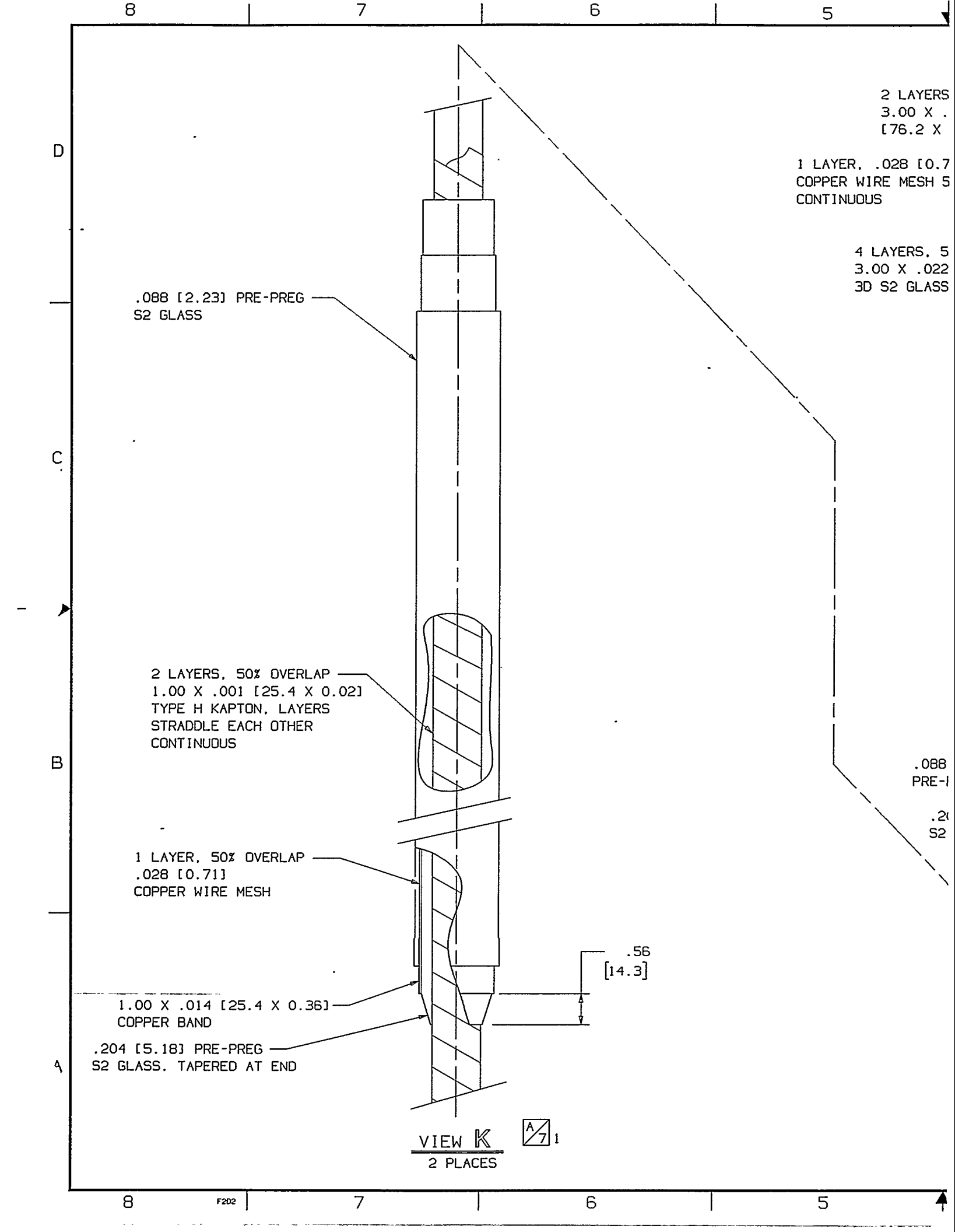
2 LAYERS, 50% OVERLAP
1.00 X .001 [25.4 X 0.02]
TYPE H KAPTON



S 1
5° CCW

TPX-D-1431073.SH004.P00 DRAFT

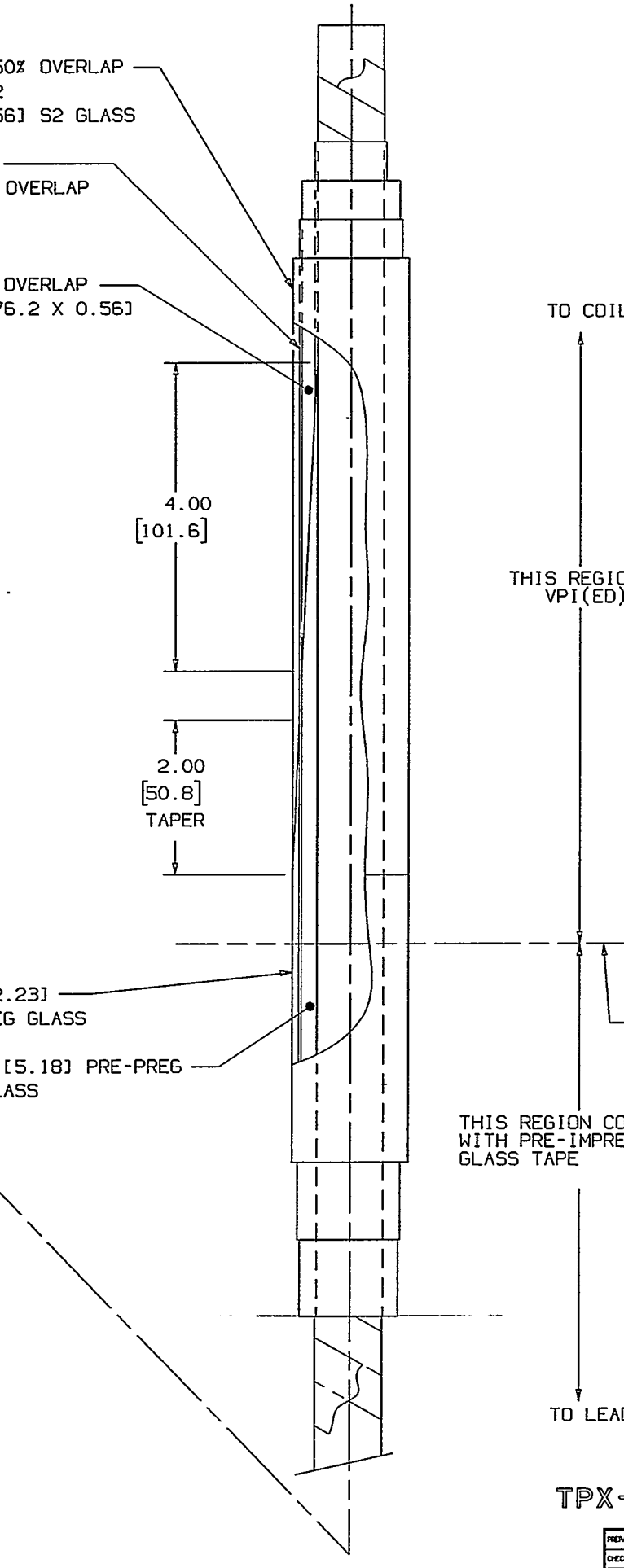
PREPARED KAWASAKI	DATE 95-8-1	SIZE D	FSCH NO. 90099	DWG NO. A-15173
CHECKED				
ENGINEER		SCALE 3/1		SHEET 4


8
7
6
5
D
C
B
A
2 LAYERS
3.00 X .
[76.2 X
1 LAYER, .028 [0.7
COPPER WIRE MESH 5
CONTINUOUS
4 LAYERS, 5
3.00 X .022
3D S2 GLASS
.088 [2.23] PRE-PREG
S2 GLASS
2 LAYERS, 50% OVERLAP
1.00 X .001 [25.4 X 0.02]
TYPE H KAPTON, LAYERS
STRADDLE EACH OTHER
CONTINUOUS
.088
PRE-I
.2(
S2
1 LAYER, 50% OVERLAP
.028 [0.71]
COPPER WIRE MESH
.56
[14.3]
1.00 X .014 [25.4 X 0.36]
COPPER BAND
.204 [5.18] PRE-PREG
S2 GLASS, TAPERED AT END
VIEW K
2 PLACES
A/7 1
8
F202
7
6
5

FSCH NO.	DWG NO.	SH
90099	A-15173	5

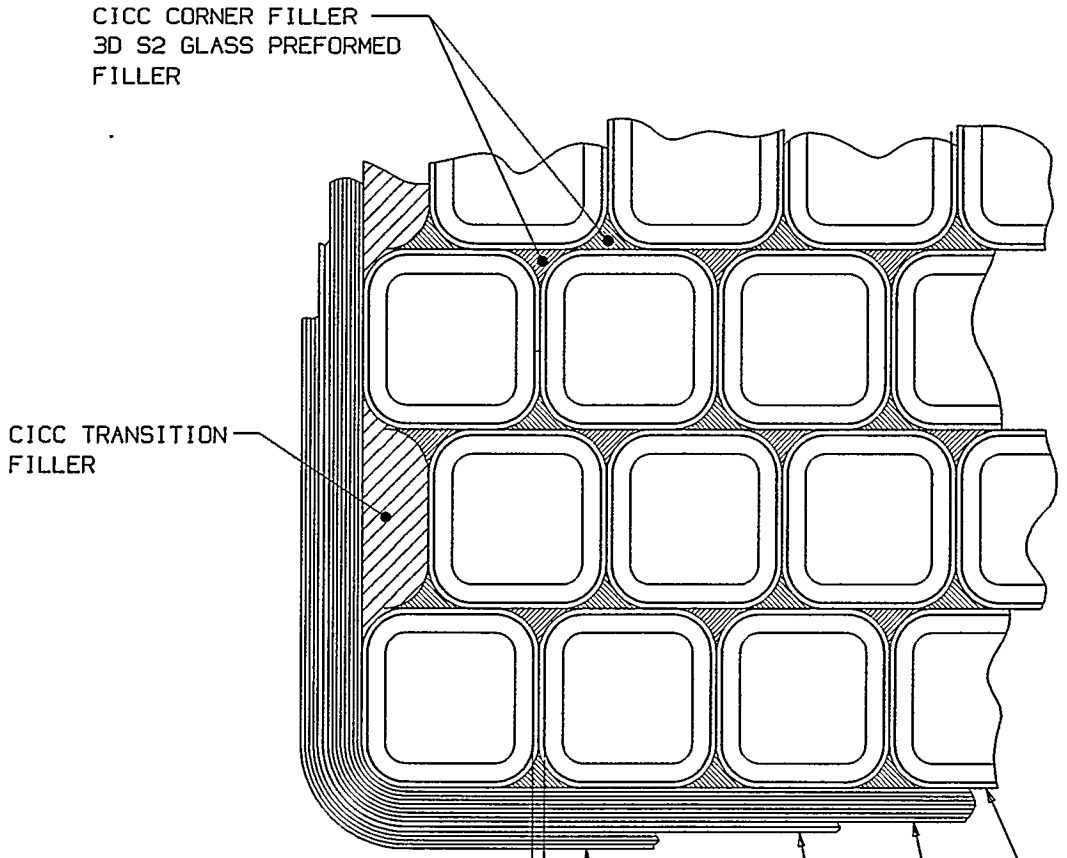
REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



TPX-D-1431073.SH005.P00 DRAFT

PREPARED KAWASAKI	DATE 95-8-1	SIZE D	FSCH NO. 90099	DWG NO. A-15173
CHECKED				
ENGINEER		SCALE 1/1		SHEET 5



VIEW F B/4 6

SCALE: 2/1

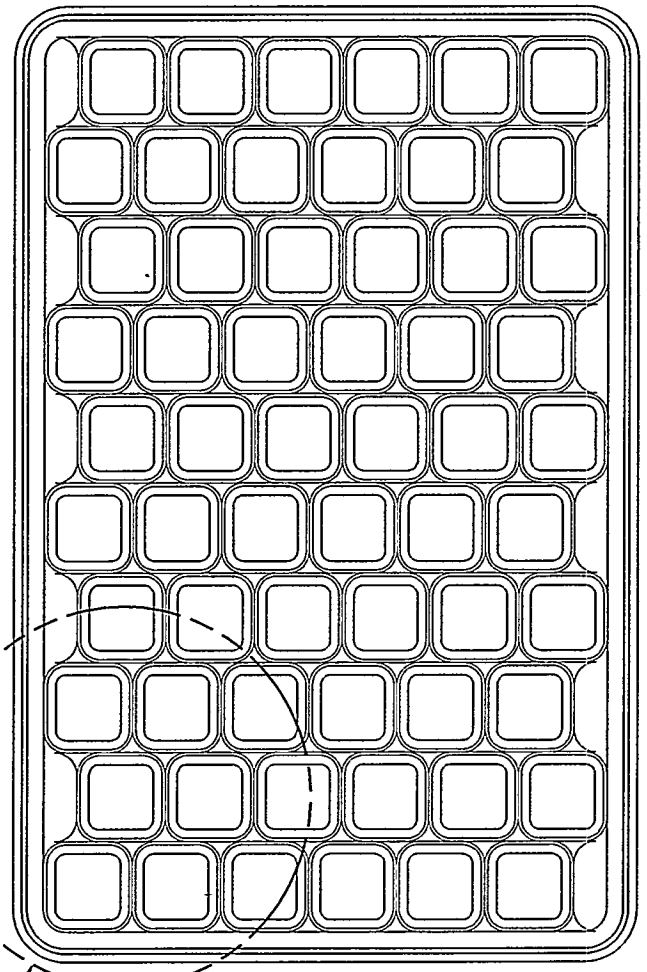
FSCH NO.	DWG NO.	SH
90099	A-15173	6

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

A/5 7

E



E

VIEW F

A/7 6

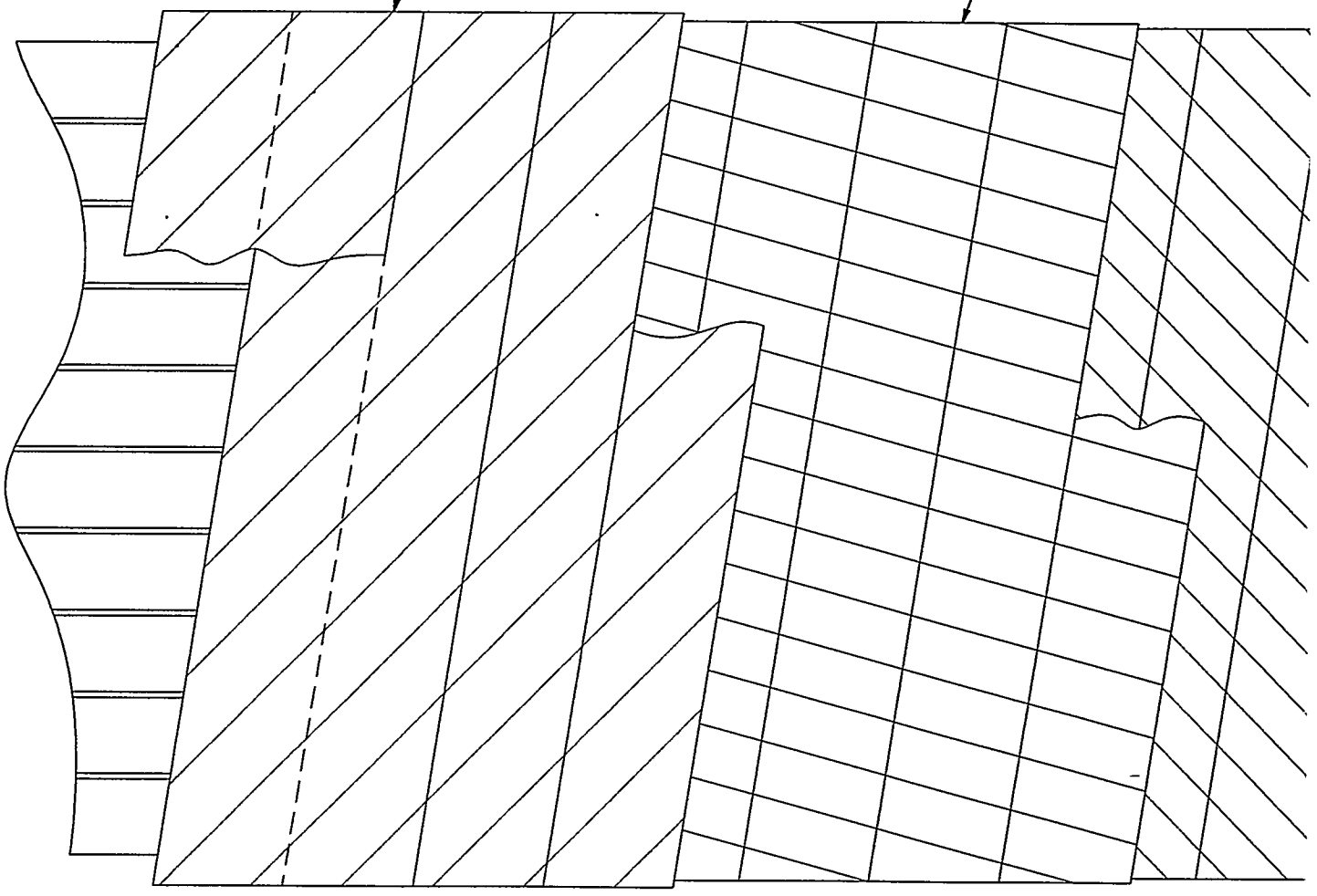
VIEW D-D D/7 1

COIL PACK INSULATION

ION
1] GLASS)

TPX-D-1431073.SH006.P00 DRAFT

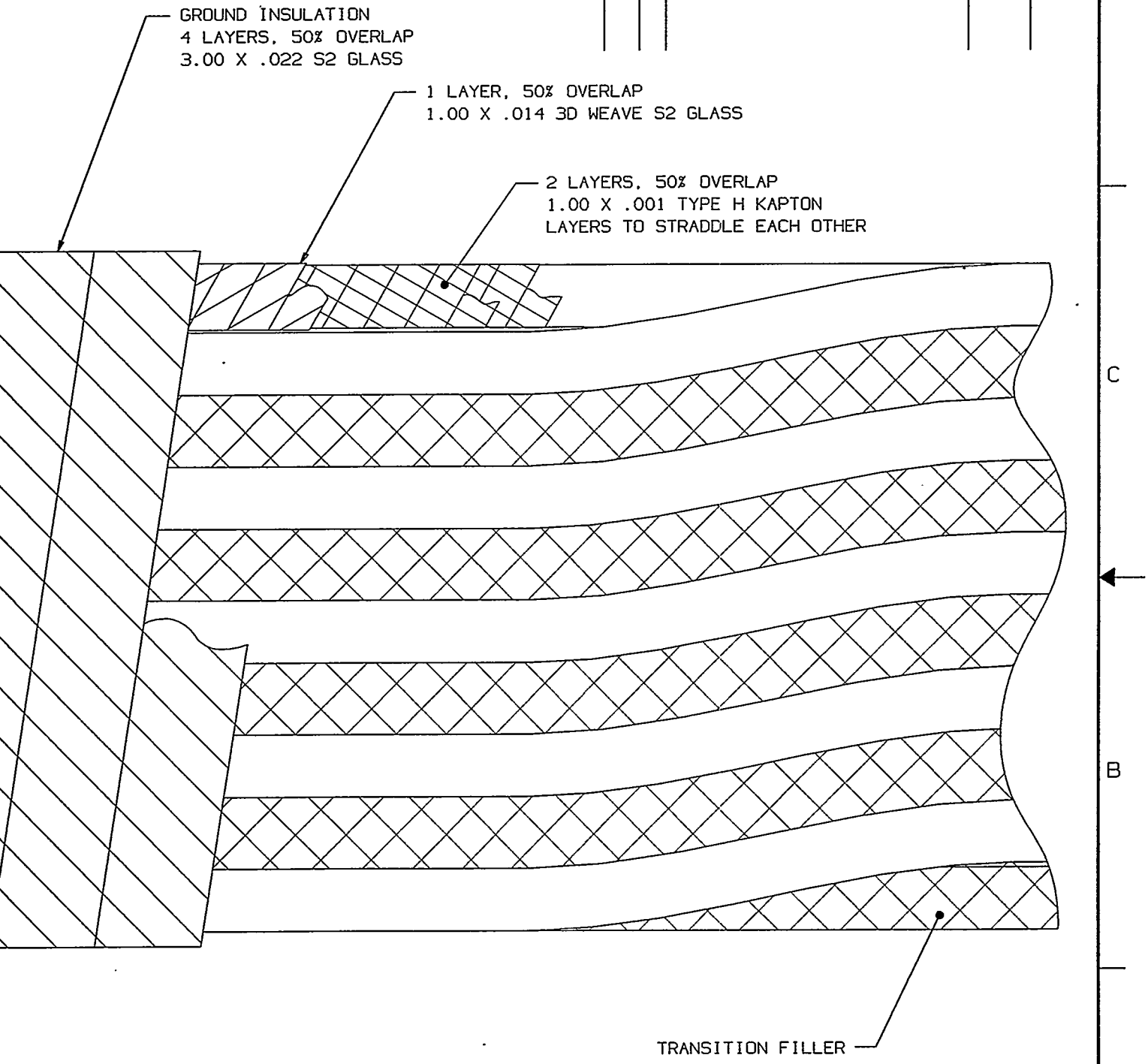
PREPARED	DATE	SIZE	FSCH NO.	DWG NO.
L. UNDERWOOD	95-08-10	D	90099	A-15173
CHECKED				
ENGINEER		SCALE 1/1 & NOTED		SHEET 6


GROUND SCREE
1 LAYER, 50%
3.00 X .028
COPPER SCREE
GROUND OVERWRAP
2 LAYERS, 50% OVERLAP
3.00 X .022 S2 GLASS

VIEW E-E D/4 6

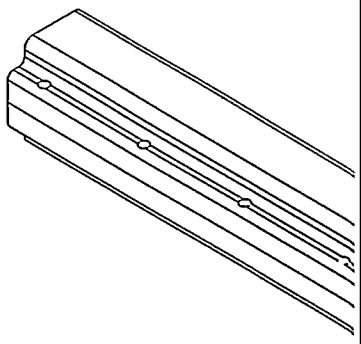
REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

VERLAP

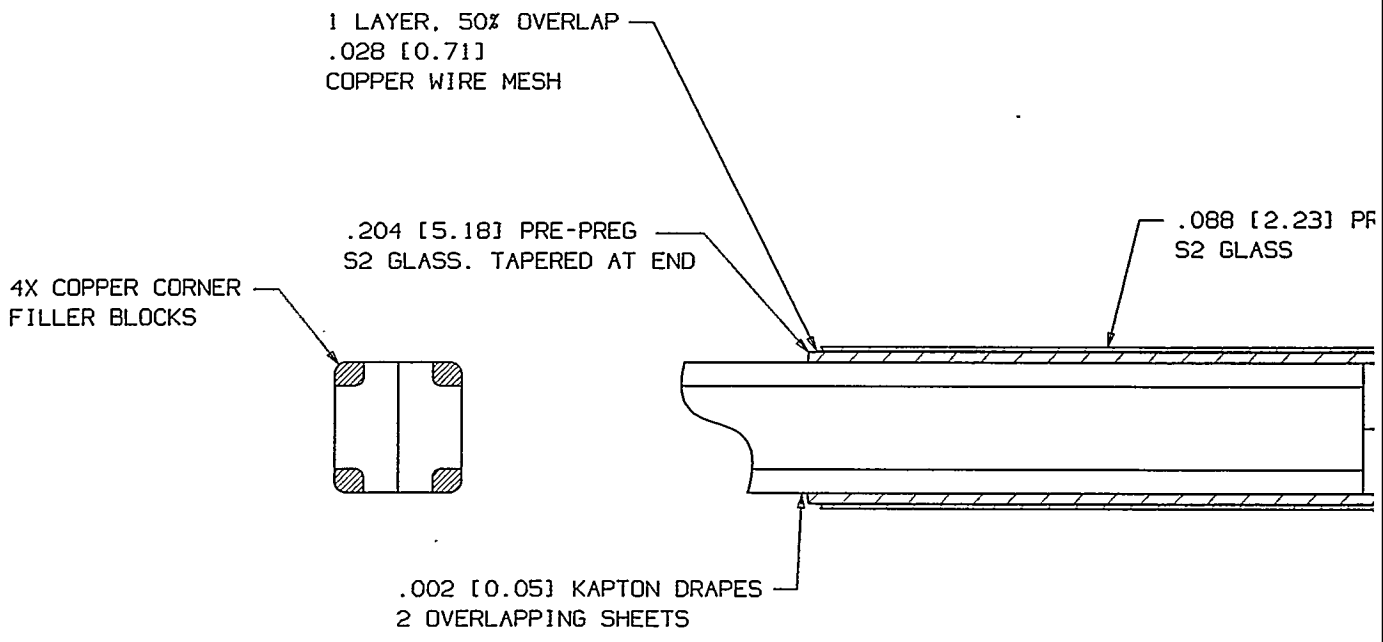


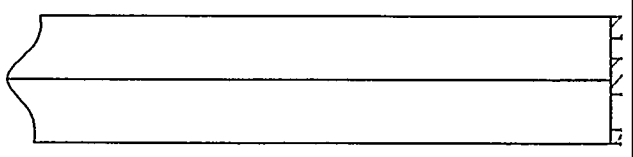
TPX-D-1431073.SH007.P00 DRAFT

PREPARED L. UNDERWOOD	DATE 95-08-10	SIZE D	FSCH NO. 90099	DWG NO. A-15173
CHECKED				
ENGINEER		SCALE 1/1		SHEET 7



UNINSULATED JOINT





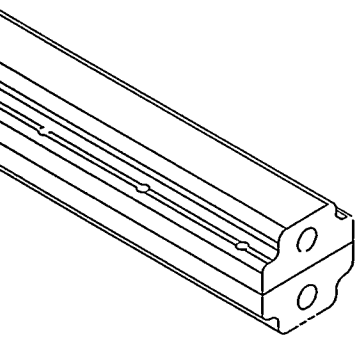
SPLIT DIELECTRIC FILLER BLOCKS
INTERNAL SURFACE CONTOUR TO
MATCH LEAD AND INSTRUMENTATION
TRANSITION

JOINT INSULATION

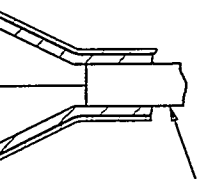
FSCH NO.	DWG NO.	SH
90099	A-15173	8

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

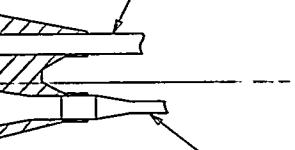


PREG



2 LAYERS, 50% OVERLAP
1.00 X .001 [25.4 X 0.02]
TYPE H KAPTON, LAYERS
STRADDLE EACH OTHER
CONTINUOUS

MAGNET LEAD OR
SUPERCONDUCTING BUS



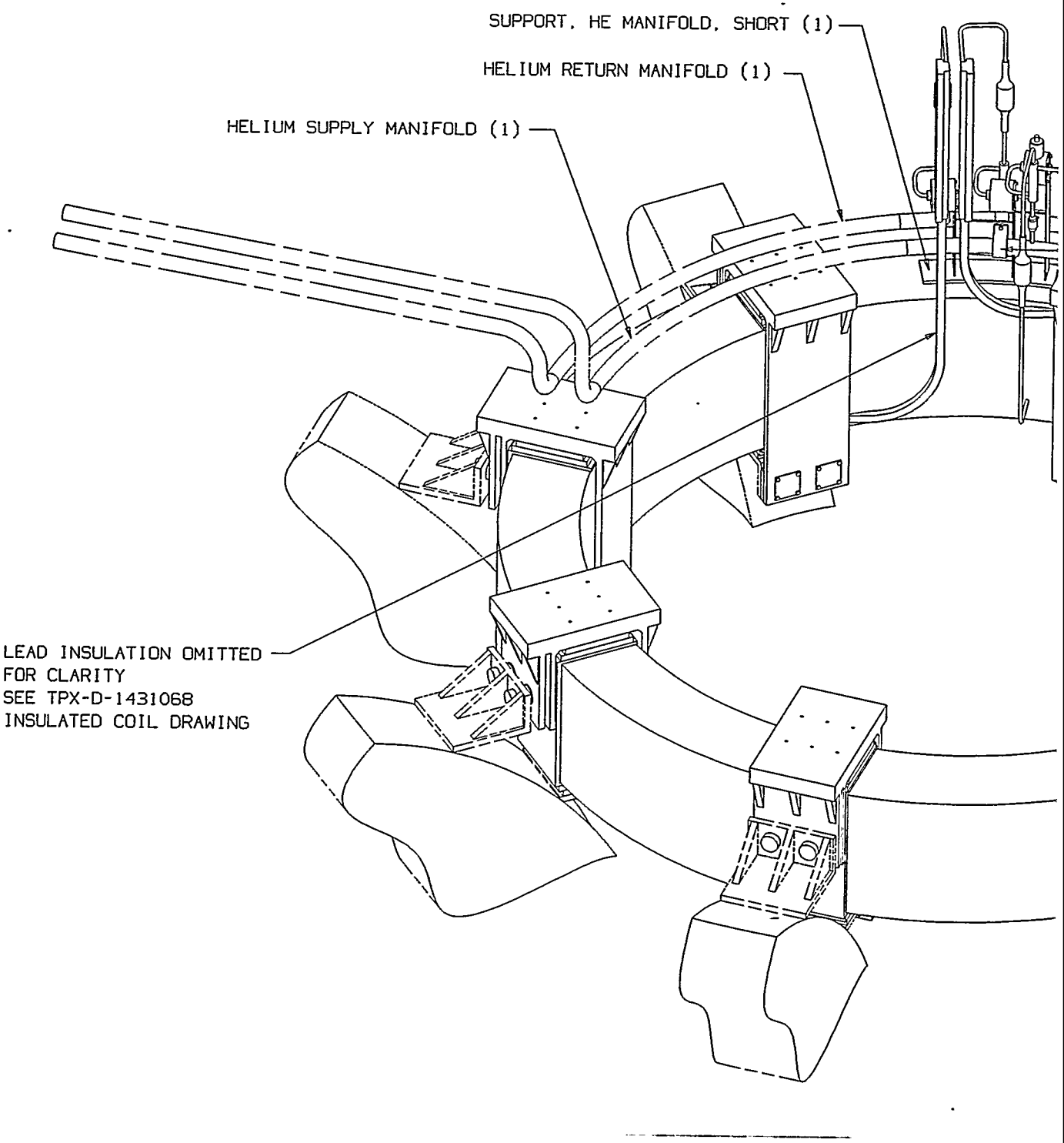
INSTRUMENTATION TRANSITION

TPX-D-1431073.SH008.P00 DRAFT

PREPARED L. UNDERWOOD	DATE 95-08-10	SIZE D	FSCH NO. 90099	DWG NO. A-15173
CHECKED				
DESIGNER		SCALE NONE		SHEET 8

NOTES:

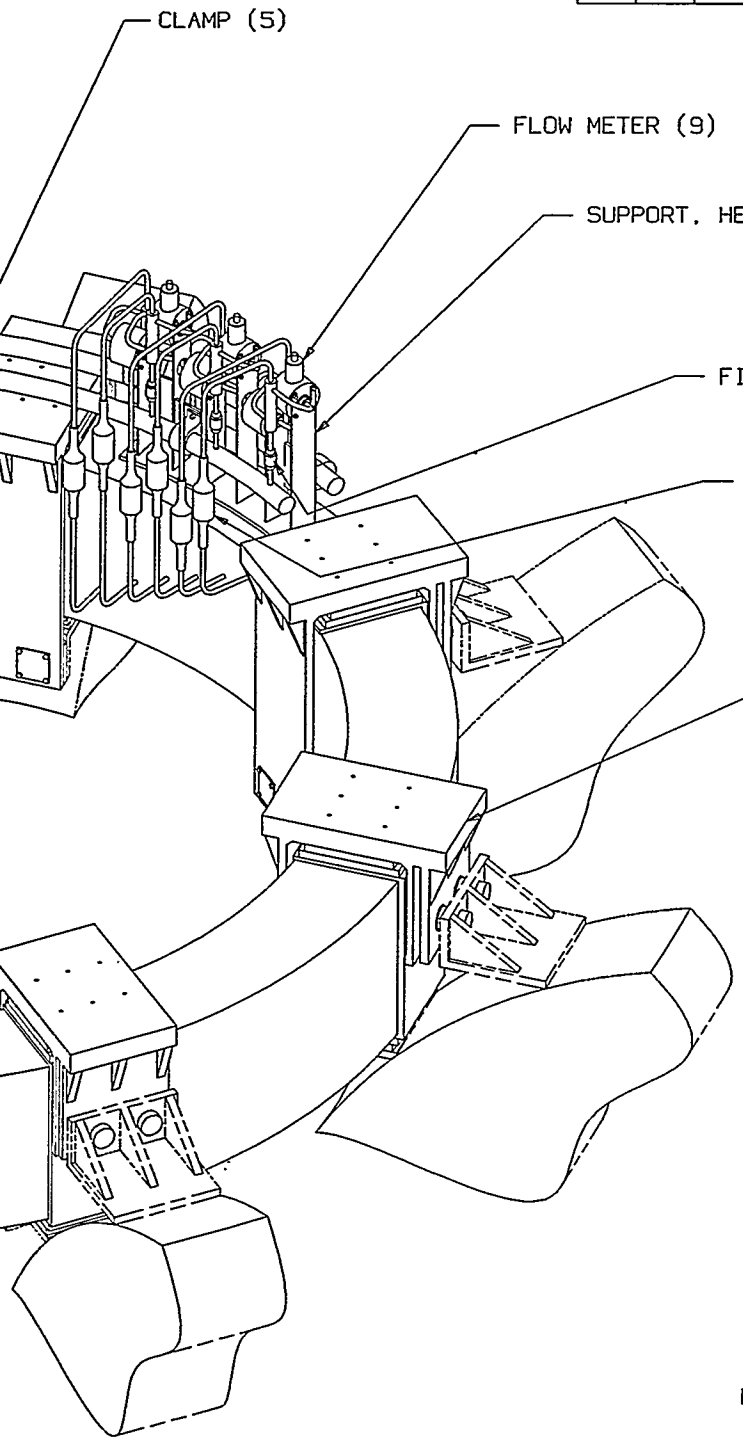
1. DIMENSIONS ARE AT ROOM TEMPERATURE.
2. INTERPRET DIMENSIONS AND TOLERANCES IN ACCORDANCE WITH ANSI Y14.5M-1982.



FSCH NO.	DWG NO.	SH
90099	A-15166	1

REV STATUS OF SHEETS			
-	SH 3	SH 2	SH 1
-	-	-	-

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



NOTE: COOLING SCHEMATIC
SHOWN ON TPX-D-1431069

TPX-D-1431066.SH001.P00 DRAFT

SIGNED	DATE	DASH NO.	NEXT ASSY	USED ON
		NONE	NONE	TPX
LNL APPROVAL		APPLICATION		REF DWG:

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± ---
3 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION

CONTRACT: B254501

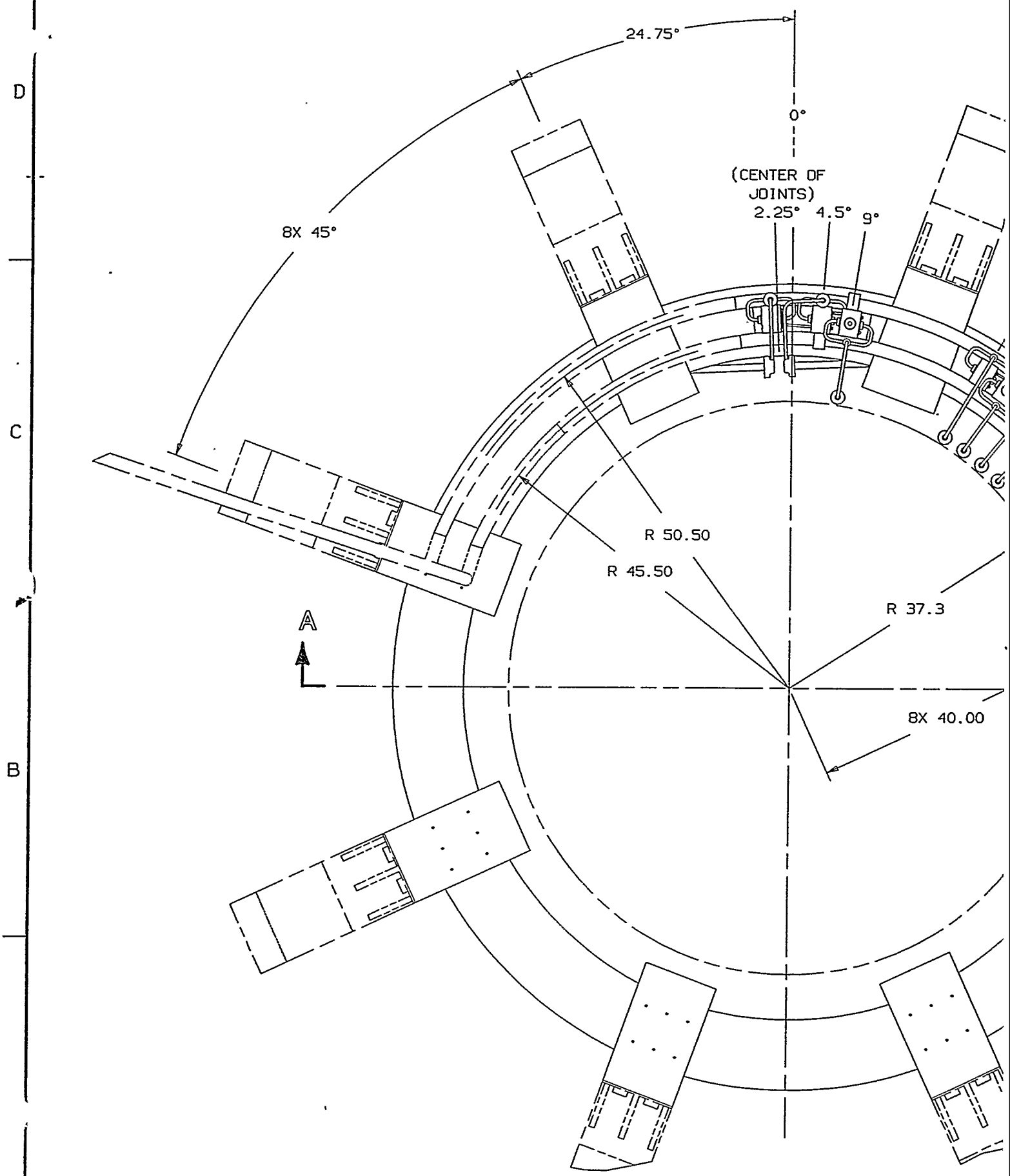
PREPARED	L. UNDERWOOD	DATE 95-8-14
CHECKED		
ENGINEER		
APPROVED		

MARINE DIVISION
Westinghouse Electric Corporation
401 HENDY AVE., SUNNYVALE, CA. 94088

PF 5 COIL ASSEMBLY - TPX
UPPER AND LOWER

SIZE	FSCH NO.	DWG NO.
D	90099	A-15166

SCALE NONE SHEET 1 OF 3



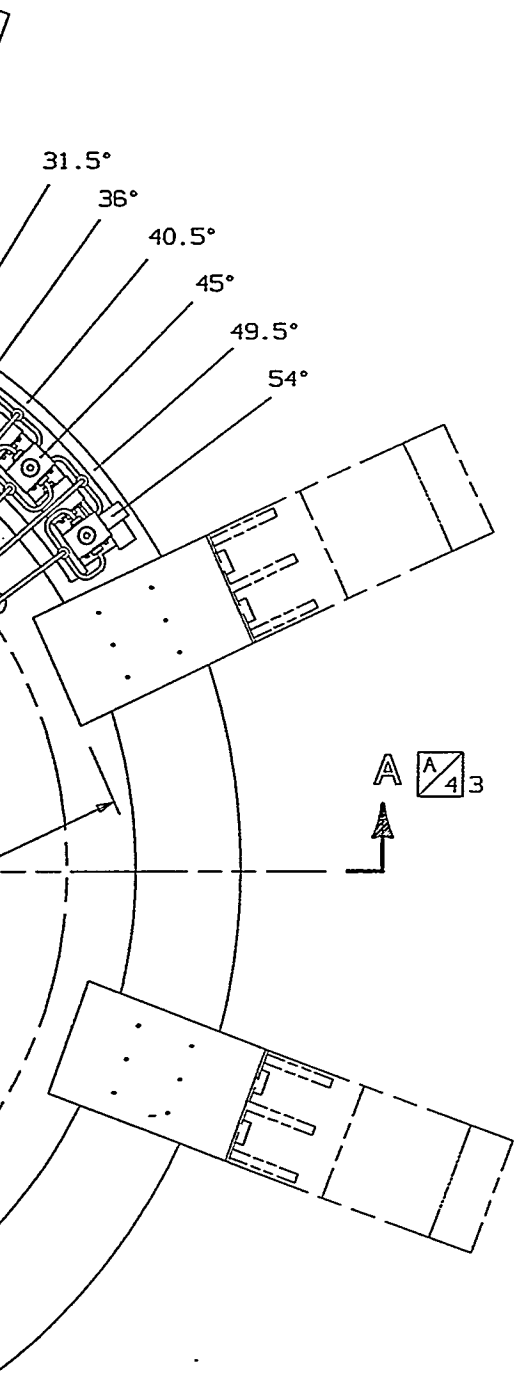
PLAN VIEW

F202

FSCH NO.	DWG NO.	SH
90099	A-15166	2

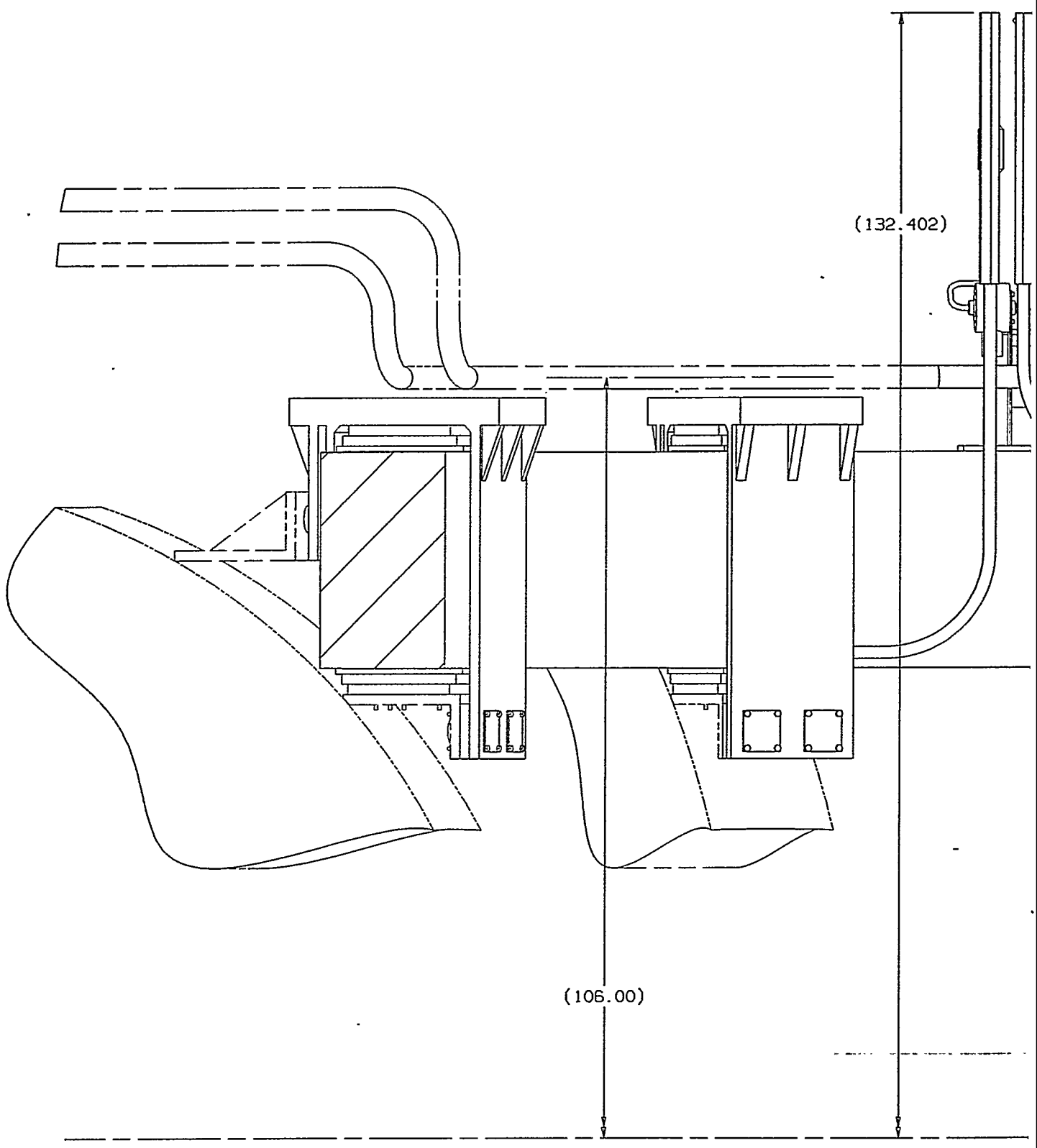
REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



TPX-D-1431066.SH002.P00 DRAFT

PREPARED	DATE	SIZE	FSCH NO.	DWG NO.
L. UNDERWOOD	95-08-14	D	90099	A-15166
CHECKED				
ENGINEER		SCALE 1/8		SHEET 2

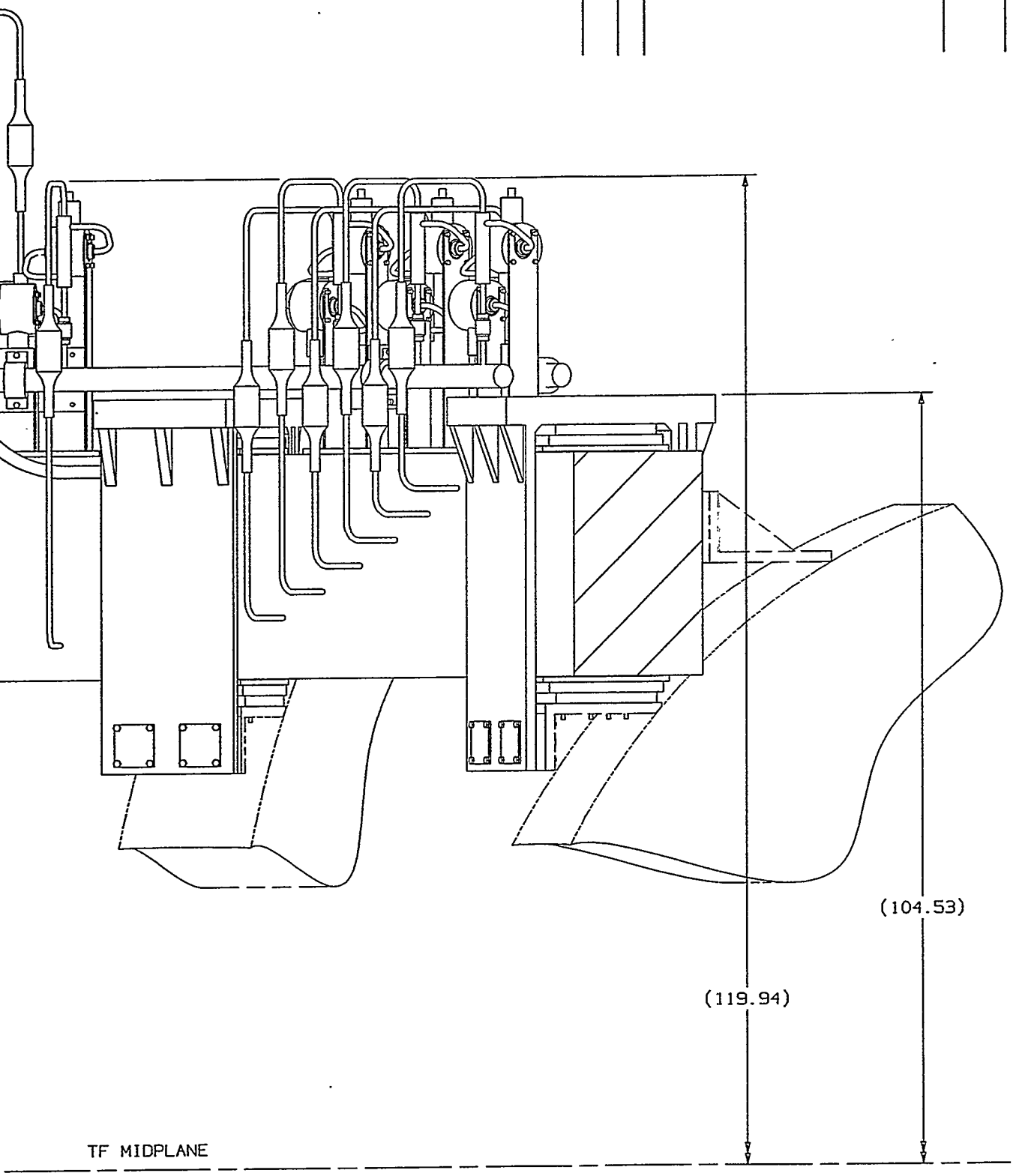


SECTION

FSCH NO.	DWG NO.	SH
90099	A-15166	3

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H44751		

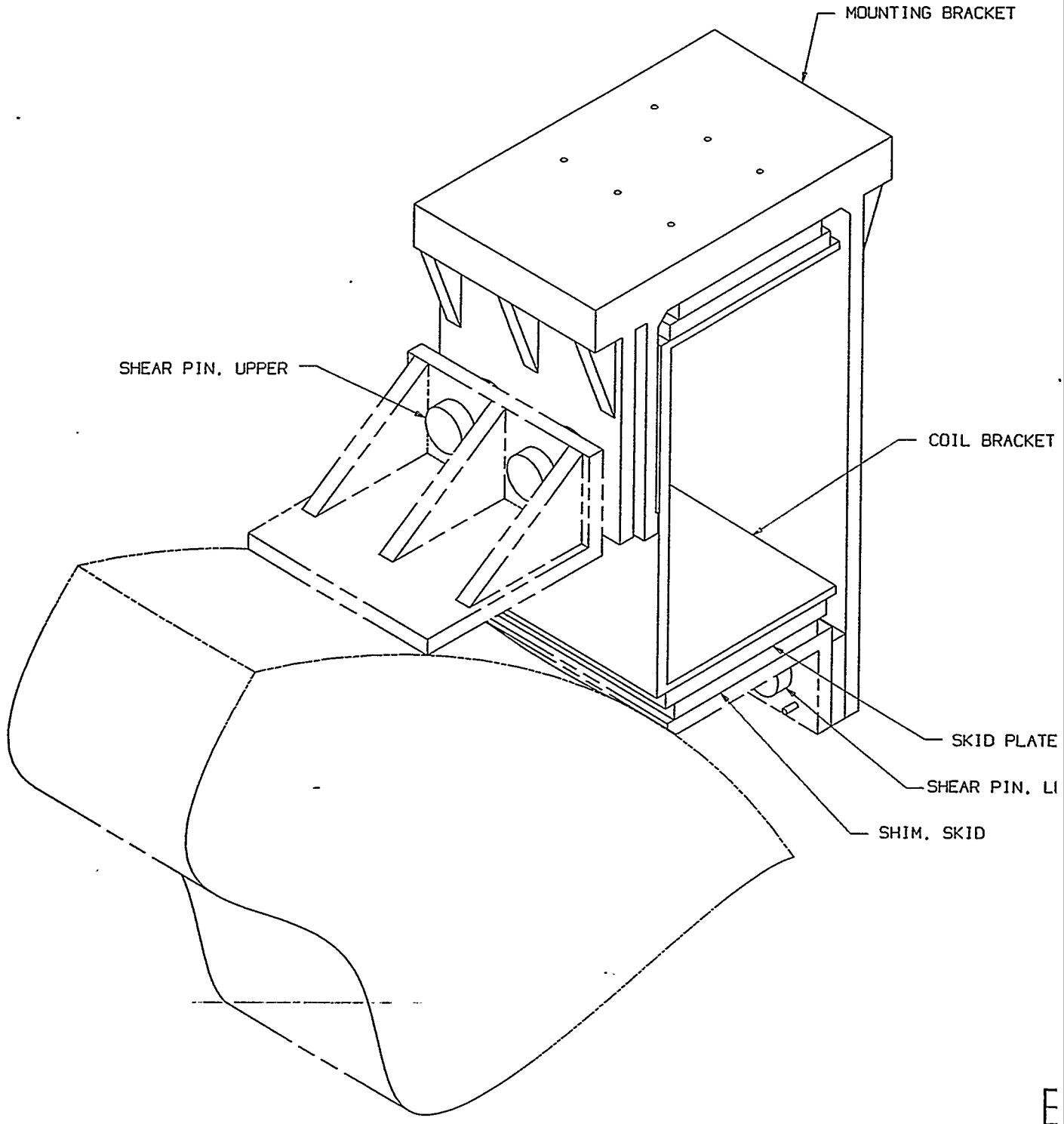


TPX-D-1431066.SH003.P00 DRAFT

PREPARED L.UNDERWOOD	DATE 95-08-14	SIZE D	FSCH NO. 90099	DWG NO. A-15166	
CHECKED		SCALE NONE			SHEET 3
ENGINEER					

NOTES:

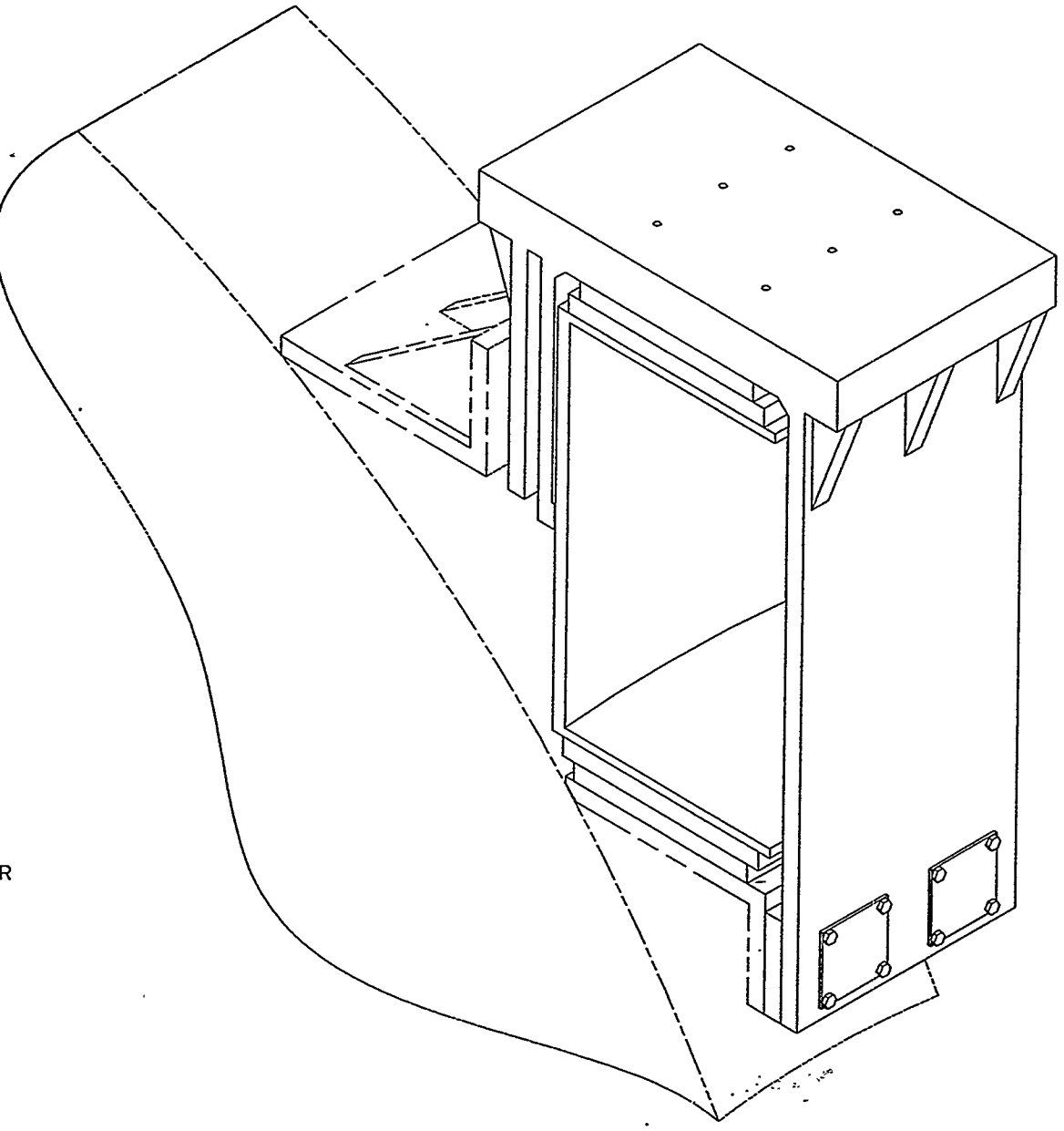
1. DIMENSIONS ARE AT ROOM TEMPERATURE.
2. INTERPRET DIMENSIONS AND TOLERANCES IN ACCORDANCE WITH ANSI Y14.5M-1982.



FSCM NO.	DWG NO.	SH
90099	A-15167	1

REV STATUS OF SHEETS		
SH 3	SH 2	SH 1
-	-	-

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



TPX-D-1431067.SH001.P00 DRAFT

SIGNED	DATE	NONE DASH NO.	NONE NEXT ASSY	TPX USED ON	
LLNL APPROVAL		APPLICATION			

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± ---
3 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
DO NOT SCALE DRAWING

THIRD ANGLE PROJECTION

REF DWG:

CONTRACT: B254501

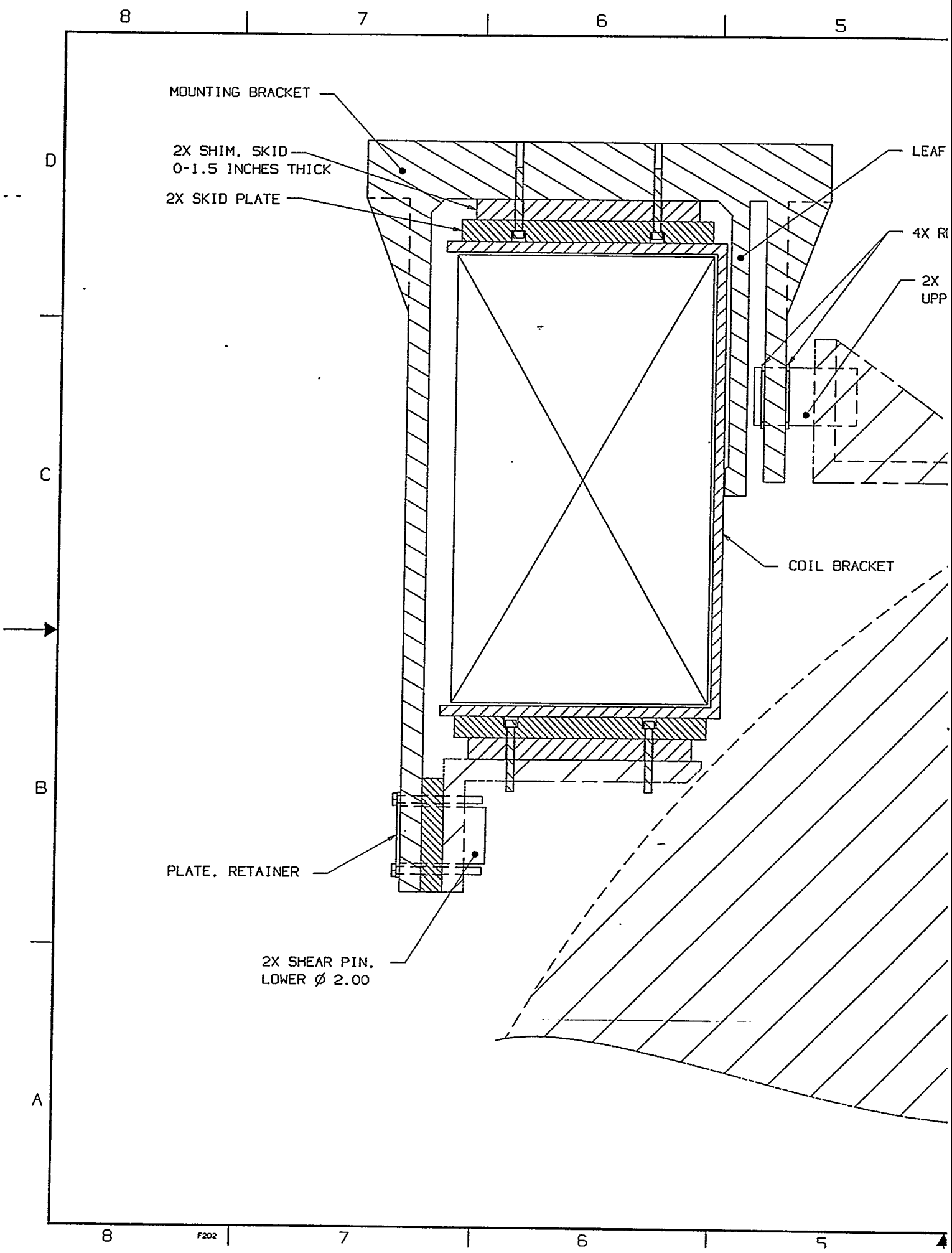
PREPARED	L. UNDERWOOD	DATE 95-8-14
CHECKED		
ENGINEER		
APPROVED		

MARINE DIVISION
Westinghouse Electric Corporation
401 HENDY AVE. SUNNYVALE, CA. 94086

PF 5 TO TF MOUNT
UPPER AND LOWER

SIZE	FSCM NO.	DWG NO.
D	90099	A-15167

SCALE NONE SHEET 1 OF 3


8
7
6
5
D
C
B
A
MOUNTING BRACKET
2X SHIM. SKID
0-1.5 INCHES THICK
2X SKID PLATE
LEAF
4X R
2X
UPP
COIL BRACKET
PLATE. RETAINER
2X SHEAR PIN.
LOWER Ø 2.00
F202

FSCM NO.	DWG NO.	SH
90099	A-15167	2

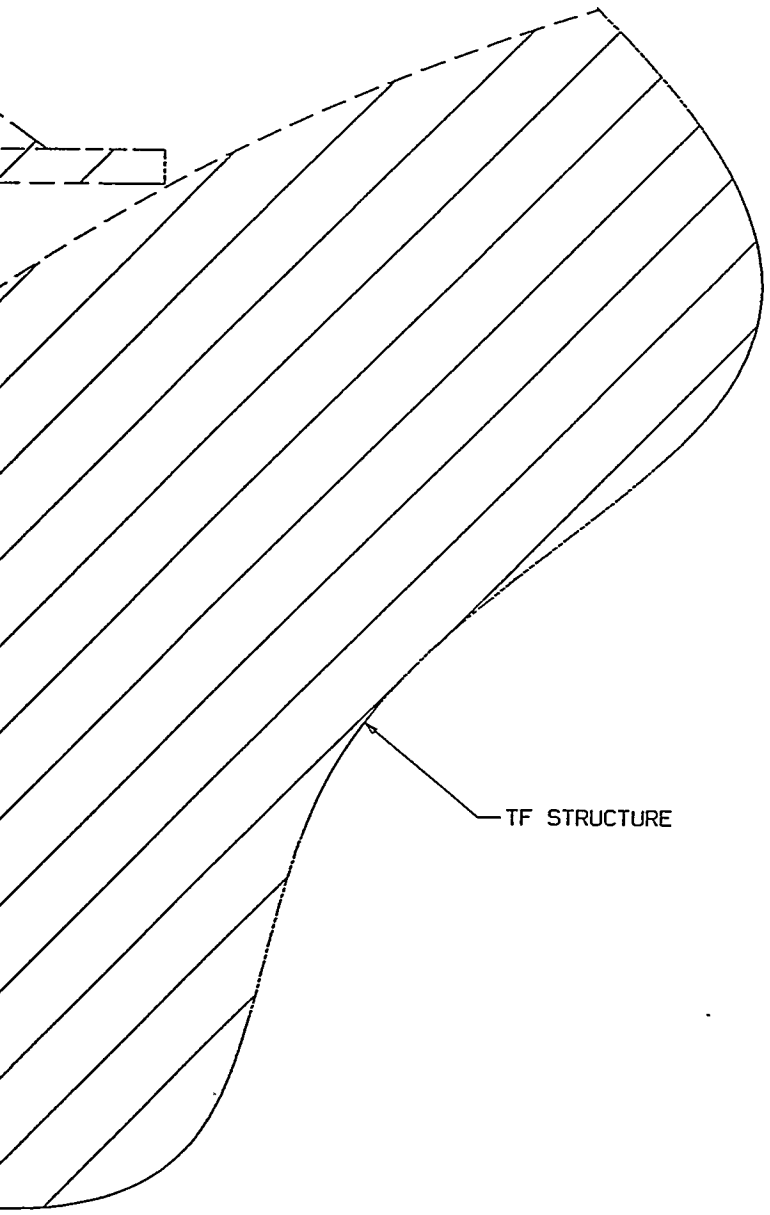
REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

RING

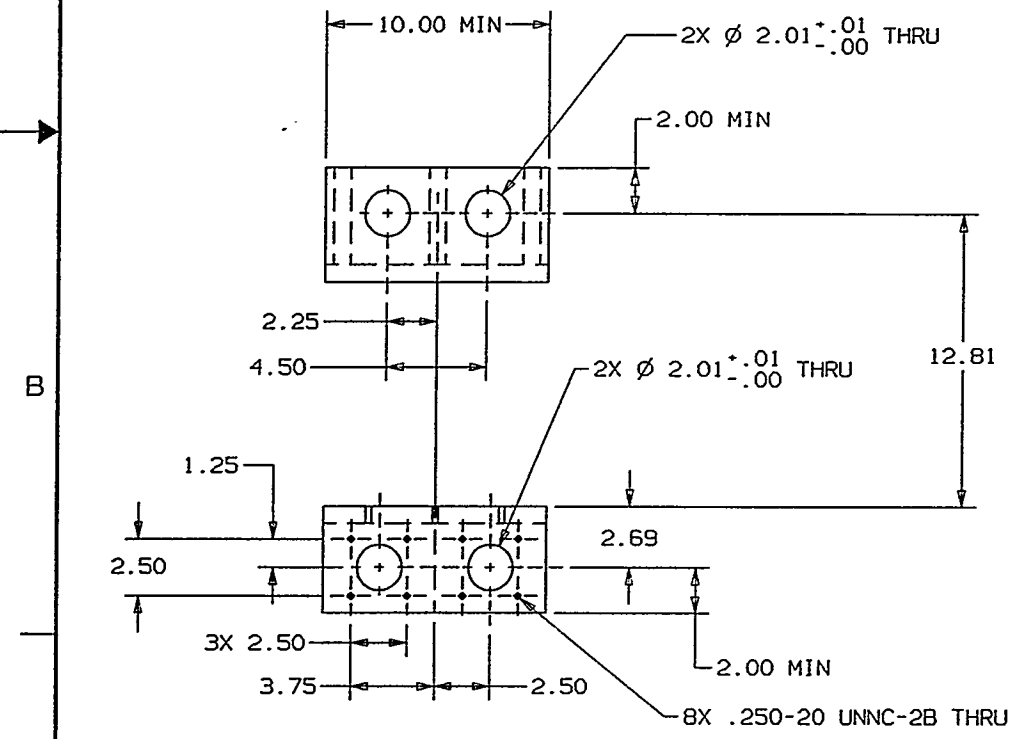
INING RING

AR PIN.
Ø 2.00

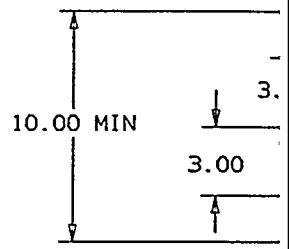


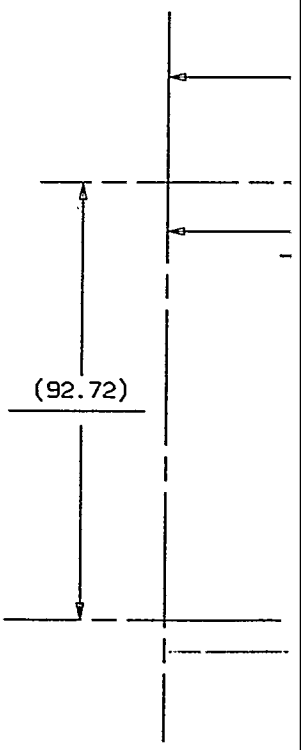
TPX-D-1431067.SH002.P00 DRAFT

PREPARED L.UNDERWOOD	DATE 95-08-14	SIZE D	FSCM NO. 90099	DWG NO. A-15167	
CHECKED					
ENGINEER		SCALE NONE			SHEET 2



6X .250-20 UNC-2B T

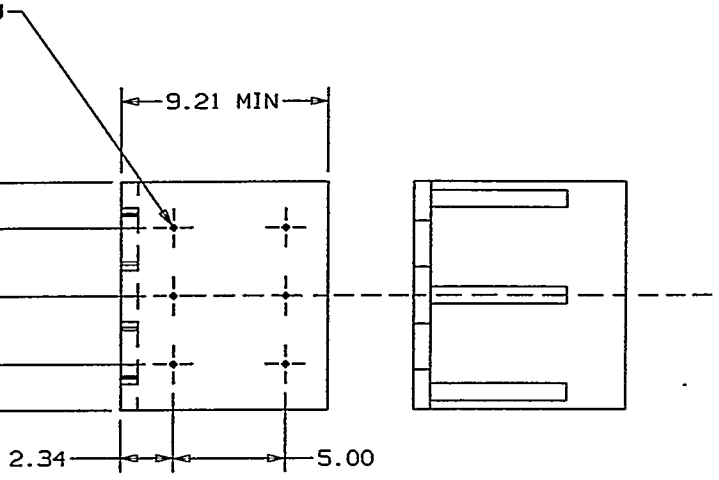


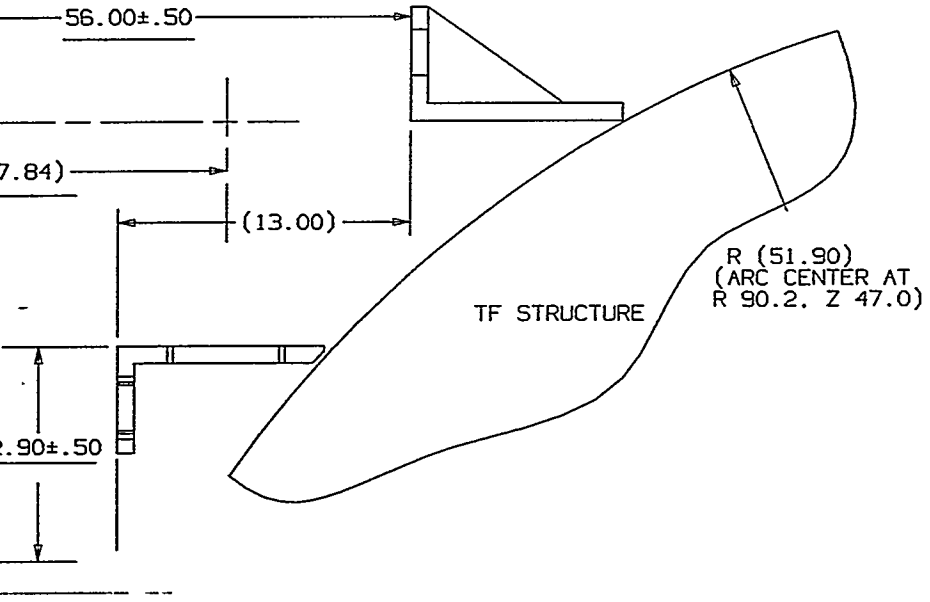


FSCH NO.	DWG NO.	SH
90099	A-15167	3

REVISIONS

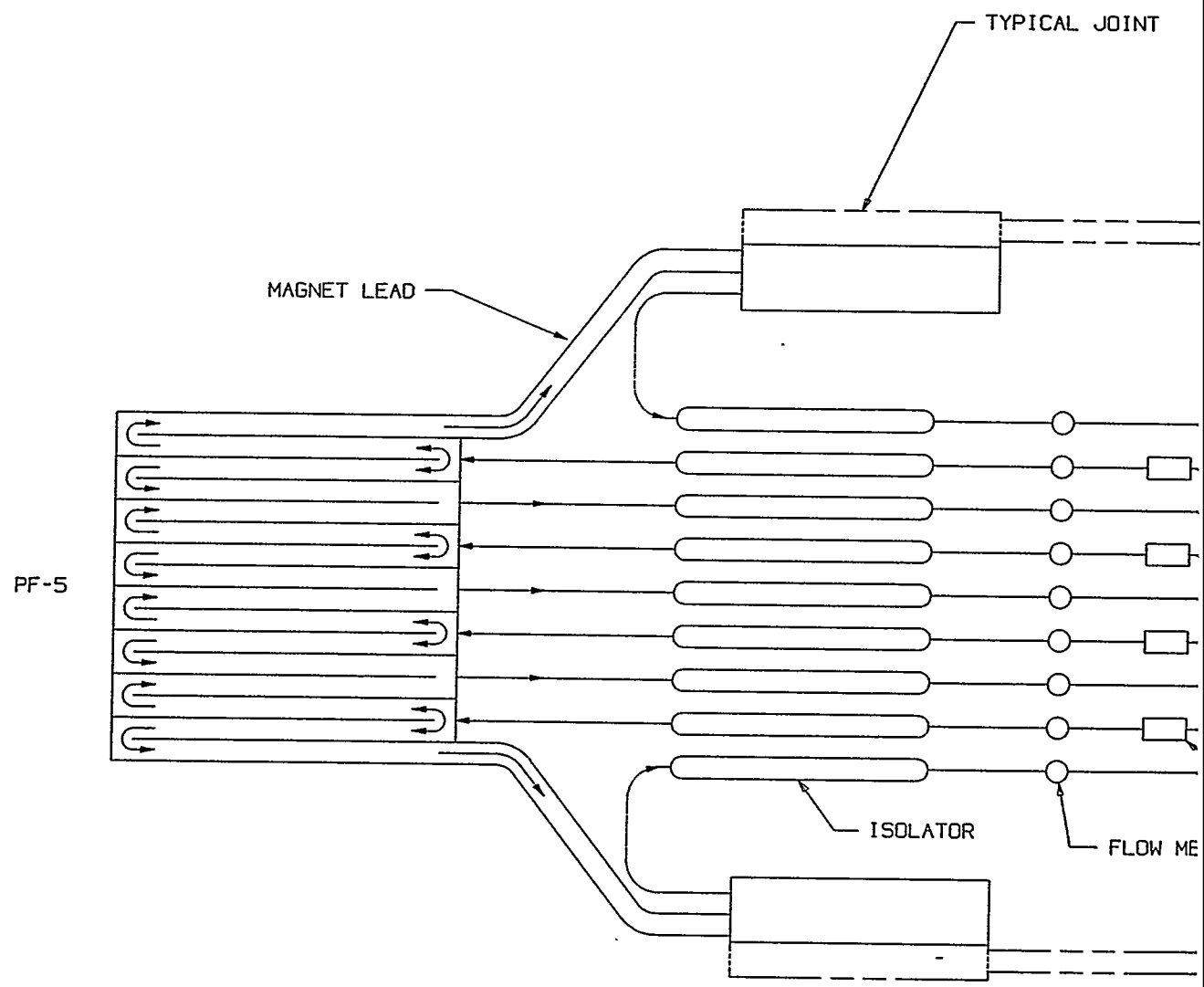
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		





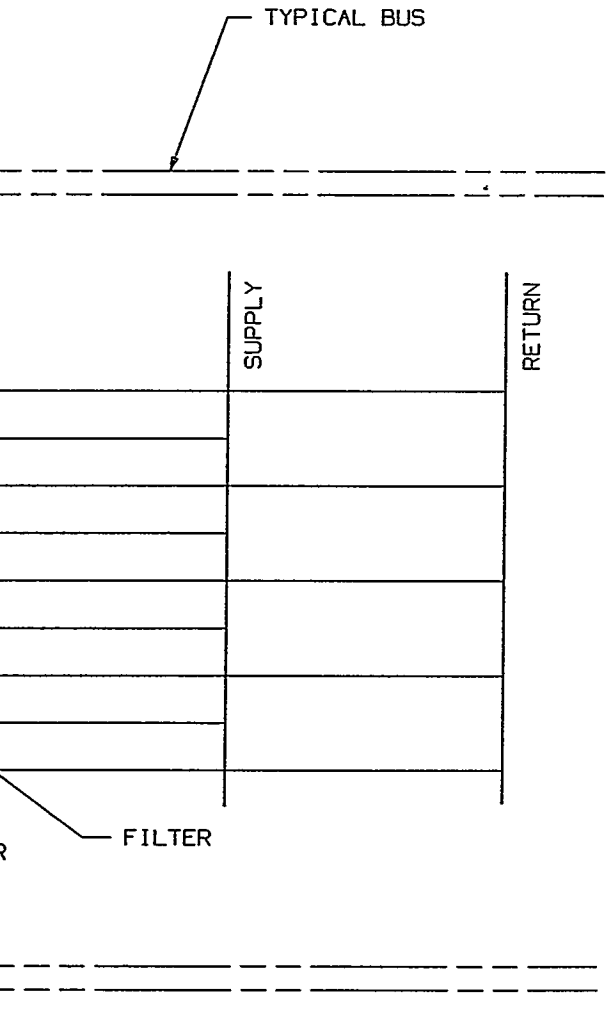
TPX-D-1431067.SH003.P00 DRAFT

PREPARED L.UNDERWOOD	DATE 95-08-14	SIZE D	FSCH NO. 90099	DWG NO. A-15167	
CHECKED					
ENGINEER		SCALE NONE			SHEET 3


TYPICAL JOINT
MAGNET LEAD
PF-5
ISOLATOR
FLOW ME

FSCM NO.	DWG NO.	SH
90099	A-15169	1

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



TPX-D-1431069.SH001.P00 DRAFT

		NONE	NONE	TPX
SIGNED	DATE	DASH NO.	NEXT ASSY	USED ON
APPROVAL		APPLICATION		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± ---
3 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION
REF DWG:

CONTRACT: B254501

PREPARED	KAWASAKI	DATE 95-8-3
CHECKED		
ENGINEER		
APPROVED		

MARINE DIVISION
Westinghouse Electric Corporation
401 HENDY AVE. SUNNYVALE, CA. 94088

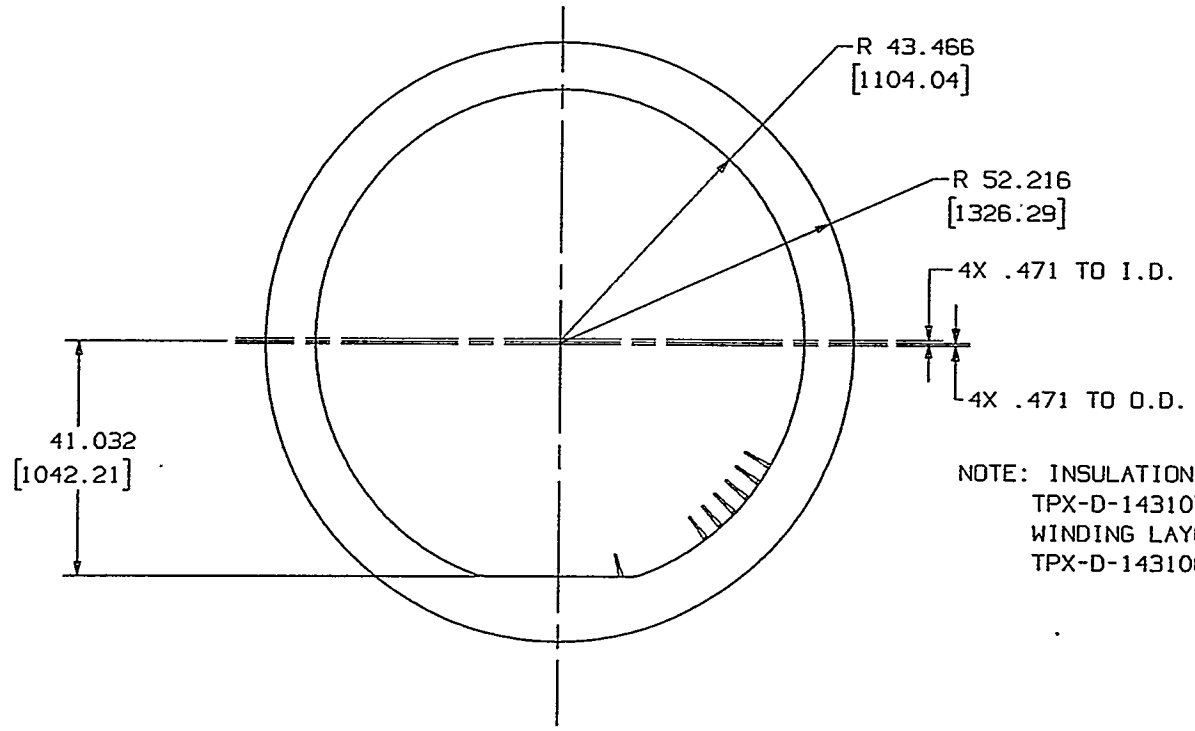
PF5 COOLING SCHEMATIC,
DOUBLE-PANCAKE

SIZE	FSCM NO.	DWG NO.
D	90099	A-15169

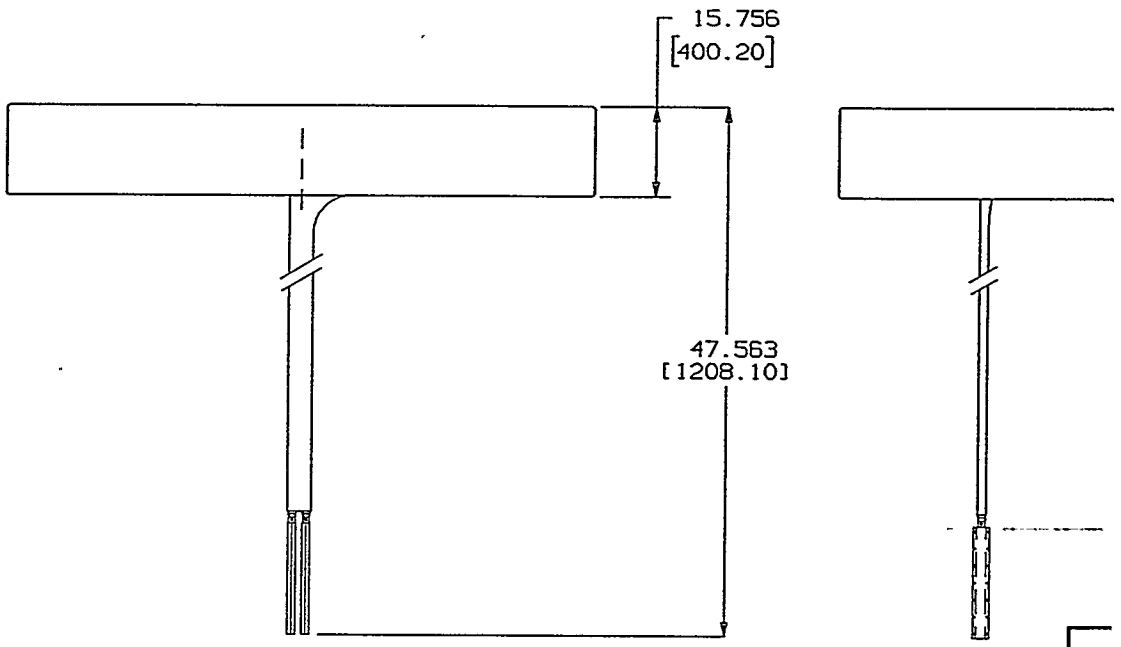
SCALE NONE SHEET 1 OF 1

NOTES:

1. DIMENSIONS ARE AT ROOM TEMPERATURE.
2. INTERPRET DIMENSIONS AND TOLERANCES IN ACCORDANCE WITH ANSI Y14.5M-1982.



NOTE: INSULATION SHOWN ON TPX-D-1431073 (A-15173)
WINDING LAYOUT SHOWN ON TPX-D-1431065 (A-15165)



FSCH NO.	DWG NO.	SH
90099	A-15168	1

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

TPX-D-1431068.SH001.P00 DRAFT

SIGNED	DATE	DASH NO.	NEXT ASSY	USED ON
		NONE	NONE	TPX

APPROVAL APPLICATION

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± ---
3 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---

DO NOT SCALE DRAWING

THIRD ANGLE PROJECTION

REF DWG:

CONTRACT: B254501

PREPARED	KAWASAKI	DATE 95-8-11
CHECKED		
ENGINEER		
APPROVED		

MARINE DIVISION
Westinghouse Electric Corporation
401 HENDY AVE. SUNNYVALE, CA. 94088

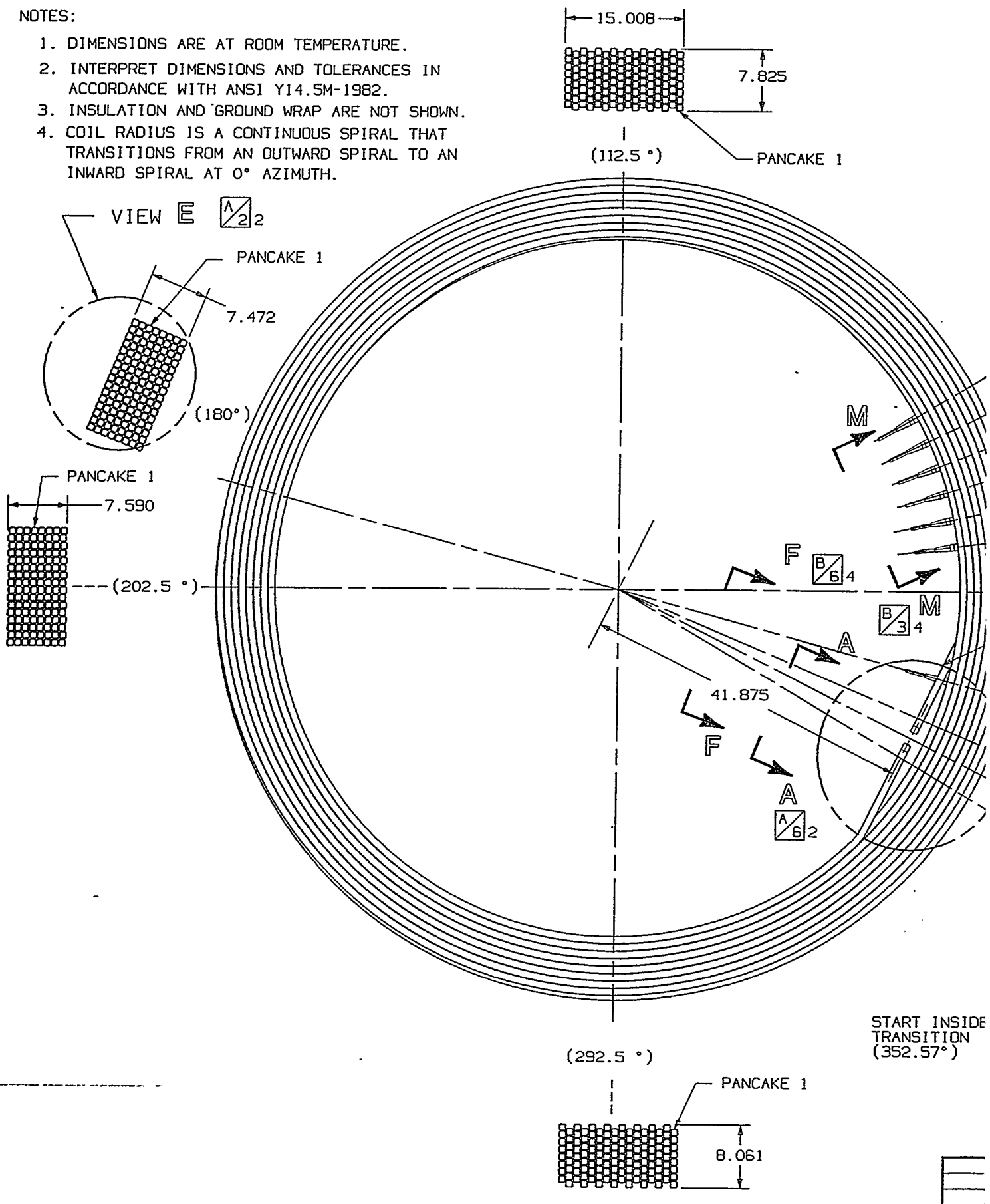
PF5 INSULATED COIL -TPX

SIZE	FSCH NO.	DWG NO.
D	90099	A-15168

SCALE NONE SHEET 1 OF 1

NOTES:

1. DIMENSIONS ARE AT ROOM TEMPERATURE.
2. INTERPRET DIMENSIONS AND TOLERANCES IN ACCORDANCE WITH ANSI Y14.5M-1982.
3. INSULATION AND GROUND WRAP ARE NOT SHOWN.
4. COIL RADIUS IS A CONTINUOUS SPIRAL THAT TRANSITIONS FROM AN OUTWARD SPIRAL TO AN INWARD SPIRAL AT 0° AZIMUTH.

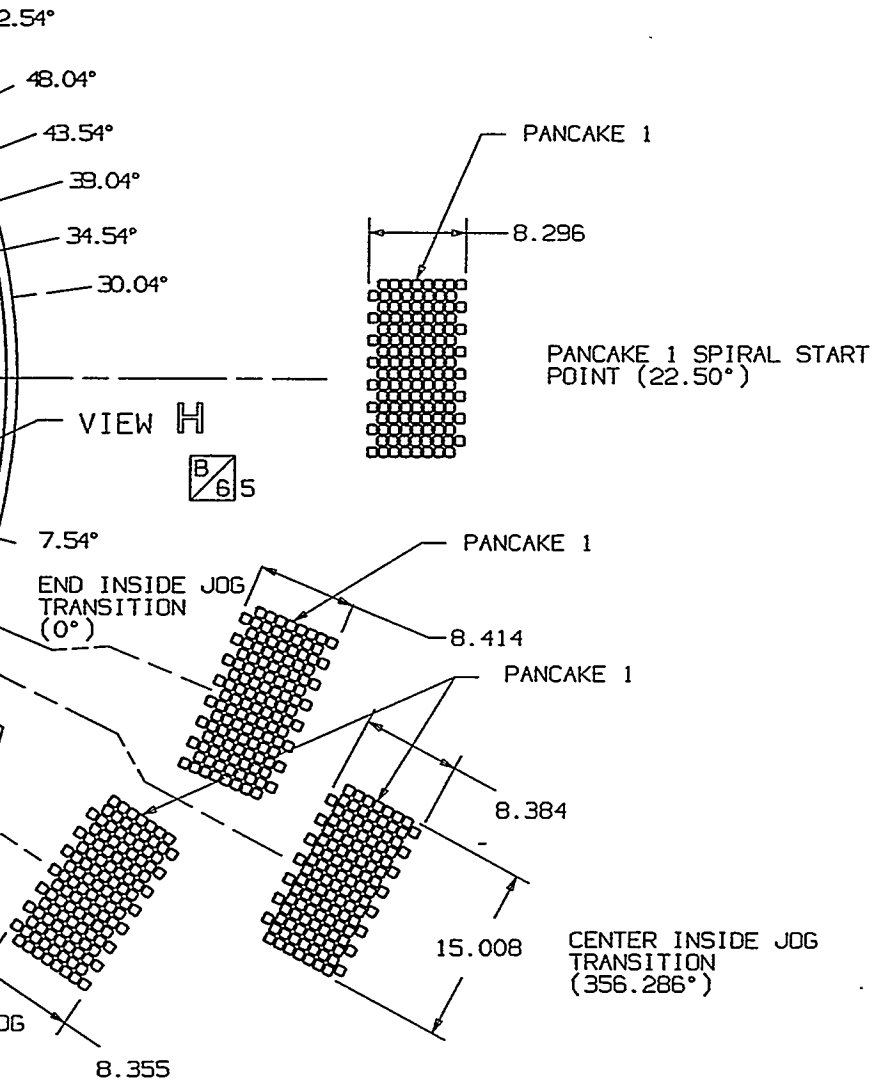


PLAN VIEW
PANCAKE LAYER 16
CCW WINDING

FSCN NO.	DWG NO.	SH
90099	A-15165	1

REV STATUS OF SHEETS					
SH 6	SH 5	SH 4	SH 3	SH 2	SH 1
-	-	-	-	-	-

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



TPX-D-1431065.SH001.P00 DRAFT

		NONE	NONE	TPX	
SIGNED	DATE	DASH NO.	NEXT ASSY	USED ON	
L APPROVAL		APPLICATION			

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± ---
3 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
2 PLACE DECIMALS ± ---
DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION
REF DWG:

CONTRACT: B254501

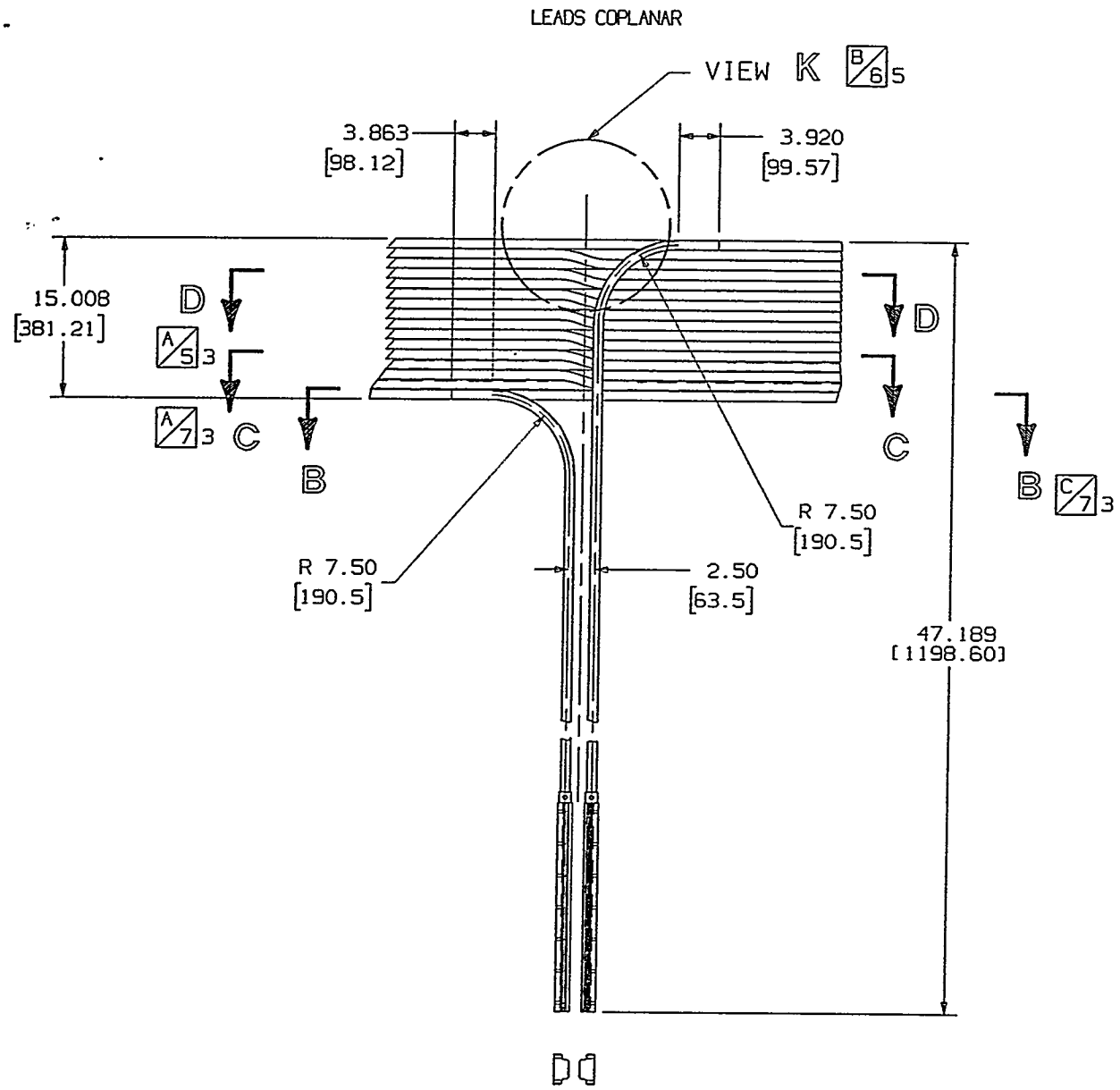
PREPARED	L. UNDERWOOD	DATE 95-8-03
CHECKED		
ENGINEER		
APPROVED		

MARINE DIVISION
Westinghouse Electric Corporation
401 HENDY AVE. SUNNYVALE, CA. 94088

WINDING LAYOUT
PF5 - TPX

SIZE	FSCN NO.	DWG NO.
D	90099	A-15165

SCALE 1/8 SHEET 1 OF 6



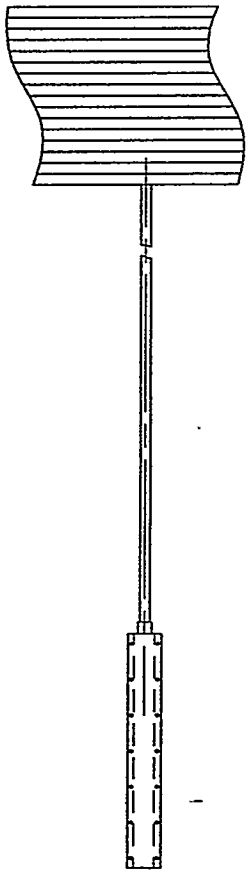
VIEW A-A B/5 1

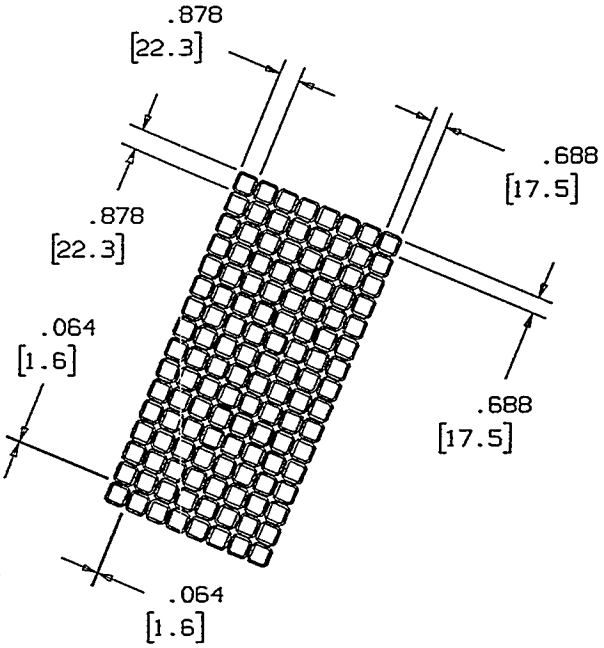
ROTATED 116.214 CCW

FSCM NO.	DWG NO.	SH
90099	A-15165	2

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		



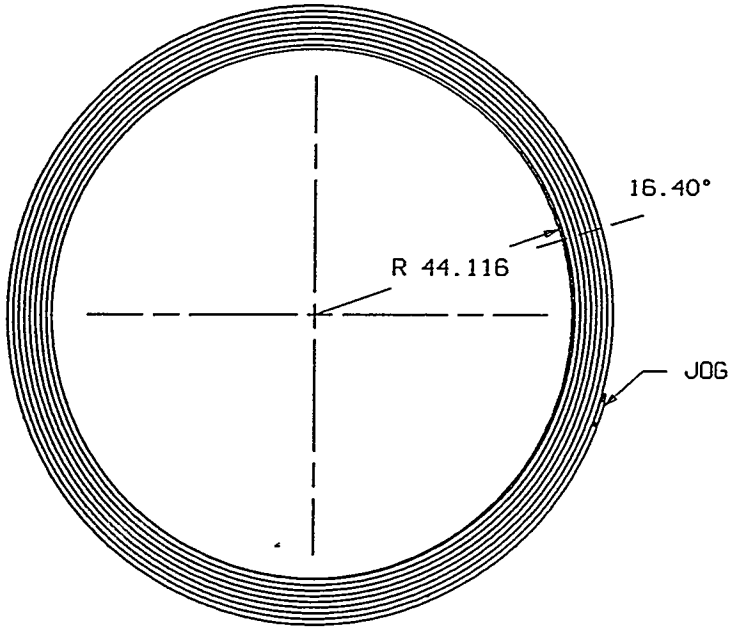


VIEW E D/7 1

SCALE: 1/4

TPX-D-1431065.SH002.P00 DRAFT

PREPARED L. UNDERWOOD	DATE 95-8-02	SIZE D	FSCM NO. 90099	DWG NO. A-15165
CHECKED		SCALE 1/8 & NOTED		SHEET 2
ENGINEER				



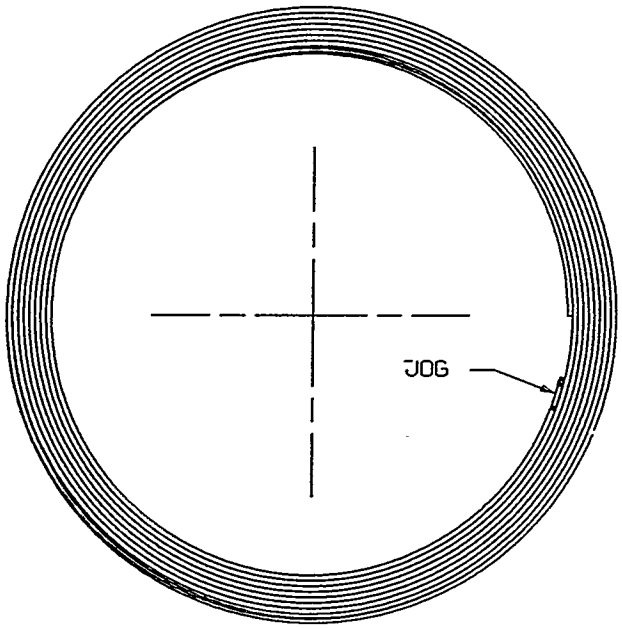
SECTION B-B C/5 2

ROTATED 112.5° CW

PANCAKE LAYER 1

NOTE: COIL RADIUS IS A CONTINUOUS S
INWARD SPIRAL AT 0° AZIMUTH.

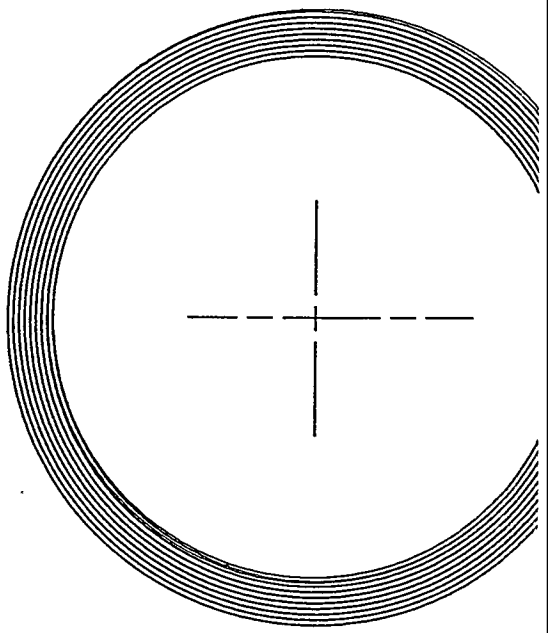
PANCAKE	START		SPIRA
	AZIMUTH	RADIUS	AZIML
1	16.40	44.116	
2	359.46	51.608	0.0(
3	0.00	44.073	
4	359.46	51.608	0.0(
5	0.00	44.073	
6	359.46	51.608	0.0(
7	0.00	44.073	
8	359.46	51.608	0.0(
9	0.00	44.073	
10	359.46	51.608	0.0(
11	0.00	44.073	
12	359.46	51.608	0.0(
13	0.00	44.073	
14	359.46	51.608	0.0(
15	0.00	44.073	
16	359.46	51.608	0.0(



SECTION C-C C/8 2

ROTATED 112.5° CW

PANCAKE LAYERS 2, 4, 6, 8,
10, 12 & 14



SECTION D-D C/8 2

ROTATED 112.5° CW

PANCAKE LAYERS 1, 3, 5, 7,
9, 11 & 15

FSCH NO.	DWG NO.	SH
90099	A-15165	3

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

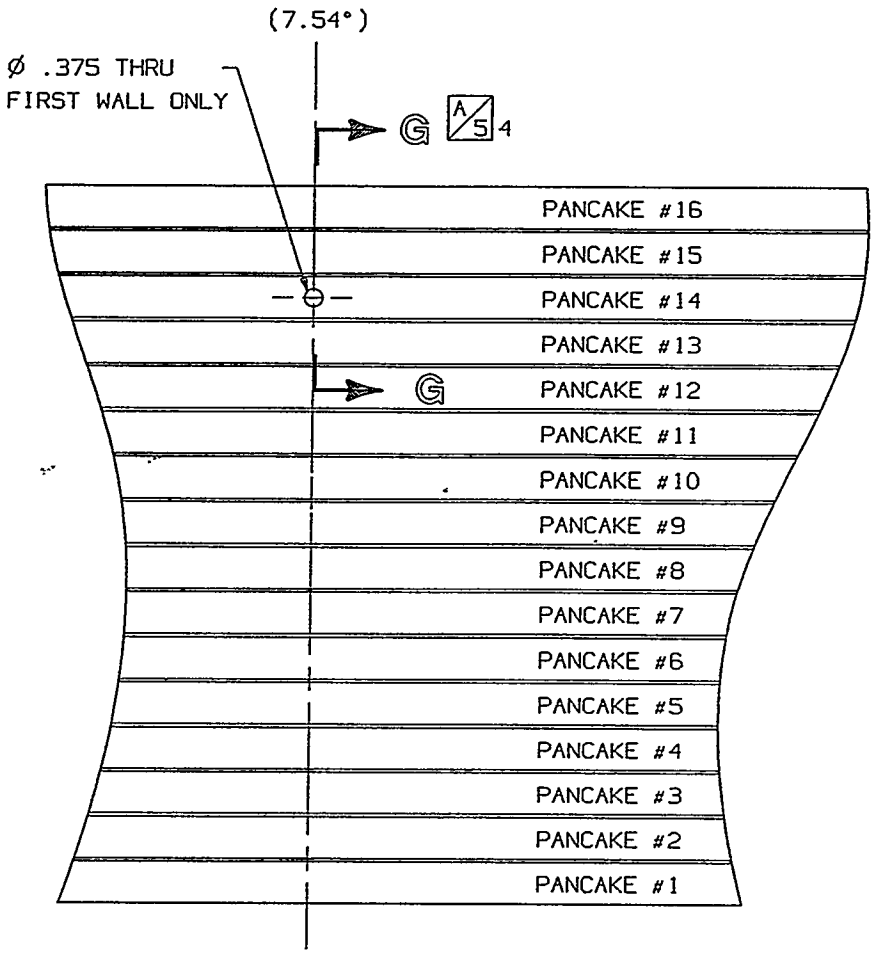
RAL THAT TRANSITIONS FROM AN OUTWARD SPIRAL TO AN

PF5 WINDING DATA					
TRANSITION		JOG START		JOG/PANCAKE END	
	RADIUS	AZIMUTH	RADIUS	AZIMUTH	RADIUS
		353.11	51.591	359.46	51.608
	51.609	352.57	44.093	360.00	44.073
		353.11	51.591	359.46	51.608
	51.609	352.57	44.093	360.00	44.073
		353.11	51.591	359.46	51.608
	51.609	352.57	44.093	360.00	44.073
		353.11	51.591	359.46	51.608
	51.609	352.57	44.093	360.00	44.073
		353.11	51.591	359.46	51.608
	51.609	352.57	44.093	360.00	44.073
		353.11	51.591	359.46	51.608
	51.609	352.57	44.093	360.00	44.073
		353.11	51.591	359.46	51.608
	51.609	352.57	44.093	360.00	44.073
		353.11	51.591	359.46	51.608
	51.609			336.09	44.136

JOG

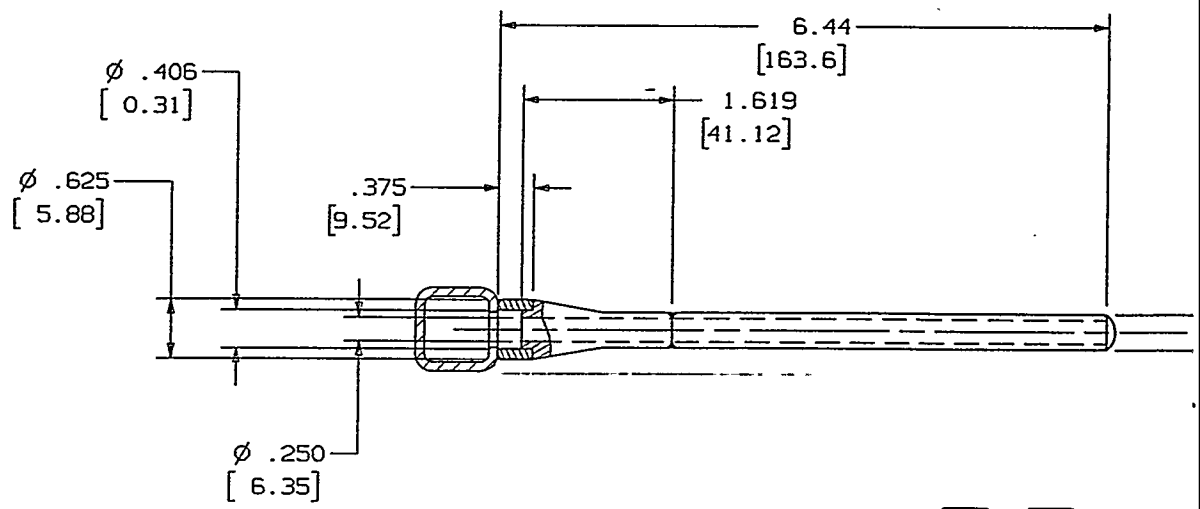
TPX-D-1431065.SH003.P00 DRAFT

DRAWN L. UNDERWOOD	DATE 95-8-01	SIZE D	FSCH NO. 90099	DWG NO. A-15165
CHECKED				
ENGINEER		SCALE 1/16		SHEET 3



6X .439
[11.15]

VIEW F-F C/5 1
ROTATED 104.96° CCW

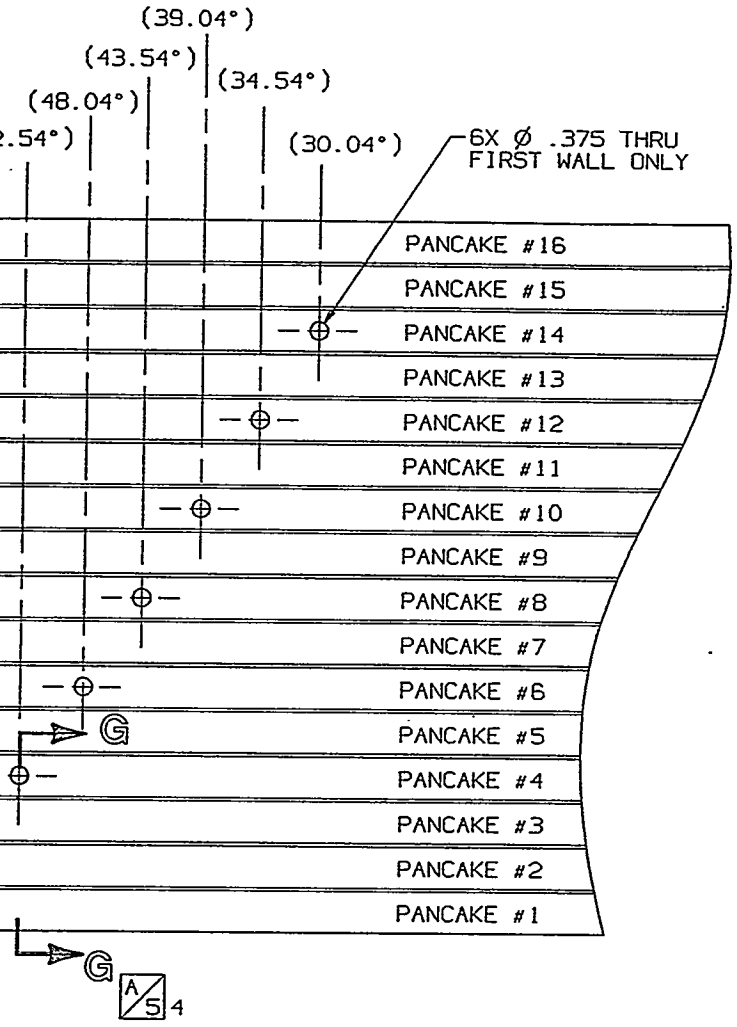


SECTION G-G B/4 4 D/7 4
SCALE: 1/1

FSCM NO.	DWG NO.	SH
90099	A-15165	4

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

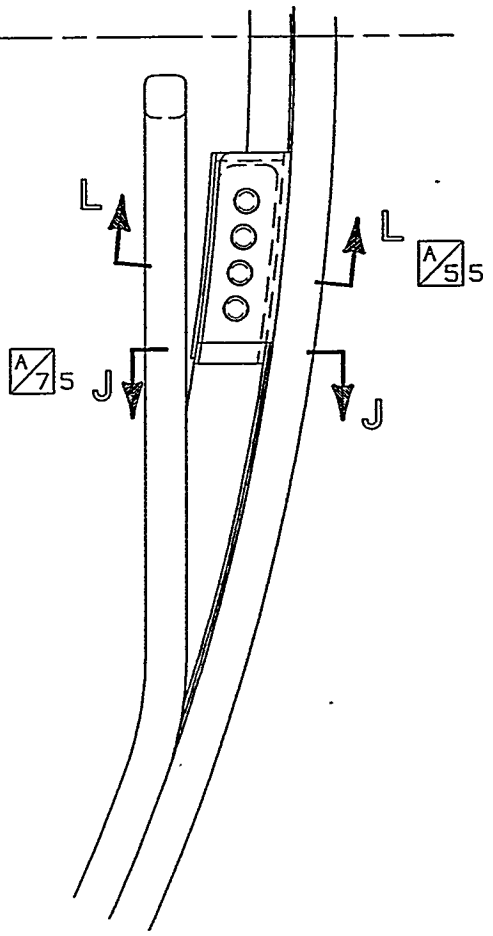


VIEW M-M C/5 1
ROTATED 68.96° CCW

Ø .375
[9.53]

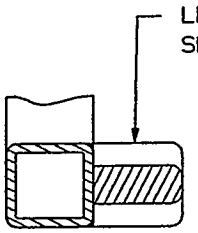
TPX-D-1431065.SH004.P00 DRAFT

DRAWN L. UNDERWOOD	DATE 95-8-01	SIZE D	FSCM NO. 90099	DWG NO. A-15165
CHECKED				
ENGINEER		SCALE 1/2 & NOTED		SHEET 4



VIEW H C/4 1

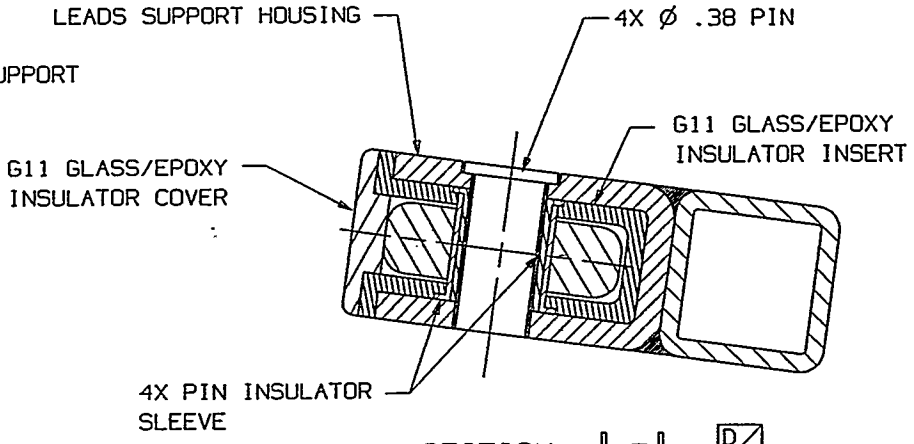
ROTATED 28.125° CCW



SECTION J-J C/6 5

SCALE: 1/1

LEADS SUPPORT 2 PLACES (TOP & BOTTOM) ALL COILS



SECTION L-L D/5 5

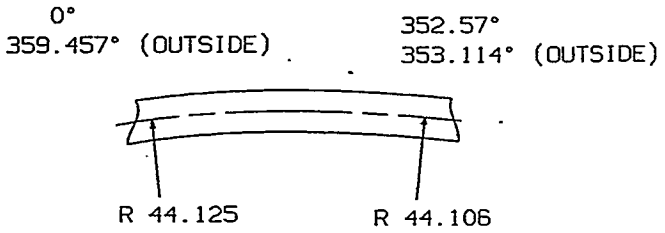
SCALE: 2/1

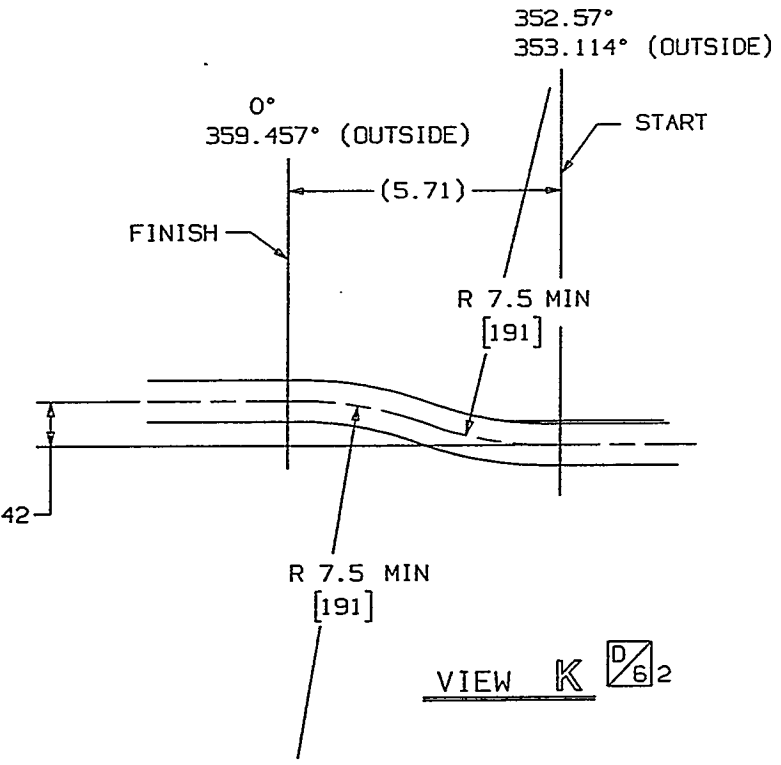
LEADS SUPPORT 2 PLACES (TOP & BOTTOM) ALL COILS

FSCH NO. 90099	DWG NO. A-15165	SH 5

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		

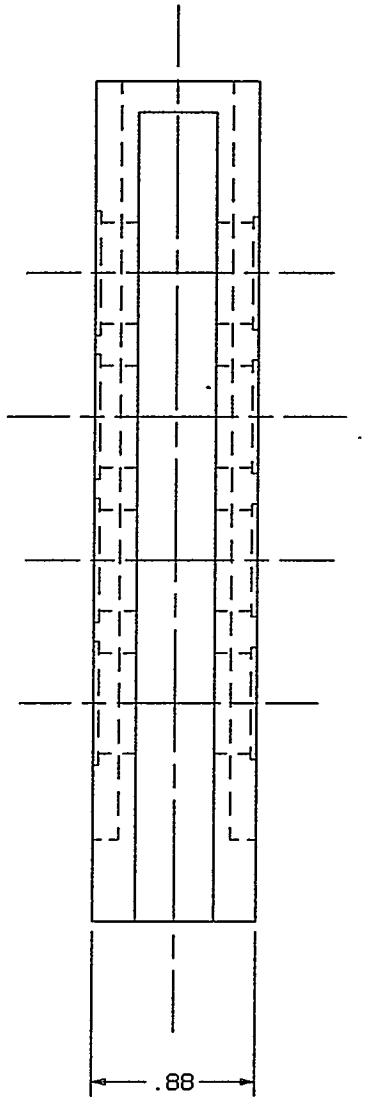


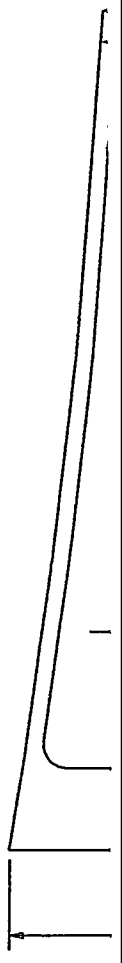


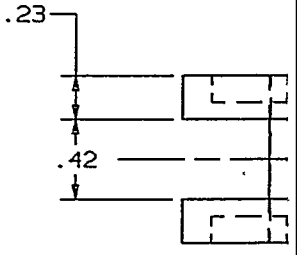
VIEW K D/6 2

TPX-D-1431065.SH005.P00 DRAFT

PREPARED L. UNDERWOOD	DATE 95-8-01	SIZE D	FSCH NO. 90099	DWG NO. A-15165
CHECKED				
ENGINEER		SCALE 1/2 & NOTED		SHEET 5





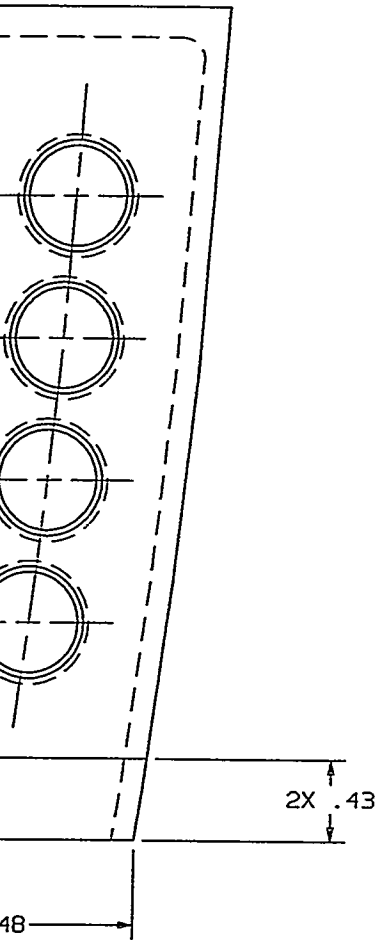


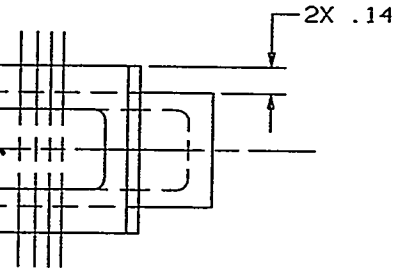
INSULAT

FSCM NO.	DWG NO.	SH
90099	A-15165	6

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
	—	C- INITIAL RELEASE E/D-H4751		





INSERT

TPX-D-1431065.SH006.P00 DRAFT

PREPARED L. UNDERWOOD	DATE 95-8-01	SIZE D	FSCM NO. 90099	DWG NO. A-15165	
CHECKED					
ENGINEER		SCALE 2/1			SHEET 6

TPX PF 6/7 Ring Coil Design

P. L. Walstrom Ph.D.
Northrop Grumman Corporation

August 18, 1995

TPX-14-950817-WEC-PWalstrom-02

APPROVED:

P.A. Sanger
Westinghouse TPX Chief Scientist

APPROVED:

D. R. Potter
Westinghouse TPX Engineering Manager

Table of Contents

A. Overview 3
B. Electromagnetics 5
C. Coil Pack Design 6
1. Winding Configuration 6
2. Electrical Insulation Design 7
D. Winding Pack and Coil Case Stresses 8
1. Cooldown Stress Results 8
2. Stresses From Magnetic Loads 9
3. Justification for Case 12
E. Coil Case Design, Coolant and Current Supply, and Instrumentation 14
1. Mechanical Design Description 14
2. Supporting Stress Analysis 15
3. Helium Coolant lines, Insulating Breaks and Electrical Lead Routing 15
4. Instrumentation 16
5. Support of Leads and Other Components 18
F. Eddy-Current Heating of the Case 20
G. Interface to TF coils 21
1. Loads and design constraints 21
2. Design Description 21
3. Installing Fiducials and Finding the Magnetic Center 22

A. Overview

The PF6 and PF7 coils occur in pairs placed symmetrically above and below the machine midplane. The upper PF6 coil is designated PF6U, the lower PF6L, etc. PF6U is essentially identical to PF6L, and PF7U essentially identical to PF7L. As part of the PF coil system, they act in concert with the other PF coils to provide the desired flux changes and time-varying field pattern in the plasma volume for plasma shaping, position control, and discharge evolution. They also act to compensate effective ring currents from the TF coils and TF current interconnects. Because they have larger diameters than the other PF coils and are located where the spaces between TF coils are larger and the ripple in the fields from the TF coils is larger, their axial and radial magnetic loads vary considerably with azimuthal angle (see Fig. A-1). The load example shown in Fig. A-1 has the PF currents of equilibrium condition 9 of Radovinski's memo of March 27, 1995, with the plasma current set to zero.

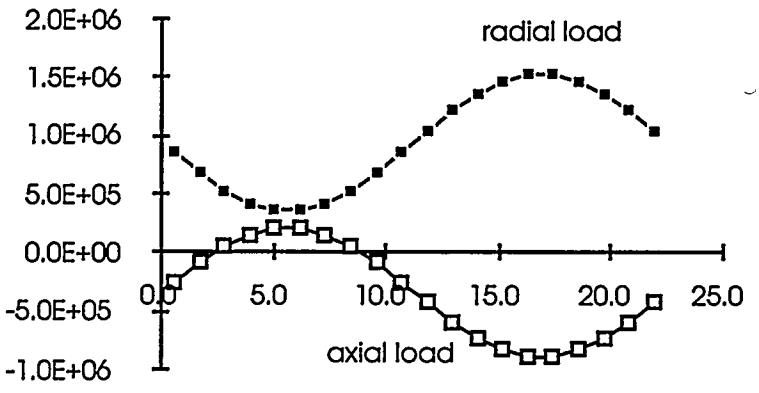


Figure A-1. Azimuthal variation of axial and radial loads over one sixteenth of the circumference of PF6. The toroidal field coils are centered at 0° and 22.5°.

This azimuthally varying component of the radial and axial loads arises from the interaction of the PF6 and 7 currents with the axial and radial components, respectively, of the ripple fields from the discrete toroidal field coils. This causes large, azimuthally varying bending moments with a fundamental period of 22.5 degrees to appear in the four coils. The only other PF coils with significant force ripple are the two PF5 coils, and their ripple component is much less than that in the PF6 and 7 coils.

The PF6 and 7 coils differ from the other PF coils in that they employ NbTi rather than Nb_3Sn cable-in-conduit superconductor. The square conduit is made of 316 stainless steel, instead of the Incoloy used in the Nb_3Sn PF coils. Use of the more ductile NbTi superconductor in these cable-in-conduit coils permits them to be wound with fully

reacted, insulated conductor and thereby eliminates the need for heat treatment and application of insulation, etc. after winding. The result is a considerably less expensive coil. However, because NbTi, which has a lower critical temperature and field than Nb_3Sn, is used in these coils, the allowable helium temperature rise for a given helium inlet temperature in the PF6 and PF7 conductor conduits is less than that in the Nb_3Sn PF coils. This is an issue of major concern.

The net magnetic and gravity loads on the PF6 and 7 coils are supported by mounts on the sixteen toroidal field (TF) coils. That is, each of PF6U, PF6L, PF7U, and PF7L is supported at sixteen points along its circumference. These supports react only vertical loads (either positive or negative) and, to some degree, moments around rays that pass radially from the machine axis through the coil mounts, but allow free movement in the remaining four degrees of freedom. In the present design, a stainless-steel coil case is provided in order to guarantee adequate stiffness and structural integrity over the entire high-cycle operating lifetime of the machine. The case is made up of bolted sections and includes two insulating breaks to stop primary eddy currents.

The winding pack configuration of PF6 and 7 is similar in concept to that of the other PF coils, with Kapton-wrapped conduits covered with fiberglass cloth that is vacuum impregnated with epoxy to form a solid structure. Both PF 6 and PF7 are have a cross section larger in the axial than the radial direction. The radial build of both PF6 and PF7 is six turns; the axial builds of PF6 and PF7 are 20 and 14 turns, respectively. In order to maximize the number of helium inlets and outlets, the coils are wound in flat spirals or pancakes (sometimes also referred to as layers), each with six turns. The pancakes are connected at the inner and outer radii with joggles. Helium inlets and outlets are located at the outer radius of the windings. As in all of the coils in the magnet system, they are made by drilling holes through the conduit and welding on helium stubs to the conduit. The helium flow at these stubs divides into two flows in opposite directions. In PF6, there are five inlets and four outlets at the outer radius, plus two outlets at the two current leads. In PF7, there are three inlets and three outlets at the outer radius; in addition, one electrical current lead is lead is a helium outlet, and one lead an inlet. Insulated holes are provided in the case to accommodate the stubs. This is described in more detail in the following case design section.

Conductor manufacturers cannot at present guarantee availability of sufficient lengths of continuous conductor to wind PF6 and PF7 coils without splices. Accordingly, two conductor splices are needed in PF6 and one conductor splice in PF7. These splices are made outside of the coil case. The same basic joint that is used to make the connection between the lead-in and lead-out conductors and the current supply busses is also used to make the intermediate splice joints. The conductors are brought out of the coil case and routed together side-by side for the splice joint. Coil-case through holes are similar in concept to those in the two lead connections.

B. Electromagnetics

Magnetic load cases were examined to determine the worst case magnetic loads for PF6 and PF7. A. Radovinsky describes worst case load conditions for PF6 and PF7 in the TPX memorandum, TPX-950327, March 27,1995. Worst case radial and axial load cases are presented separately. Two conditions were identified for PF6, a disruption after equilibrium condition 9 which results in a worst case radial load, and a disruption after equilibrium condition 19 which results in a worst case axial load. From the coil currents for equilibrium condition 9 with the plasma current off, the axial load increases to 7.83 MN. This is within 5% of the maximum axial load condition and results in the maximum radial loads; therefore the analysis for PF6 was done for equilibrium condition 9 with the plasma current off. The analysis for PF7 was done for equilibrium condition 18, which has the largest axial load, 3.58 MN. For both PF6 and PF7 these loads occur on the upper coils with the axial load downward toward the center of TPX.

The azimuthal variation of load is applied based on the equations provided by M. Krefta, in memorandum TPX.STC.MPK.STC.BH.M006.02.22.95, February 23, 1995. These equations indicate that the maximum azimuthal load variation is radial for PF6 and axial for PF7. The analysis presented in the structural report indicates that the maximum bending stresses occur in the axial direction due to a summing of the axial variational loads and the bending loads from the vertical supports.

Thermal stresses are determined separately from the stresses due to magnetic loads. These stresses are then summed to determine the overall stress level. They must be combined based on local normal and local shear stresses prior to determining principal and tresca stresses. This will be done in the next phase with detail models so that accurate combination of the stresses can be obtained.

C. Coil Pack Design

1. Winding Configuration

The main considerations in choosing a winding configuration were to minimize the length of the cooling channels and to facilitate manufacturing. Since both PF6 and PF7 are thinner in radial than in axial build, minimizing cooling path length leads to a construction with flat spirals or pancakes, also sometimes called layers in this report. In this configuration, inlet and outlet fluid connections can be made at the outside radius of the spirals, and the maximum cooling length is the length of a double spiral, since the helium coolant flows down to the inner radius, crosses over to the other spiral in the pair, and back out to an outlet on the outer radius. Also, in a pancake-wound coil with an even number of spirals, both electrical current lead connections can be made at the outer radius. These lead connections also serve as locations for fluid connections. In principle, cooling channel lengths can be further reduced by adding helium stubs at the inner radius of the coil. This a possible approach to increasing the stability margin in particular pancakes that are subjected to especially high nuclear heating and have a lower stability margin as a result. The major difficulty in adding these coolant connections is the restricted space at the inner radius of the coils.

In winding the pancakes (flat spirals), turns with constant radius over 270°of the circumference and transitions between successive turns that ramp up within a 90° arc of the circumference are used. (See Winding Layout drawings). This involves very little conductor bending in view of large ratio of the radius of the PF6 and PF 7 coils to the conduit width. In contrast, in the smaller-radius central-solenoid coils, uniform spirals are wound– i.e., the whole circumference is used in transitioning from one turn to the next. Restricting the arc for the turn-to-turn transition to 90° instead of the full 360° in PF6 and 7 reduces the winding cost by speeding up the winding process and simplifying the fiberglass 3-D-weave pieces that are used to fill the voids caused by the transitions.

The lateral joggles at the inner and outer radii that make the transition between pancakes occupy 22.5° of arc and are placed all in a row at the same azimuthal angle. This configuration was chosen to facilitate winding, addition of helium stubs, etc., but it also minimizes the effect of the joggles on the field errors, since the current in the return lead passes over the middle of the joggle region and tends to cancel the field due to the axial component of the current in the joggles.

Helium stubs are distributed on the outer radius of the coils and are staggered in the axial (vertical) direction in order to maintain enough separation between them to accommodate the insulating fluid connections and inlet and outlet manifolding. In the PF1 through PF5 coils, which have no coil cases, current leads are brought in at the inner radius, and lead spurs, which connect the lead-in of a pancake to the next turn, are required to carry the hoop tension that reacts the radially outward magnetic load. In PF6 and 7, leads are brought in at the outer radius, in a lower-field region where the radial force is inward and

where any outward radial load that may be transmitted from the inner turns is reacted by the coil case. As a result, no lead spur is required in PF 6 and 7.

2. Electrical Insulation Design

The basic winding pack insulation scheme is the same as that in all of the PF coils. The major difference is that the insulation is applied during winding, rather than after winding and reaction, as in PF1 through PF5. The conduit is first wrapped with two layers of unbonded polyimide tape, 0.001 in. thick and 1 in. wide, 50% half-lapped. This is overwrapped with two layers of 1 in. wide fiberglass 3-D weave tape, each with an as-wound thickness of 0.014 in. After all turns are wound, the entire winding pack is wrapped with 13-14 layers of half-lapped, 3 in. wide, 0.022 in. thick fiberglass tape. This basic insulation scheme is brought some distance out of the coil case wherever penetrations are made for leads and helium stubs. Cutouts in the coil case for current leads and splice joints are reinforced with bolted covers that carry loads around the cutouts and that also fill in all of the cutout area except for clearance for insulation around the conduit. During the epoxy impregnation process, temporary VPI (vacuum impregnation) molds are placed around the leads and helium stubs. They allow the epoxy impregnation to be continued for a distance of a few inches outside of the coil case. Since the coil case forms a ground envelope, there is no separate ground screen layer inside the case. A ground screen covers the electrical-lead and helium-stub insulation outside of the coil case. It is brought down to the coil case and attached electrically to the coil case around the leads so that the case, together with the screen, forms a continuous ground envelope around any parts of the coil that can reach high voltage during a fast coil discharge. Insulation is continued past the impregnated length by first scarfing back the insulation and then applying polyimide film and epoxy-pre-impregnated fiberglass. The ground screen is also applied in this process. The ground screen is covered with a layer of prepreg epoxy-fiberglass in order to protect it from mechanical damage. Details of the field curing of the prepreg have not yet been worked out, but some combination of heat lamps, forced hot air, and/or resistive electrical tape heaters will be used. Since this field-applied insulation is a feature common to all of the electrical leads within the cryostat, both on the coil sides of the joints and on the supply side, a standardized process specification will be developed in the final design phase of the project. The combined ground envelope is connected to the machine ground at one point, so that no closed loops that could couple inductively to the PF coil system are present.

The voids formed by the turn-to-turn transitions and joggles are filled with specially formed fiberglass transition fillers with a cross section of approximately 1 in. by 1 in. These pieces are built up of many layers of 3-D-weave fiberglass tape and are designed to maximize the through-thickness glass fiber content. They are custom-trimmed to fit the voids and are packed in tightly in order to avoid resin-rich volumes during epoxy impregnation. Also, after wrapping with polyimide tape and the standard two layers of fiberglass, custom trimmed polyimide and fiberglass insulation pieces are packed around the helium stubs and lead-in and lead-out conduits.

D. Winding Pack and Coil Case Stresses

1. Cooldown Stress Results

Thermal stresses were determined from an axisymmetric finite element model, which included all the conduit cell components, the filler block, and the ground wrap; the effects of the coil case are not yet included. The model is the full width of the PF6 and PF7 coils, 6 turns. Only a partial height model was used (8 pancakes) since this is large enough to capture all the important thermal stress effects. The model includes gap elements between the 316LN conduits and the Kapton. Material properties which were used were provided by Westinghouse STC. The model was run to determine stresses due to only thermal loads set up from a reference temperature of 293K and assuming all materials are at 4K. The model does not include a coil case. Thermal stresses including a coil case will be determined in the next phase.

Stress limits for the glass/epoxy are given as follows. The equation to predict the failure for the 3D weave components under shear and normal compression are as follows:

- Allowable shear/compression stress (MPa) = .7*compressive stress + 52 MPa
- Tension only Allowable (MPa) = 46.12
- Allowable shear/tension stress (MPa) = -1.13*tensile stress + 52 MPa

Stresses due to a difference in coefficient of thermal expansion between the 316LN conduits, the 3-D corner fill and the ground wrap are shown in Table D.1

Table D.1 Summary of Thermal Stresses Due to Cooldown.

Material	Max Tresca MPa	Max Principal MPa	Through Thickness MPa	Shear In Interlaminar Direction MPa	Max Stress Laminar Direction MPa	Hoop Stress MPa
316LN Conduit	118. MPa	127 MPa				
Kapton			2.6	4.3	31.8	19.7
Turn Wrap			11.8	17.5	128.1	34.0
Corner Fill			33.3	36.6	109.1	30.8
3D Block Fill			46.0	11.5	34.5	14.9
Ground Wrap			33.4	36.5	63.4	-11.1

The stresses shown in the shaded region indicate values which are near or over the limits assumed for 60000 cycles (50% degradation). This represents risk since the glass/epoxy structure must carry 95% of the magnetic bending loads. This is shown in the next section where bending stresses are compared for several different winding pack configurations.

2. Stresses From Magnetic Loads

The presence of a slip plane between the conduits and the glass/epoxy results in a unique type of structure. This structure will allow hoop loads to be shared between the conduits and the glass/epoxy, according to the usual ratio of membrane stiffness (E_1A_1/E_2A_2) for two constituents 1 and 2, where E_1 is the Young's modulus and A_1 the cross-sectional area of the first constituent, and similarly for the second constituent. If no coil case is used, the bending loads are shared between the 316LN conduits and the glass/epoxy by the bending stiffness ratio (E_1I_1/E_2I_2), where I_1 and I_2 are the moments of inertia of the glass-epoxy and stainless-steel conduits, respectively. In calculating the moment of inertia of the glass-epoxy, the moment is calculated for the multiply-connected glass-epoxy as one single piece, ignoring possible cracks and defects that may be present. The moment of inertia of the conduits taken together is, however, taken to be the sum of the individual moments of inertia of the conduits, since the conduits are allowed to slip with respect to the glass/epoxy. As a result, the moment of inertia of the conduits as a unit is low and they resist less than 5% of the bending load. Without a coil case, 95% of the bending load would be resisted by the glass/epoxy structure. When a case is added, it carries almost all of the bending loads since its stiffness dominates the overall coil stiffness, and bending stresses in the interior drop dramatically from their no-case values. This structural report presents the sharing of magnetic loads between the 316LN stainless steel structure (with and without a coil case, or a radial band on the outer radius of the ground wrap which has been suggested as an alternative to the coil case) and the glass/epoxy and resulting stresses. For purposes of understanding the effects of the slip plane a design assuming a bond between the conduits and Kapton was also examined.

Analyses to determine the effects of magnetic loads were performed to achieve the following:

- Separate bending loads from hoop loads.
- Determine the level of stress in the glass/epoxy and 316LN for different configurations.
- Determine the effects of a coil case.
- Determine the effects of a radial band.

Determine the performance of a winding pack which has structurally failed in the glass epoxy and in which all bending loads are resisted in the conduits, assuming no coil case or radial band.

Solid finite element models were not used to determine the results of these configurations. Instead, beam models were used to input the azimuthal variation in radial and axial load and to obtain the bending moments, hoop loads, and shear loads separately. From the ratios of membrane stiffness and bending stiffness, the loads and stresses in the 316LN structure and the glass/epoxy were determined. Five different configurations were analyzed as follows:

- Configuration 1 — Baseline design which includes slip plane between the conduit and kapton
- Configuration 2 — Assume no slip plane between the conduit and kapton
- Configuration 3 — With slip plane assume failure of glass/epoxy
- Configuration 4 — 5/8 Coil Case with slip plane
- Configuration 5 — 1.725 inch thick radial band on outer radial surface with slip plane

A summary of the maximum stresses resulting from the magnetic load analyses are given in Tables D.2 through D.5. The load share between the 316LN stainless steel and the glass/epoxy was determined from the ratio of the appropriate stiffness. The stresses were then determined base on this load share. Tables D.2 and D.4 show PF6 hoop stress and PF7 hoop stress respectively. For all configurations and for both coils the 316LN carries most of the hoop load. Bending loads result in a much different load share. The slip planes between the conduits and glass epoxy reduce the moment of inertia of the conduits to such a small level that 95% of the bending loads are carried in the glass/epoxy for the baseline configuration (configuration 1).

Table D.2 Summary of PF6 Max Hoop and Max Shear Stresses.

Configuration	Max Hoop 316LN Stress MPa SBR	Max Hoop Glass/Epoxy Stress MPa SBR	Max Shear Stress MPa 316LN SYZ	Max Shear Stress MPa Glass/Epoxy SYZ
PF6 Config 1	140.	21.8	.128	7.53
PF6 Config 2	140.	21.8	9.49	1.74
PF6 Config 3	175.	-	13.2	-
PF6 Config 4	74.2	11.6	5.15	1.01
PF6 Config 5	75.6	11.8	4.84	1.62

Table D.3 Summary of PF6 Max Bending Stresses.

Configuration	Max Bending Stress MPa 316LN SBR	Max Bending Stress MPa Glass/Epoxy SBR	Max Bending Stress MPa 316LN SBZ	Max Bending Stress MPa Glass/Epoxy SBZ
PF6 Config 1	15.4	19.7	22.0	75.9
PF6 Config 2	49.4	7.71	113.0	17.6
PF6 Config 3	304.	-	2110.	-
PF6 Config 4	17.3	2.30	64.9	10.1
PF6 Config 5	17.9	2.79	102.0	16.0

Table D.4 Summary of PF7 Max Hoop and Max Shear Stresses.

Configuration	Max Hoop 316LN Stress MPa SBR	Max Hoop Glass/Epoxy Stress MPa SBR	Max Shear Stress MPa 316LN SYZ	Max Shear Stress MPa Glass/Epoxy SYZ
PF7 Config 1	59.1	9.22	.261	7.96
PF7 Config 2	59.1	9.22	14.7	2.84
PF7 Config 3	74.6	-	31.5	-
PF7 Config 4	40.4	6.30	17.3	1.35
PF7 Config 5	42.3	6.61	1.53	2.63

Table D.5 Summary of PF7 Max Bending Stresses.

Configuration	Max Bending Stress MPa 316LN SBR	Max Bending Stress MPa Glass/Epoxy SBR	Max Bending Stress MPa 316LN SBZ	Max Bending Stress MPa Glass/Epoxy SBZ
PF7 Config 1	12.7	16.2	33.5	81.0
PF7 Config 2	41.3	6.40	131.	20.4
PF7 Config 3	254.	-	1590.	-
PF7 Config 4	13.8	1.83	67.1	9.58
PF7 Config 5	15.4	2.40	118.	18.4

Results of adding a coil case are shown in the results of configuration 4, which shows that most of the bending loads are resisted by the coil case, in fact all of the bending loads can be resisted by the coil case. Configuration 5 shows the results from a radial band which replaces the coil case. This band will resist the bending loads if the shear bond between it and the ground wrap holds.

Configuration 3 represents failure of the glass/epoxy. The stresses in the conduit go above their allowable and the conduits fail. The glass/epoxy therefore must be considered the primary structure for resisting bending loads.

3. Justification for Case

The decision to include a coil case in the design of PF6 and 7 was made by balancing a number of considerations, some of which favored a coil case, and some that favored no case. They are summarized below.

Reasons for having a coil case:

1. A case of sufficient strength guarantees the structural integrity of the coil and greatly reduces the stresses in the winding-pack insulation. If the coil has no case, bending stresses due to the ripple component of the axial and radial loads must be carried mostly by the web of epoxy-fiberglass formed by the conduit insulation and ground wall insulation. The exact distribution of stresses and the high-cycle fatigue behavior and failure modes of this complicated web structure cannot be predicted with complete confidence; in addition, resin-poor and resin-rich regions may occur in actual production and make the local epoxy-fiberglass properties less than the ideal ones.

2. A case provides a stable and convenient structure for mounting to the TF coil support structure.

3. A case provides a stable, flat reference surface for alignment fiducials.

4. A case eliminates the need for lead spurs in the lead terminations and intermediate splices. Lead spurs are needed in the uncased coils to carry hoop tension from the end of the last turn in the spirals to the turn below. With a coil case, radially outward loads on the outer turns are transmitted to the outer coil case. These lead spurs add significantly to the fabrication cost and would be an area of considerable technical risk in the NbTi magnets since attachment involves welding to the conduit, with the possibility of overheating the superconductor.

5. A case acts as a neutron shield, thereby reducing the neutron heating of the winding pack and increasing the margin between the current-sharing temperature and the helium coolant temperature (provided that additional cooling is supplied to the

coil case). In the final design phase, adding higher-temperature neutron shielding should also be considered.

6. A case eliminates the need for a separate vacuum impregnation mold, since the coil windings are potted into the coil case.

7. A case provides a convenient structure from which to support leads, flow meters, helium lines and insulating breaks, etc.

Reasons for not having a coil case:

1. A case adds to the expense of the PF coil system. The cost of the coil case is only partly offset by eliminating the cost of the vacuum impregnation mold, since one vacuum impregnation mold can serve for two coils, and the coil case is made of stainless steel instead of carbon steel and has shear pins, bolts, etc. that are not required for the vacuum impregnation mold.

2. A case increases the total load on the 5K cryogenic system because the total neutron heating of the windings plus case is greater than the heating of the windings without a case. In addition, significant eddy-current heating of the case due to changing magnetic fields from the PF coils occurs.

3. A case increases the volume occupied by the PF6 and 7 coils and reduces system clearances in some places.

4. A case increases the weight of the PF coil system and increases the size of the gravity support columns, their heat leak, etc.

In the balance, the arguments for the coil case won out over the arguments against the coil case.

E. Coil Case Design, Coolant and Current Supply, and Instrumentation

1. Mechanical Design Description

A coil case is required for both PF6 and PF7. Both coil cases have the same nominal thickness, .625 inches. The material is stainless steel, 316L.

Plate stock availability governs the number of sectors making up the coil case. There are eight (8) sectors in each of the coils. The sectors are joined by a lap-type splice at six (6) location and an insulated joint, to prevent the formation of eddy currents, at two (2) locations. The coil case configuration for both coils is similar in that the basic construction is the same. The case consists of four plates; two flat plates for the upper and lower covers and two roll-formed plates for the outer and inner walls. The four plates are joined at the corners by 0.25 inch diameter bolts fitted into tapped holes in the inner and outer walls. Located between the bolts are a number of close fitting shear pins. The numbers of bolts and shear pins is governed by the shear and tension forces required to be reacted by the bolts and pins. The spacing for the attachment of the lower cover is less than that required for the upper cover. There is an o-ring fitted between the upper and lower covers and the inner and outer walls. The groove for the lower o-ring is in the lower cover and the groove for the upper o-ring is in the upper surface of the walls. O-rings are required in the coil case only for coil assembly reasons as the coil case also acts as the molding tool for the winding pack.

The sector-to-sector joints are of two types, as mentioned previously. The lap-type splice is made up of four plates, one on each side of the case. These plates are attached to the sectors by bolts and pins in shear to transfer the bending loads. The two eddy current breaks require a flanged tension type joint to simplify the inclusion of the insulation system. The sectors are insulated by a two piece overlapping G10 gasket between the flanges and shoulder bushings for the bolts. All eight joints are positioned on the centerline of bays, ie, the mid-point between TF coils, as the bending moments are close to minimum. The inter-sector joints are also sealed using o-rings.

Referring to drawing TPX-E-1431018SH1P0 PF6 upper coil case, sectors 1 and 6 are identical; sectors 3, and 8 are identical; and sectors 2, 4, 5 and 7 all have special features which makes them unique. Sector 2 has two cutouts in the outer wall allowing a conductor joint to be made outside of the case. The cutouts are reinforced with doubler plates bolted to the outer wall. Sector 4 has five (5) holes drilled in the outer plate to allow the penetration of the helium stubs. Sector 5 has four holes drilled in the outer plate to allow for the penetration of the remaining helium stubs, and has two reinforced rectangular slots to enable conductor entry and exit. Sector 7 has two reinforced rectangular holes for the second intermediate conductor joint. Each of the reinforced holes have o-ring seals. Areas not sealed by o-rings will be sealed using a suitable RTV. All seals and sealing liquid will be left in place after coil fabrication.

The design of PF7 coil case follows the concepts developed for the PF6 case. Again there are four (4) sectors, two (2) eddy current splices and six (6) lap-type splices. Sectors 1, 2, 5 and 6 are identical. Sector 3 has cutouts for the only intermediate lead joint. Sector 7 has cutouts for the conductor lead-in and lead-out. Sector 8 has seven (7) holes drilled to allow for the penetration of the helium stubs. Sector 4 has no cutouts and has lap-type splices at each end.

One of the benefits of having a structural coil case is that it lends itself to the attachment of other structures. Supports for the conductor joints, the conductor lead-in and lead out, and the cooling manifolds have been design to take advantage of the coil case structure - see Section E5.

2. Supporting Stress Analysis

Shear flow was calculated for the PF6 coil case to determine the bolt and shear pin spacing, and to determine if the 5/8 coil case was thick enough to support the hardware. The maximum shear flow was about 2000 LB/in and occurred near the model supports. Since the model assumed a single node line for vertical support the resulting shear flow is conservative. The largest positive normal load was 1200 Lb/inch and also considered conservative due to the model.

3. Helium Coolant lines, Insulating Breaks and Electrical Lead Routing

Cooling is required to three separate areas:

(a) the coil pack
(b) the conductor lead-in and lead-out
(c) the intermediate joint(s)
(4) the coil case

The PF6 coil pack has helium cooling supplied to layers 3, 7, 11, 15 and 19 and returned from layers 5, 9, 13 and 17. The conductor lead-in and lead-out has one return each from the conduit, and a supply to the lead-in and the lead-out interface blocks

The PF6 coil has two intermediate conductor joints. These joints use the same design as the interface blocks from the coil lead-in and lead-out interfaces. Each conductor at the intermediate joint has a helium return. Each of the two joint blocks have one supply and one return.

In total PF6 has nine (9) helium supply and twelve (12) helium return loops. Each loop has an electrical insulator as the first component in the line nearest to the attachment of the line to the coil.

The PF7 coil pack has helium cooling supplied to layers 2, 6, 10 and 14 and returned from layers 4, 8, and 12.

The conductor lead-in and lead-out has one return from the conduit, and a supply to the lead-in and lead-out interface blocks.

The PF7 coil has one intermediate conductor joint. This joint uses the same design as the interface blocks from the lead-in and lead-out interfaces. Each conductor at the intermediate joint has a helium return. The joint block has a supply and return.

In total PF7 has seven (7) helium supply and eight (8) helium return loops. Each loop has an electrical insulator as the first component in the line nearest to the attachment of the line to the coil.

Additional cooling lines will be needed for cooling the case. This will require a mimimum of 8 circuits. The exact number required will depend upon the results of a complete thermal analysis of the case.

4. Instrumentation

Instrumentation is required in the PF6 and 7 coils to monitor and control cooldown and normal operation, and to detect quenches. The instrumentation installation task includes mounting of flowmeters, absolute pressure sensors, and temperature sensors, installation of strain gauges, etc., and routing and protection of lead wires for these sensors, including voltage tap wires, which are critical for quench detection. Many of these sensors are under development and final dimensions and installation details are not presently available. Exact numbers and type of sensors will be specified in the final design phase. In most cases, the sensors will be installed during installation of the coils in the facility. The main exceptions are the co-wound voltage taps and fiber-optics temperature sensors, which must be installed in the cable-in-conduit conductor during its manufacture.

Wherever a lead termination or conductor splice occurs, voltage-tap connections will be made. The detailed procedure for the connections will be part of the lead termination process specification, which is under development and which will apply to all of the coils in the system. Making the connection will involve extracting six coaxial cables from the conductor cable after the conduit has been removed and the cable installed in the lead termination block. The coaxial cables inside the conduit will be made up of a center wire insulated with S-glass braid and surrounded by a copper braided sheath and coaxial stainless-steel sheath. The differential voltage between the sheath and center wire is the raw quench signal that is input to the quench-detection signal-conditioning system. As the coaxes leave the conductor cable, a transition will be made to a single cable with six insulated inner conductors, surrounded by a single conducting sheath that is connected to one of the coax sheaths or the cable (the sheaths and cable at a given point are essentially all at the same potential). The insulation of the inner wires will be designed to withstand the peak differential voltages, which are mainly due to resistive voltages developed in normal zones in the conductor. An insulation rating of a few hundred volts is sufficient to withstand these voltages with an adequate margin of safety. If better noise performance is required, use of 12 individual twisted pairs inside a sheath could be

considerd. The outer sheath will be surrounded by solid high-voltage insulation, a grounded sheath, and an outer insulation layer. The sheath will be connected to the coil ground and insulated to prevent major eddy-current loops. The inner wires will be twisted and the cable routed to the vacuum interface in such a way as to minimize inductive pickup, and connected to high-voltage vacuum feedthroughs either with a removable connector, or with direct connections. If a satisfactory cold connector can be found, a break near the lead termination will also be included. Since this is a critical instrumentation channel, redundant lead connections should be considered.

One possible backup appproach to internal voltage taps is to co-wind a Kapton-insulated metal ribbon with the conduit. The signal-to-noise performance of this would not be as good as that of the internal coax, but would be much better than that of conventional taps.

Voltage taps across all conductor joints for monitoring joint voltage drops will also be installed. These are installed in redundant pairs with separate high-voltage cabling.

Fiber-optics temperature-sensing cables require an fiber-optics interface, and do not involve high-voltage cabling. Details of the interface are under development.

The other methods of quench detection involve sensing sudden increases in either helium flow rate or pressure at the ends of a particular flow channel that are caused by a resistive zone in the channel. A final flowmeter approach has not yet been selected. Venturi tubes with differential pressure gauges have been used for precision liquid helium flow measurement. In the Large Coil Program in Oak Ridge, capillary tubes were used to transmit the pressure signals from Venturi tubes in the liquid helium inlets and outlets to warm differential pressure transducers. Commercially available variable-reluctance type differential pressure transducers, intended for room temeprature use, were sucessfully tested at helium temperature for use in LCP, but were not used in the final LCP installation because of questions of reliability (helium leak tightness) and magnetic-field sensitivity. The capillary lengths were approximately four meters. The pressure transducers were magnetically shielded with soft iron and mu metal. The time delay for flow-rate transients incurred by using capillary tubes was not directly measured, but was on the order of a tenth of a second. The flow measurements were used mostly for monitoring operating flow rates, but were also inputs to the quench detection system. The differential pressure from Venturi tubes varies as the square of the mass flow rate. As a result, it is difficult to find differential pressure transducers with sufficient dynamic range to measure nominal flow rates but also withstand the quench transients, and be capable of operating at low temperature and in a magnetic field. At the present level of design, locations, but not specific types of flowmeters are given. The flowmeters are assumed be cooled to near liquid helium temperature during use.

One absolute pressure pressure transducer will be installed on the inlet manifold of each coil and one on the outlet manifold. The present concept calls for a cold installation.

For monitoring helium temperature, one or two temperature sensors on the inlet manifolds and at least one sensor on each outlet (helium stub or lead termination) will be

used. The installations will be "wet" (i.e., the sensor and some length of lead wires will be immersed in the helium) to ensure accurate readings. This requires use of a multipin liquid helium/vacuum feedthrough with a high pressure rating. The installation will be made on the ground side of the insulating breaks. For long-term reliability, a combination of a germanium resistance thermometer (GRT) and a carbon glass resistance thermometer (CGRT) should be used. The GRT has a long-term temperature stability, even after repeated temperature cycling, of better than 10 mK, but is field sensitive. The CGRT is less field sensitive, but has poorer stability with thermal cycling. For cooldown, other thermometers, e.g., platinum resistance thermometers, must be used to cover the 300-20K range, since the CGRT and GRT lose sensitivity at higher temperatures.

A number of additional temperature sensors will be used to monitor coil case temperature during cooldown. A relatively inexpensive approach that covers the most critical portion of the cooldown cycle (300-50K) with adequate accuracy is to use type E (chromel-constantan) thermocouples .

Strain gauges will be mounted on the coil case. As in the LCP, these will be installed in active/dummy compensating pairs, and read out with ac carrier amplifires to eliminate spurious thermal voltages. The exact number required is to be determined. In addition, the use of displacement transducers to monitor the position of the coils with respect to the TF mounts is recommended, since this information cannot be obtained directly from strain measurements. A moving-coil differential transformer (MCDT) that behaves in much the same as the LVDT, but has no ferromagnetic parts, was developed and used sucessfully in the LCP program in Oak Ridge for displacement measurements on the superconducting test coils inside the LCP magnet test cryostat. In the LCP tests, the change in inside horizontal and vertical coil bore dimensions was measured.

5. Support of Leads and Other Components

The configurations of the conductor lead in, lead out and intermediate conductor joint(s) are very similar and will require essentially the same support treatment. The length of the conductor between the coil case and the joint block has been kept to a minimum. The conductor, as it emerges from the coil pack, retains the conduit up to a point just over an inch from the joint block. Between the end of the conduit and the joint block the cable is covered with a circular copper sleeve swaged to it. This is a "soft" area of the conductor and requires supporting. The conductor as it leaves the coil case is well supported by the case. The conductor joint block is supported by a bracket attached to the coil case. The joint block bracket provides a mounting point for a clamp to protect the conductor "soft" point.

Other components requiring support are the helium cooling manifolds. Manifold supports have been designed for the upper coils and it is expected that the supports for the lower coil manifolds will be very similar. The brackets used to support the conductor joints have been configured to support adjacent cooling manifolds. The support brackets must electrically isolate the conductor and the manifold from each other and the coil

case; therefore it is proposed to fabricate the brackets from G10. Other local supports for just the manifolds are shown, also made from G10. A detailed thermal analysis of the helium supply and return tubing and the manifolds has not been done. An analysis of the cooling system may show that bellows are required to keep tubing, component and support stresses within acceptable levels. The addition of bellows will require the manifold support system to be re-evaluated. This is planned for the final design phase.

F. Eddy-Current Heating of the Case

Eddy current heating in the PF6 and 7 coil cases was calculated in the full-penetration limit. This means that changing fields due to eddy currents themselves are neglected- i.e., the changing external fields are not shielded out by the eddy currents and penetrate without eddy-current attenuation. This approximation is conservative in that it overestimates the heating and is justified by the fact that the classical skin depth in stainless steel at the frequencies of interest (less than tens of Hz) is much greater than the case thickness. It was also assumed at the outset that the primary eddy-current loop in the coil is blocked by an insulating break, as in the designed coil– there is no net loop current. The eddy-current pattern, except near the insulating breaks where the currrents flow across the top and bottom of the case, is composed of currents that flow around the major circumference. The current density in a cross section of the case away from the breaks is negative in some areas and positive in others, with a total average current density of zero. The second approximation made was to treat the problem in two dimensions– case curvature was neglected and the coil was treated as an infinitely long rectangular current-carrying buss. In this way, the complicated current pattern near the breaks is ignored. The changing magnetic field that drives eddy currents is dominated in PF6 and 7 by the self-field of the respective coils. The eddy-current power density is highest around the four case corners and is greater in PF6 than in PF7, with a peak-to-average ratio of about three to one.

With the above model, the eddy-current heating due to the changing self fields in PF6 and PF 7 was computed for one of the possible current-programing cycles– the 24-second HC scenario. For the scenario used in the calculation, the cycle-averaged eddy-current case heating is calculated to be 85 W in PF6 and 35 W in PF7. These figures should be compared with typical nuclear heating averages of 77 W for the PF6 case and 254 W for PF7.

A more detailed treatment of the problem would include a search of the proposed scenarios for the one with the maximum time-averaged square of dI/dt, and include the thermal transients in the case and helium streams. A realistic model of the heat transfer from the case through the insulation system, conduit wall, and foil wrap to the helium stream inside the conduits is needed to compute the margin between the current-sharing temperature and helium temperature in the conduit as function of time and position in the winding pack. With such a model, the flow rate, temperature, and distribution of the case coolant stream required to accomodate the worst-case scenario of simultaneous eddy-current and nuclear heating can then be determined.

G. Interface to TF coils

1. Loads and design constraints

The interface between the TF coils and the PF coils is a radially sliding joint with a 0.010 inch gap between the top of the coil case and the shim on the bottom of the TF interface. This restrains the coil only in the vertical direction unless the gap is taken up by displacements of the PF or displacements of the TF coils. For the magnetic load cases in which a reversal of load exists tending to lift the coils the gap will be taken up before it is restrained vertically. Additional analysis will be completed in the next phase to determine the load transfer at the interface for all appropriate load conditions.

2. Design Description

Structure is attached to the TF coils to provide support for the PF coils. The structure is designed to support the vertical loads exerted by the PF coils and to keep the PF coils centered relative to the TF coils. The upper PF coil supports are subjected to a maximum load in the downward direction with the addition of the gravity load. There is also a smaller net load in the upward direction. The lower PF coils are subjected to maximum load in the upward direction with the gravity load being subtracted. There is also a net load in the downward direction. The loads are reacted through pads attached to the coil case structure. The coils are electrically insulated from the support structure by G10 plates attached to the upper and lower brackets. The G10 plates also react the vertical loads transferred by the pads.

Automatic centering of the coils is achieved by cantilevered leaf springs attached to each of the support structures (16), whose free end applies an inward horizontal force. The magnitude of the force is such that, under any operational condition, the horizontal component of friction is overcome and the PF coils remain in the proper position relative to the TF coils. The motions of the PF coils relative to the TF coils is such that an installation pre-load of the leaf springs is required. The reaction between the spring end and the PF coil is taken on a G10 pad attached to the coil - the pad also provides electrical insulation between the coil and the support structure.

Because of assembly requirements and differences in the configuration of the TF coils in the region of the PF coil support structure there are differences in the configuration of the upper and lower PF coil support structures– mostly in the design of the PF6 support structures.

The PF6 upper support structure consists of a lower bracket which is welded to the TF coil structure and is an integral part of the TF coil case and is supplied by the TF coil fabricator. A shim plate and an insulation plate is attached to the bracket. The Upper PF coil is placed on the insulation plate. The upper bracket, with its shim and insulation plates attached, is bolted to the TF coil (8 bolts). A key is installed between the upper bracket and the TF coil structure to react all the vertically upward forces. With the upper

bracket installed the leaf spring can be added. Between the leaf spring and the upper bracket a shim plate can be added so that the proper spring pre-load can be attained.

The lower PF6 coil is lower onto the cryostat base before the TF coils are assembled to the machine. This requires that the PF6 lower support structure be designed to allow the coil to be raised into position at the support. The upper support bracket is welded to the TF coil structure and is supplied by the TF coil fabricator. Shimming and electrical insulation of the PF6 lower coil is achieved in a manner similar to the PF6 upper coil. Before the lower bracket can be installed the coil has to be jacked in place against the upper bracket. Because of space limitations between the outward facing surface of the TF coil and the inner surface of the PF coil there is insufficient space to install attachment bolts. Therefore, bolts and shear keys to react the vertical forces are installed to each side of the TF coil structure.

PF7 upper and lower support assemblies are identical. The lower structure being the mirror image of the upper. The PF7 upper support assembly must be removable to allow assembly of the PF7 lower coil. Although the lower bracket for the PF 7 lower coil could be an integral part of the TF coil structure, it was designed to be identical to the PF7 upper coil upper bracket to increase the number of common parts. The design principles of the PF7 support structure is the same as that for the PF6 support structure and has, therefore, identifiably similar components allowing a similar assembly procedure.

The design of the PF coil support structures allows the coils to be accurately positioned on the machine. Adjustment of the position of the coils in the vertical and horizontal directions is achieved by shimming. The design drawings show the coil in three nominal position with .50 inch thick shims. The design of the structure allows for shim thickness to vary from 0.00 to 1.00 inches. Shimming of the coils in the vertical direction is completed with a small gap (~.02 inches) being maintained between the upper surface of the coil and the upper brackets to ensure that the coils do not bind up during the operationally induced relative motion between the PF and TF coils.

3. Installing Fiducials and Finding the Magnetic Center.

After fabrication, but before installation in TPX, the magnetic field of the coil, energized as a single separate magnet, will be characterized by magnetic field measurements at points that are referenced to a set of fiducial points fixed in the coil case. Fiducial holes, sized for holding removable targets for computerized-theodolite optical alignment, will be drilled in the top and bottom of the coil case at 8 points on the top, and 8 points on the bottom cover of coil case, halfway azimuthally between the TF mounts and at the mean winding radius. The holes will be (typically) 1/8 in. wide and 1/4 in. deep.

The radial position and height of the nominal winding-pack centroid is independent of azimuthal angle in the present coil design. However, the effective width of the winding pack does vary with angle (see the Winding Layout drawings). For the room-temperature magnetic-field measurements, the helium flow channels witll be temporarily connected to a supply of compressed dried and filtered instrument air for cooling. When

the coil is energized at room temperature, a current of 500A can be sustained for times of a few minutes without excessive heating. Approximately 7000 watts is generated in each double pancake. This level of current in PF6 gives a peak field of over 600 gauss (0.06 T), which is high enough for precision Hall-probe field measurements (a typical drift offset for the Hall probe measurements is 0.1 gauss; with temperature-compensated probes, better performance is possible). After this time, a longer time with the current off and air flowing is taken to allow the windings to cool off before the coil can be energized again. The measurements will be made in a facility that is free of large nearby ferromagnetic structures that could distort the field, and the coil will be supported with wooden cribbing. One proposed magnetic-center characterization measurement is depicted schematically below. The reference points shown are either the 16 fiducial holes or additional points on the coil-case surface that are referenced to the fiducials with a computerized theodolite sytem. The four dashed lines represent field scan lines, along which the parallel (vertical on the sides and horizontal on the top and bottom) and normal (vertical on the top and bottom and horizontal on the sides) field components in the coil cross-section plane will be measured. Approximately ten measurements will be made on each scan line. The field scans will be made at at least 16, and possible more, if needed, azimuthal positions around the coil. Magnet current measurements will be made concurrently with the field measurements so that the measurements can be normalized to the same current. The scan lines will be generated by leveling a ruled bar with a precision level. The Hall probes will be held in a fixture that slides along the bar.The bar will be kept at a fixed distance from the reference point with a rigid rod with a ball tip. Only non-ferromagnetic materials will be used in this fixture. The effective winding pack width and centroid at each azimuthal angle will be determined by fitting the magnetic field data with a simplified winding-pack current-distribution model. A specific model is required for this, since it is impossible in principle to determine the current distribution inside a volume solely from field measurements external to the volume.

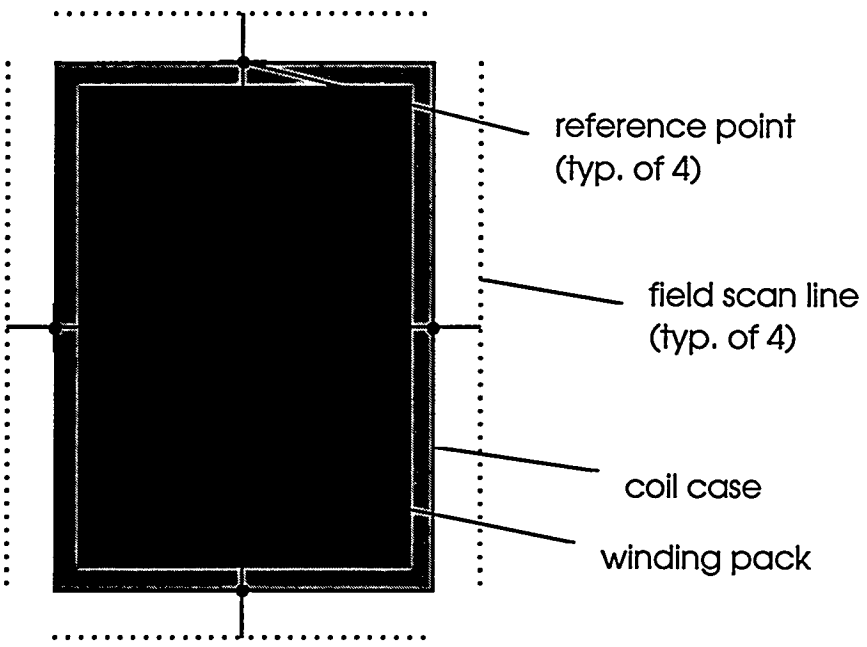


Fig. G-3a. Magnetic center characterization concept

tpx017		8:15:95								
PF6 and PF7 Drawing Tree										
TPX-E-1431001SH1P0					PF6 & 7 Coil Assembly				Not Available	
	TPX-E-1431002SH1P0				PF6 Upper and Lower Winding Geometry					
	TPX-E-1431002SH2P0				"	"	"	"		
	TPX-E-1431002SH3P0				"	"	"	"		
	TPX-E-1431002SH4P0				"	"	"	"		
	TPX-E-1431003SH1P0				PF7 Upper and Lower Winding Geometry					
	TPX-E-1431005SH1P0				PF6 & 7 Insulation Details					
	TPX-E-1431-010SH1P0				PF6 Coil Assembly - Upper					
		TPX-E-1431012SH1P0			PF6 Winding Layout - Upper					
		TPX-E-1431016SH1P0			PF6 Support Assembly - Upper					
		TPX-E-1431018SH1P0			PF6 Coil Case Asembly - Upper					
		TPX-E-1431018SH2P0			"	"	"			
	TPX-E-1431020SH1P0				PF6 Coil Assembly - Lower				Not Available	
		TPX-E-1431022SH1P0			PF6 Winding Layout - Lower					
		TPX-E-1431026SH1P0			PF6 Support Assembly - Lower					
	TPX-E-1431030SH1P0				PF7 Coil Assembly - Upper					
		TPX-E-1431032SH1P0			PF7 Winding Layout - Upper					
		TPX-E-1431036SH1P0			PF7 Support Assembly - Upper					
		TPX-E-1431038SH1P0			PF7 Coil Case Assembly - Upper					
	TPX-E-1431040SH1P0				PF7 Coil Asembly - Lower				Not Available	
		TPX-E-1431042SH1P0			PF 7 Winding Payout - Lower					
		TPX-E-1431046SH1P0			PF7 Support Assembly - Lower					

SUPPLEMENTARY DATA NOTE: UNLESS OTHERWISE SPECIFIED NOTES CHECKED ✓ APPLY TO THIS DWG.	
RUBBER STAMP PART NUMBER AND OTHER IDENTIFICATION MARKINGS PER 6554710 CL 2A ☐ IN REGION MARKED ☒ USE BOTH SIDES IF NECESSARY ☐ LOCATION OPTIONAL	
BREAK ALL EDGES	.005-.015 .015-.031
✓ SURFACE ROUGHNESS FOR ALL SURFACES PER ANSI B46.1	
✓ SURFACE ROUGHNESS FOR ALL BORES PER ANSI B46.1	
SURFACE ROUGHNESS/WAVINESS PER 66304, TYPE 316	
PERMISSIBLE WAVINESS PER 66304 FOR INSIDE INTERSECTING CORNERS TYPE 2A: MAX TYPE 2B: MAX	
WAVINESS STEP OF MAX. 10 PERMISSIBLE DUE TO CHAMF OF CUTTERS AT INSIDE INTERSECTING SURFACES	
DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THD P.D. IMPERFECT THREADS BEYOND PERMISSIBLE	
EXTERNAL THREAD LENGTH SHOWN INCLUDES 2 IMPERFECT THREADS MAX	
DIMENSIONING AND TOLERANCING PER ANSI Y14.5M	
ABBREVIATIONS PER MIL-STD-12 & SAEPA.	
ALL DIMENSIONS SHOWN TO BE MET BEFORE CADMIUM PLATING THICKNESS OF PLATE .0000 MIN, .0000 MAX NO ALLOWANCE FOR PLATING IN HOLES	
DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH DOUBLE ASTERISK.	
HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION.	
GRAIN DIRECTION OPTIONAL	
ALL DIMENSIONS SHOWN TO BE MET AFTER ANY WELDING AND/OR HEAT TREATING	

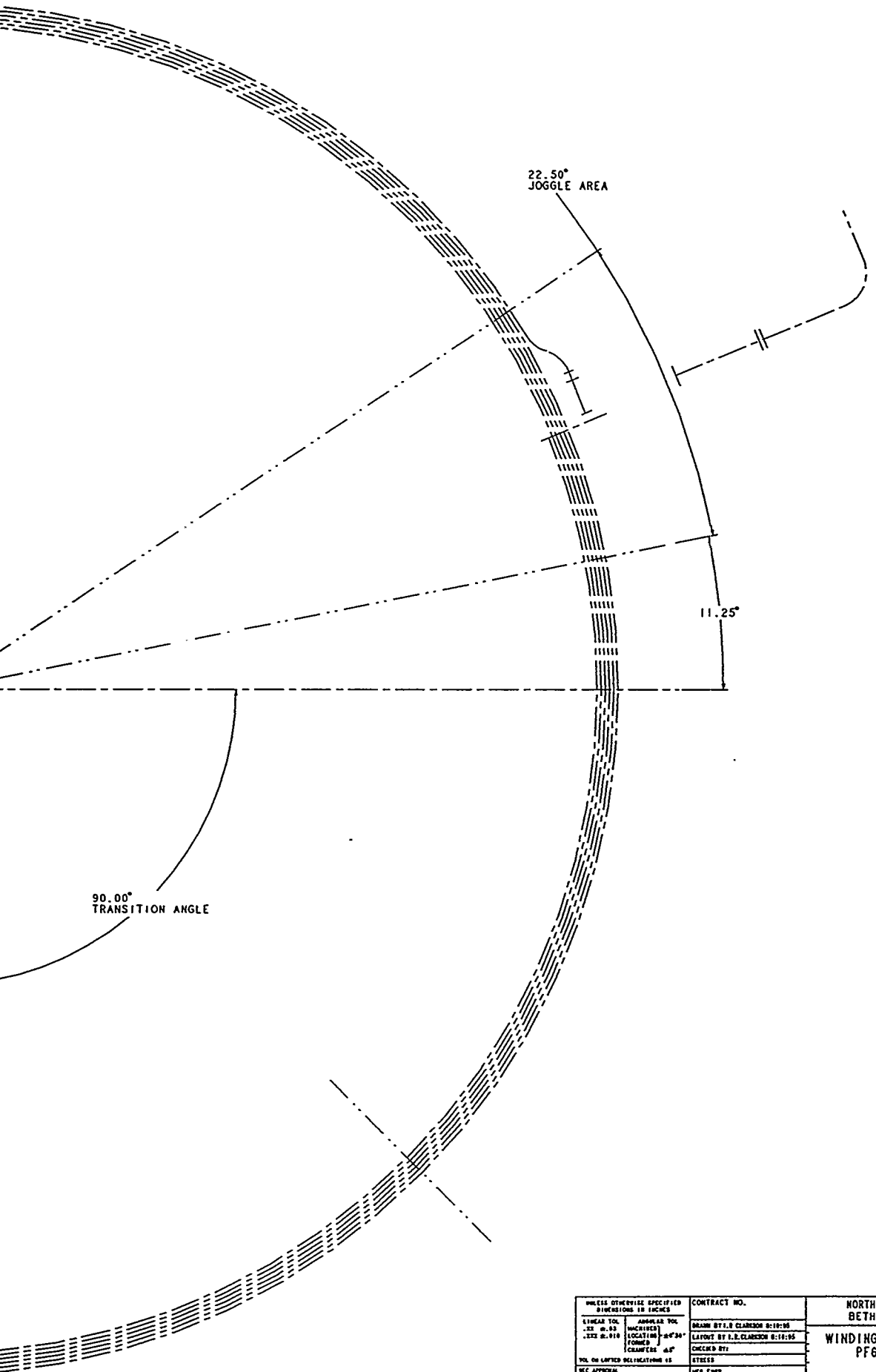
LAYER 1

VIEW LOOKING DOWN ON PF6 UPPER

VIEW LOOKING UP ON PF6 LOWER

NOTES:

REVISIONS						
ZONE	LTR	DESCRIPTION	EFF CODE	MODEL	DATE	APPROVED



PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
LINEAR TOL .XX ±.03 .XXX ±.010
ANGULAR TOL MACHINED ±1° LOCATION FORMED ±2°30' CHAMFERS ±5°
TOL ON LAYED DELINEATIONS IS

CONTRACT NO.
DRAWN BY I.B CLARKSON 8:10:95
LAYOUT BY I.B.CLARKSON 8:10:95
CHECKED BY:
STRESS
MFG ENGR
ENGR APPROVAL
ENGR APPROVAL

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

WINDING CENTERLINE GEOMETRY
PF6 UPPER AND LOWER

FSCM No.	PROGRAM	SIZE	DWG NO.	SET No	REV
76823	TPX	E	1431002	SH 1	P0

SCALE 1/10 SHEET 1 OF 4

TPX-E-1431002SHIP0

TPX-E-1431002SHIP0

014-3344

SUPPLEMENTARY DATA

NOTE: UNLESS OTHERWISE SPECIFIED NOTES CHECKED ✓ APPLY TO THIS DWG

NUMBER STAMP PART NUMBER AND OTHER IDENTIFICATION MARKINGS PER 6554710 CL 2A ☐ IN REGION MARKED ☒ USE BOTH SIDES IF NECESSARY ☐ LOCATION OPTIONAL	
REMOVE ALL BURRS BREAK ALL EDGES .005 .015 / .015 .031	
63 ✓ SURFACE ROUGHNESS FOR ALL SURFACES PER ANSI B46.1	
63 ✓ SURFACE ROUGHNESS FOR ALL HOLES PER ANSI B46.1	
SURFACE ROUGHNESS/FORMATION PER 6620A, TYPE 2&4	
PERMISSIBLE MISMATCH PER 6620A FOR INSIDE INTERSECTING CORNERS TYPE 2A MAX TYPE 2B MAX	
INCREASED SIZE OF MAX IS PERMISSIBLE DUE TO CHAMFER OF CUTTERS AT INSIDE INTERSECTING SURFACES	
DEPTH SHOWN FOR TAPPED HOLES +0 FOR FULL THRD 2-3 IMPERFECT THREADS BEYOND PERMISSIBLE	
EXTERNAL THREAD LENGTH SHOWN INCLUDES 2 IMPERFECT THREADS MAX	
DIMENSIONING AND TOLERANCING PER ANSI Y14.5M	
ABBREVIATIONS PER MIL-STD-12 & GAIZA	
ALL DIMENSIONS SHOWN TO BE MET BEFORE CADMIUM PLATING THICKNESS OF PLATE 0000 MIN TO 0000 MAX NO ALLOWANCE FOR PLATING IN HOLES	
DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH DOUBLE ASTERISK	
HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION	
GRAIN DIRECTION OPTIONAL	
ALL DIMENSIONS SHOWN TO BE MET AFTER ANY WELDING AND/OR HEAT TREATING	

LAYERS 2, 4, 6, 8, 10, 12, 14, 16, AND 18

VIEW LOOKING DOWN ON PF6 UPPER

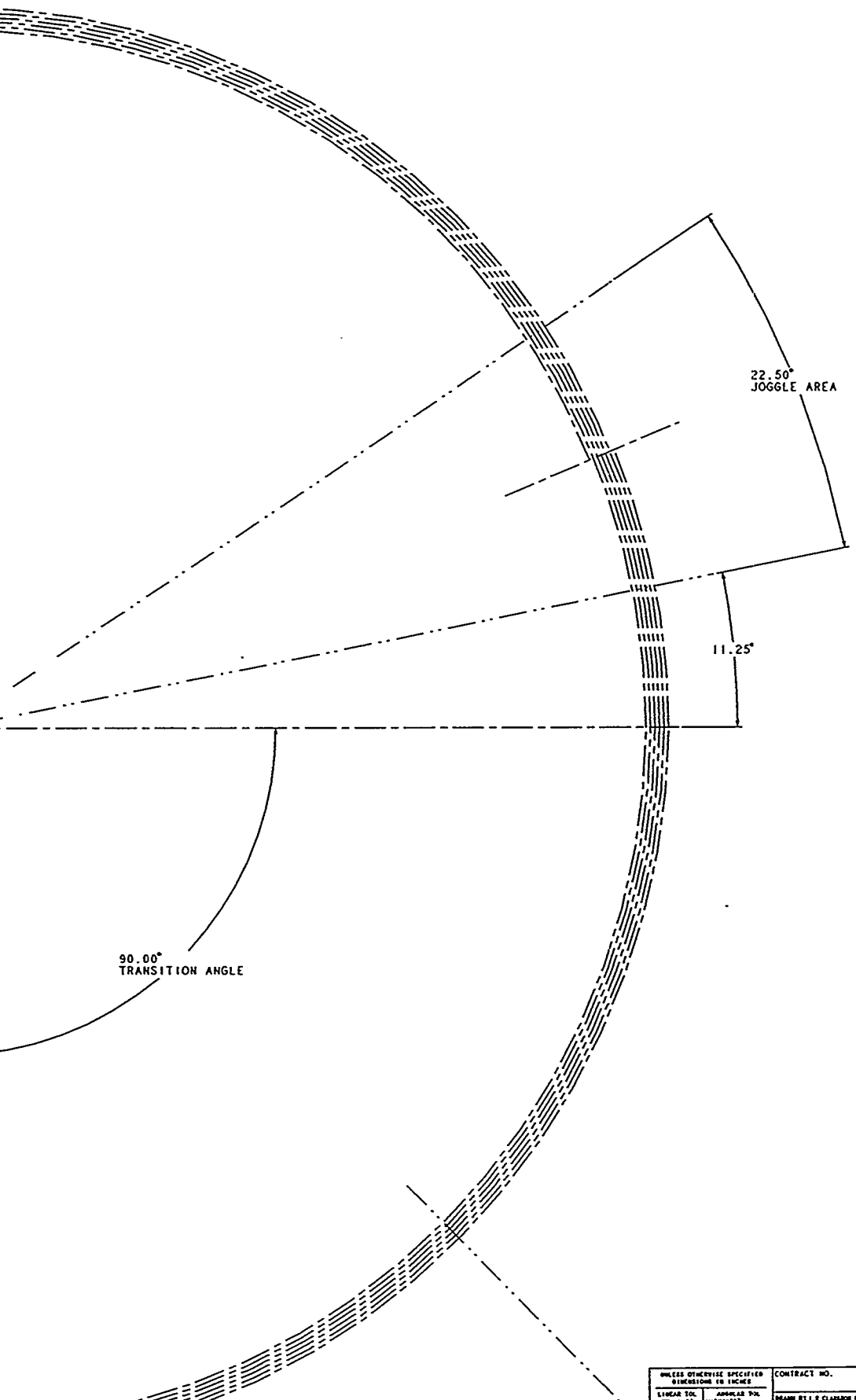
VIEW LOOKING UP ON PF6 LOWER

H G F E D C B A

8 7 6 5

NOTES:

REVISIONS						
ZONE	LTR	DESCRIPTION	ENG CODE	MODEL	DATE	APPROVED



PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
LINEAR TOL .XX ±0.03 .XXX ±0.010
ANGULAR TOL MACHINED LOCATION FORMED CHAMFERS ±0° ±0°30'
TOL ON LOFTED DELINEATIONS ±0

CONTRACT NO.
DRAWN BY J.R CLARKSON 8-10-95
LAYOUT BY J R CLARKSON 8-10-95
CHECKED BY
STRESS
MFG ENGR
ENGR MGR
QCC APPROVAL
LSRL APPROVAL

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

WINDING CETERLINE GEOMETRY
PF6 UPPER AND LOWER

TECH No.	PROGRAM	SIZE	DWG NO.	SHT No	REV
76823	TPX	E	1431002	SH 2	PD

SCALE 1/10 | SHEET 2 OF 4

014-3344

TPX-E-1431002SH2PD

TPS-E-1431002SH2PD

4 3 2 1

H G F E D C B A

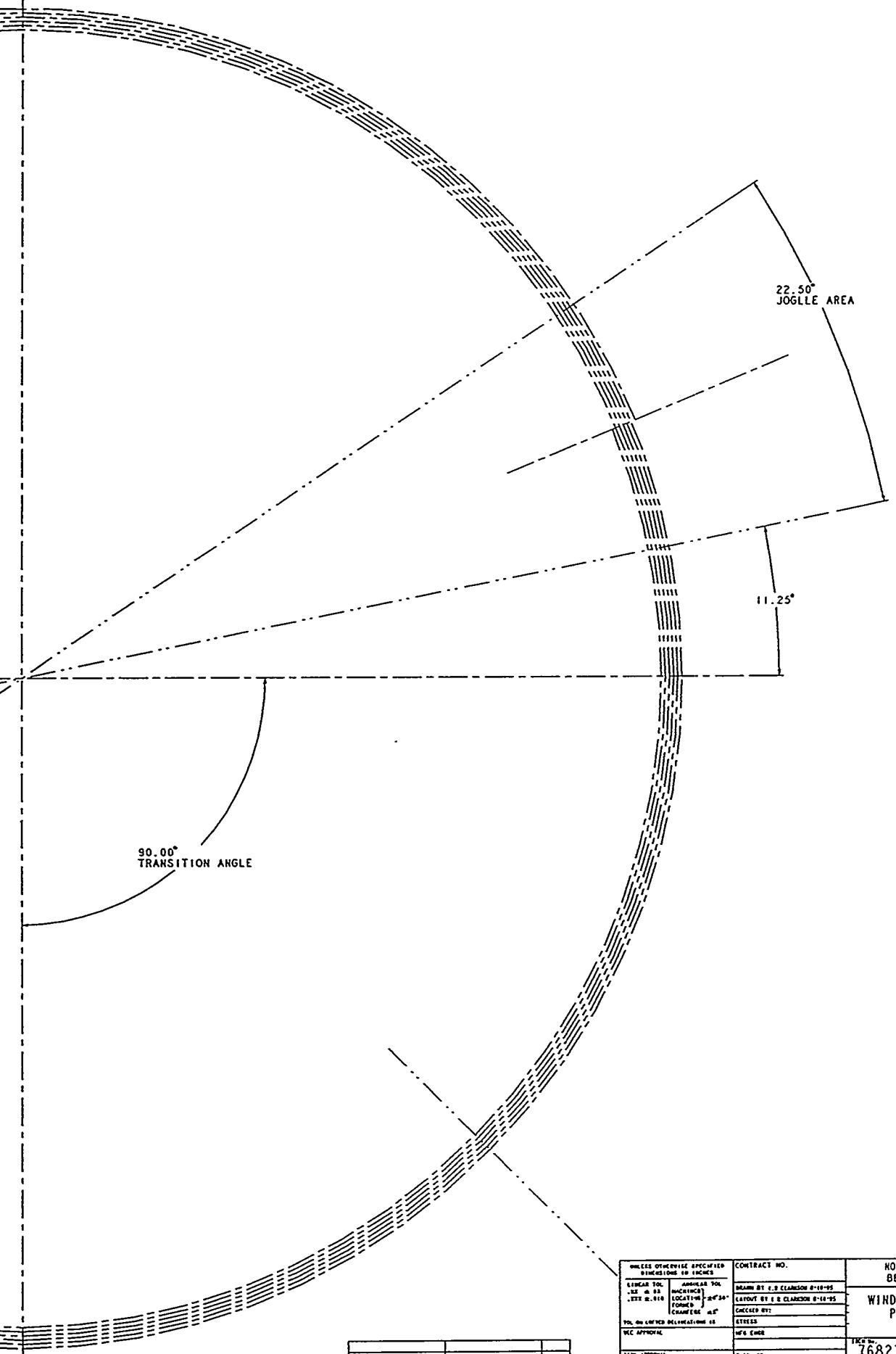
SUPPLEMENTARY DATA NOTE: UNLESS OTHERWISE SPECIFIED NOTES CHECKED ✓ APPLY TO THIS DWG.	
DIMENSIONS STAMP PART NUMBER AND OTHER IDENTIFICATION MARKINGS PER 8334716 CL 2A ☐ NO REGION MARKED ☒ USE BOTH SIDES IF NECESSARY ☐ LOCATION OPTIONAL	
REMOVE ALL BURRS BREAK ALL EDGES	.005-.015 .015-.031
✓ SURFACE ROUGHNESS FOR ALL SURFACES PER ANSI B46.1	
✓ SURFACE ROUGHNESS FOR ALL HOLES PER ANSI B46.1	
SURFACE ROUGHNESS/WAVINESS PER 6320A, TYPE 2&4	
PERMISSIBLE DISMATCH PER 6320A FOR BASIC INTERSECTING CORNERS TYPE 4A MAX TYPE 5A MAX	
MISMATCH STEP OF MAX IS PERMISSIBLE DUE TO CHAMF. OF CUTTERS AT INSIDE INTERSECTION SURFACES	
DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THDS 2-3 IMPERFECT THREADS BEYOND PERMISSIBLE	
EXTERNAL THREAD LENGTH SHOWN INCLUDES 2 IMPERFECT THREADS MAX	
DIMENSIONING AND TOLERANCING PER ANSI Y14.5M	
ABBREVIATIONS PER MIL-STD-12 & GUIDE	
ALL DIMENSIONS SHOWN TO BE MET BEFORE CADMIUM PLATING THICKNESS OF PLATE .0000 MIN TO .0000 MAX NO ALLOWANCE FOR PLATING IN HOLES	
DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH DOUBLE ASTERISK	
HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION.	
GRAIN DIRECTION OPTIONAL	
ALL DIMENSIONS SHOWN TO BE MET AFTER ANY WELDING AND/OR HEAT TREATING	

LAYERS 3,5,7,9,11,13,15,17 AND 1

VIEW LOOKING DOWN ON PF6 UPPER
VIEW LOOKING UP ON PF6 LOWER

NOTES:

REVISIONS						
ZONE	LTR	DESCRIPTION	ECP CODE	MODEL	DATE	APPROVED



PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
LINEAR TOL .XX ± .03, .XXX ± .010
ANGULAR TOL MACHINED LOCATING FORMED CHAMFERS ±2° ±30' ±2°
TOL ON LIMITED DELINEATIONS ±5

CONTRACT NO.
DRAWN BY E.B CLARKSON 8-10-95
LAYOUT BY E.B CLARKSON 8-10-95
CHECKED BY:
STRESS
MFG ENGR
ENGR APPROVAL
MFG APPROVAL

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

WINDING CENTERLINE GEOMETRY
PF6 UPPER AND LOWER

TECH No.	PROGRAM	SIZE	DWG NO.	SHT No	REV
76823	TPX	E	1431002	SH 3	P0

SCALE 1/10 SHEET 3 OF 4

014-3344

TPX-E-1431002SH3P0

TPX-E-1431002SH3P0

SUPPLEMENTARY DATA

NOTE: UNLESS OTHERWISE SPECIFIED
NOTES CHECKED ✓ APPLY TO THIS DWG

MARKED STAMP PART NUMBER AND OTHER IDENTIFICATION MARKINGS PER MSS4710 CL 2A	
☐ ID REGION MARKED ☒ USE BOTH SIDES IF NECESSARY	
☐ LOCATION OPTIONAL	
REMOVE ALL BURRS SHARP ALL EDGES	.005-.015
	.015-.031
✓ 63 SURFACE ROUGHNESS FOR ALL SURFACES PER ANSI B46.1	
✓ 63 SURFACE ROUGHNESS FOR ALL HOLES PER ANSI B46.1	
SURFACE ROUGHNESS/DIMENSION PER MIL-STD-1312, TYPE III	
PERMISSIBLE MISMATCH PER MS2566 FOR INSIDE INTERSECTING CORNERS TYPE 1A MAX TYPE 1B MAX	
MISMATCH STEP OF MAX IS PERMISSIBLE DUE TO CHANGE OF CUTTERS AT INSIDE INTERSECTING SURFACES	
DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THRD 1-3 IMPERFECT THREADS BEYOND PERMISSIBLE	
EXTERNAL THREAD LENGTH SHOWN INCLUDES 2 IMPERFECT THREADS MAX	
DIMENSIONING AND TOLERANCING PER ANSI Y14.5M	
ABBREVIATIONS PER MIL-STD-12 & MIL-STD-1312	
ALL DIMENSIONS SHOWN TO BE MET BEFORE CADMIUM PLATING THICKNESS OF PLATE .0002 MIN TO .0005 MAX NO ALLOWANCE FOR PLATING IN HOLES	
DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH DOUBLE ASTERISK	
HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION	
GRAIN DIRECTION OPTIONAL	
ALL DIMENSIONS SHOWN TO BE MET AFTER ANY WELDING AND/OR HEAT TREATING	

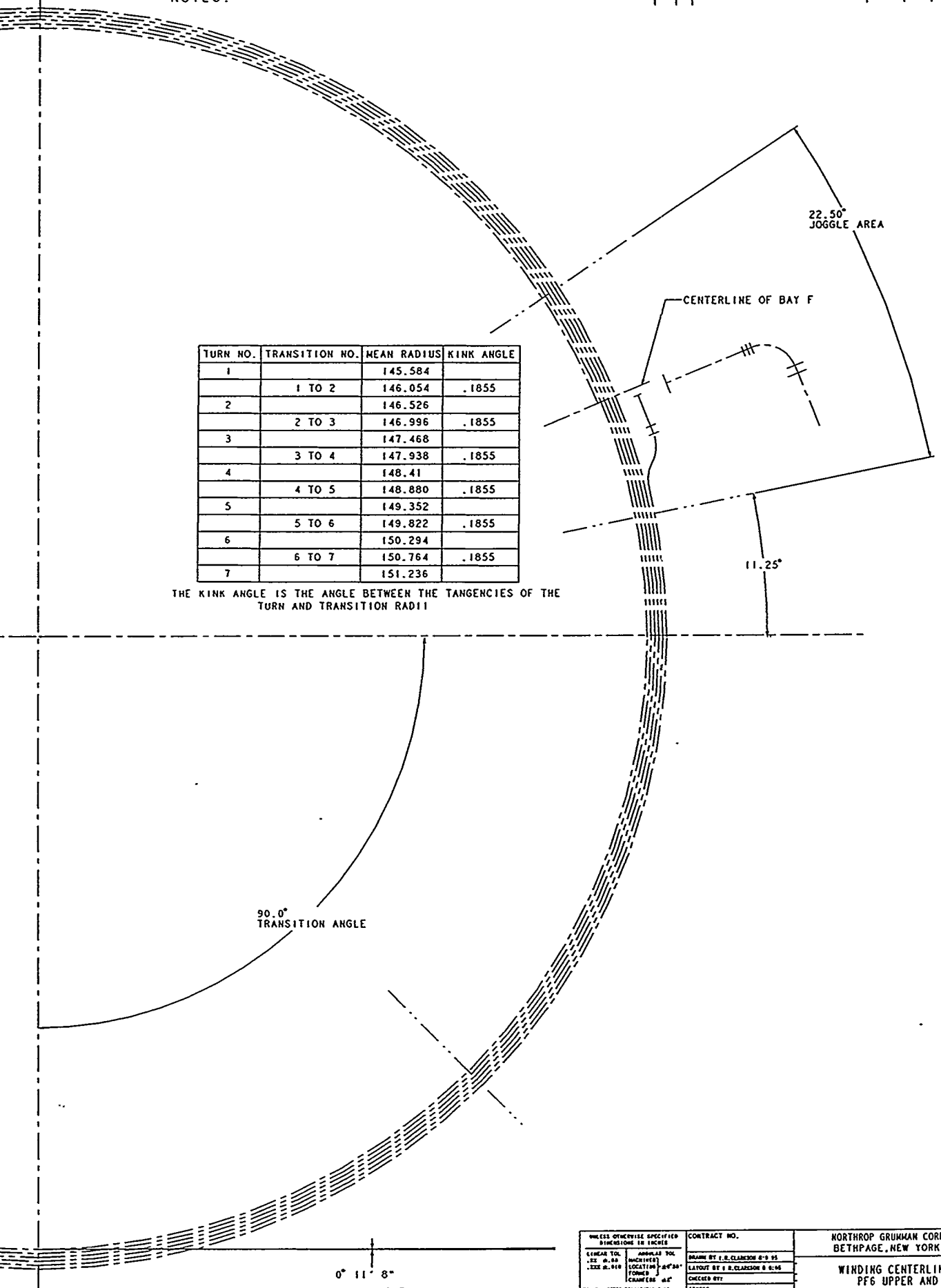
LAYER 20

VIEW LOOKING DOWN ON PF6 UPPER

VIEW LOOKING UP ON PF6 LOWER

NOTES:

REVISIONS						
ZONE	LTR	DESCRIPTION	ECP CODE	MODEL	DATE	APPROVED



TURN NO.	TRANSITION NO.	MEAN RADIUS	KINK ANGLE
1		145.584	
	1 TO 2	146.054	.1855
2		146.526	
	2 TO 3	146.996	.1855
3		147.468	
	3 TO 4	147.938	.1855
4		148.41	
	4 TO 5	148.880	.1855
5		149.352	
	5 TO 6	149.822	.1855
6		150.294	
	6 TO 7	150.764	.1855
7		151.236	

THE KINK ANGLE IS THE ANGLE BETWEEN THE TANGENCIES OF THE TURN AND TRANSITION RADII

PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
LINEAR TOL .XX ±0.03 .XXX ±0.010
ANGULAR TOL MACHINED ±0°30' LOCATING TURNED ±0°30' CHAMFERS ±1°
TOL ON LOFTED DELINEATIONS IS
WEC APPROVAL
ILMC APPROVAL

CONTRACT NO.
DRAWN BY I.R.CLARKSON 8-9-95
LAYOUT BY I.R.CLARKSON 8-9-95
CHECKED BY:
STRESS
MFG ENGR
ENGR MGR:

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

WINDING CENTERLINE GEOMETRY
PF6 UPPER AND LOWER

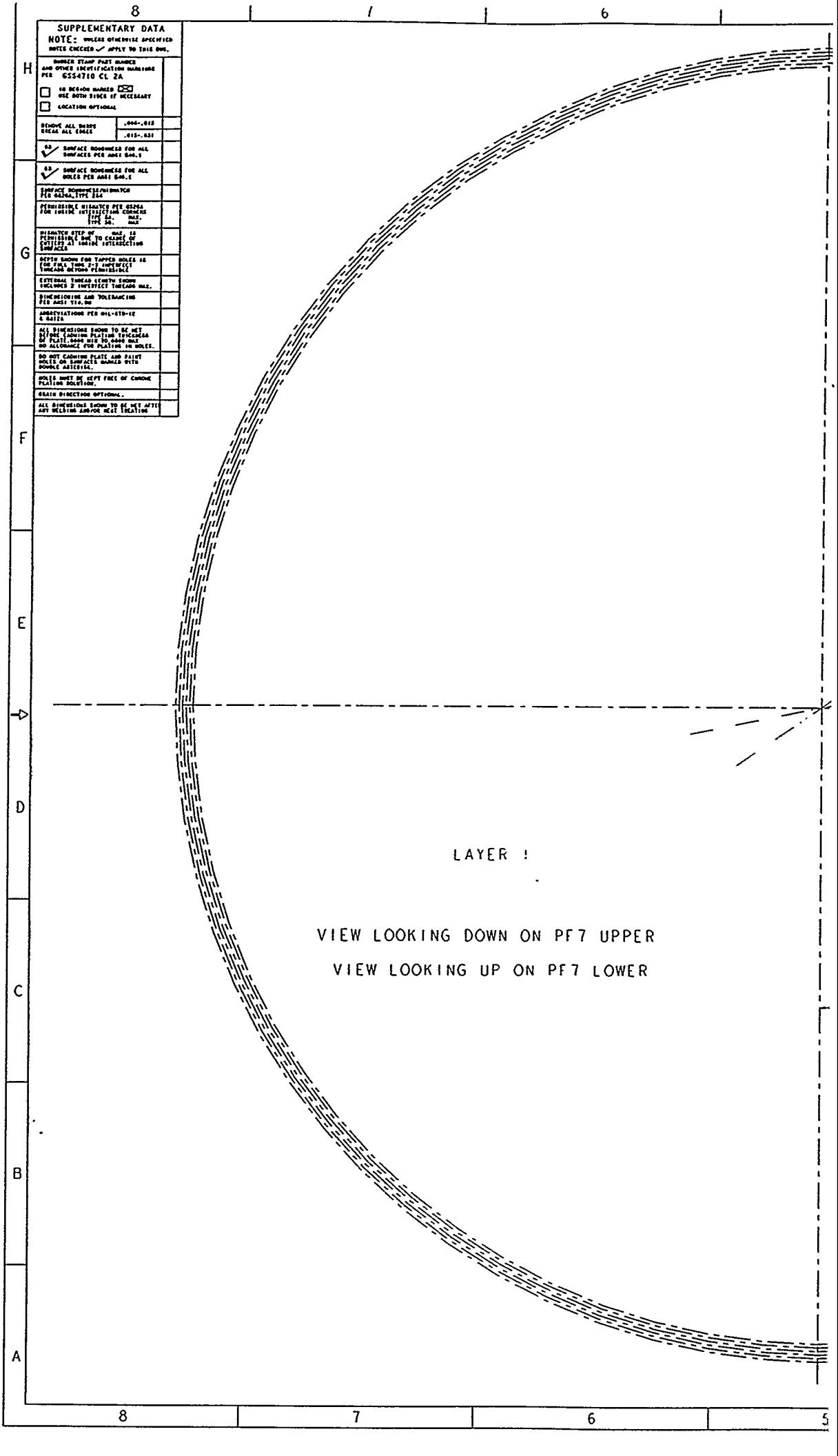
FSCM No.	PROGRAM	SIZE	DWG NO.	SHT No	REV
76823	TPX	E	1431002	SH 4	P0

SCALE 1/10 SHEET 4 OF 4

TPX-E-1431002SH4P0

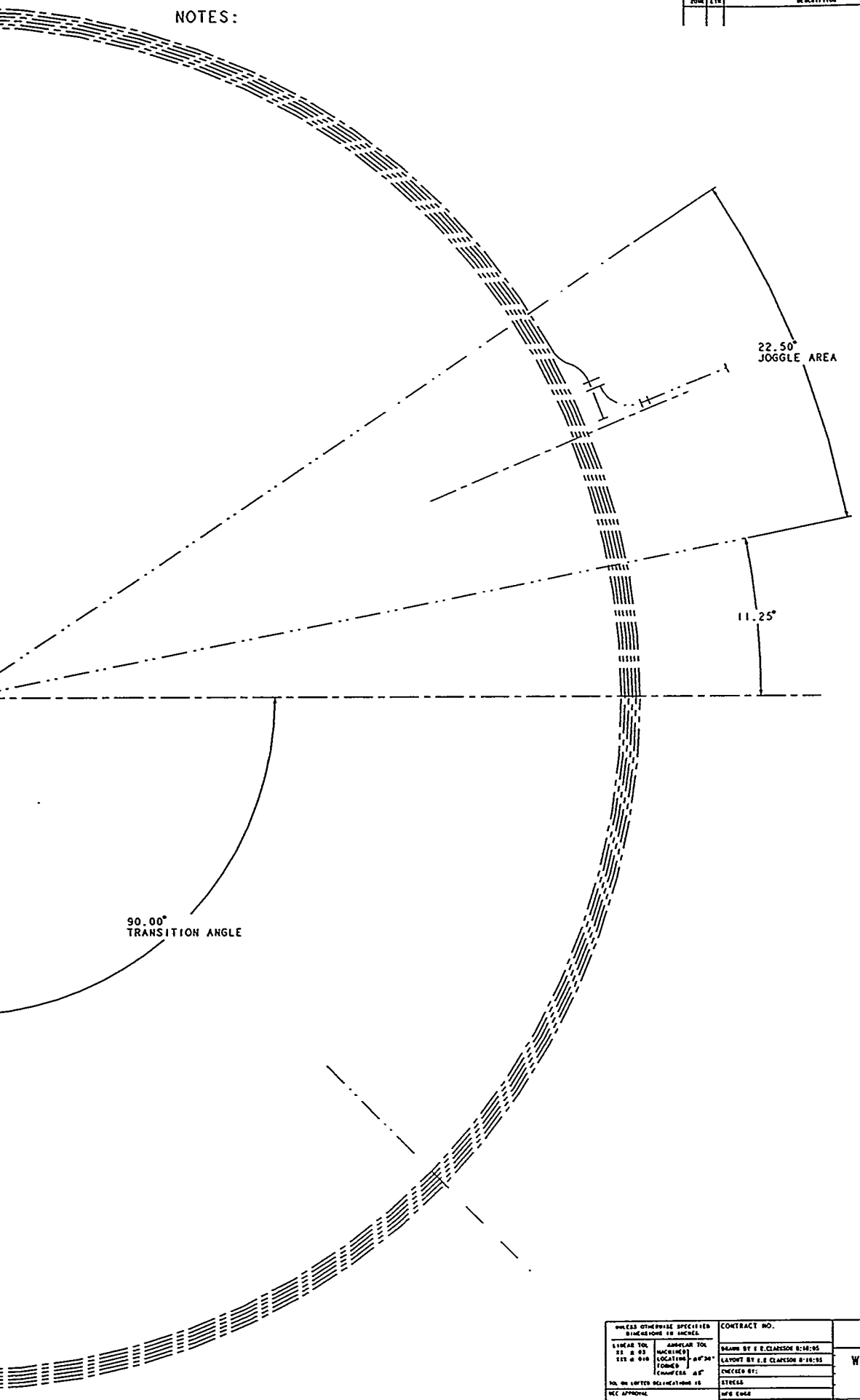
TPX-E-1431002SH4P0

014-3344


SUPPLEMENTARY DATA
NOTE: UNLESS OTHERWISE SPECIFIED
NOTES CHECKED ✓ APPLY TO THIS DWG.
BREAK ALL EDGES
LAYER 1
VIEW LOOKING DOWN ON PF7 UPPER
VIEW LOOKING UP ON PF7 LOWER

NOTES:

REVISIONS						
ZONE	LTR	DESCRIPTION	EFF CODE	MODEL	DATE	APPROVED



PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
LINEAR TOL .XX ± .03 .XXX ± .010
ANGULAR TOL MACHINED ±0°30' LOCATING ±0°30' FORGED ±1° CHAMFERS ±1°
TOL ON LOFTED DELINEATIONS IS
REC APPROVAL
LEM APPROVAL

CONTRACT NO.
DRAWN BY E.E.CLARKSON 8:10:95
LAYOUT BY E.E CLARKSON 8-10-95
CHECKED BY:
STRESS
MFG ENGR
ENGR MGR.

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

WINDING CENTERLINE GEOMETRY
PF7 UPPER AND LOWER

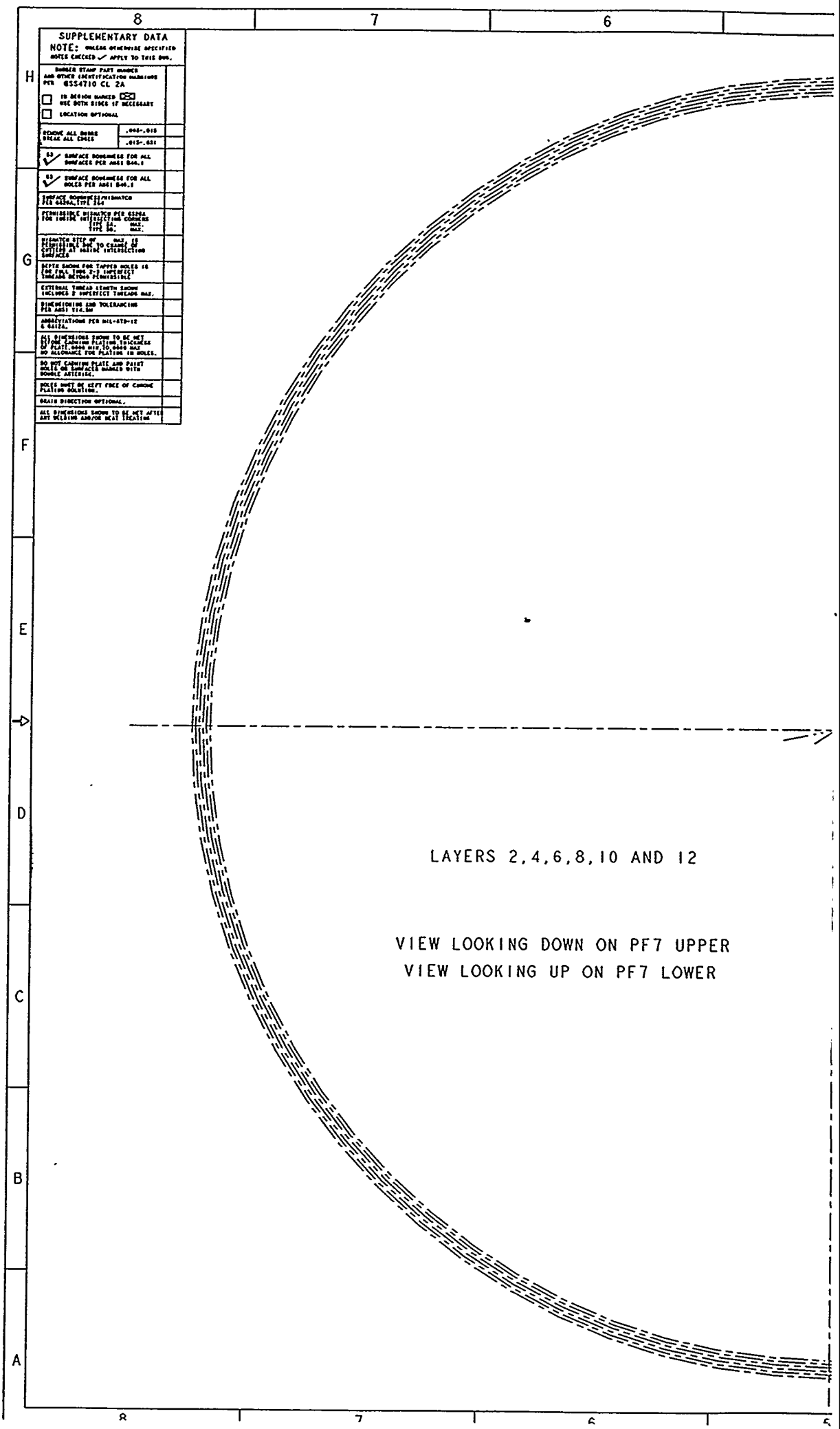
TSCM No.	PROGRAM	SIZE	DWG NO.	SHT No	REV
76823	TPX	E	1431003	SH 1	P0

SCALE 1/10 SHEET 1 OF 4

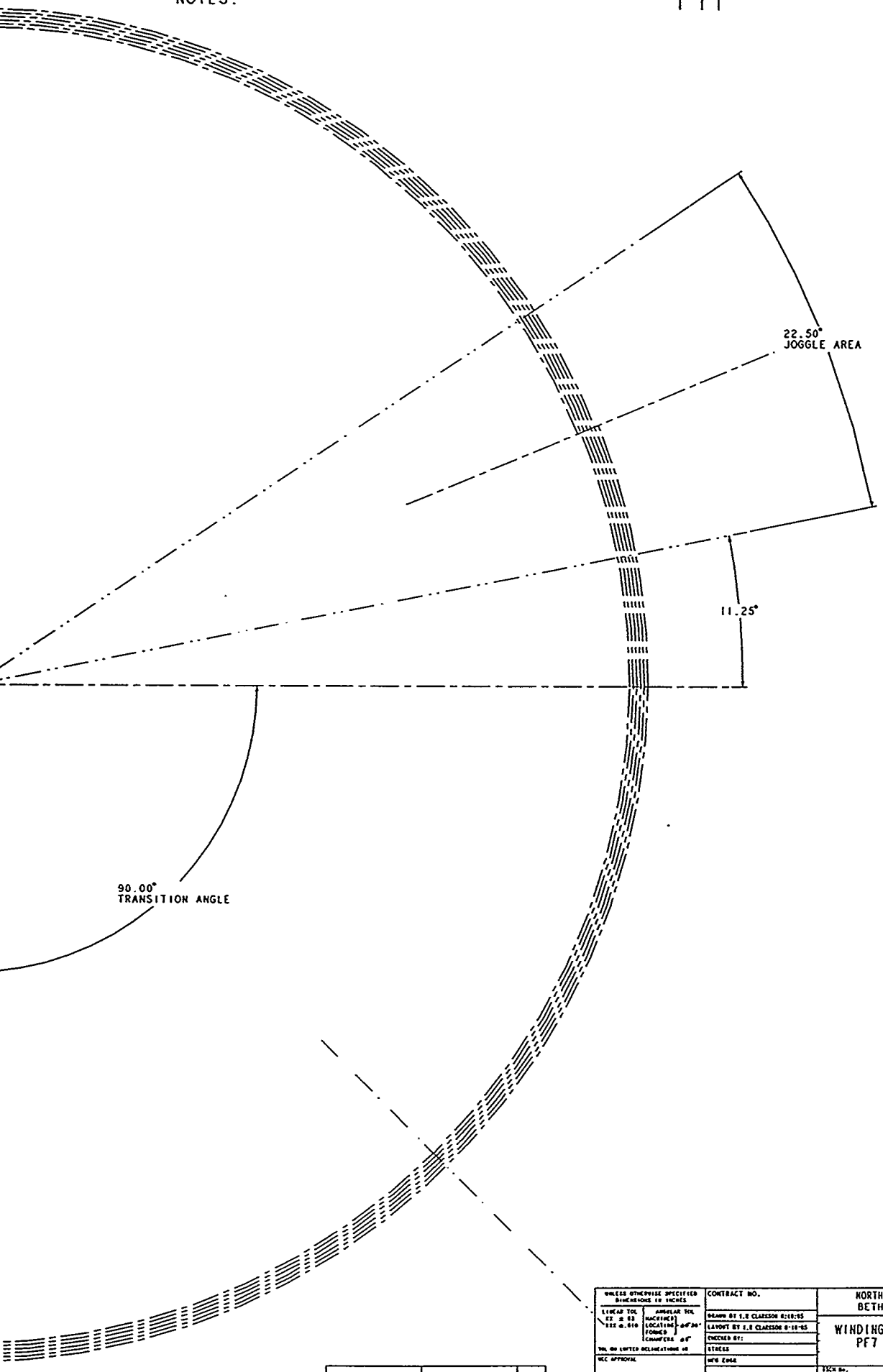
014-3344

TPX-E-1431003SHIP0

TPX-E-1431003SHIP0


8
7
6
SUPPLEMENTARY DATA
NOTE: UNLESS OTHERWISE SPECIFIED
NOTES CHECKED ✓ APPLY TO THIS DWG.
DIE STAMP PART NUMBER AND OTHER IDENTIFICATION MARKINGS PER GSS4710 CL 2A
IN REGION MARKED
USE BOTH SIDES IF NECESSARY
LOCATION OPTIONAL
REMOVE ALL BURRS BREAK ALL EDGES
.005-.015
.015-.035
SURFACE ROUGHNESS FOR ALL SURFACES PER ANSI B46.1
SURFACE ROUGHNESS FOR ALL HOLES PER ANSI B46.1
SURFACE ROUGHNESS/WAVINESS PER GSSM4, TYPE 214
PERMISSIBLE MISMATCH PER GSSM4 FOR TOOLING SURFACES CONTAINED
TYPE 2A: MAX.
TYPE 3B: MAX.
MISMATCH STEP OF MAX IS PERMISSIBLE DUE TO CHANGE OF CONTOUR AT ADJOINING INTERSECTION SURFACES
DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THDS & IMPERFECT THREADS BEYOND PERMISSIBLE
EXTERNAL THREAD LENGTH SHOWN INCLUDES 2 IMPERFECT THREADS MAX.
DIMENSIONING AND TOLERANCING PER ANSI Y14.5M
ABBREVIATIONS PER MIL-STD-12 & GSSTM.
ALL DIMENSIONS SHOWN TO BE NET AFTER CADMIUM PLATING THICKNESS OF PLATE: .0009 MIN TO .0040 MAX NO ALLOWANCE FOR PLATING IN HOLES.
DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH DOUBLE ARTERISK.
HOLES SHALL BE KEPT FREE OF CHROME PLATING DURATION.
GRAIN DIRECTION OPTIONAL.
ALL DIMENSIONS SHOWN TO BE NET AFTER ANY WELDING AND/OR HEAT TREATING
H
G
F
E
D
C
B
A
LAYERS 2,4,6,8,10 AND 12
VIEW LOOKING DOWN ON PF7 UPPER
VIEW LOOKING UP ON PF7 LOWER
8
7
6
5

NOTES:



REVISIONS						
ZONE	LTR	DESCRIPTION	EFF CODE	MODEL	DATE	APPROVED

PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
LINEAR TOL .XX ± .03 .XXX ± .010
ANGULAR TOL MACHINED LOCATING CORNER CHAMFERS .01" ±0°30'
TOL ON LISTED DELINEATIONS ±0

CONTRACT NO.
DRAWN BY S.E CLARKSON 8:10:95
LAYOUT BY S.E CLARKSON 8-10-95
CHECKED BY:
STRESS
MFG ENGR
ENGR MGR:
WEC APPROVAL
GOVT APPROVAL

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

WINDING CENTERLINE GEOMETRY
PF7 UPPER AND LOWER

ENG No.	PROGRAM	SIZE	DWG NO.	SH No.	REV
76823	TPX	E	1431003	SH 2	P0

SCALE 1/100 SHEET 2 OF 4

TPX-E-1431003SH2P0

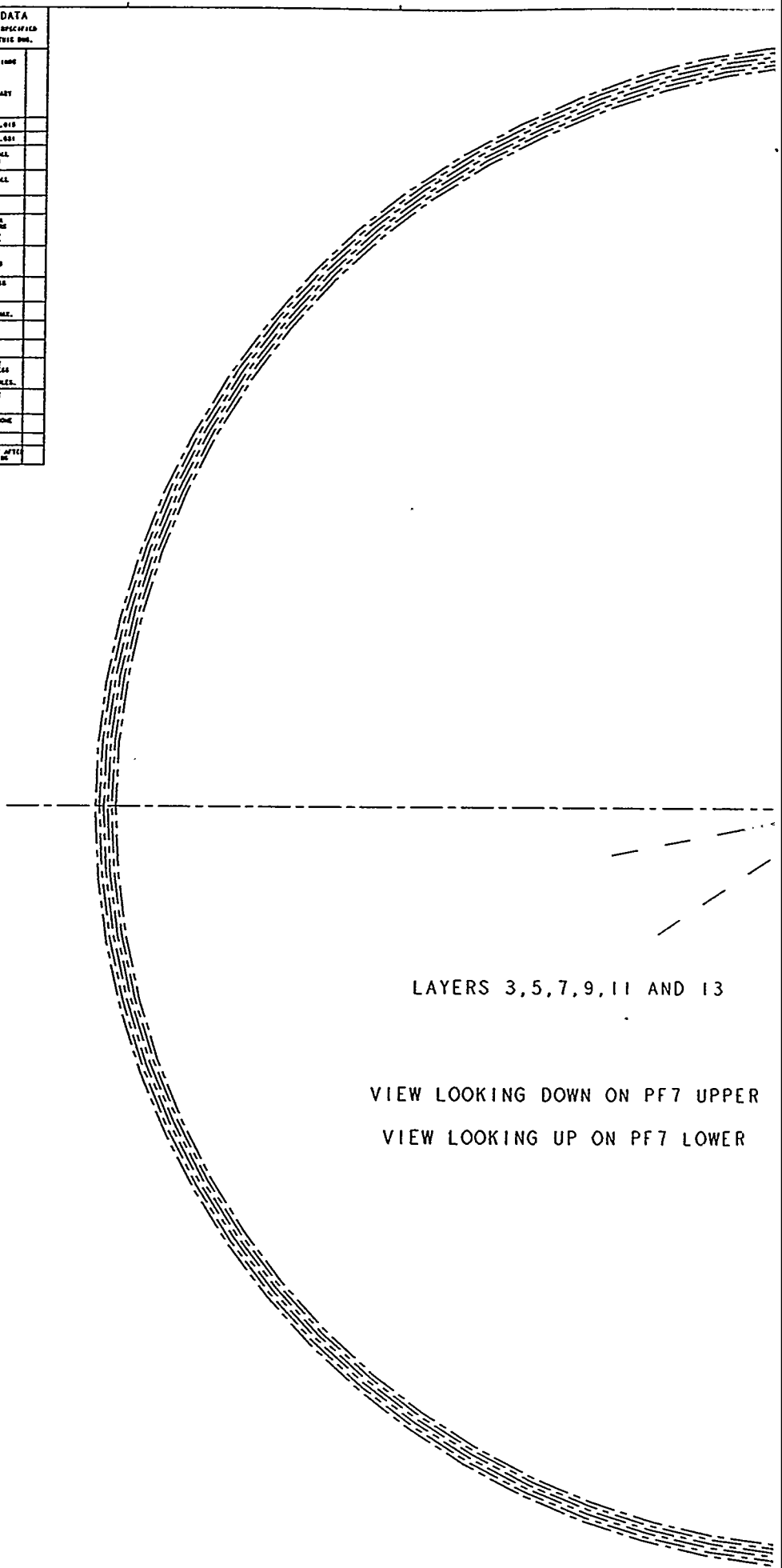
TPX-E-1431003SH2P0

014-3344

SUPPLEMENTARY DATA

NOTE: UNLESS OTHERWISE SPECIFIED NOTES CHECKED ✓ APPLY TO THIS DWG.

NUMBER STAMP PART NUMBER AND OTHER IDENTIFICATION MARKINGS PER GSS4710 CL 2A ☐ IN REGION MARKED ☒ USE BOTH SIDES IF NECESSARY ☐ LOCATION OPTIONAL	
REMOVE ALL BURRS BREAK ALL EDGES .000-.015 / .015-.031	
63 ✓ SURFACE ROUGHNESS FOR ALL SURFACES PER ANSI B46.1	
63 ✓ SURFACE ROUGHNESS FOR ALL HOLES PER ANSI B46.1	
SURFACE ROUGHNESS/FINISH PER GS264A, TYPE 254	
PERMISSIBLE MISMATCH PER GS264 FOR ENDING INTERSECTING CORNERS TYPE 54. MAX. TYPE 56. MAX.	
MISMATCH STEP OF MAX. IS PERMISSIBLE DUE TO CHANGE OF CUTTERS AT ENDING INTERSECTING SURFACES	
DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THDS. 2-3 IMPERFECT THREADS BEYOND PERMISSIBLE	
EXTERNAL THREAD LENGTH SHOWN INCLUDES 2 IMPERFECT THREADS MAX.	
DIMENSIONING AND TOLERANCING PER ANSI Y14.5M	
ABBREVIATIONS PER MIL-STD-12 & GAIDA.	
ALL DIMENSIONS SHOWN TO BE MET BEFORE CADMIUM PLATING THICKNESS OF PLATE .0003 MIN TO .0005 MAX NO ALLOWANCE FOR PLATING IN HOLES.	
DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH DOUBLE ASTERISK.	
HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION.	
GRAIN DIRECTION OPTIONAL.	
ALL DIMENSIONS SHOWN TO BE MET AFTER ANY WELDING AND/OR HEAT TREATING	



LAYERS 3,5,7,9,11 AND 13

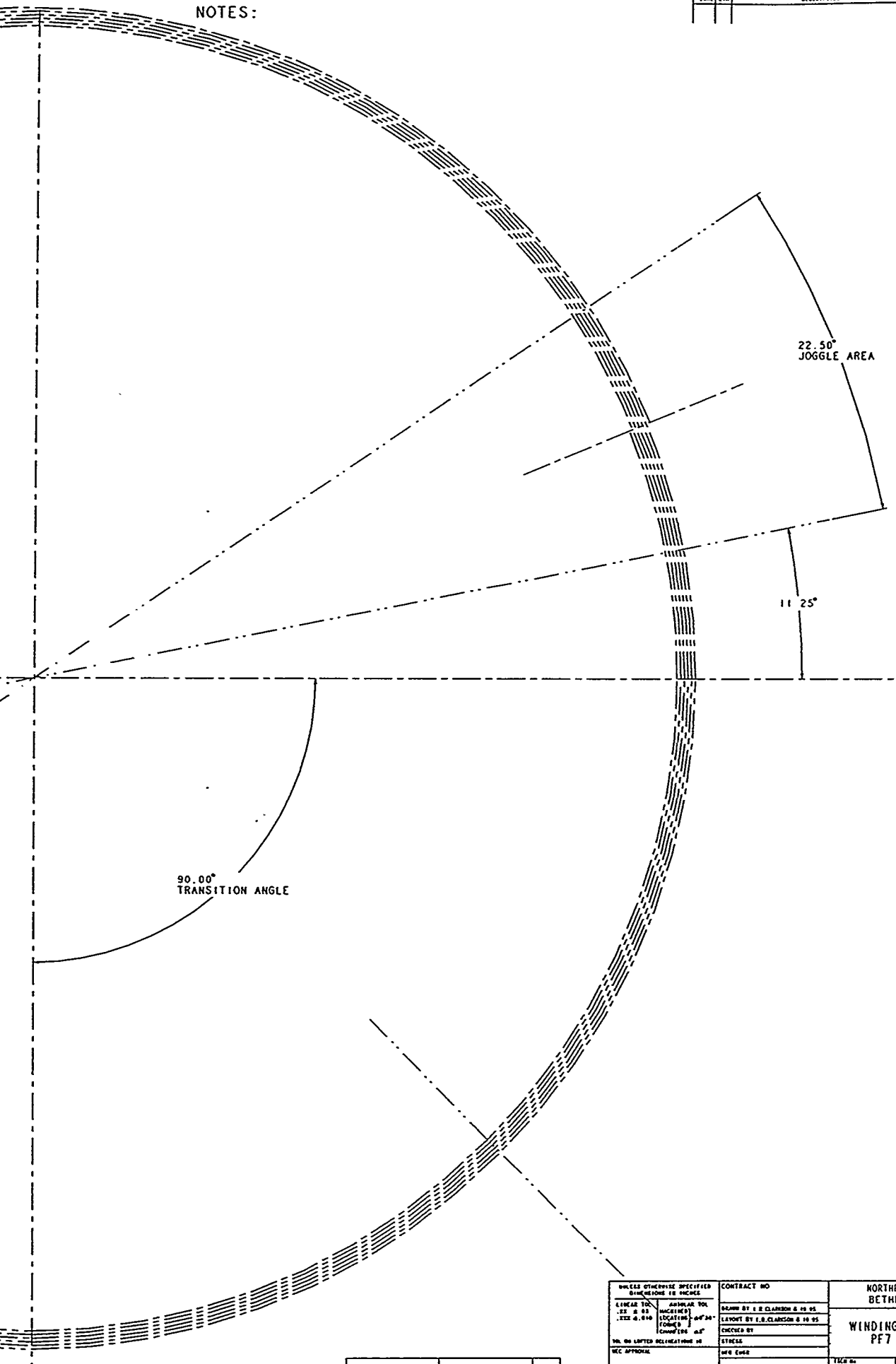
VIEW LOOKING DOWN ON PF7 UPPER

VIEW LOOKING UP ON PF7 LOWER

H G F E D C B A

8 7 6

NOTES:



REVISIONS						
ZONE	LTR	DESCRIPTION	ECP CODE	NUMBER	DATE	APPROVED

PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
LINEAR TOL .XX ± 0.03 .XXX ± .010
ANGULAR TOL MACHINED ± 00°30' LOCATING HOLES ± 00°15' FORMED ± 1° CHAMFERS ± 5°
TOL ON LAYER DELINEATIONS ±0

CONTRACT NO
DRAWN BY I.B.CLARKSON 8 10 95
LAYOUT BY I.B.CLARKSON 8 10 95
CHECKED BY
STRESS
MFG CHKR
MFG APPROVAL
ENGR APPROVAL
ENGR DATE:

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

WINDING CENTRELINE GEOMETRY
PF7 UPPER AND LOWER

TECH No	PROGRAM	SIZE	DWG NO.	SAT No	REV
76823	TPX	E	1431003	SH3	P0

SCALE 1/10 SHEET 3 OF 4

TPX-E-1431003SH3P0

TPX-E-1431003SH3P0

014-3344

H G F E D C B A

4 3 2 1

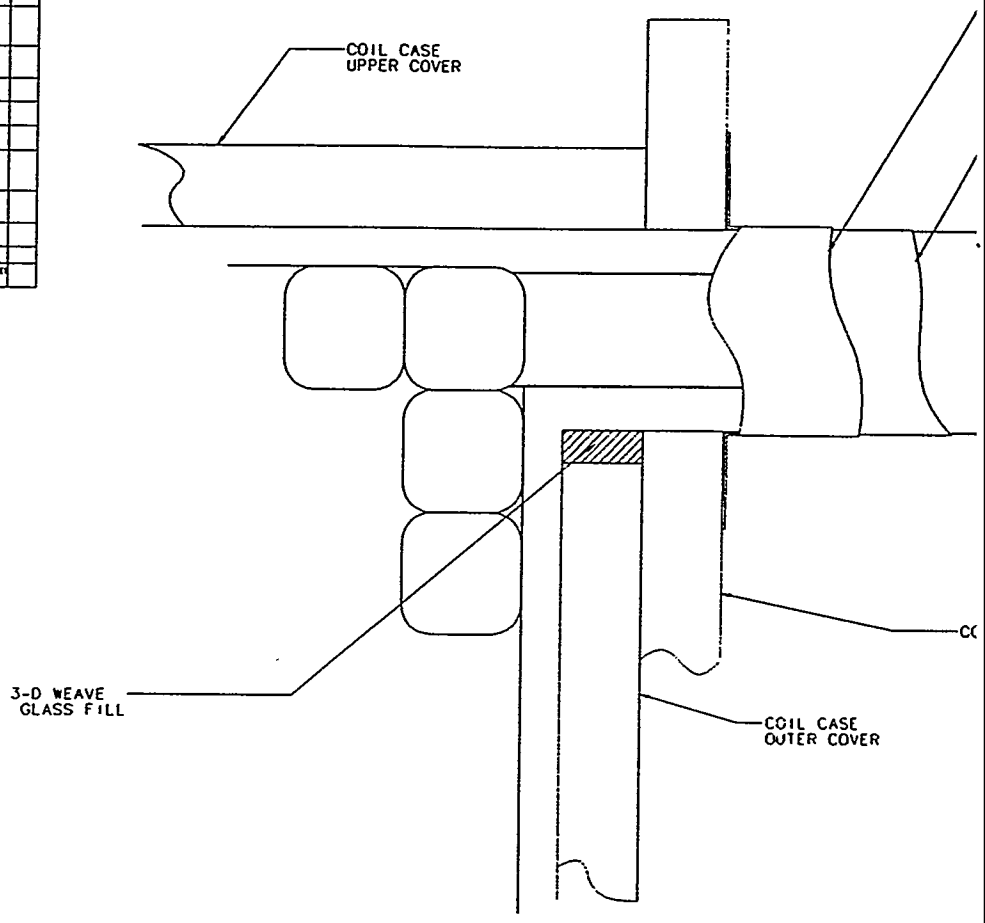
NOTE: UNLESS OTHERWISE SPECIFIED NOTES CHECKED ✓ APPLY TO THIS DWG.

RUBBER STAMP PART NUMBER AND OTHER IDENTIFICATION MARKINGS PER GSS4710 CL 2A	
☐ NO POSITION MARKED ☒ USE BOTH SIDES IF NECESSARY	
☐ LOCATION OPTIONAL	
REMOVE ALL BURRS BREAK ALL EDGES	.005-.015 / .015-.031
✓ 63 SURFACE ROUGHNESS FOR ALL SURFACES PER ANSI B46.1	
✓ 63 SURFACE ROUGHNESS FOR ALL HOLES PER ANSI B46.1	
SURFACE ROUGHNESS/WAVINESS PER GR284, TYPE 304	
PERMISSIBLE WAVINESS PER GR284 FOR INSIDE INTERSECTING CORNERS TYPE 54, MAX. TYPE 30, MAX.	
WAVINESS STEP OF MAX. IS PERMISSIBLE DUE TO CHANCE OF CUTTERS AT INSIDE INTERSECTING SURFACES	
DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THDS. 2-3 IMPERFECT THREADS BEYOND PERMISSIBLE	
EXTERNAL THREAD LENGTH SHOWN INCLUDES 2 IMPERFECT THREADS MAX.	
DIMENSIONING AND TOLERANCING PER ANSI Y14.5M	
ABBREVIATIONS PER MIL-STD-12 & G12A.	
ALL DIMENSIONS SHOWN TO BE MET BEFORE CADMIUM PLATING. THICKNESS OF PLATE .0000 MIN TO .0000 MAX NO ALLOWANCE FOR PLATING IN HOLES	
DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH DOUBLE ASTERISK	
HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION.	
GRAIN DIRECTION OPTIONAL.	
ALL DIMENSIONS SHOWN TO BE MET AFTER ANY WELDING AND/OR HEAT TREATING	

SECTION AT LEAD PENETRATI(THROUGH THE COIL CASE

TYPICAL WRAP CONFIGURATION FOR ALL CONDUIT PENETRATIONS

SCALE 2/1



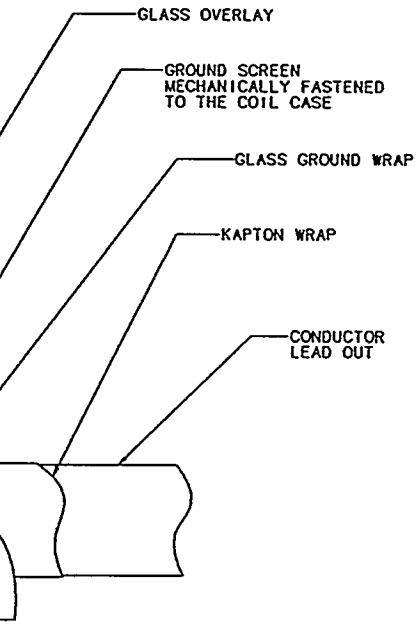
INTER-CONDUIT
FILLER - 3D-WEAVE

GROUND WRAP

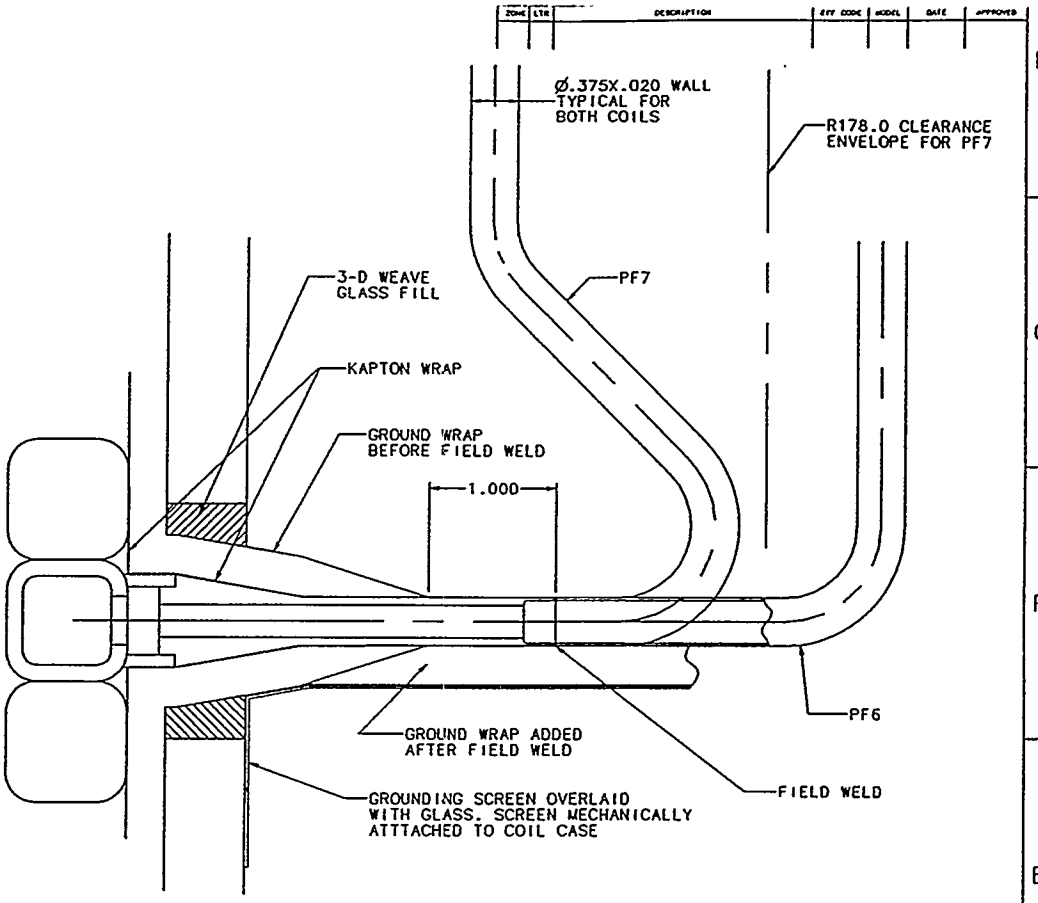
H G F E D C B A

8 7 6

NOTES:

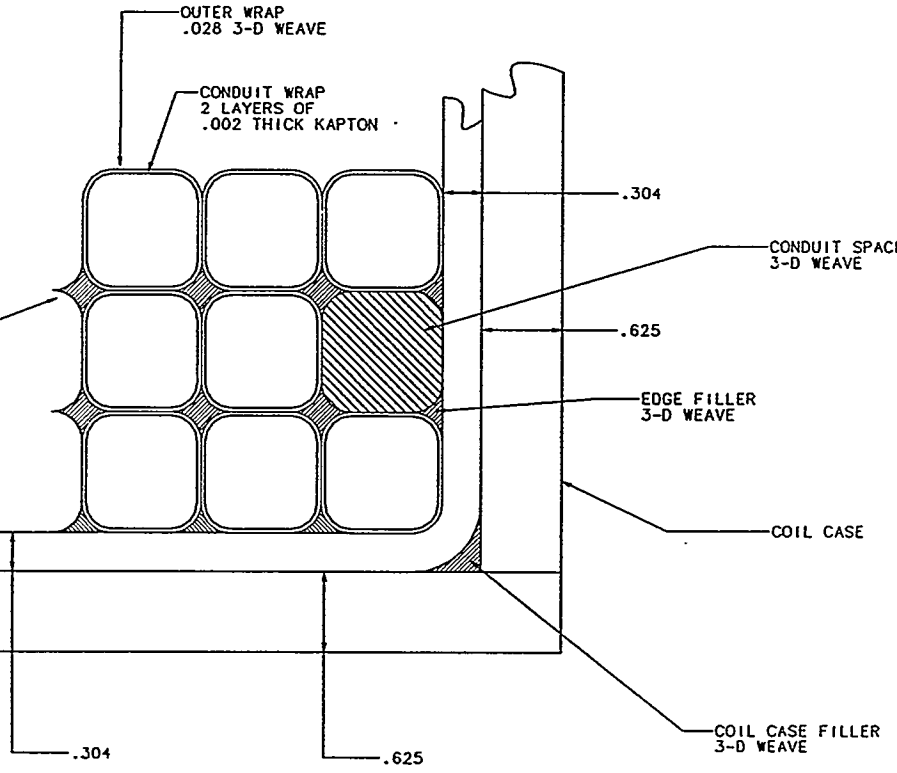


CASE SPLICE



SECTION THROUGH HELIUM STUB

SCALE 2/1



PICAL COIL CROSS SECTION PF6 AND PF7

SCALE 2/1

PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
LINEAR TOL .XX ±.01 .XXX ±.010
ANGULAR TOL MACHINED LOCATING FORMED ±0°30' CHAMFERS ±5°
TOL ON LOFTED DELAMINATING ±6

CONTRACT NO.
DRAWN BY L.R.CLARKSON 8x14x85
LAYOUT BY L.R.CLARKSON 8x14x85
CHECKED BY:
STRESS
MFG ENGR
ENGR MGR:
MFG APPROVAL
LLNL APPROVAL

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

INSULATION DETAILS PF6 AND PF7

SCAN NO.	PROGRAM	SIZE	DWG NO.	SHT NO	REV
76823	TPX	E	1431005	SH1	P0

SCALE 2/1 SHEET 1 OF 1

TPX-E-1431005SH1P0

TPX-E-1431005SH1P0

4 3 2 014-N344 1

SUPPLEMENTARY DATA NOTE: UNLESS OTHERWISE SPECIFIED NOTES CHECKED ✓ APPLY TO THIS DWG.	
NUMBER STAMP PART NUMBER AND OTHER IDENTIFICATION MARKINGS PER 6554710 CL 2A ☐ NO REGION MARKED ☒ USE BOTH SIDES IF NECESSARY ☐ LOCATION OPTIONAL	
REMOVE ALL BURRS BREAK ALL EDGES .005-.015 .015-.035	
✓ SURFACE ROUGHNESS FOR ALL SURFACES PER ANSI B46.1	
✓ SURFACE ROUGHNESS FOR ALL HOLES PER ANSI B46.1	
SURFACE ROUGHNESS/WAVINESS PER 6638A,TYPE 2&4	
PERMISSIBLE MISMATCH PER 6526A FOR INSIDE INTERSECTING CORNERS TYPE 1A: MAX. TYPE 1B: MAX.	
MISMATCH STEP OF MAY BE PERMISSIBLE DUE TO CHANGE OF CONTOUR AT INSIDE INTERSECTION SURFACES	
DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THDS. 2-3 IMPERFECT THREADS BEYOND PERMISSIBLE	
EXTERNAL THREAD LENGTH SHOWN INCLUDES 2 IMPERFECT THREADS MAX.	
DIMENSIONING AND TOLERANCING PER ANSI Y14.5M	
ABBREVIATIONS PER MIL-STD-12 & 6612A	
ALL DIMENSIONS SHOWN TO BE MET BEFORE CADMIUM PLATING INCREASE OF PLATE .0000 MIN TO .0008 MAX NO ALLOWANCE FOR PLATING IN HOLES.	
DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH DOUBLE ASTERISK.	
HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION.	
GRAIN DIRECTION OPTIONAL.	
ALL DIMENSIONS SHOWN TO BE MET AFTER ANY WELDING AND/OR HEAT TREATING	

LAYER 14

VIEW LOOKING DOWN ON PF7 UPPER

VIEW LOOKING UP ON PF7 LOWER

NOTES:

TURN NO.	TRANSITION NO.	MEAN RADIUS	KINK ANGLE
1		166.856	
	1 TO 2	167.328	.1618
2		167.798	
	2 TO 3	168.268	.1618
3		168.74	
	3 TO 4	169.210	.1618
4		169.682	
	4 TO 5	170.152	.1618
5		170.624	
	5 TO 6	171.094	.1618
6		171.566	
	6 TO 7	172.036	.1618
7		172.508	

THE KINK ANGLE IS THE ANGLE BETWEEN THE TANGENCIES OF THE TURN AND TRANSITION RADII

22.50° JOGGLE AREA

11.25°

90° 0' 0" TRANSITION ANGLE

KINK ANGLE	
0° 9' 43"	
PART NUMBER	NEXT ASS'Y QTY

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

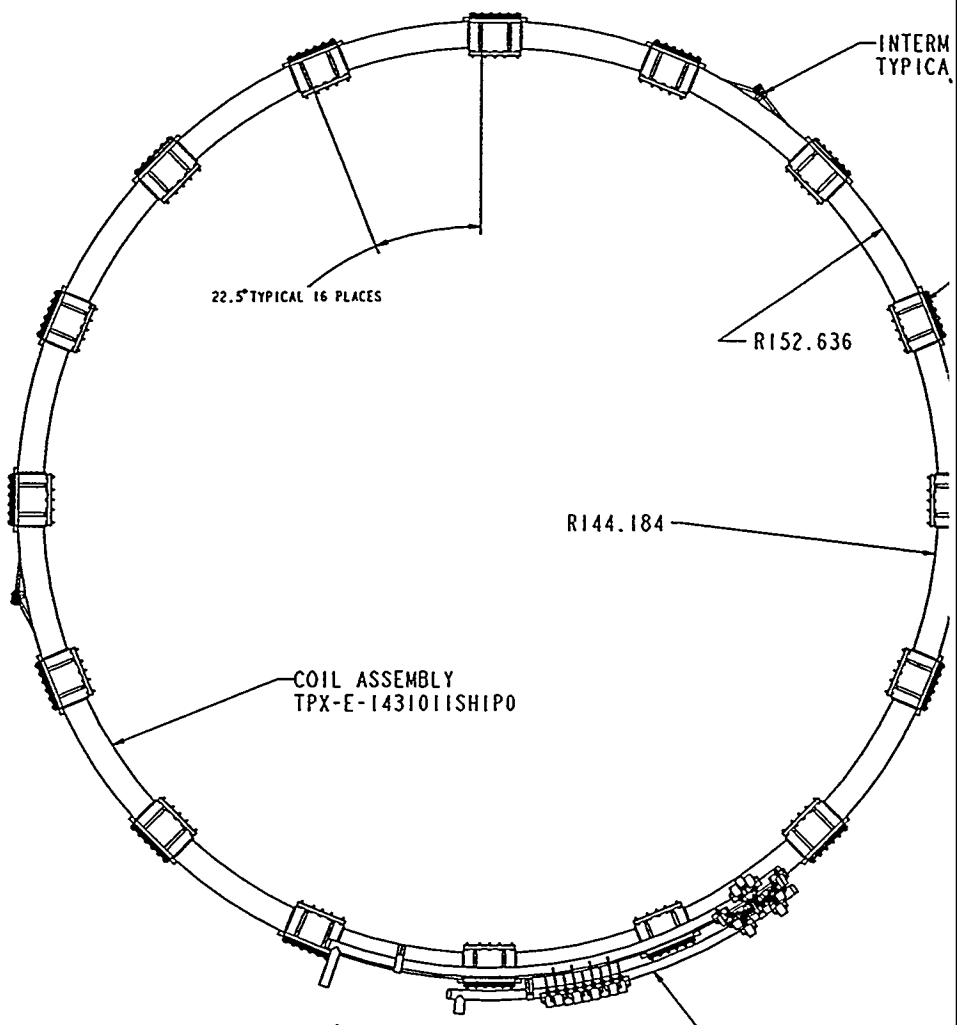
WINDING CENTERLINE GEOMETRY
PF7 UPPER AND LOWER

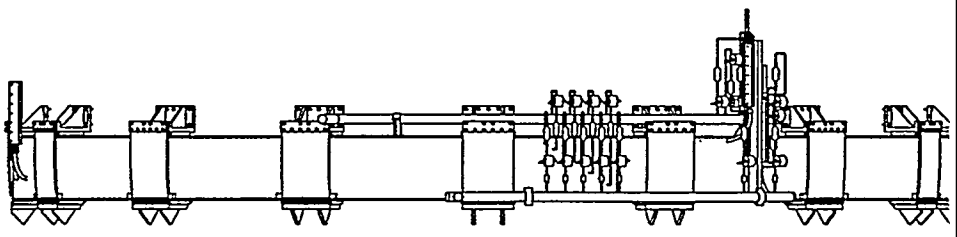
TPX-E-1431003SH4P0

TPX-E-1431003SH4P0

014-3344

SUPPLEMENTARY DATA NOTE: UNLESS OTHERWISE SPECIFIED NOTES CHECKED ✓ APPLY TO THIS DWG.	
BORDER STAMP PART NUMBER AND OTHER IDENTIFICATION MARKINGS PER GSS4710 CL 2A ☐ IN REGION MARKED ⊠ USE BOTH SIDES IF NECESSARY ☐ LOCATION OPTIONAL	
REMOVE ALL BURRS BREAK ALL EDGES .005-.015 .015-.031	
✓ SURFACE ROUGHNESS FOR ALL SURFACES PER ANSI B46.1	
✓ SURFACE ROUGHNESS FOR ALL HOLES PER ANSI B46.1	
SURFACE ROUGHNESS/FINISH PER GS30A, TYPE 254	
PERMISSIBLE MISMATCH PER GS30A FOR WELDED BUTT JOINTS AND CORNERS TYP EA. MAX. TYP SO. MAX.	
MISMATCH STEP OF MAX. IS PERMISSIBLE DUE TO CHANGE OF CONTOUR AT WELDED INTERSECTING SURFACES	
DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THDS. 2-3 IMPERFECT THREADS BEYOND PENETRATION	
EXTERNAL THREAD LENGTH SHOWN INCLUDES 2 IMPERFECT THREADS MAX.	
DIMENSIONING AND TOLERANCING PER ANSI Y14.5M	
ABBREVIATIONS PER MIL-STD-12 & GAITA	
ALL DIMENSIONS SHOWN TO BE NET AFTER CADMIUM PLATING THICKNESS OF PLATE .0400 MIN TO .0460 MAX NO ALLOWANCE FOR PLATING IN HOLES.	
DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH DOUBLE ARTERISK.	
HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION.	
GRAIN DIRECTION OPTIONAL.	
ALL DIMENSIONS SHOWN TO BE NET AFTER ANY WELDING AND/OR HEAT TREATING	





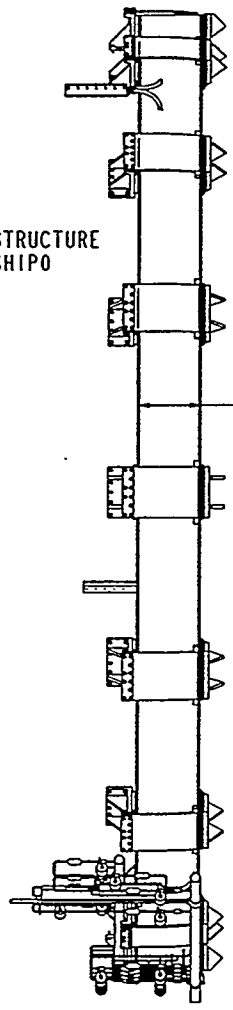
REVISIONS						
ZONE	LTR	DESCRIPTION	EFF CODE	MODEL	DATE	APPROVED

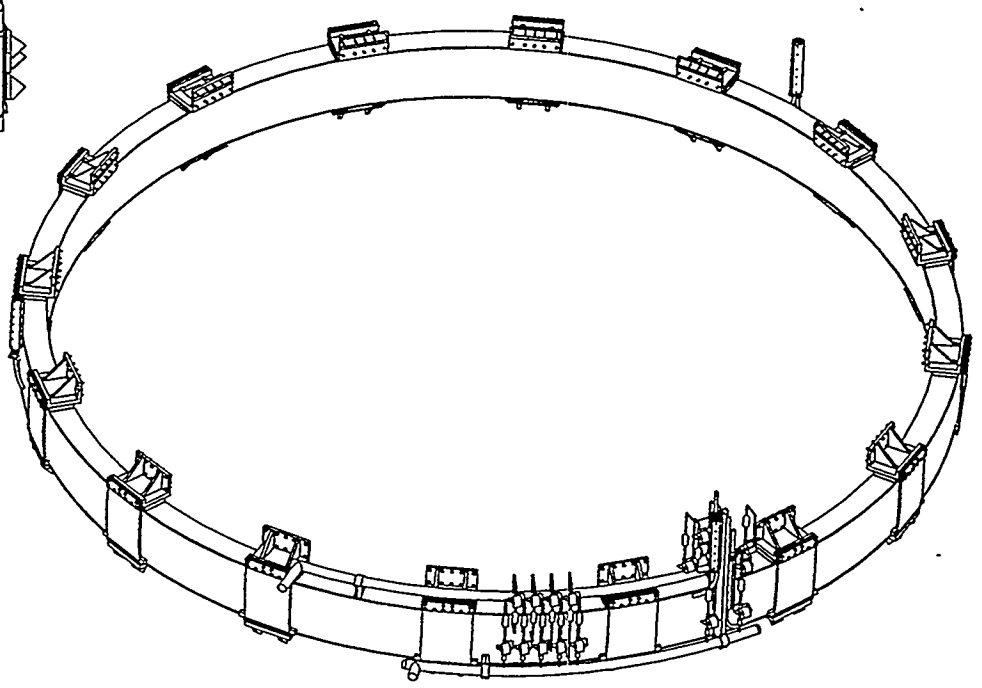
NOTES:

ATE JOINT
PLACES

COIL SUPPORT STRUCTURE
TPX-E-1431016SHIP0

20 698





SCALE 0 050

PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	CONTRACT NO
LINEAR TOL XX ± 03 XXX ± 010	DRAWN BY I R CLARKSON 8 14 95
ANGULAR TOL MACHINED ± 30' LOCATING ± 01° 30' FORMED ± 1° CHAMFERS ± 1°	LAYOUT BY I R CLARKSON 8 14 95
TOL ON LISTED DECIMALS ±	CHECKED BY
MFG APPROVAL	STRESS
ENGR APPROVAL	MFG ENGR
	EDGE MGR

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

COIL ASSEMBLY
PF6 UPPER

TECH No.	PROGRAM	SIZE	WBS NO	SAT No.	REV
76823	TPX	E	1431010	SH 1	P0

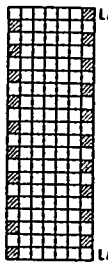
SCALE 1/20 SHEET 1 OF 5

014-3344

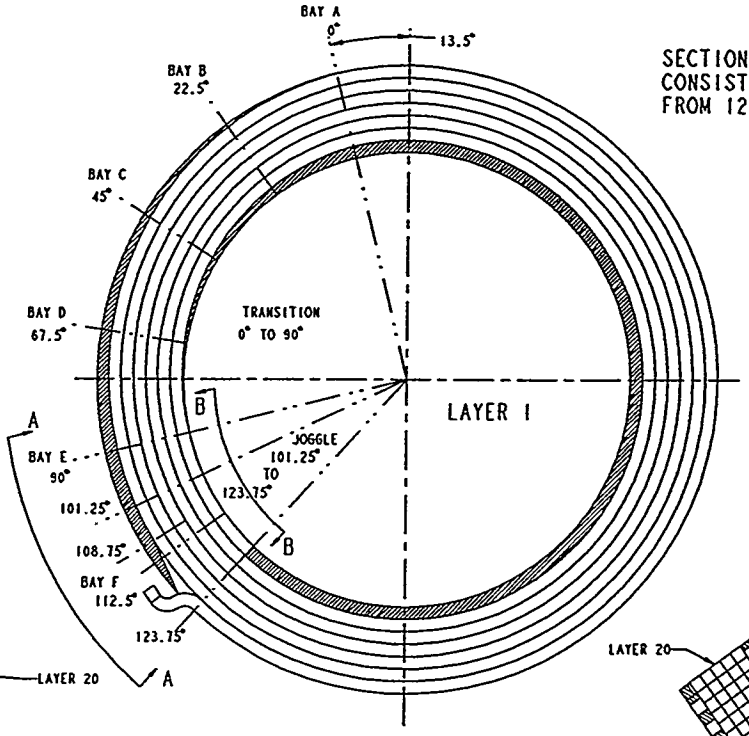
TPX-E-1431010SHIP0

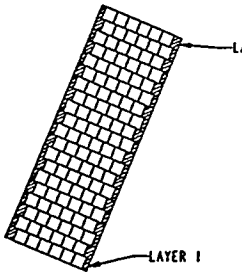
TPX-E-1431010SHIP0

SUPPLEMENTARY DATA NOTE: UNLESS OTHERWISE SPECIFIED NOTES CHECKED ✓ APPLY TO THIS DWG.
DIGGER STAMP PART NUMBER AND OTHER IDENTIFICATION MARKINGS PER 6534710 CL 2A
☐ ON REGION MARKED ☒ USE BOTH SIDES IF NECESSARY
☐ LOCATION OPTIONAL
BREAK ALL EDGES .005-.015 / .015-.031
✓ (2) SURFACE ROUGHNESS FOR ALL SURFACES PER ASME B46.1
✓ (2) SURFACE ROUGHNESS FOR ALL HOLES PER ASME B46.1
SURFACE ROUGHNESS/ORIENTATION PER 4536A, TYPE 21A
PERMISSIBLE MISMATCH PER 6529A FOR INSIDE SKIN/SKIN CORNERS TYPE 1A: MAX. TYPE 2A: MAX.
MISMATCH STEP OF ONE SKIN TO CHORD OF PERMISSIBLE GAP TO CHORD OF CURVATURE AT ANGLE INTERSECTION SURFACES
NOTCH SHOWN FOR TAPER RELIEF TO BE (2) .125 R.; (2) .187 MIN. UNLESS OTHERWISE PERMISSIBLE
EXTERNAL SHARP EDGES FACING SURFACE 3 IMPERFECT THREADS MAX.
DIMENSIONING AND TOLERANCING PER ASME Y14.5M
ABBREVIATIONS PER MIL-STD-12 & 8AISC.
(3) DIMENSIONS SHOWN TO BE MET AFTER ANY AND ALL CADMIUM PLATING THICKNESS OF .0001-.0005 MIN./.0020 MAX ARE ALLOWANCE FOR PLATING OR BOLTS.
DO NOT CADMIUM PLATE AND PAINT BOLTS OR SURFACES MARKED WITH DOUBLE ARTERISK.
BOLTS SHALL BE KEPT FREE OF CHROME PLATING SOLUTION.
GRAIN DIRECTION OPTIONAL.
ALL DIMENSIONS SHOWN TO BE MET AFTER ANY WELDING AND/OR HEAT TREATING

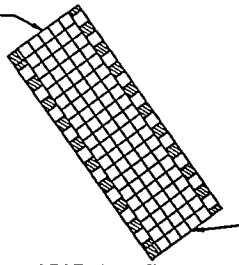


SECTION AT 256.5°
CONSISTENT FOR SECTIONS
FROM 123.75° THROUGH 360°

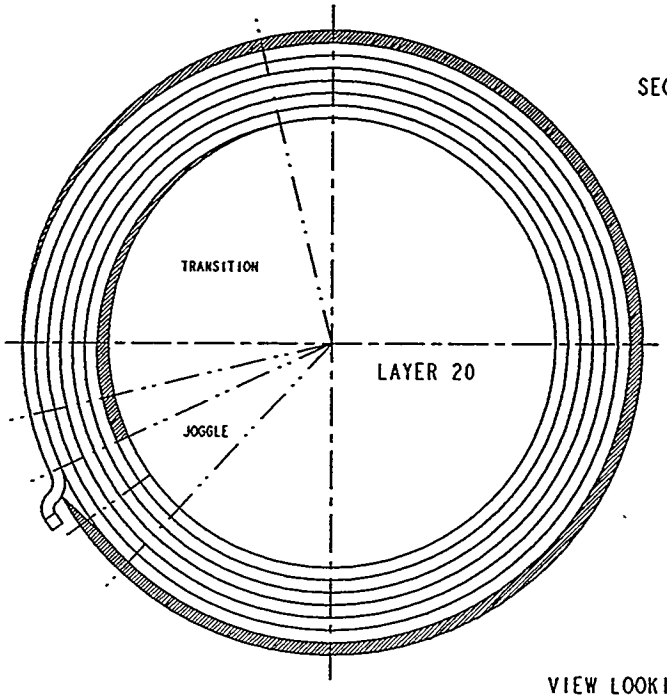




SECTION AT 54°



SECTION AT 112.5

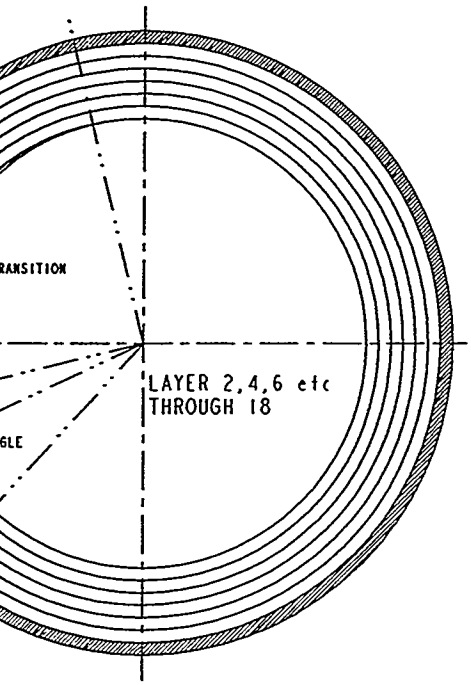


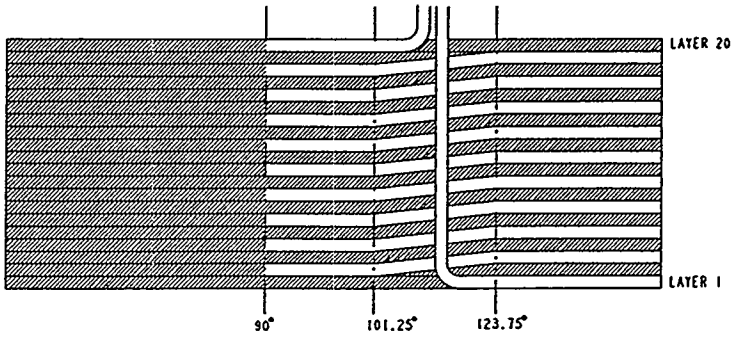
VIEW LOOKING DOWN ON EACH LAYE

REVISIONS						
ZONE	LTR	DESCRIPTION	ECP CODE	MODEL	DATE	APPROVED

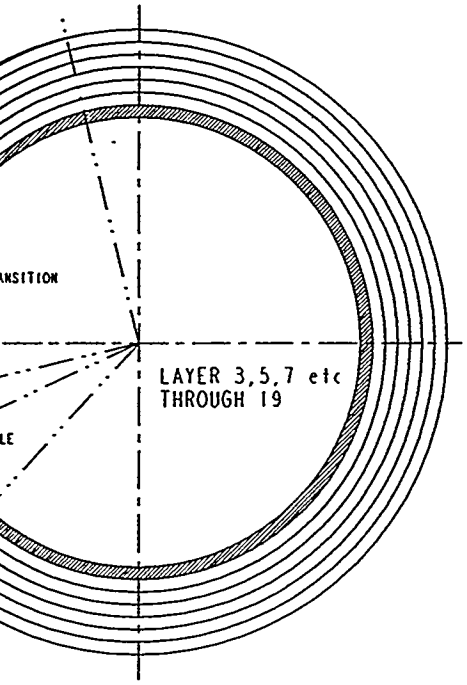
NOTES:

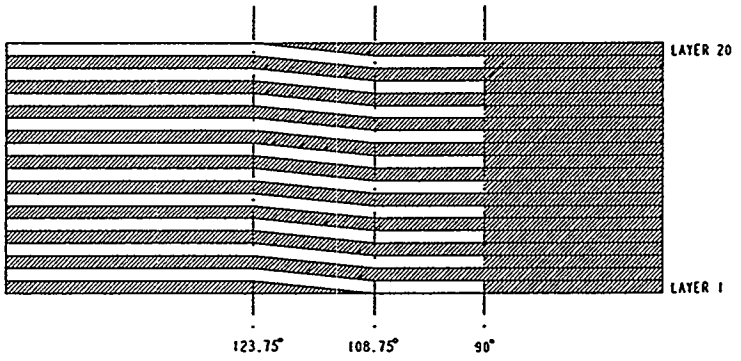
1 SHADED AREAS DENOTE FILLER AND CLEAR AREAS DENOTE CONDUCTOR





VIEW AA





VIEW BB

Pro/ENGINEER MODEL - CLARKSON/TPXPD/012.DWG

PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES	CONTRACT NO.
LINEAR TOL: XX ± .03, XXX ± .010; ANGULAR TOL: MACHINED LOCATING FORMED ±2°30', CHAMFERS ±5°	DRAWN BY K.E CLARKSON 1:31:95
TOL ON LISTED DIMENSIONS ±5	LAYOUT BY K.E CLARKSON 1:31:95
MFG APPROVAL	CHECKED BY:
ENGR APPROVAL	STRESS
	MFG ENGR
	ENGR MGR.

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

WINDING LAYOUT
PF COIL #6 UPPER

TECH No.	PROGRAM	SIZE	DWG NO.	SHT No	REV
76823	TPX	E	1431012	SH 1	P0

SCALE - NONE SHEET 1 OF 1

TPX-E-1431SHIP0

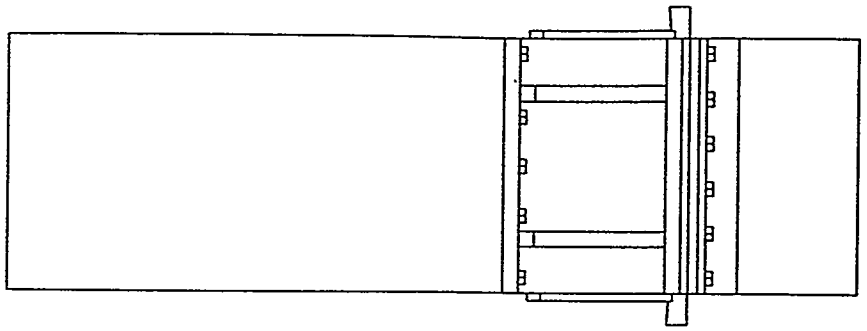
TPX-E-1431012SHIP01

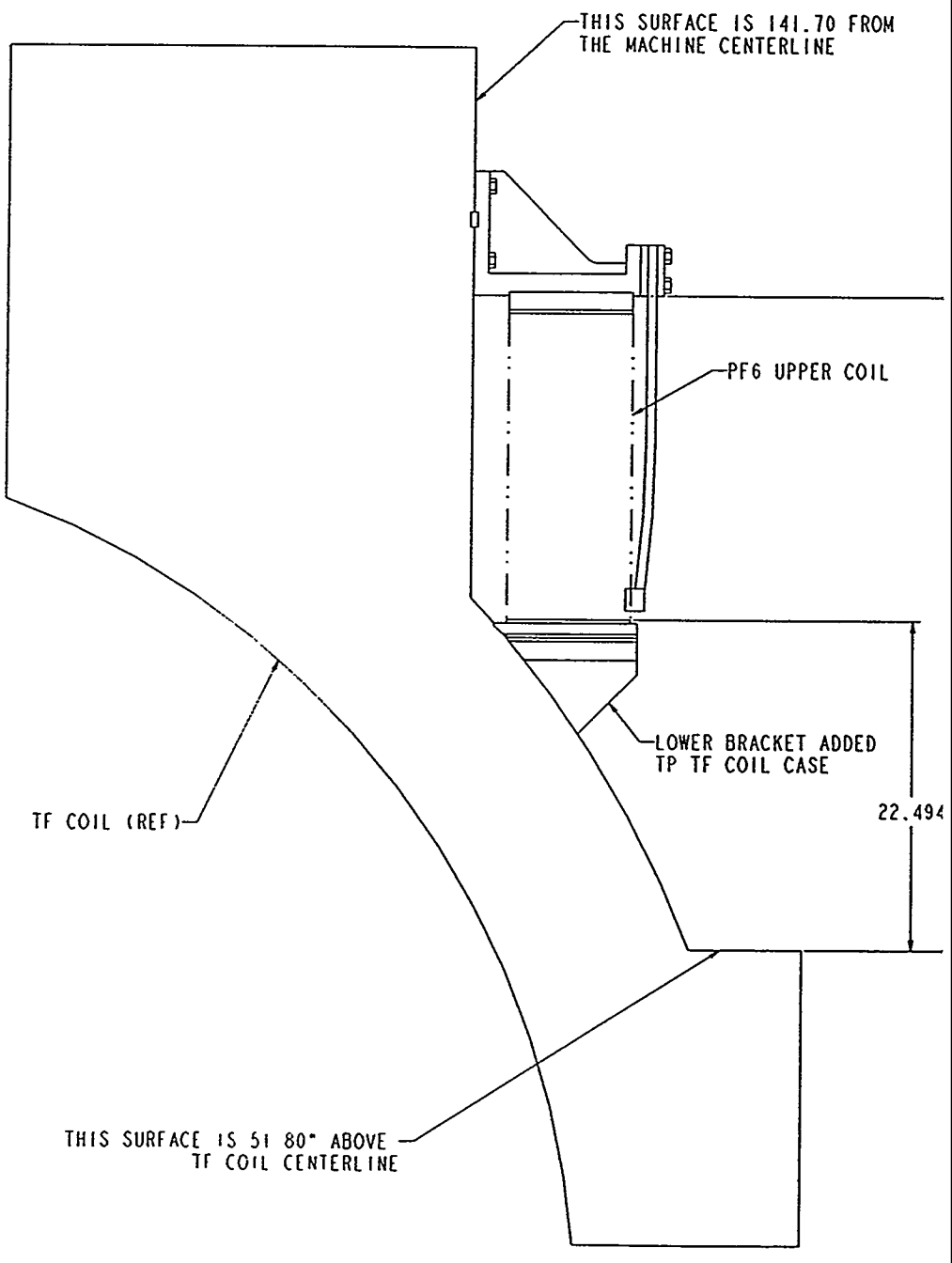
014-3344

SUPPLEMENTARY DATA

NOTE: UNLESS OTHERWISE SPECIFIED NOTES CHECKED ✓ APPLY TO THIS DWG

- NUMBER STAMP PART NUMBER AND OTHER IDENTIFICATION MARKINGS PER GSS4710 CL 2A
  - ☐ NO REGION MARKED ☒ USE BOTH SIDES IF NECESSARY
  - ☐ LOCATION OPTIONAL
- REMOVE ALL BURRS BREAK ALL EDGES .004-.015 / .015-.031
- ✓ 63 SURFACE ROUGHNESS FOR ALL SURFACES PER ANSI B46.1
- ✓ 63 SURFACE ROUGHNESS FOR ALL HOLES PER ANSI B46.1
- SURFACE ROUGHNESS/ORIENTATION PER GENERAL TYPE 254
- PERMISSIBLE MISMATCH PER 63254 FOR INSIDE INTERSECTING CORNERS TYPE 5A MAX TYPE 5B. MAX
- MISMATCH STEP OF MAX. IS PERMISSIBLE BUT TO CHAMFER OR FILLET AT INSIDE INTERSECTION SURFACES
- DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THDS 2-3 UNTHREADED THREADS BEYOND PERMISSIBLE
- EXTERNAL THREAD LENGTH SHOWN INCLUDES 2 IMPERFECT THREADS MAX
- DIMENSIONING AND TOLERANCING PER ANSI Y14.5M
- ABBREVIATIONS PER MIL-STD-12 & DATA.
- ALL DIMENSIONS SHOWN TO BE MET BEFORE CADMIUM PLATING THICKNESS OF PLATE .0000 MIN TO .0000 MAX NO ALLOWANCE FOR PLATING IN HOLES
- DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH DOUBLE ASTERISK.
- HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION.
- GRAIN DIRECTION OPTIONAL.
- ALL DIMENSIONS SHOWN TO BE MET AFTER ANY WELDING AND/OR HEAT TREATING

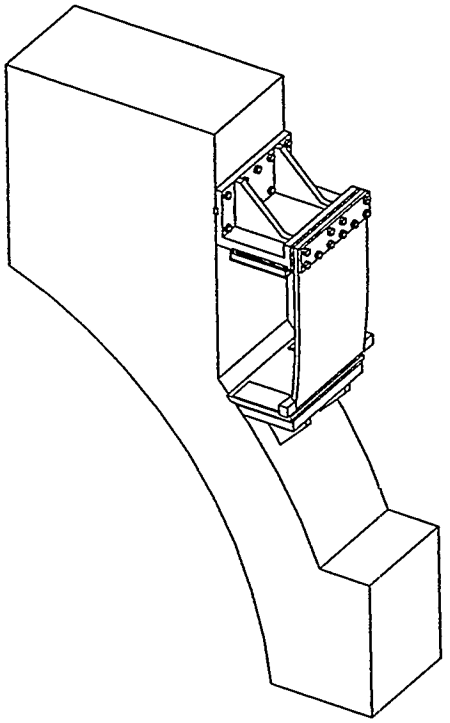




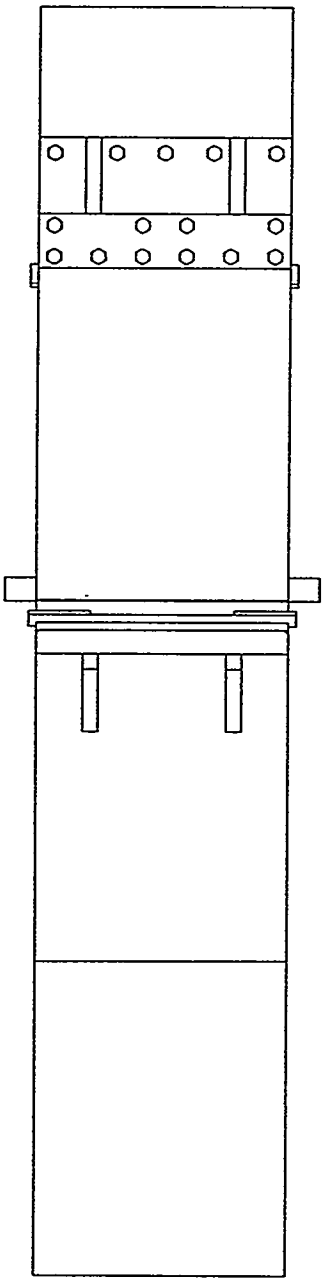
NOTES:

1. SEE DRAWING TPX-E-1431026SHIP0 FOR MORE DETAILS OF MATERIALS

REVISIONS						
ZONE	LTR	DESCRIPTION	EFF CODE	MODEL	DATE	APPROVED



SCALE 0.125



442

PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	CONTRACT NO.
LINEAR TOL .XX ±0.03 .XXX ±0.010	DRAWN BY E.R.CLARKSON 8.14.85
ANGULAR TOL MACHINED LOCATION ±0°30' FORMED CHAMFERS ±1°	LAYOUT BY E.R.CLARKSON 8.14.85
TOL ON LIMITED DELINEATIONS IS	CHECKED BY:
MCC APPROVAL	STRESS
	MFG CODE
E.M. APPROVAL	CODE IDENT:

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

SUPPORT ASSEMBLY
PF6 UPPER

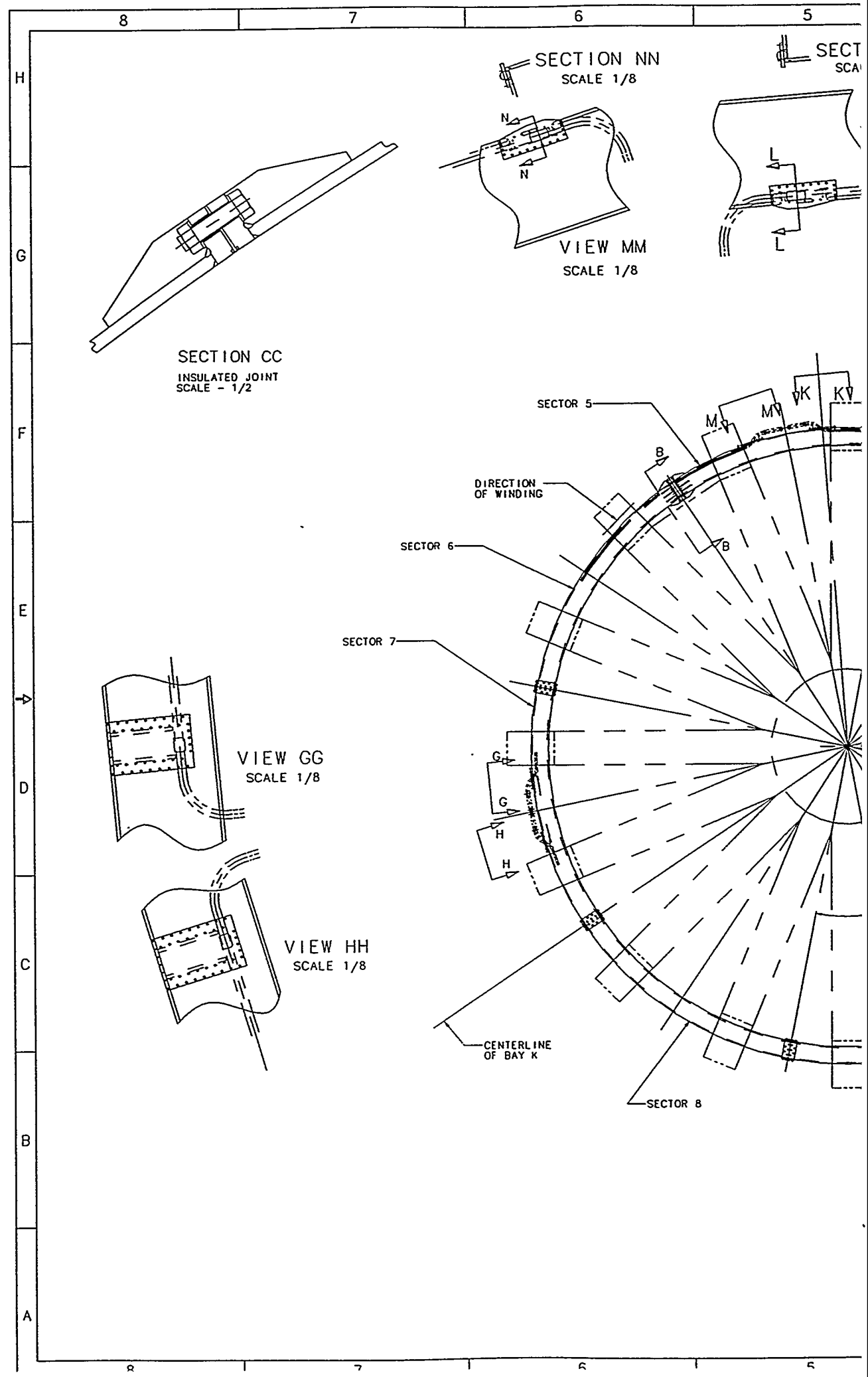
TPO No.	PROGRAM	SIZE	DWG NO.	SHT No.	REV
76823	TPX	E	1431016	SH1	P0

SCALE 1/4 SHEET 1 OF 1

TPX-E-1431016SHIP0

TPX-E-1431016SHIP0

014-3344


8
7
6
5
H
G
F
E
D
C
B
A
SECTION NN
SCALE 1/8
SECT
SCA
N
N
VIEW MM
SCALE 1/8
L
L
SECTION CC
INSULATED JOINT
SCALE - 1/2
SECTOR 5
M
M
K
K
B
B
DIRECTION
OF WINDING
SECTOR 6
SECTOR 7
G
G
H
H
VIEW GG
SCALE 1/8
VIEW HH
SCALE 1/8
CENTERLINE
OF BAY K
SECTOR 8

N LL
1/8

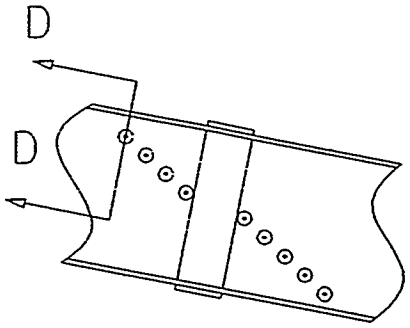
EW KK
ALE 1/8

NOTES:

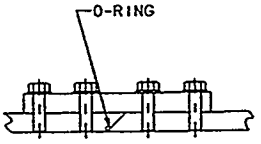
REVISIONS

ZONE	LTR	DESCRIPTION	ETT CODE	MODEL	DATE	APPROVED

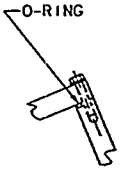
SECTION DD
TYPICAL 9 PLACES



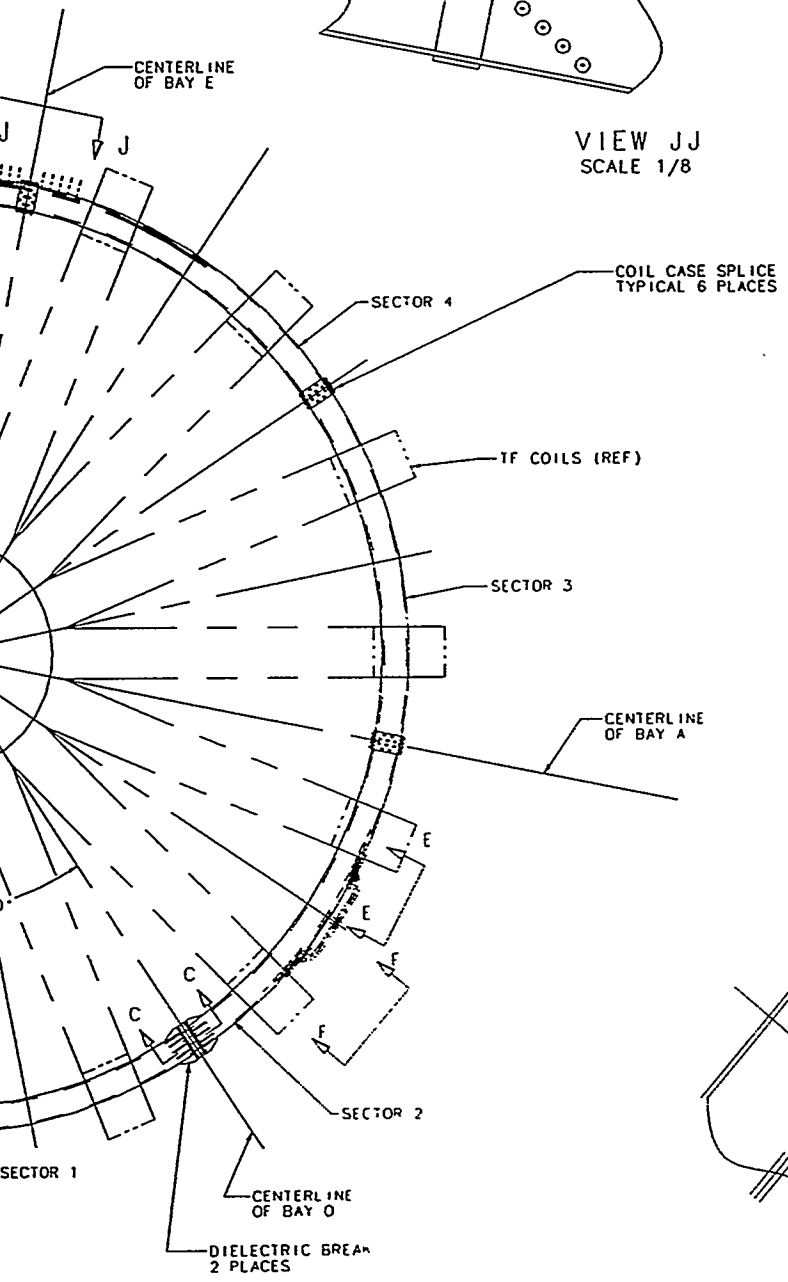
VIEW JJ
SCALE 1/8

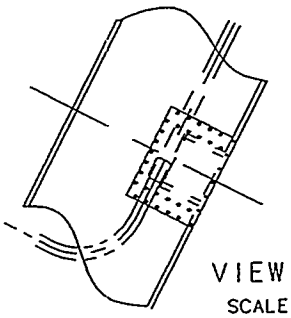


TYPICAL SPLICE
SCALE - 1/2

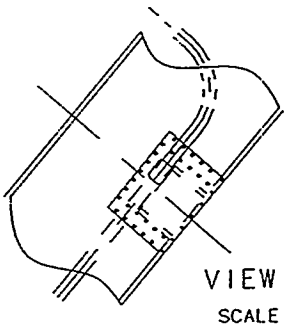


TYPICAL CORNER
JOINT
SCALE - 1/2





VIEW EE
SCALE 1/8



VIEW FF
SCALE 1/8

PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
LINEAR TOL .X ±.03 .XXX ±.010
ANGULAR TOL MACHINED ±0°30' LOCATING HOLES ±0°30' CHAMFERS ±0°
TOL ON LISTED DELINEATIONS ±0

CONTRACT NO.
DRAWN BY R.R.CLARKSON 8:1:95
LAYOUT BY R.R.CLARKSON 8:1:95
CHECKED BY:
STRESS
MFG APPROVAL
MFG ENGR
LUE APPROVAL
ENGR MGR

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

COIL CASE ASSEMBLY
PF6 UPPER

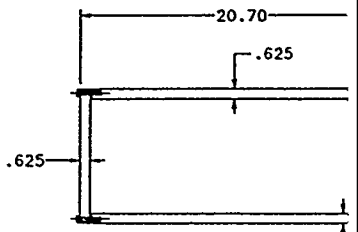
SCM NO.	PROGRAM	SIZE	DWG NO.	SHT NO	QTY
76823	TPX	E	1431018	SH1	P0

SCALE - 1/2 SHEET 1 OF 2

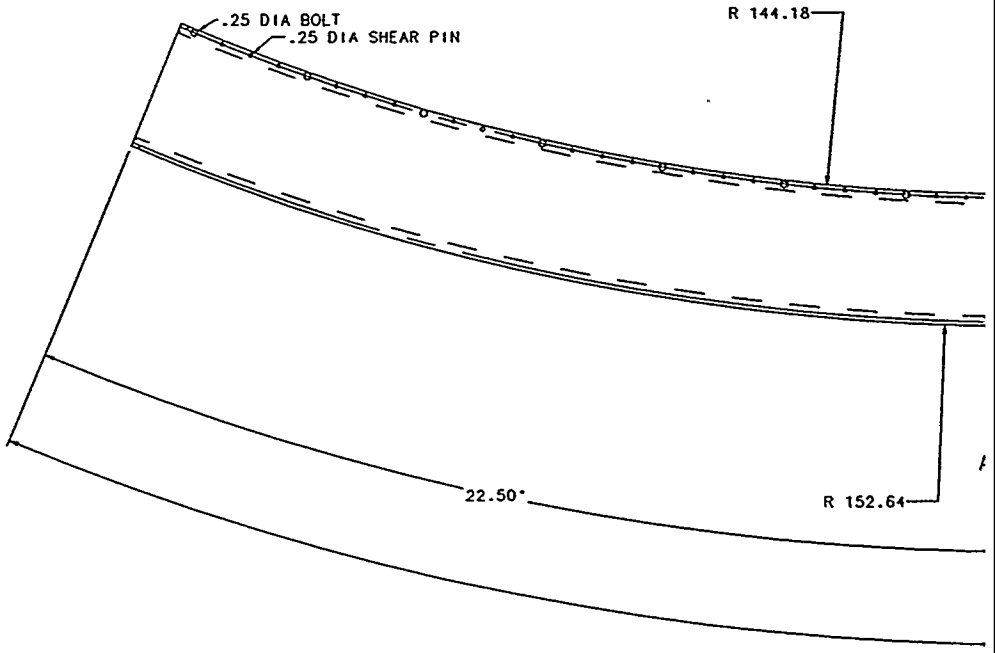
TPX-E-1431018SH1P0

TPX-E-1431018SH1P0

014-N344



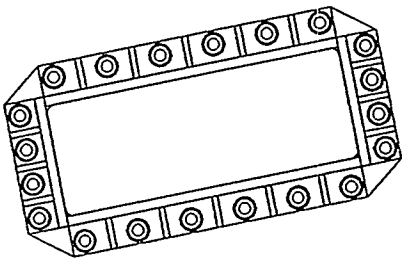
SECTION AA
SCALE 1/4



.625 8.45

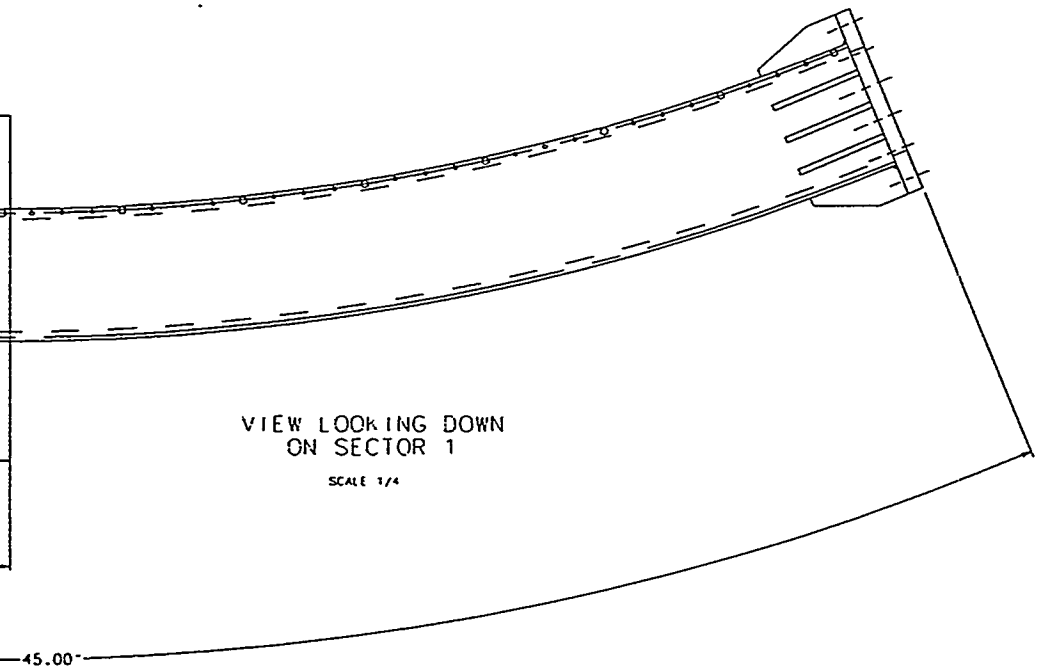
625

NOTE - THE INSULATING GASKET MUST
BE MADE IN TWO PIECES.
THE PIECES MUST OVERLAP



VIEW BB

SCALE 1/4



VIEW LOOKING DOWN
ON SECTOR 1

SCALE 1/4

45.00°

PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
LINEAR TOL .X ± .03 .XX ± .010
ANGULAR TOL MACHINED ± 0°30' LOCATING FORMED ± 0°30' CHAMFERS ± 0°
TOL ON LOFTED DELINEATIONS ±0

CONTRACT NO.
DRAWN BY I.R.CLARKSON 6-11-85
LAYOUT BY I.R.CLARKSON 6-11-90
CHECKED BY:
STRESS
MFG ENGR
ENGR MGR:
MFG APPROVAL
ILSE APPROVAL

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

COIL CASE ASSMBLY
PF 6 UPPER

DSN NO.	PROGRAM	SIZE	DWG NO.	SHT no	REV
76823	TPX	E	1431018	SH2	P0

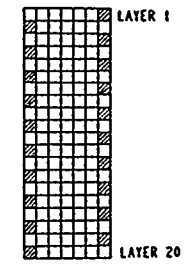
SCALE NOTED SHEET 2 OF 3

TPX-E-1431018SH2P0

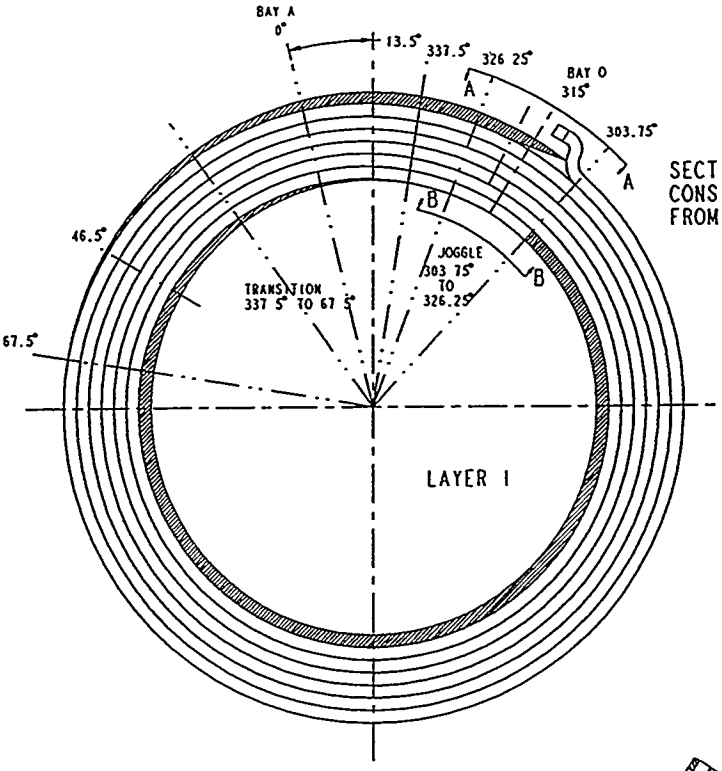
TPX-E-1431018SH2P0

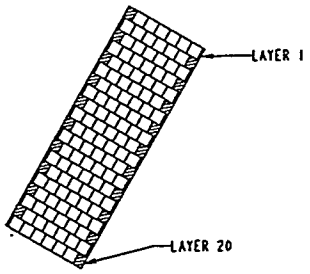
014-N344

SUPPLEMENTARY DATA NOTE: UNLESS OTHERWISE SPECIFIED NOTES CHECKED ✓ APPLY TO THIS DWG.	
DOGGER STAMP PART NUMBER AND OTHER IDENTIFICATION MARKINGS PER 8254716 CL 2A	
☐ IN REGION MARKED ☒ USE BOTH SIDES IF NECESSARY	
☐ LOCATION OPTIONAL	
REMOVE ALL BURRS INSIDE ALL EDGES	.005-.015 .015-.031
✓ SURFACE ROUGHNESS FOR ALL SURFACES PER ANSI B46.1	
✓ SURFACE ROUGHNESS FOR ALL HOLES PER ANSI B46.1	
SURFACE ROUGHNESS/TREATMENT PER 65266, TYPE 254	
PERMISSIBLE VARIATION PER 65266 FOR ANGLE BETWEEN CORNERS TYPE 1A: MAX. TYPE 1B: MAX.	
DIAMETER SIZE OF HOLE IS PERMISSIBLE ONE TO CHAMFER OR CUTTING AT ANGLE TO SURFACES	
DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THDS T.I. (MIN) THREADS BOTTOM PERMISSIBLE	
EXTERNAL THREADS (UNLESS NOTED INCLUDES 2 IMPERFECT THREADS MAX.	
DIMENSIONING AND TOLERANCING PER ANSI Y14.5M	
ABBREVIATIONS PER MIL-STD-12 & 6412A.	
ALL DIMENSIONS SHOWN TO BE NET AFTER CADMIUM PLATING THICKNESS OF PLATE .0005 MIN TO .0060 MAX NO ALLOWANCE FOR PLATING IN HOLES.	
DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH DOUBLE ASTERISK.	
HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION.	
GRAIN DIRECTION OPTIONAL.	
ALL DIMENSIONS SHOWN TO BE NET AFTER ANY DEBURR AND/OR HEAT TREATING	

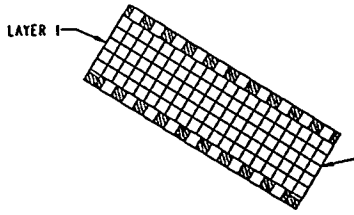


SECTION AT 256.5°
CONSISTENT FOR SECTIONS
FROM 67.5° TO 303.75°

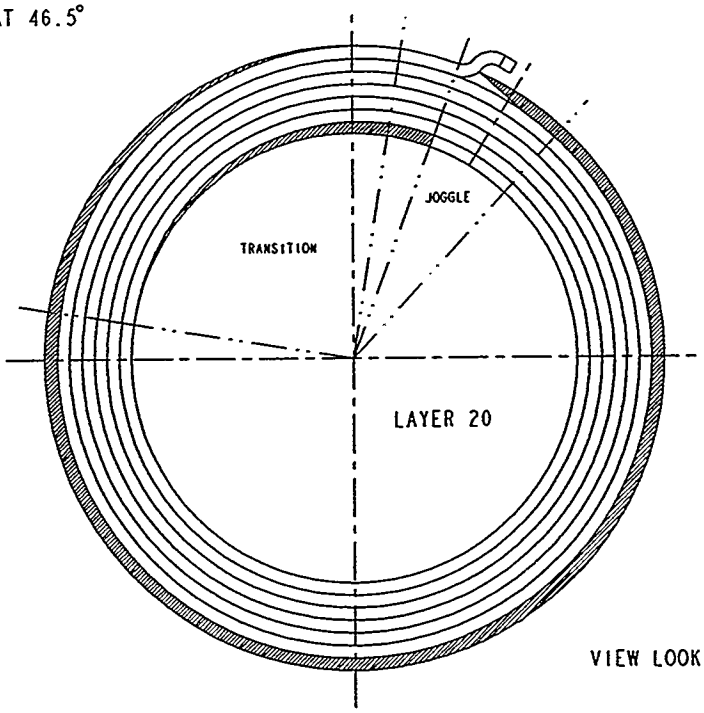




SECTION AT 46.5°



SECTION AT 315



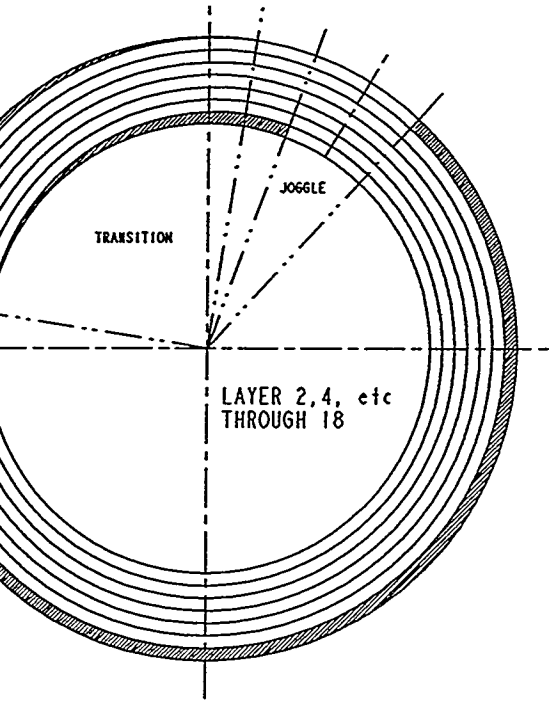
VIEW LOOKING DOWN ON EACH LAY

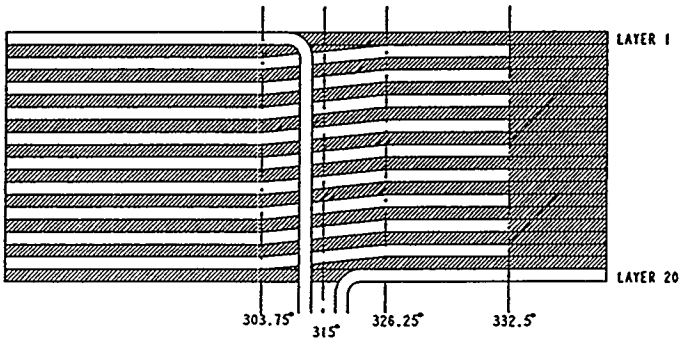
NOTES:

1. SHADED AREAS DENOTE FILLER AND CLEAR AREAS DENOTE CONDUCTOR

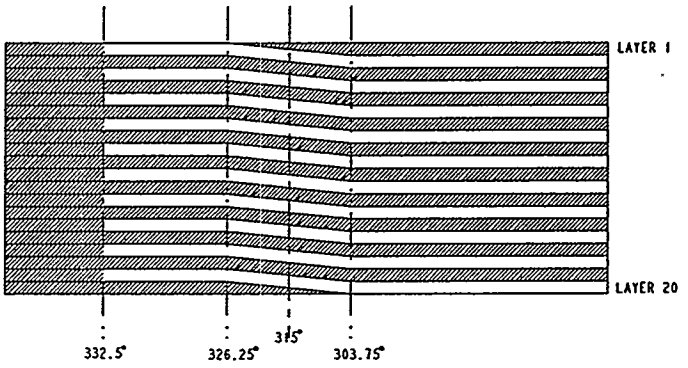
REVISIONS

ZONE	LTR	DESCRIPTION	ECP CODE	MODEL	DATE	APPROVED

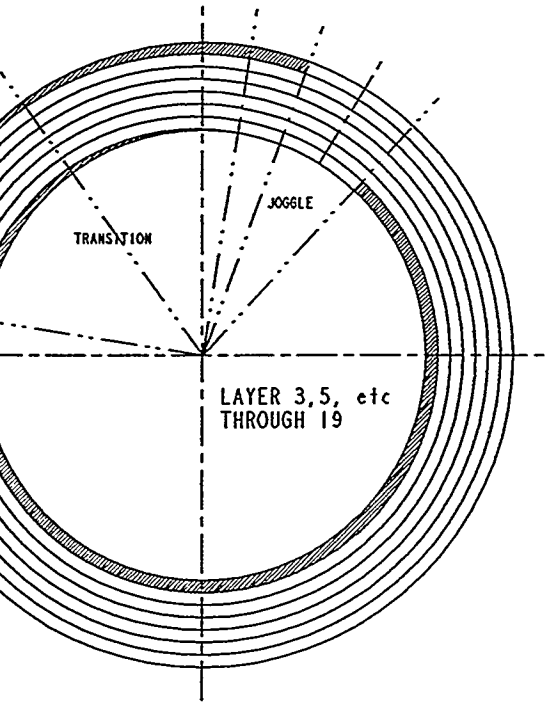




VIEW AA



VIEW BB



Pro/ENGINEER MODEL - CLARKSON/TPXPD/022

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES LINEAR TOL .XX ± 0.03 .XXX ± .010 ANGULAR TOL MACHINED ± 30' LOCATING FORMED ± 2° CRIMPED ± 5° TOL ON LOWER DESIGNATIONS IS	CONTRACT NO. DRAWN BY I.R.CLARKSON 3 31:95 LAYOUT BY I R CLARKSON 3:31:95 CHECKED BY: STRESS MFG ENGR ENGR APPR	NORTHROP GRUMMAN CORPORATION BETHPAGE, NEW YORK 11714 WINDING LAYOUT PF COIL #6 LOWER TECH No. 76823 PROGRAM TPX SIZE E DWG NO. 1431022 SHT No. SH 1 REV P0 SCALE - NONE SHEET 1 OF 1

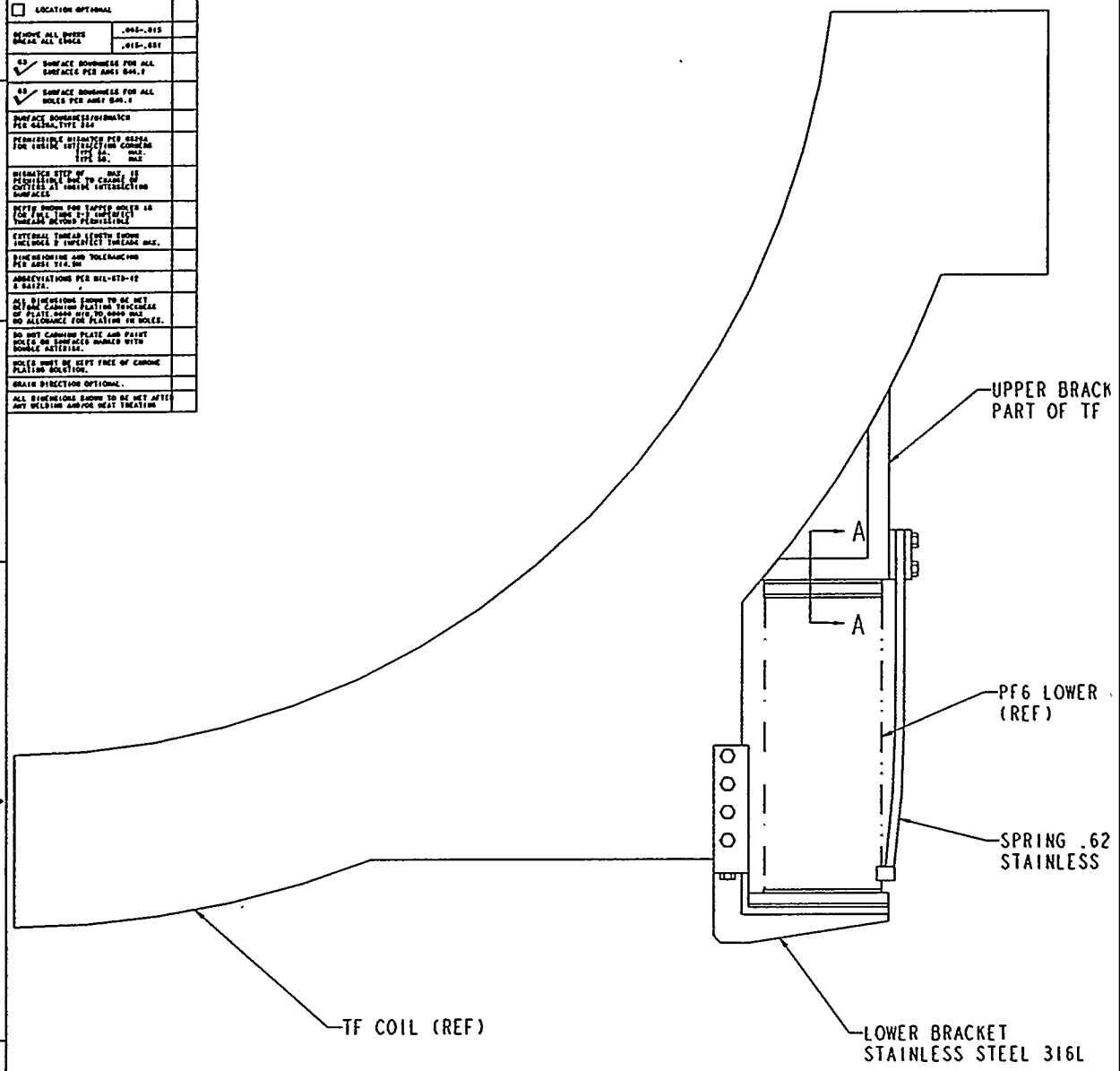
PART NUMBER	NEXT ASS'Y	QTY

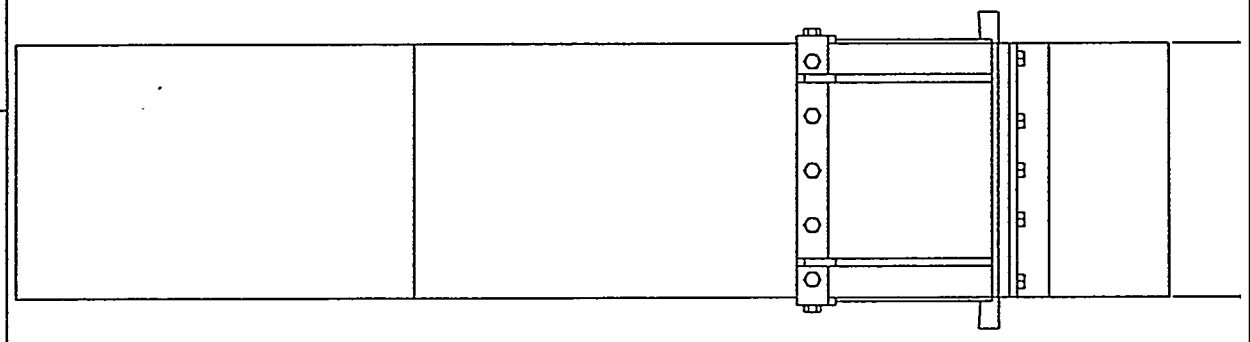
014-3344

TPX-E-1431022SHIP0

TPX-E-1431022SHIP0

SUPPLEMENTARY DATA NOTE: UNLESS OTHERWISE SPECIFIED NOTES CHECKED ✓ APPLY TO THIS DWG.	
NUMBER STAMP PART NUMBER AND OTHER IDENTIFICATION MARKINGS PER 6534710 CL 2A ☐ IN REGION MARKED ☒ USE BOTH SIDES IF NECESSARY ☐ LOCATION OPTIONAL	
REMOVE ALL BURRS BREAK ALL EDGES	.005-.015 .015-.031
✓ SURFACE ROUGHNESS FOR ALL SURFACE PER ANSI B46.1	
✓ SURFACE ROUGHNESS FOR ALL HOLES PER ANSI B46.1	
SURFACE ROUGHNESS/WAVINESS PER 6221A1, TYPE 2&4	
PERMISSIBLE MISMATCH PER 6221A1 FOR INSIDE INTERSECTING CORNERS TYPE 1A: MAX TYPE 1B: MAX	
MISMATCH STEP OF MAX IS PERMISSIBLE DUE TO CHANGE OF CUTTERS AT INSIDE INTERSECTING SURFACES	
DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THDS P-3 IMPERFECT THREADS BEYOND PERMISSIBLE	
EXTERNAL THREAD LENGTH SHOWN INCLUDES 3 IMPERFECT THREADS MAX.	
DIMENSIONING AND TOLERANCING PER ANSI Y14.5M	
ABBREVIATIONS PER MIL-STD-12 & 6221A:	
ALL DIMENSIONS SHOWN TO BE NET BEFORE CADMIUM PLATING THICKNESS OF PLATE .0000 MIN TO .0000 MAX NO ALLOWANCE FOR PLATING IN HOLES.	
DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH BONDLOK ACTIVISE.	
HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION.	
GRAIN DIRECTION OPTIONAL.	
ALL DIMENSIONS SHOWN TO BE MET AFTER ANY WELDING AND/OR HEAT TREATING	

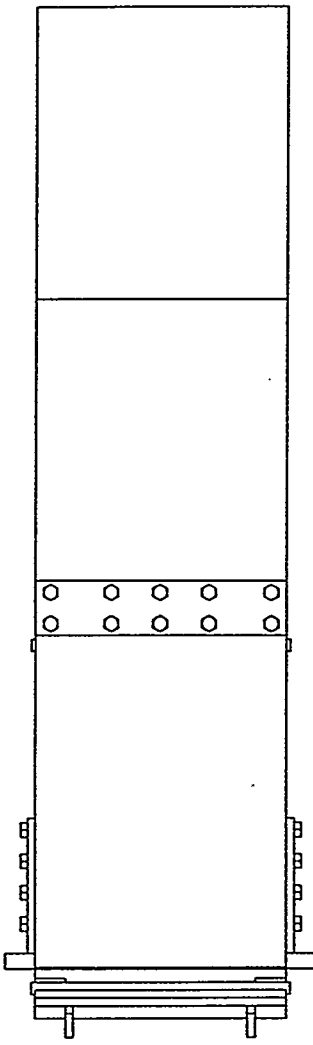


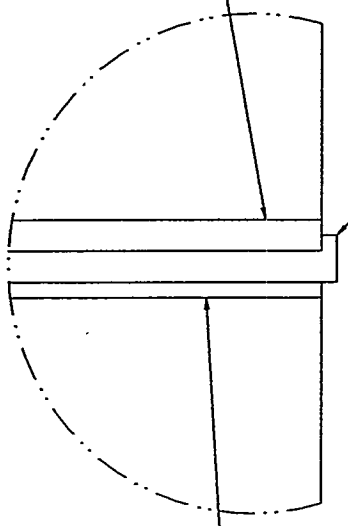


NOTES:

REVISIONS

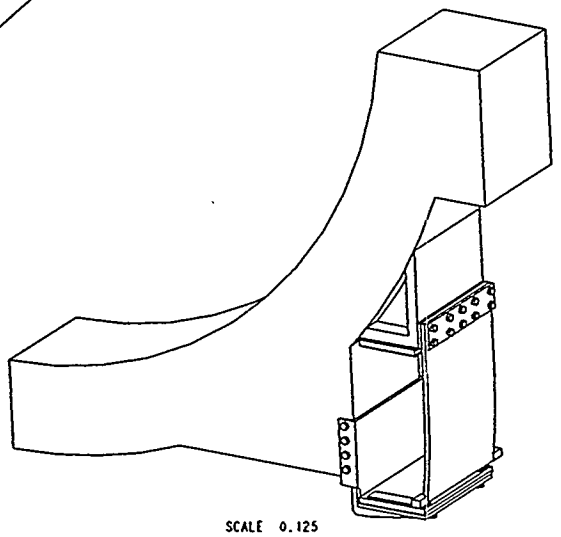
ZONE	LTR	DESCRIPTION	ECO CODE	MODEL	DATE	APPROVED





SECTION AA

SPRING RUBBING STRIP
AND LATERAL GUIDE
ATTACHED TO COIL CASE
MATERIAL G10



SCALE 0.125

PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
LINEAR TOL .XX ± .03 .XXX ± .010
ANGULAR TOL MACHINED ± 30' FORMED ± 2°
CHAMFERS 45°
TOL ON LISTED DESIGNATIONS ±5

CONTRACT NO.

DRAWN BY J. E. CLARKSON 8.8.85
LAYOUT BY J. E. CLARKSON 8-8-85
CHECKED BY
STRESS
MFG ENGR
CODE IDENT

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

SUPPPORT ASSEMBLY
PF6 LOWER

TECH No.	PROGRAM	SIZE	DWG NO.	SHT No.	REV
76823	TPX	E	1431026	SH 1	P0

SCALE 1/4 SHEET 1 OF 1

014-3344

TPX-E-1431026SHIP0

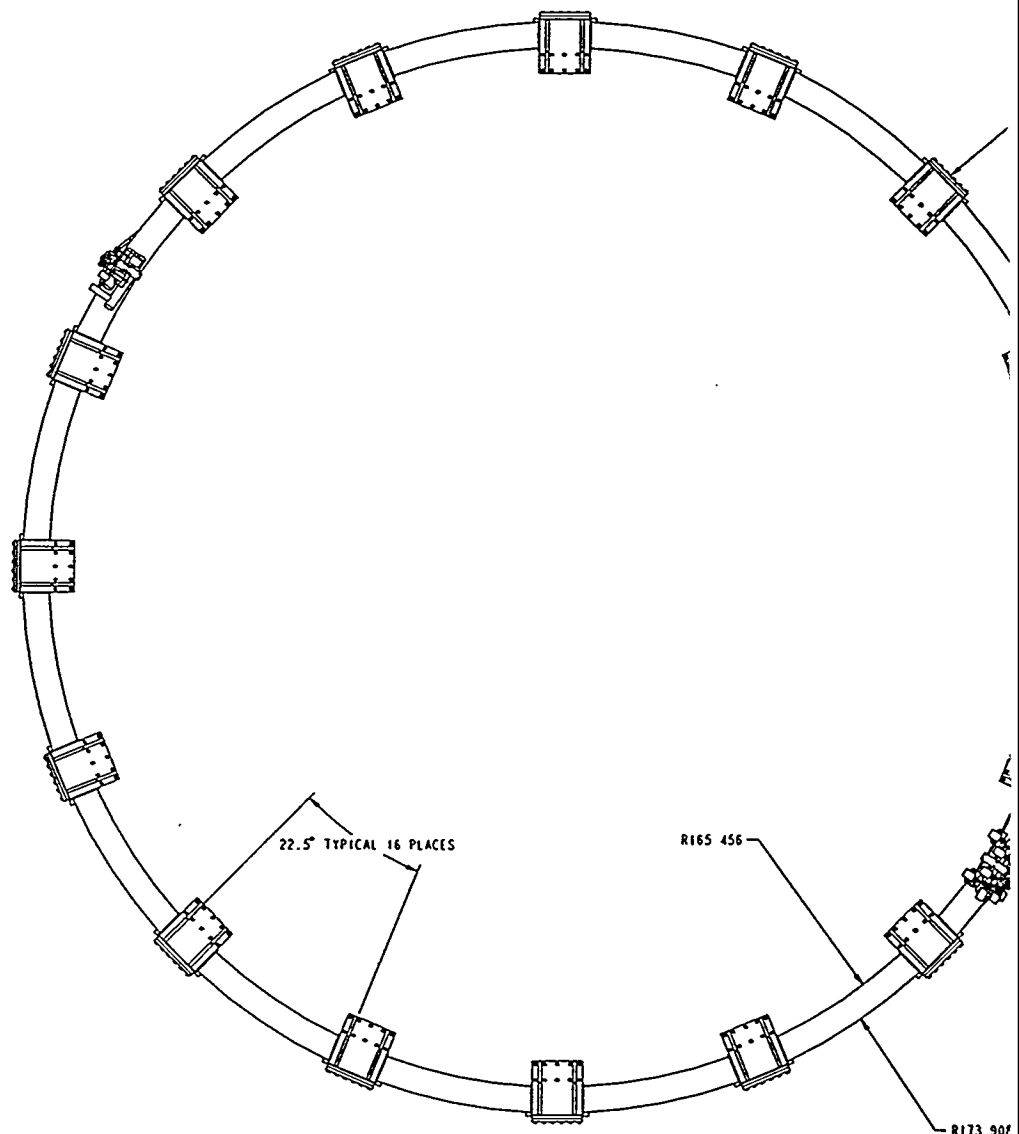
TPX-E-1431-26SHIP0

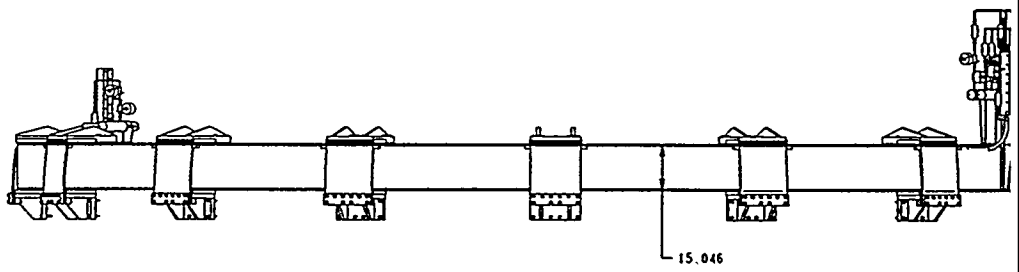
16.308

SUPPLEMENTARY DATA

NOTE: UNLESS OTHERWISE SPECIFIED NOTES CHECKED ✓ APPLY TO THIS DWG

BOMBER STAMP PART NUMBER AND OTHER IDENTIFICATION MARKING PER 6554710 CL 2A	
☐ NO REGION MARKED ☒ USE BOTH SIDES IF NECESSARY	
☐ LOCATION OPTIONAL	
REMOVE ALL BURRS BREAK ALL EDGES .005-.015 / .015-.031	
02 ✓ SURFACE ROUGHNESS FOR ALL SURFACES PER ANSI B46.1	
03 ✓ SURFACE ROUGHNESS FOR ALL HOLES PER ANSI B46.1	
SURFACE ROUGHNESS/WAVINESS PER 6629A,TYPE 254	
PERMISSIBLE MISMATCH PER 6228A FOR MACHINE SURFACES/EDGES AT JOINING SURFACES: TYPE 1A .005 MAX, TYPE 1B .010 MAX	
MISMATCH STEP OF .010 IS PERMISSIBLE DUE TO CHANGE OF CONTOUR AT JOINING INTERSECTING SURFACES	
DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THDS. 1-2 IMPERFECT THREADS BEYOND PERMISSIBLE	
EXTERNAL THREAD LENGTH SHOWN INCLUDES 2 IMPERFECT THREADS MAX	
DIMENSIONING AND TOLERANCING PER ANSI Y14.5M	
ABBREVIATIONS PER MIL-STD-12 & SAE/A	
ALL DIMENSIONS SHOWN TO BE NET BEFORE CADMIUM PLATING THICKNESS OF PLATE .0003 MIN TO .0005 MAX NO ALLOWANCE FOR PLATING IN HOLES	
DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH BUBBLE ARTERIES	
HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION	
GRAIN DIRECTION OPTIONAL	
ALL DIMENSIONS SHOWN TO BE NET AFTER ANY WELDING AND/OR HEAT TREATING	





F E D C B A

8 7 6 5

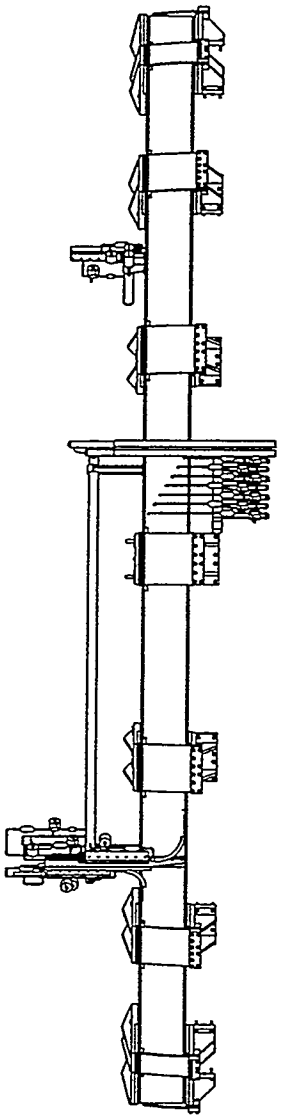
NOTES:

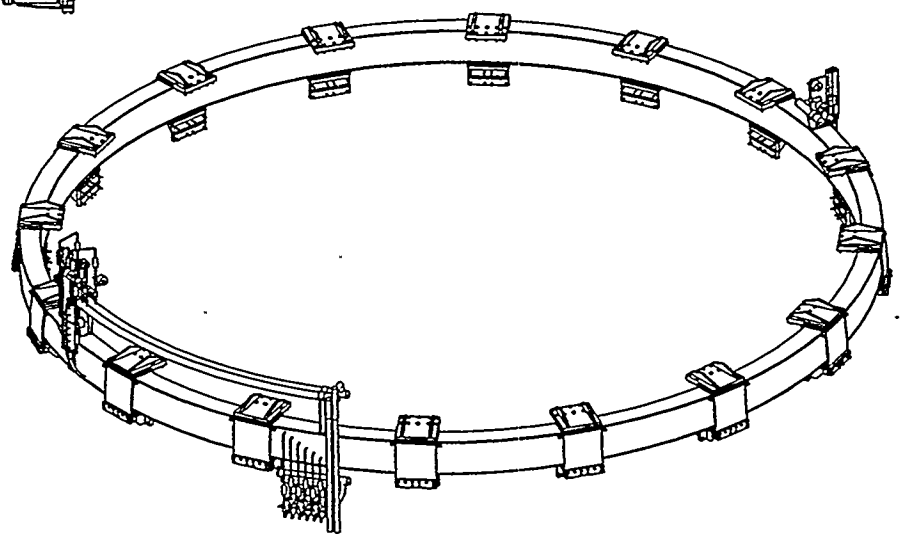
REVISIONS						
ZONE	LTR	DESCRIPTION	ECP CODE	MODEL	DATE	APPROVED

COIL SUPPORT STRUCTURE
TPX-E-1431026SHIPO

COIL ASSEMBLY
TPX-E-1431031SHIPO

COOLING ASSEMBLY
TPX-E-1431032SHIPO





SCALE 0.040

PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES	CONTRACT NO.	NORTHROP GRUMMAN CORPORATION BETHPAGE, NEW YORK 11714
LINEAR TOL .XX ±.03 .XXX ±.010 / ANGULAR TOL MACHINED LOCATING ±0°30' FORMED CHAMFERS ±0°	DRAWN BY T.B.CLARKSON 8 11:05	COIL ASSEMBLY PF7 UPPER
TOL ON LISTED DIMENSIONS IS	LAYOUT BY T.B.CLARKSON 8:11:05	
	CHECKED BY:	
	STRESS	
MCC APPROVAL	MFG ENGR	
LLNL APPROVAL	ENGR DES:	

FSCM No.	PROGRAM	SIZE	DWG NO.	SHT No.	REV
76823	TPX	E	1431030	SH 1	PO
SCALE 1/20				SHEET 1 OF	

TPX-E-1431030SHIPO

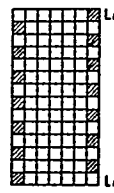
TPX-E-1431030SHIPO

014-3344

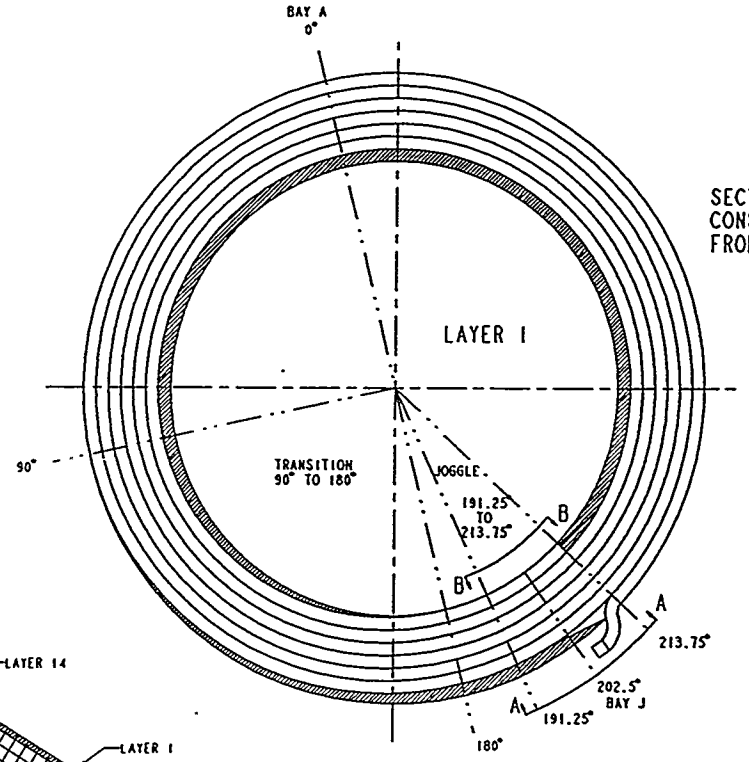
4 3 2 1

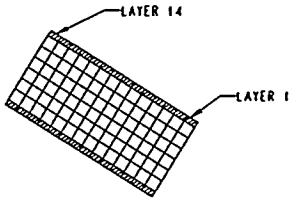
H G F E D C B A

SUPPLEMENTARY DATA NOTE: UNLESS OTHERWISE SPECIFIED BOXES CHECKED ✓ APPLY TO THIS DWG.
RUBBER STAMP PART MARKED AND OTHER IDENTIFICATION MARKINGS PER 6554710 CL 2A
☐ AS SHOWN MARKED ☒ USE BOTH SIDES IF NECESSARY
☐ LOCATION OPTIONAL
REMOVE ALL BURRS BREAK ALL EDGES .003-.015 / .015-.031
✓ SURFACE ROUGHNESS FOR ALL SURFACES PER ANSI B46.1
✓ SURFACE ROUGHNESS FOR ALL HOLES PER ANSI B46.1
SURFACE ROUGHNESS/HIRMAICO PER 6528A, TYPE 254
PERMISSIBLE HIRMAICO PER 6528A FOR SHARP INTERSECTING CORNERS TYPE 5A MAX / TYPE 5B MAX
HIRMAICO STEP OF MAX IS PERMISSIBLE BUT NO CHANGE OF CONTOUR AT ANGULAR INTERSECTING SURFACES
DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THD P.; IMPERFECT THREADS BEYOND PERMISSIBLE
EXTERNAL THREAD LENGTH SHOWN SHOWING 2 IMPERFECT THREADS MAX
DIMENSIONING AND TOLERANCING PER ANSI Y14.5M
ABBREVIATIONS PER MIL-STD-12 & 6412A
ALL DIMENSIONS SHOWN TO BE MET BEFORE CADMIUM PLATING THICKNESS OF PLATE .0005 MIN TO .0009 MAX NO ALLOWANCE FOR PLATING IN HOLES.
DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH DOUBLE ASTERISK
HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION.
GRAIN DIRECTION OPTIONAL
ALL DIMENSIONS SHOWN TO BE MET AFTER ANY WELDING AND/OR HEAT TREATING

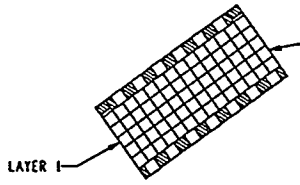


SECTION AT 256.5°
CONSISTENT FOR SECTIONS
FROM 213.5° TO 90°

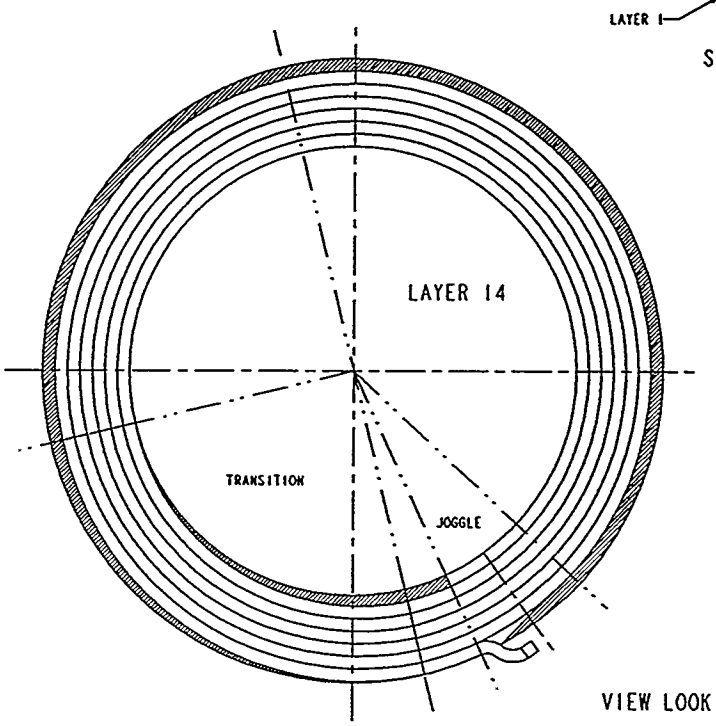




SECTION AT 135°



SECTION AT 202.5°

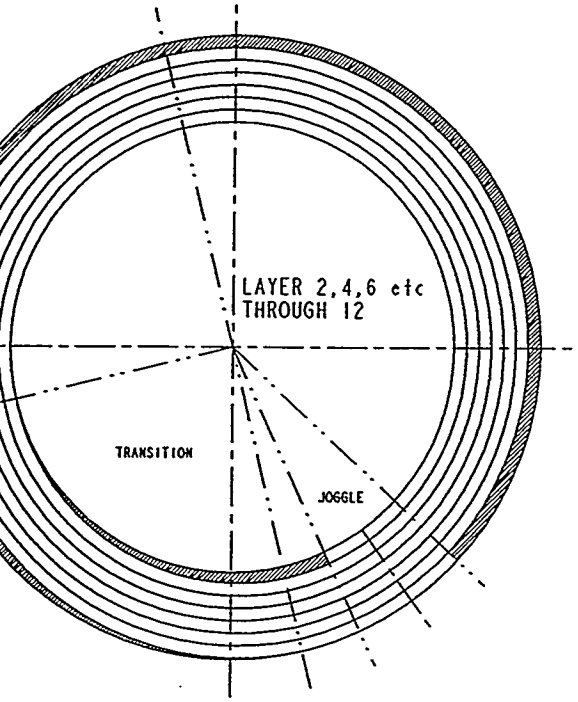


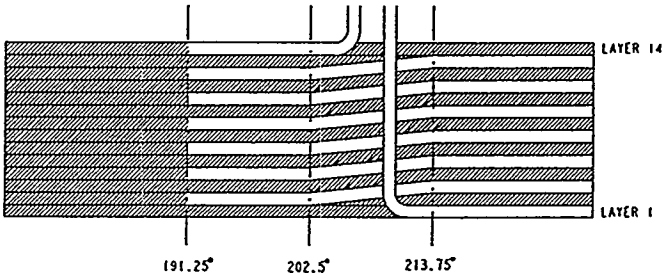
VIEW LOOKING DOWN ON EACH LAY

REVISIONS						
ZONE	LTR	DESCRIPTION	EFF CODE	MODEL	DATE	APPROVED

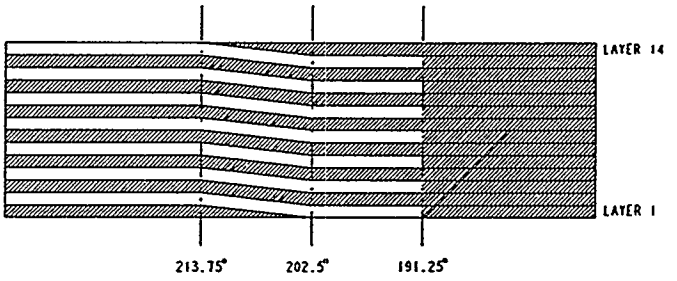
NOTES:

1. SHADED AREAS DENOTE FILLER AND CLEAR AREAS DENOTE CONDUCTOR

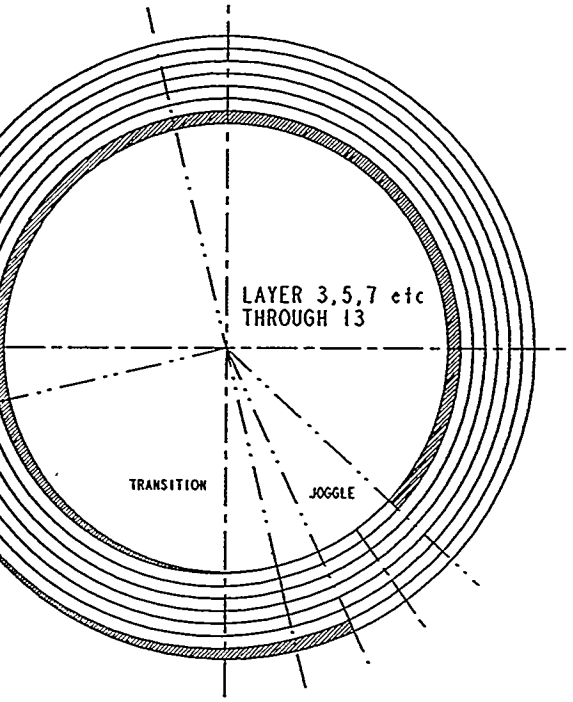




VIEW AA



VIEW BB



PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
LINEAR TOL .XX ± .03 .XXX ± .010
ANGULAR TOL MACHINED LOCATION FORMED ±0°30' CHAMFERS ±5°
TOL ON LISTED DELINEATIONS IS

CONTRACT NO.
DRAWN BY I.B.CLARKSON 4-5-85
LAYOUT BY I.B.CLARKSON 4-5-85
CHECKED BY:
STRESS
MFG ENGR
ENGR MGR:
MCC APPROVAL
ENGR APPROVAL

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

WINDING LAYOUT
PF COIL #7 UPPER

TECH No.	PROGRAM	SIZE	DWG NO	SHT No	REV
76823	TPX	E	1431032	SH 1	P0

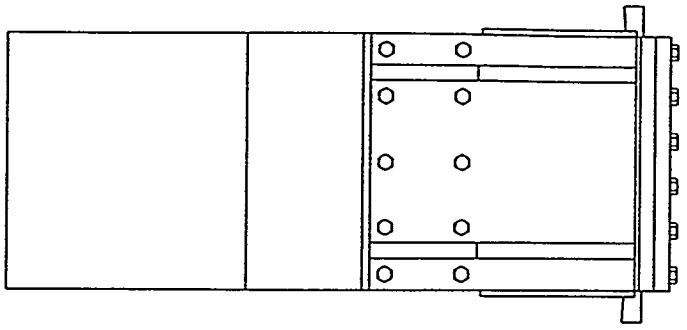
SCALE - NONE SHEET 1 OF 1

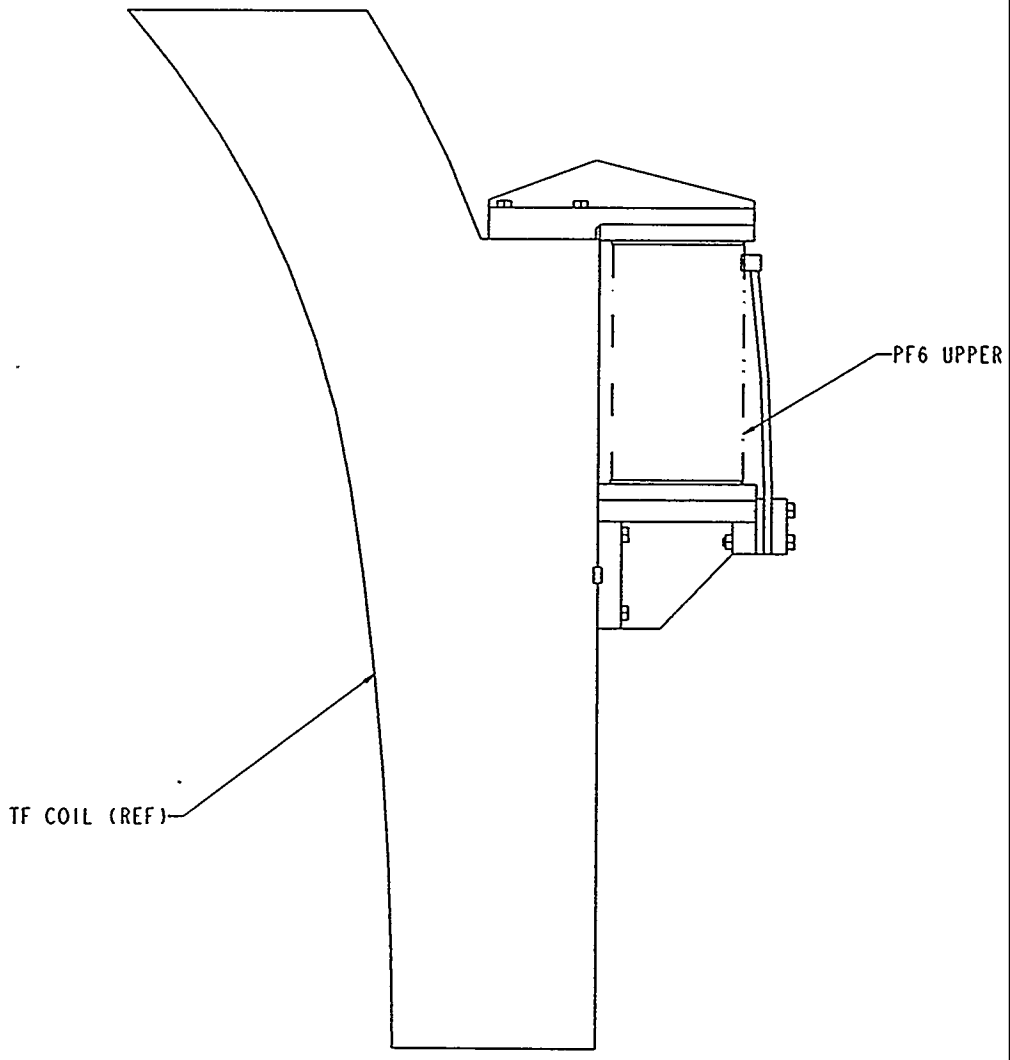
014-3344

TPX-E-1431032SHIP0

TPX-E-1431032SHIP0

SUPPLEMENTARY DATA NOTE: UNLESS OTHERWISE SPECIFIED BOXES CHECKED ✓ APPLY TO THIS DWG.	
NUMBER STAMP PART NUMBER AND OTHER IDENTIFICATION MARKINGS PER GSS4710 CL 2A ☐ AS SHOWN MARKED ☒ USE BOTH BOXES IF NECESSARY ☐ LOCATION OPTIONAL	
REMOVE ALL BURRS BREAK ALL EDGES	.000-.010 .015-.031
✓ SURFACE ROUGHNESS FOR ALL SURFACES PER ANSI B46.1	
✓ SURFACE ROUGHNESS FOR ALL HOLES PER ANSI B46.1	
SURFACE ROUGHNESS/ORIENTATION PER ASME Y14.36M, TYPE 154	
PERMISSIBLE RADIUS PER ASME Y14.5M FOR INSIDE INTERSECTING CORNERS TYPE 5A MAX TYPE 5B MAX	
MISMATCH STEP OF MAX. IS PERMISSIBLE DUE TO CHAMF OR CHAMFER AT ADJOINING INTERSECTING SURFACES	
DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THDS 2-3 IMPERFECT THREADS BEYOND PERMISSIBLE	
EXTERNAL THREAD LENGTH SHOWN INCLUDES 2 IMPERFECT THREADS MAX	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994	
ABBREVIATIONS PER MIL-STD-12D & 8412A	
ALL DIMENSIONS SHOWN TO BE MET BEFORE CADMIUM PLATING THICKNESS OF PLATE, .0004 MIN TO .0010 MAX NO ALLOWANCE FOR PLATING IN HOLES	
DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH DOUBLE ARTERISK.	
HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION.	
GRAIN DIRECTION OPTIONAL.	
ALL DIMENSIONS SHOWN TO BE MET AFTER ANY WELDING AND/OR HEAT TREATING	



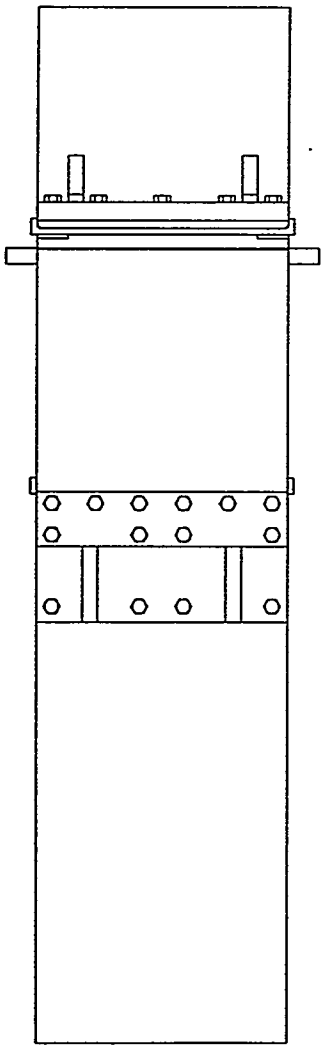


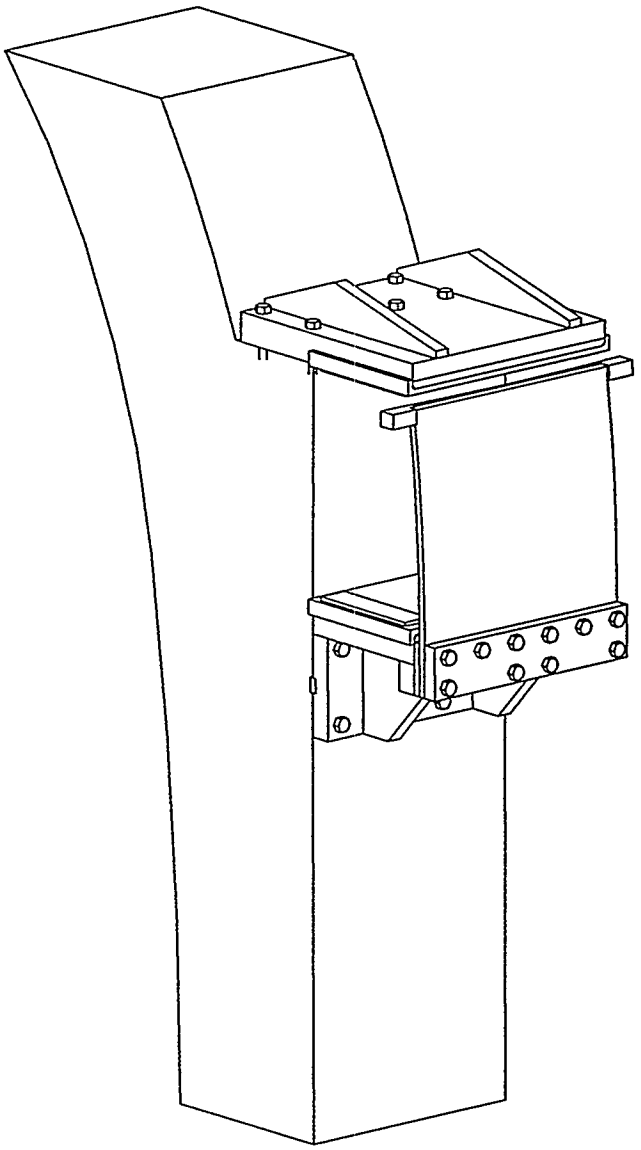
REVISIONS						
ZONE	LTR	DESCRIPTION	ECP CODE	MODEL	DATE	APPROVED

NOTES:

1. SEE DRAWING TPX-E-1431026SHIP0 FOR MORE DETAILS OF MATERIALS USED

2. ALL PARTS USED IN THIS ASSEMBLY ARE IDENTICAL TO THOSE USED IN TPX-E-1431046SHIP0





SCALE 0.250

PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
LINEAR TOL .XX ± .03 .XXX ± .010
ANGULAR TOL MACHINED ±0°30'
LOCATING HOLES ±0°30'
CORNER CHAMFERS .03"
TOL ON LIMITED DELINEATION ±.005

CONTRACT NO
DRAWN BY I. G. CLARKSON 6/6 95
LAYOUT BY I. G. CLARKSON 6 6 95
CHECKED BY:
STRESS
MFG ENGR
NGC APPROVAL
ENGR MGR
CLIN. APPROVAL

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

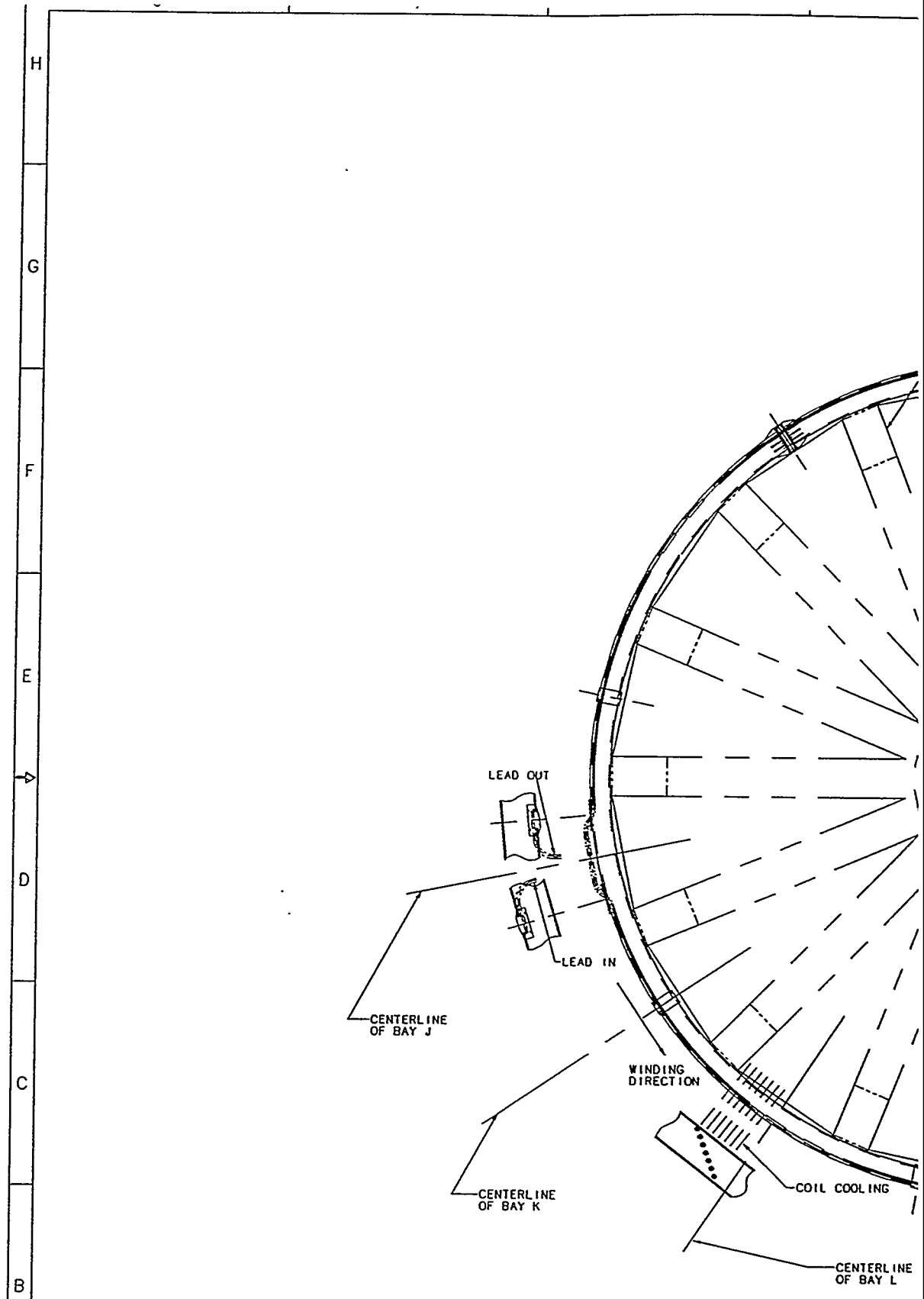
SUPPORT ASSEMBLY
PF7 UPPER

TECH No.	PROGRAM	SIZE	DWG NO.	SHT No	REV
76823	TPX	E	1431036	SH 1	P0

SCALE 6/6 SHEET 1 OF 1

TPX-E-1431036SHIP0

014-3344

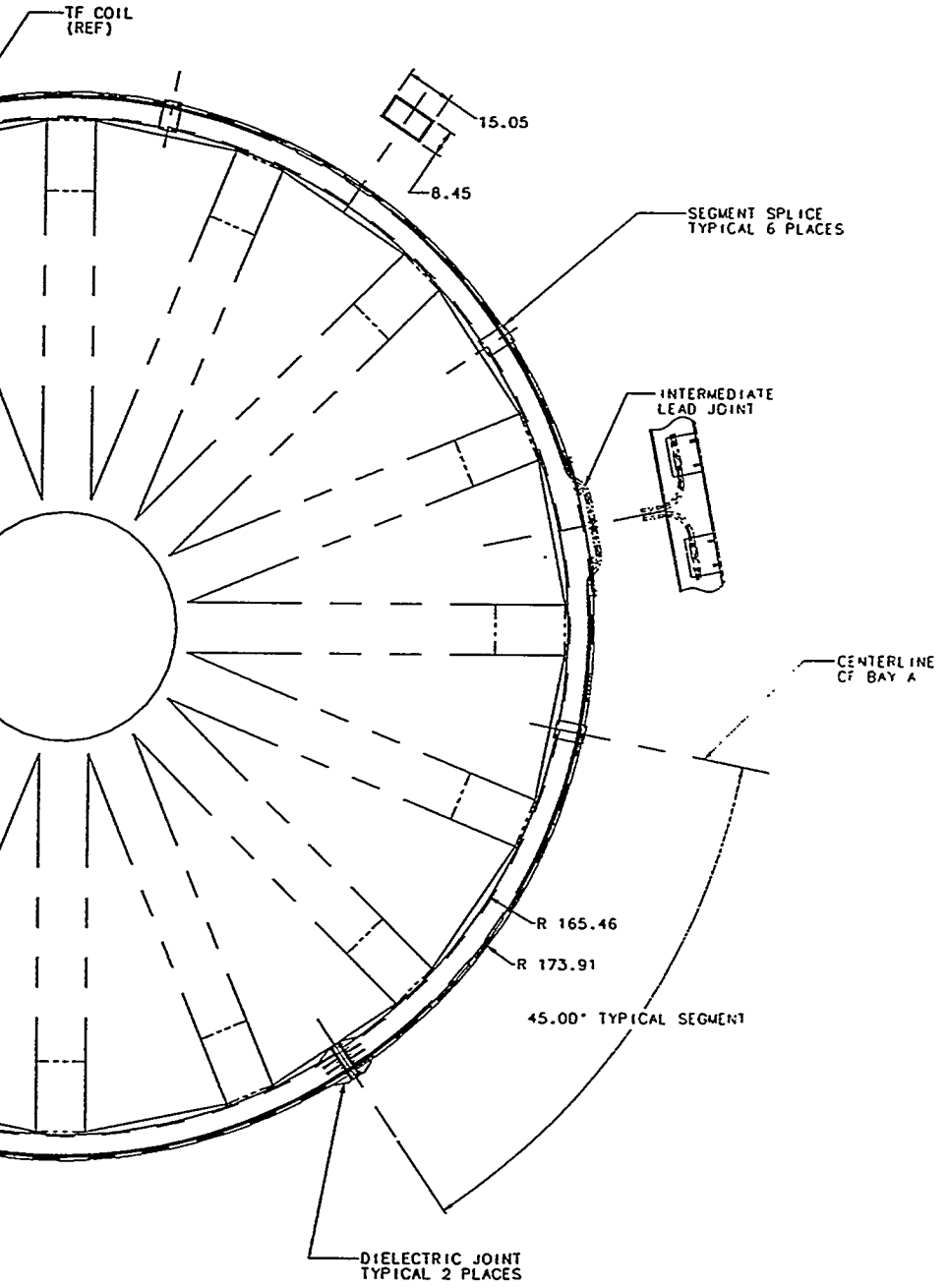

H
G
F
E
D
C
B
A
8
7
6
LEAD OUT
LEAD IN
CENTERLINE OF BAY J
WINDING DIRECTION
CENTERLINE OF BAY K
COIL COOLING
CENTERLINE OF BAY L

NOTES:

1. SEE DRAWING TPX-E-1431018SH1P0 FOR OTHER DETAILS OF DESIGN PRINCIPLES

REVISIONS

ZONE	LTR	DESCRIPTION	ECP CODE	MODEL	DATE	APPROVED



PART NUMBER	NEXT ASS'Y	QTY:

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
LINEAR TOL: .XX ±.03, .XXX ±.010
ANGULAR TOL: MACHINED ±0°30', LOCATING HOLES ±0°30', FORMED ±1°
TOL ON LOFTED OR HEAT-FORMED PARTS
REC APPROVAL
LLNL APPROVAL

CONTRACT NO.
DRAWN BY I.R.CLARKSON 8:7:95
LAYOUT BY I.R.CLARKSON 8:7:95
CHECKED BY:
STRESS
MFG ENGR
ENGR GRP.

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

COIL CASE ASSEMBLY
PF7 UPPER

DSCH NO	PROGRAM	SIZE	DWG NO	SHT No	REV
76823	TPX	E	1431038	SH1	P0

SCALE - 1/20 SHEET 1 OF 1

014-N344

TPX-E-1431038SH1P0

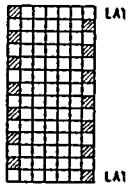
TPX-E-1431038SH1P0

8	7	6	5

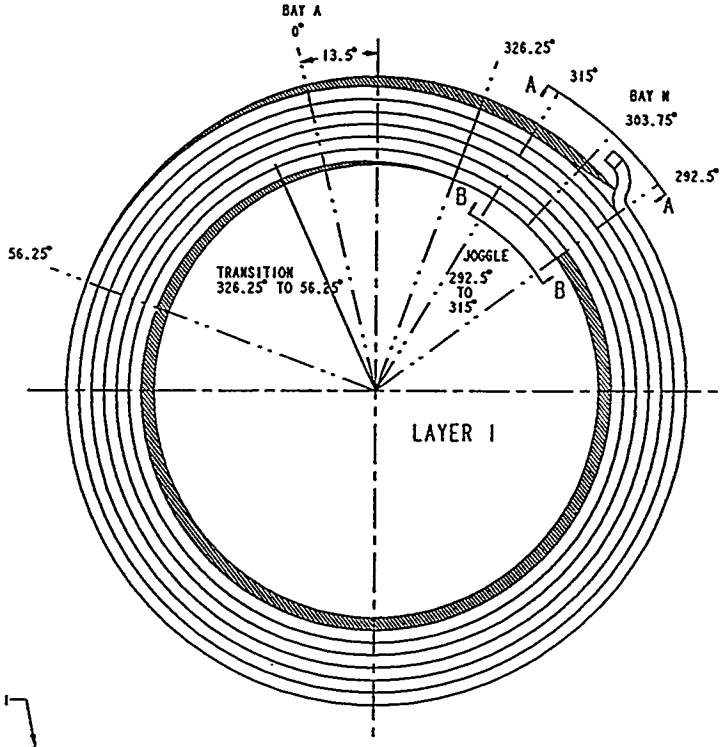
SUPPLEMENTARY DATA

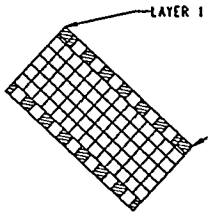
NOTE: UNLESS OTHERWISE SPECIFIED BOXES CHECKED ✓ APPLY TO THIS DWG.

- ☐ PART MARKED AND OTHER IDENTIFICATION MARKING PER 6354710 CL 2A
  - ☐ ON REGION MARKED ⊠ SEE DETAIL SHEET IF NECESSARY
  - ☐ LOCATION OPTIONAL
- REMOVE ALL BURRS BREAK ALL EDGES: .005-.015 / .015-.031
- ✓ 63 SURFACE ROUGHNESS FOR ALL SURFACES PER ASME B46.1
- ✓ 63 SURFACE ROUGHNESS FOR ALL HOLES PER ASME B46.1
- SURFACE ROUGHNESS/DISCONTINUITY PER 6420A, TYPE 256
- PERMISSIBLE MISMATCH PER 6420A FOR INSIDE INTERSECTING CORNERS: TYPE 1A MAX, TYPE 2B MAX
- MISMATCH STEP OF MAX IS PERMISSIBLE ONLY TO CASUAL OF CUTTING AT INSIDE INTERSECTING SURFACES
- DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THDS P.D. INTERFACE THREAD DEPTH PERMISSIBLE
- EXTERNAL THREAD LENGTH SHOWN WITHIN 2 THREADS OF INTERFACE THREAD MAX.
- DIMENSIONING AND TOLERANCING PER ASME Y14.5M
- ABBREVIATIONS PER MIL-STD-12 & 6412A
- ALL DIMENSIONS SHOWN TO BE NET BEFORE CADMIUM PLATING THICKNESS OF PLATE 0000 MIN, 30,0000 MAX NO ALLOWANCE FOR PLATING IN HOLES.
- DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH DOUBLE ASTERISK.
- HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION.
- GRAIN DIRECTION OPTIONAL
- ALL DIMENSIONS SHOWN TO BE NET AFTER ANY WELDING AND/OR HEAT TREATING

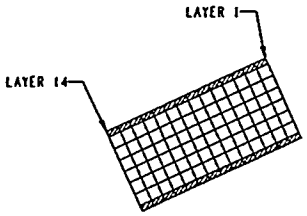


SECTION AT 256
CONSISTENT FOR
FROM 56.25° TO

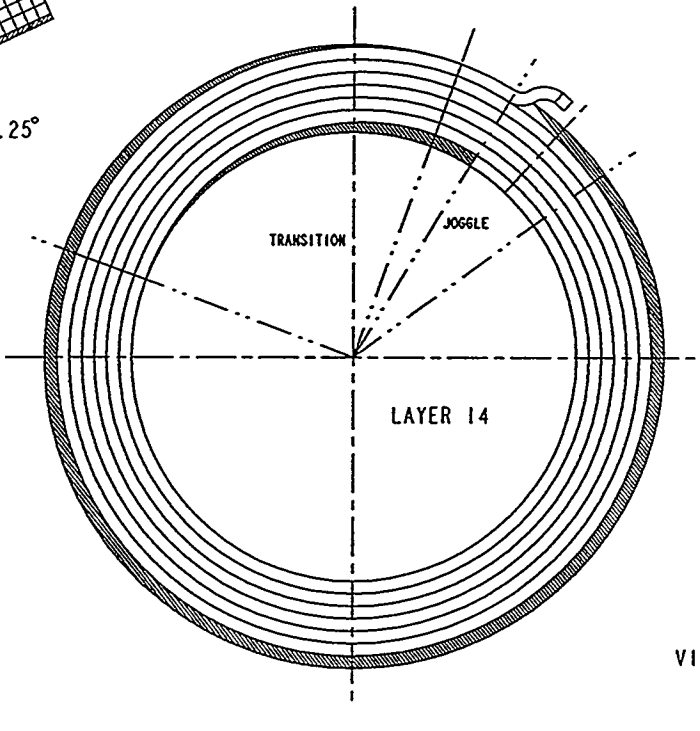




SECTION AT .



SECTION AT 11.25°



VIEW LOOKING DOWN ON

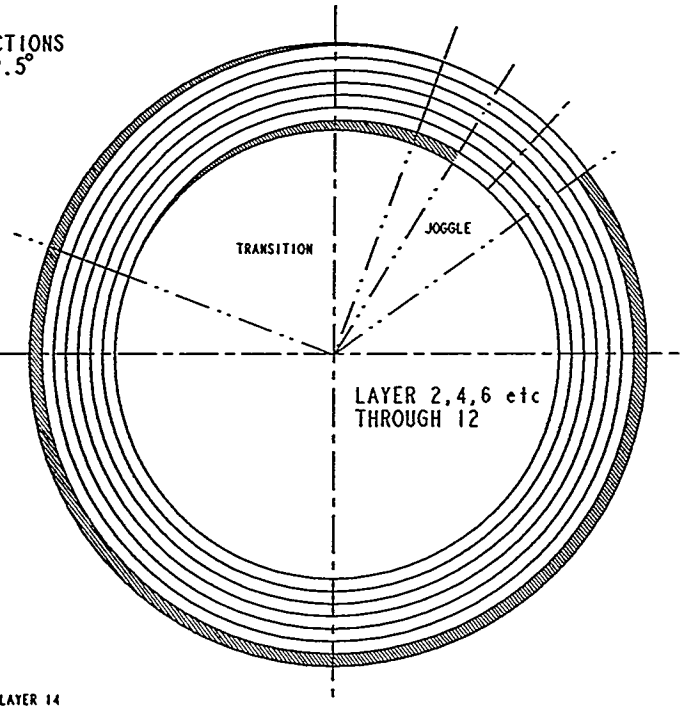
8	7	6	5

REVISIONS						
ZONE	LTR	DESCRIPTION	ECP CODE	MODEL	DATE	APPROVED

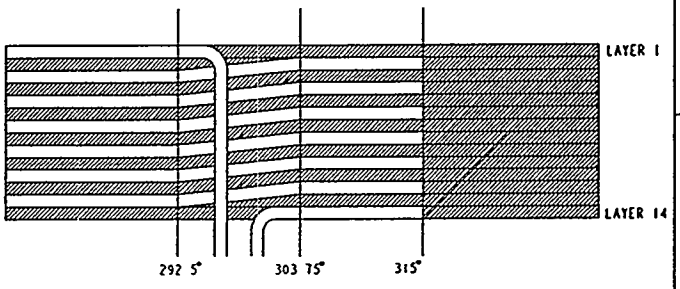
NOTES:

1. SHADED AREAS DENOTE FILLER AND CLEAR AREAS DENOTE CONDUCTOR

CTIONS
.5°

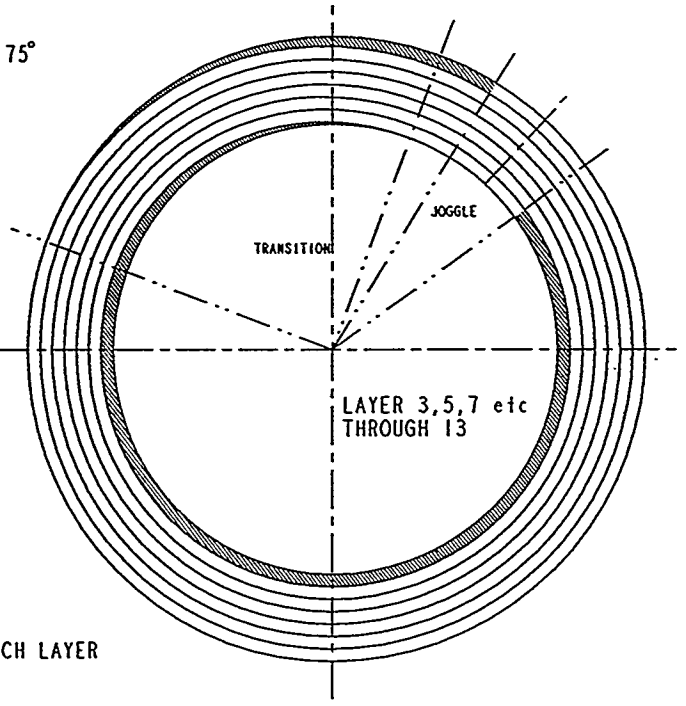


LAYER 14

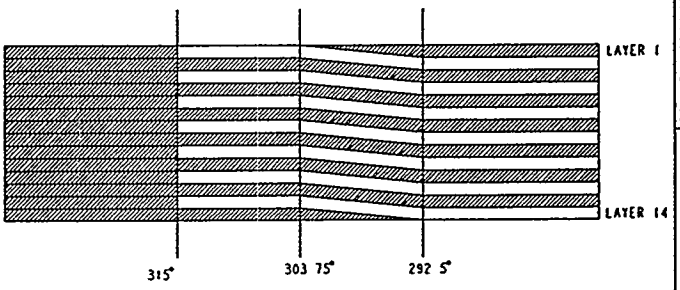


VIEW AA

75°



CH LAYER



VIEW BB

PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
LINEAR TOL .XX ± .03 .XXX ± .010
ANGULAR TOL ± 30'
MACHINED LOCATING SURFACES 63
FORMED CHAMFERS 45°
TOL ON LOFTED DEVELOPMENTS ±1
MFG APPROVAL
ENG APPROVAL

CONTRACT NO
DRAWN BY J. B. CLARKSON 4-6-95
LAYOUT BY J. B. CLARKSON 4-6-95
CHECKED BY
STRESS
MFG ENGR
ENGR

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

WINDING LAYOUT
PF COIL #7 LOWER

TRK or No.	PROGRAM	SIZE	DWG NO	SET No.	DEV
76823	TPX	E	1431042	SH 1	P0

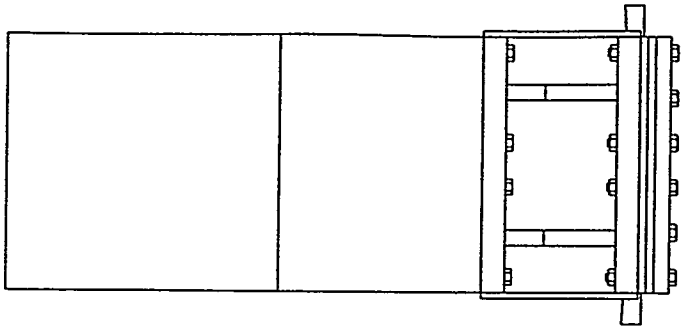
SCALE - NONE SHEET 1 OF 1

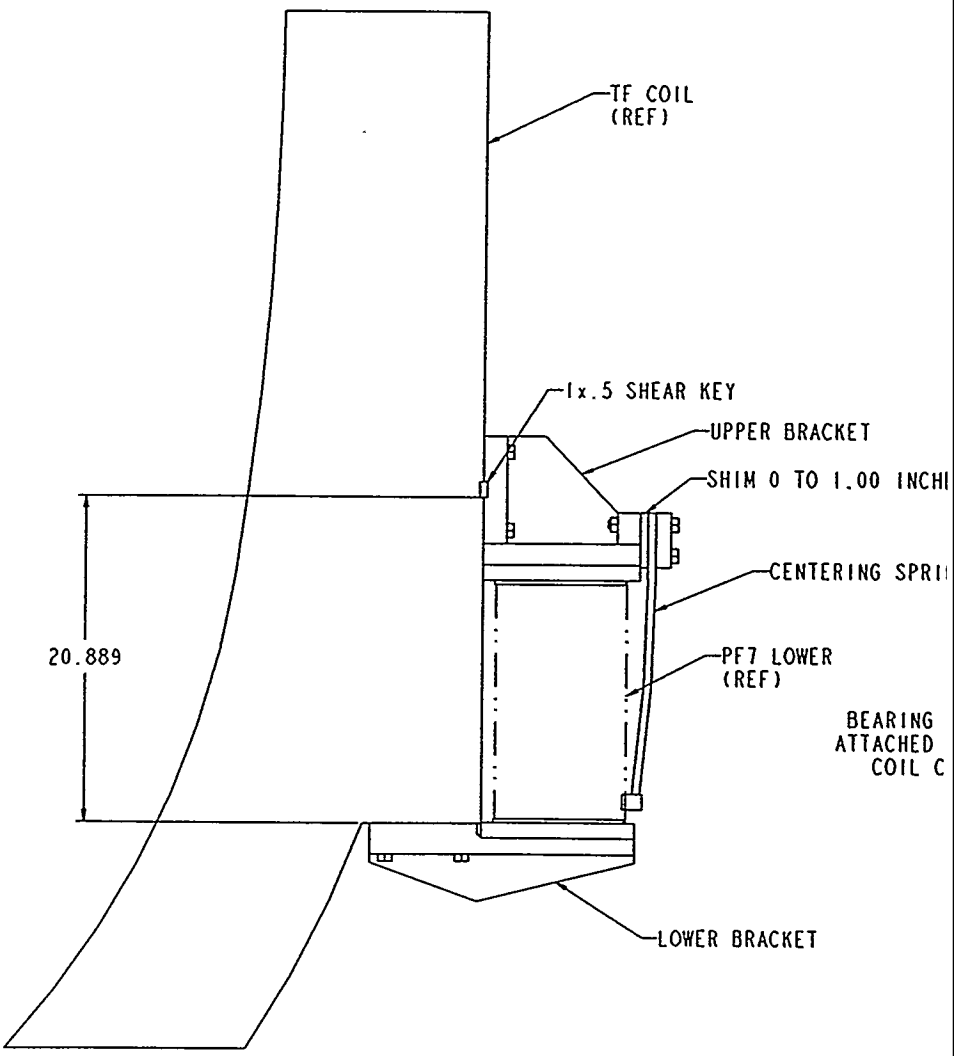
TPX-E-1431042SHIP0

TPX-E-1431042SHIP0

014-3344

SUPPLEMENTARY DATA
NOTE: UNLESS OTHERWISE SPECIFIED NOTES CHECKED ✓ APPLY TO THIS DWG
MARKED STAMP PART NUMBER AND OTHER IDENTIFICATION MARKING PER 6554710 CL 2A
☐ NO MEDIUM MARKED ☒ USE BOTH SIDES IF NECESSARY
☐ LOCATION OPTIONAL
REMOVE ALL BURRS BREAK ALL EDGES .005-.015 / .015-.031
✓ 63 SURFACE ROUGHNESS FOR ALL SURFACES PER ANSI B46.1
✓ 63 SURFACE ROUGHNESS FOR ALL BORES PER ANSI B46.1
SURFACE ROUGHNESS PERFORMED PER 6626A, TYPE 2SA
PERMISSIBLE MISMATCH PER 6626A FOR INSIDE INTERSECTING CORNERS TYPE 5A MAX / TYPE 5B MAX
MISMATCH STEP OF MAX .10 PERMISSIBLE DUE TO CLOSE OF CUTTER AT INSIDE INTERSECTION SURFACES
DEPTH SHOWN FOR TAPPED HOLES IS FOR FULL THDS P/D IMPERFECT THREADS BEYOND PERMISSIBLE
EXTERNAL THREAD LENGTH SHOWN INCLUDES 2 IMPERFECT THREADS MAX
DIMENSIONING AND TOLERANCING PER ANSI Y14.5M
ABBREVIATIONS PER MIL-STD-12 & GA1E4
ALL DIMENSIONS SHOWN TO BE MET BEFORE CADMIUM PLATING TOLERANCE OF PLATE .0000 MIN TO .0000 MAX NO ALLOWANCE FOR PLATING IN HOLES
DO NOT CADMIUM PLATE AND PAINT HOLES OR SURFACES MARKED WITH DOUBLE ASTERISK
HOLES MUST BE KEPT FREE OF CHROME PLATING SOLUTION
GRAIN DIRECTION OPTIONAL
ALL DIMENSIONS SHOWN TO BE MET AFTER ANY WELDING AND/OR HEAT TREATING

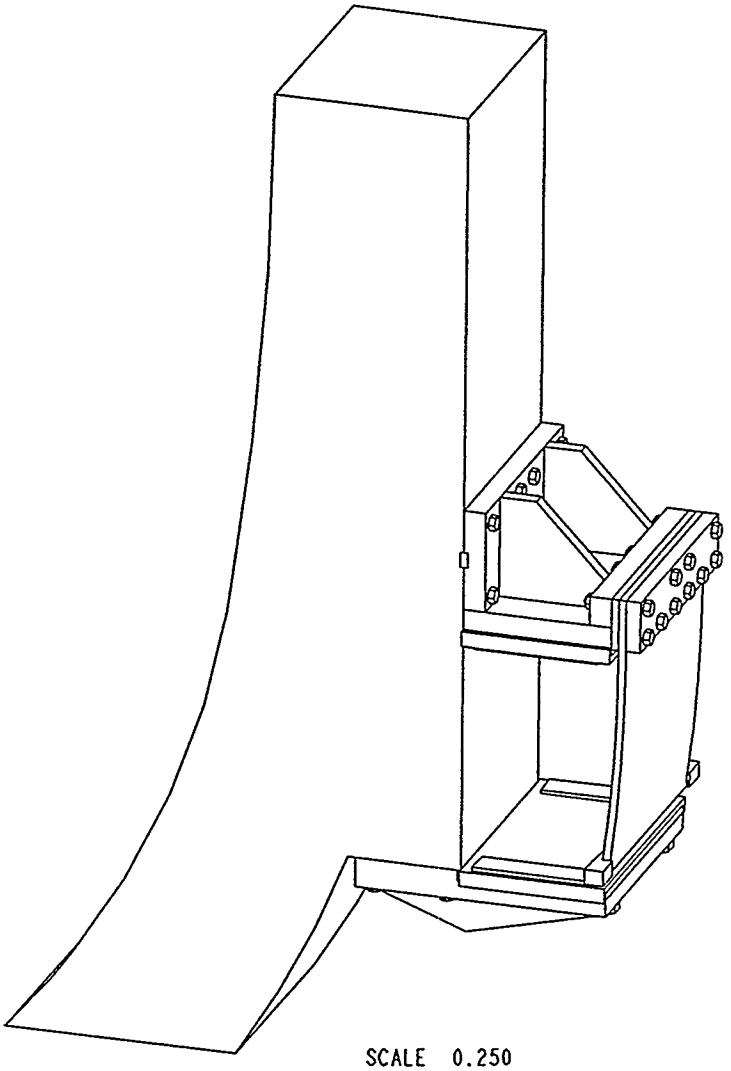




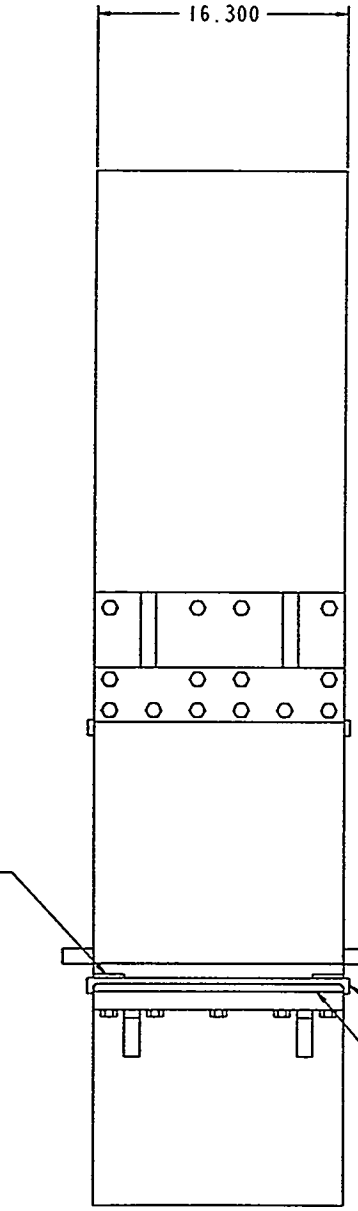
REVISIONS						
ZONE	LTR	DESCRIPTION	EFF CODE	MODEL	DATE	APPROVED

NOTES:

1. SEE DRAWING TPX-E-1431026 FOR MORE DETAILS OF MATERIALS USED



SCALE 0.250



PART NUMBER	NEXT ASS'Y	QTY

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES
LINEAR TOL .XX ±.03 .XXX ±.010
ANGULAR TOL MACHINED LOCATING ±0°30' CONICS CHAMFERS ±5°
TOL ON LAYED DIMENSIONS ±E

CONTRACT NO.

DRAWN BY E.R.CLARKSON 8-9-95
LAYOUT BY E.R.CLARKSON 8-9-95
CHECKED BY:
STRESS
MFG ENGR
CODE IDENT:

MFG APPROVAL
ENG APPROVAL

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK 11714

SUPPORT ASSEMBLY
PF7 LOWER

FSCM No.	PROGRAM	SIZE	DWG NO.	SAT No.	REV
76823	TPX	E	1431046	SH 1	P0

SCALE 1/4 SHEET 1 OF 1

TPX-E-1431046SHIP0

TPX-E-1431046SHIP0

014-3344

TPX Poloidal Field Magnets
Central Solenoid
Preload and Worst Coil Loads

Al Corpuz
ESG TPX Design Engineering

July 17, 1995

TPX 14-950717-WEC-ACorpuz-01

APPROVED:

P.A. Sanger
Westinghouse TPX Chief Scientist

APPROVED:

D. R. Potter
Westinghouse TPX Engineering Manager

Westinghouse Electric Corporation
Electronic Systems Group

401 East Hendy Avenue, Sunnyvale, California 94088-3499

CS Preload and Worst Coil Loads

I. Overview and Summary

The focus of the initial Central Solenoid (CS) structural analysis effort was to provide input to detailed coil modeling and testing efforts. The objectives were:

1. To determine the required preload (applied as a prestrain) required to maintain vertical compressive loading in the coils
2. To determine the worst case coil interface loads to act as boundary conditions for detailed coil model analyses
3. To determine coil interface forces vs. time for the HC scenario

An ANSYS 2D axisymmetric structural model of the CS with smeared coil properties was used to investigate the following cases:

Cooldown cases

- Cooldown without preload
- Room temperature preload: ~9.4 MN at CS center
- Room temperature preload; structure at room temperature; coils at 4K
- Room temperature preload; structure and coils at 4K: ~14.8 MN at CS center

Electromagnetic (EM) cases (including cooldown)

- Maximum separation force: used to determine preload
- Maximum vertical body force: ~3.7MN upward on CS
- Maximum compressive force: ~32.5 MN at CS center *
- Maximum radial force, normal case *
- Maximum radial force, fault case *

High Current (HC) scenario: to characterize force vs. time *

* Worst case boundary conditions provided for use in detailed coil model analyses as well as interface forces for the HC scenario are included in the attachment (EXCEL spreadsheets 495RUNR1.XLS and HCINTFR1.XLS).

II. Identification of Worst Load Cases

A number of papers have been generated, most recently by Schultz[1] and Radovinsky[2] [3], evaluating the worst case forces for different electromagnetic events (i.e., normal operating

[1] Schultz, J., "Selection of Scenario Points for FEA Analysis," 4/20/95, TPX Report #1314-950420-MIT-JSchultz-01.

[2] Radovinsky, A. L., "The Worst Fault Load Cases on the Coils of the TPX PF Set due to a Vertical Plasma Disruption Followed by a System Dump with Shorted PF Coils Terminals at the Twenty-Three Equilibria," 3/27/95, TPX Report #14-950327-MIT-ARadovinsky-01.

[3] Radovinsky, A. L., "The Worst Loads on the Coils of the TPX, Revision 1," 4/27/95, TPX Report #1314-950427-MIT-ARadovinsky-01.

conditions, which includes disruptions, as well as various fault scenarios). WEC participated in the process of reducing the number of cases from a few thousand to a manageable set. Identifying coil loads for the individually mounted coils (PF 5-7) is relatively straightforward, while for the central solenoid (PF 1-4), the effects of the combination of loads from all eight coils must be examined.

For CS coil-to-coil interface loads, MIT identified the worst cases using an algorithm assuming rigid coils (developed with WEC). The rigid coil algorithm provides loads which are indicators of worst case, but are not the actual loads in the coil. Loads are reduced when coil and structure stiffnesses are included. Also, published loads (references 1, 2, and 3) do not add preload. The CS structural analysis includes both preload and the effect of stiffness. The results are discussed below. One key result is that the maximum compressive load case changes when stiffness is considered. The maximum separation load case (and location in CS) did not change with stiffness.

III. Model Description

The 2D axisymmetric model is an expanded version of the University's baseline model. The model maintained the approach of using reduced hoop direction properties to simulate the response of a segmented structure. The lower portion of the coil pack was added (from four to the full eight coils) as well as upper and lower portions of the preload structure. Initial analyses were of the CDR baseline design, including angled links as the CS-to-TF support. A compressive prestrain is included in the support link to account for differential thermal contraction between the CS and the TF structure. The model is shown in figure 1.

Input to the model was net EM forces per coil. Vertical forces were evenly distributed throughout each coil. Radial forces were linearly distributed from maximum at the inner diameter to zero at the outer diameter. This approximation was considered adequate for this level of analysis since the actual conductor force distribution would be used in the detailed coil analysis models.

Updated smeared properties were used for the coils[4]. The width of the coils corresponds to seven conductors wide, which is the maximum width of a six-turn wide spiral wound coil. Since the smeared properties were developed with a six turn wide aligned ("regimented") pack, this assumption has the effect of stiffening the coil. The assumption of a larger coil is conservative when developing coil loads since it increases loads. Coil stresses are investigated in the detailed coil models which are six conductors wide. Investigating the variation of coil stiffness was conducted as a separate effort and is also described below.

The model assumed that the coil-to-coil interface did not slip, i.e., it acted as a glued interface. The glued coil assumption is further addressed below in the maximum separation load case discussion.

[4] Schultheiss, T. "Smeared Properties for Insulation as of 3/29/95", TPX/MAG/SCHULT/95-005

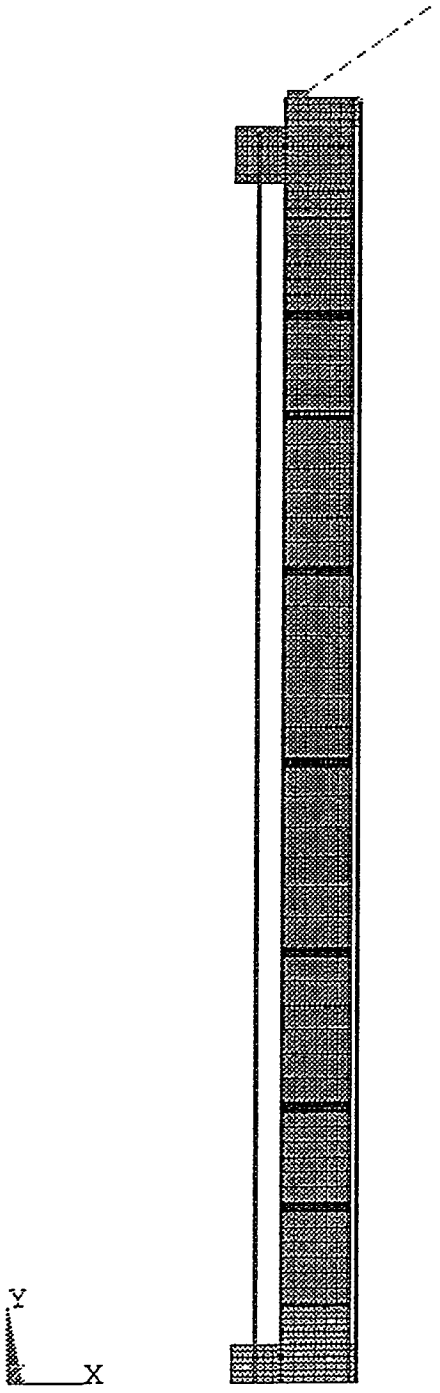


Figure 1. ANSYS 2-D Axisymmetric Model.

IV. Model Verification

In addition to the axisymmetric structural model, an ANSYS spring model was created modeling the coils and structure as linear springs. The model consisted of sixteen springs in series (two per coil) with one spring in parallel (representing the structure). Spring stiffnesses were derived from the axisymmetric model and checked by comparing to the stiffness values calculated from: (Area)(Modulus)/Length. This model provided a check against the axisymmetric model results in the vertical direction as well as providing a means of understanding how the interface forces vary with the coil forces.

A further check of the results will occur when they are compared with the detailed coil model results. Both interface forces and deflections are provided as boundary conditions for the detailed models. Input forces should provide similar deflections in both models.

V. Analysis of Load Cases

Analyses are based on loads provided in reference 2. Factors are included to account for the changes in loads identified in references 1 and 3. Other factors are included based on sensitivity studies and parametric analyses. These are described in the following case by case discussion.

VI. Preload Determination Using Max Separation Load Case

The maximum coil-to-coil separation force case was used to determine required preload at operating temperature. Preload is a result of applied room temperature prestrain plus differential contraction during cooldown (determined in the cooldown analyses). The overall goal is minimization or elimination of tension in the insulation. The analysis groundrule is to eliminate any separation force between coils.

Reference 2 identified the max separation load as 10.2 MN located between PF 1U and 2U (Equilibria #12 with an upper disruption and fault in PF1U). The structural model run of same case reduced the load to 9.8 MN due to the inclusion of stiffness effects. At first cut, this can be zeroed out with 4.4 MN room temperature preload (~2mm prestrain) plus 5.4 MN from cooldown. However, there are a number of factors which increase the required preload by ~5MN:

- Although the net force is zero, the force distribution across the PF 1U to 2U interface still included some tension. An increase of ~2 MN (20%) was required to completely eliminate tension.
- References 2 and 4 list the maximum separation load as 11.4 MN (equilibria #12 with an upper disruption and no fault) which results in a 1.2 MN (12%) increase in required preload.
- Coil stiffness sensitivity studies indicate approximately 3% variation in loads assuming a 30% variation in coil stiffness. (This only applies to the maximum separation case. Other cases could have a different variation.) An increase of 0.3 MN (3%) is needed to cover variation in coil stiffness.
- 10% contingency factor is included for unknowns.

There are a number of issues which could affect preload, but intentionally have not been accounted for since increasing preload is not desirable for the coils:

- There may be tension developed when the coils cool before the structure. This could be eliminated with increased preload, however there are other design solutions.
- Preload creep is assumed to be addressed with maintenance.
- Potential changes to the CDR baseline are not accounted for in the the development of the worst case since changes are intended to improve loading conditions.
- The analysis assumes the coils are "glued". To avoid actually using an adhesive, it may be necessary to increase preload to a minimum normal force for maintaining friction and preventing sliding.

When the max separation case from reference 2 is run with the factors discussed, the results are as follows:

- Room temperature preload: ~9.4 MN at CS center
- Room temperature preload; structure and coils at 4K: ~14.8 MN at CS center
- Minimum interface force: ~5.1 MN at the PF 1U to 2U interface
- Min friction coefficient: Radial force / Max separation force = 0.9/5.1 = 0. 18

The preload developed above was utilized for all subsequent runs. The preload is actually a prestrain in the preload structure, which acts as a spring in parallel with the stack of coil springs. The interface forces between the coils vary with the system of forces applied to the coils. The interface forces start at the same level (room temperature preload plus cooldown) and then increase or decrease, but never go below the minimum. An example of how coil forces vary with time is shown in figure 2 for the HC scenario. The HC scenario includes equilibria #1 through #6, but the graph includes intermediate force points generated using a simplified method[5].

[5] Krefta, M. P, "Simple algebraic expressions for TPX EM force calculations," 5/3/95, Westinghouse #TPX.STC.MPK.STC.PS.M009.05.02.95.

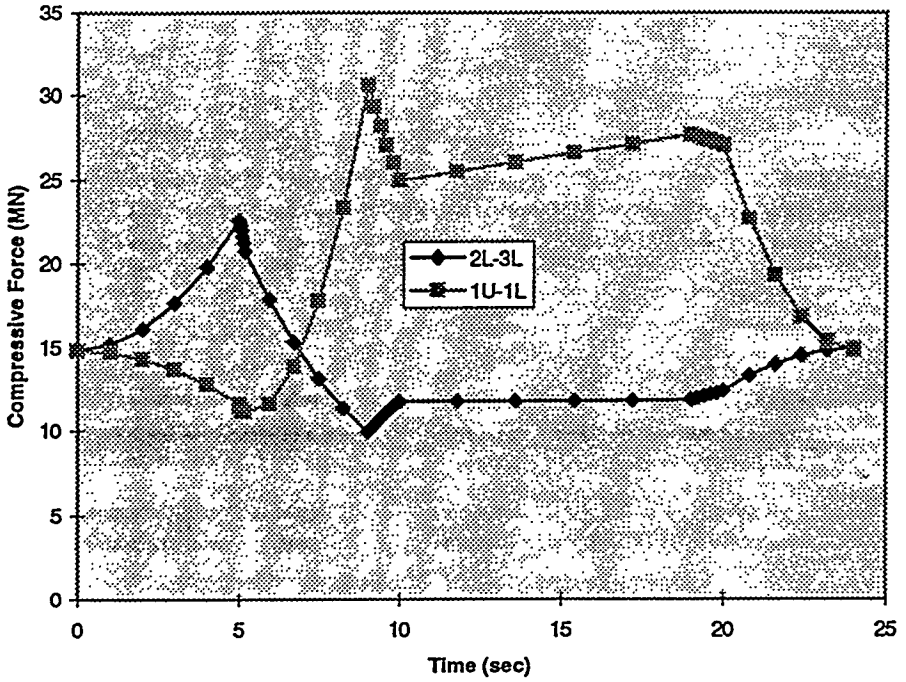


Figure 2. HC Scenario Interface Forces.

VII. Max Compression Load Case

Reference 2 identified the max compressive load as 23 MN located at center of CS between 1U and 1L (equilibria #15 with an upper disruption and no fault). Reference 1 eliminated the disruption case and listed the worst case as equilibria #15. The inclusion of stiffness changes the worst case from equilibria #15 to #16. The interface force measured at the center of the CS for equilibria #16 (including the preload described above) is 31.3 MN.

When eliminating the disruption case, reference 1 cited the TPX Structural and Cryogenic Design Criteria (S&CDC) I-4.1.5 as allowing a "10% increase in allowable stress when evaluating upset conditions, such as disruptions". However, the S&CDC I-2.1 includes disruptions as normal events. Although the frequency of disruptions could be considered in fatigue testing or analysis, it seems prudent to define the worst case as being the disruption case.

Input data had not been requested for case #16 with a disruption since it was originally thought that case #15 was the most severe. Equilibria #16 results were factored up by 4% to account for the force amplification associated with a disruption. The percentage was developed by looking at the difference between equilibria #15 with and without a disruption (including the effects of preload and stiffness). Thus, the estimated result of the max compressive load case of equilibria #16 plus a disruption is:

- Maximum compressive force: ~32.5 MN at CS center

VIII. Stiffness Sensitivity Study

As noted earlier, a factor affecting the results is the variation of forces with coil stiffness. If the coils are stiffer than modeled, then the maximum coil interface separation force increases which would require increasing the preload. This effect has been taken into account in the analyses performed. However, the maximum compressive force would also increase as a result of stiffer coils. Equilibria #16 (a high compressive force case) was run with coil stiffnesses varying from +30% to -30% of nominal. The resulting forces at the center of the CS are -11.1% and +8.6% respectively, showing that stiffness variation can have a significant effect.

Uncertainty in the coil stiffness is based on the uncertainty in the smeared property analysis which is affected by: a) the aligned/regimented vs. staggered CICC, and b) the variation in the individual component properties. As noted earlier, the coil width used in the model provides the effect of a conservative stiffness assumption.

IX. Worst Cases for Coil Loads

In addition to the max compressive load case, other worst cases from the perspective of conductor pack loading are peak radial loading during normal and fault conditions. The cases are Equilibria #1 and Equilibria #1 with a fault in PF 3U. These were identified by examining the load on a per-turn basis. Originally a distinction was made between the max force and the max differential force, but they turn out to be the same case. During a fault, current and forces are maximum in the faulted coil and near zero in the adjacent coils.

These cases were run in the CS structural model and all coil forces and stresses were examined to determine the worst conditions. The interface forces for the worst loaded coils are provided as boundary conditions for the detailed coil models in the attached spreadsheet. It should be noted that since smeared properties are used for the coils, the stresses listed can only be used for comparison purposes. True stress levels are determined by the detailed coil models.

X. Max Vertical Body Force

References 1 and 3 list the maximum upward vertical body force as 2.87 MN and the maximum downward vertical body force as 3.68 MN. Reference 2 lists the max vertical body force as 3.61 MN (equilibria #14 with a lower disruption). An earlier reference[6] listed the value as 3.72 MN which has been adopted as being conservative.

- Maximum vertical body force: ~3.7 MN upward on CS

The reference 2 case was run in the CS structural model. As expected, it illustrated the amplification of the vertical loading into the TF interface caused by the angled link in the CDR baseline. This configuration also causes a bending moment in the top plate of the CS structure. (Note that the link connection point is radially inboard of the coil, not aligned

[6] Radovinsky, A. L., "Forces on the PF Coils due to a Vertical Plasma Disruption Followed by a System Dump with Shorted PF Coils Terminals at the Twenty-Three Equilibria in TPX, Revision 1," 2/17/95, TPX Report #14-950217-MIT-ARadovinsky-01.

with the coil center.) Coil stresses are undesirably increased as a result of this support configuration. Results for this case show that the radial force at the top of PF 4U is 2.1 MN, which is greater than the 1.4 MN max radial force in equilibria #1. However, this case was not used as one of the worst coil load cases. The angled link design is being eliminated to avoid this because of this problem.

XI. Conclusion

The preload defined and the attached coil interface load definition provide a "nominal", or reasonably conservative worst case load set for detailed coil analysis and testing efforts. Factors are included which account for specific items and a small contingency is included.

14-950717-WEC-ACorpuz-01

Notes on Interface Forces

Model

1. All cases run with a structural model of the University baseline, NOT including design changes.
2. Smeared properties are from 3/95 NG calculations (used for both coils and ground wrap).
3. Vertical EM forces are evenly distributed over the coils (not ground wrap). See note 7 for radial EM forces.
4. Coils are modelled as "glued" together and to the structure.
5. TF contraction is modelled by including a compressive prestrain in the supporting link.
6. All cases are based on TPX-950327 by Radovinsky, NOT the 4/20 & 4/27 memos by Schultz and Radovinsky (see note 8b).

Rev 1 Changes

7. Radial forces are linearly distributed from max @ ID to 0 @ OD.
8. Preload has been increased ~5MN to account for the following:
    a. 2.0 MN (20%) to eliminate tension in force distribution across an interface (total was compressive).
    b. 1.2 MN (12%) due to a new worst separation value identified by Radovinsky.
    c. 0.3 MN (3%) due to assumed 30% variation in coil stiffness (preliminary sensitivity study).
    d. 10% contingency factor. (Note that no factors are applied to radial loading.)
9. The following issues have NOT been accounted for (with rationale):
    a. Design changes to the University baseline design (intended to improve loading conditions).
    b. Tension developed when coils cool before structure (there are other solutions than increasing preload).
    c. Preload creep (assumed to be addressed with maintenance).
    d. Increased preload to a minimum normal force for maintaining friction and preventing sliding at interfaces. (IF we want the CS to act as a glued structure without using glue).
10. The above creates a nominal worst case. Additional margin has NOT been added.

Cases Included

Radial3A_R1 = Eq# 1	(Max Radial Normal Case)
Radial3_R1 = Eq# 1+F	(Max Radial Fault Case)
Compr1A_R1 = Eq# 16	(Max Compressive Case)

Force Nomenclature

Forces are at the center of the 3/8" stainless steel bearing plate between coils.
FR=Radial (total around circumference, positive outward from CS centerline); FZ=Vertical (positive up).
Sign of force reflects reaction loads as applied to the coil between the interfaces.
Reaction forces exerted by first coil on second, e.g., 4U-3U is the force exerted by 4U on 3U.

Attachment

Stresses (MPa) * Interface force distributions are provided for the coils exhibiting the highest stresses.
Coil and Ground Wrap are modelled with the same smeared properties. Plates are 3/8" stainless steel.

Radial3A_R1 = Eq# 1 Coil Stresses, not incl. Grd Wrap

		Shear SRZ	Radial SR	Hoop SH	Grd Wrap Shear SRZ	Plates Shear SRZ	FYI: Equilibria #1 Hoop Forces F hoop	pancakes	Fh/pan
	4U	0.38	3.55	69.07	1.55	1.95	2.48	10	0.248
	3U	0.60	4.11	71.50	1.76	2.29	2.74	10	0.274
	2U	1.22	4.04	71.44	2.10	3.44	4.35	16	0.272
	1U	0.65	1.16	34.54	2.11	3.62	1.51	20	0.076
	1L	0.7	1.17	34.51	2.15	3.69	1.51	20	0.076
*	2L	1.29	4.07	71.33	2.01	3.61	4.35	16	0.272
*	3L	0.53	4.14	71.11	1.61	2.93	2.74	10	0.274
	4L	0.78	3.60	65.64	1.58	2.41	2.48	10	0.248

Recommendation: m PF3 in Equilibria #1 was originally selected since it has the highest hoop force per pancake.
However, PF2 has similar force per pancake, radial and hoop stresses, while also having the highest shear stresses.

Radial3_R1 = Eq# 1+ Shear Stress SRZ (MPa)

		Coil	Grd Wrap	Plates
	4U	3.52	5.57	8.59
*	3U	4.45	6.20	9.46
	2U	2.88	5.43	8.70
	1U	0.25	2.93	2.78
	1L	0.12	2.66	2.64
	2L	0.23	2.52	2.70
	3L	0.48	2.59	2.87
	4L	1.13	3.89	3.36

Compr1A_R1 = Eq# 1 Compressive Stress SZ (MPa)

		Coil	Grd Wrap	Plates
	4U	14.66	19.89	16.40
	3U	11.68	15.84	17.32
	2U	17.57	23.42	24.85
	1U	33.40	42.60	47.30
*	1L	33.55	42.55	47.25
	2L	19.22	25.70	27.49
	3L	12.95	16.29	18.34
	4L	15.18	26.34	16.18

Node Definition R & Z are original room temp. node locations in mm; DR & DZ are change in node location.
Z dimension is listed below for each interface.

	Ground Wrap: 2 ele., 3 nodes								Ground Wrap: 2 ele., 3 nodes		
R (for nodes below):	718.31	722.27	726.24	754.58	782.93	811.28	839.62	867.97	896.32	900.28	904.24
			Coil width: 6 elements; 7 nodes								

Interface Force Distribution

Max Vertical Compression Case Compr1A_R1 = Eq# 16

1U-1L Z = 1638.7

Node#s	1367	1368	1364	1382	1383	1384	1385	1386	1376	1392	1390
DR (mm)	-0.36	-0.37	-0.38	-0.46	-0.54	-0.62	-0.70	-0.78	-0.86	-0.88	-0.89
DZ (mm)	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62
FR (MN)	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FZ (MN)	-0.50	-0.68	-2.38	-4.51	-4.79	-4.92	-4.95	-4.84	-2.61	-0.68	-0.47

1L

2L-1L Z = 1135.0

Node#s	1334	1335	1331	1349	1350	1351	1352	1353	1343	1359	1357
DR (mm)	-0.70	-0.71	-0.72	-0.81	-0.89	-0.97	-1.06	-1.14	-1.22	-1.23	-1.24
DZ (mm)	9.10	9.10	9.09	9.06	9.03	9.01	8.98	8.95	8.90	8.89	8.89
FR (MN)	0.02	0.03	-0.05	-0.20	-0.23	-0.22	-0.27	-0.13	0.04	0.04	0.02
FZ (MN)	0.27	0.39	1.32	2.45	2.61	2.74	2.83	2.90	1.66	0.46	0.32

Max Radial Fault Case Radial3_R1 = Eq# 1+F

4U-3U Z = 2814.6

Node#s	1466	1467	1463	1481	1482	1483	1484	1485	1475	1491	1489
DR (mm)	-0.16	-0.17	-0.18	-0.27	-0.35	-0.44	-0.52	-0.61	-0.69	-0.71	-0.72
DZ (mm)	0.72	0.74	0.76	0.86	0.91	0.92	0.93	0.95	1.02	1.03	1.05
FR (MN)	0.11	0.22	0.12	-0.68	-1.24	-1.17	-1.39	-0.80	0.13	0.23	0.11
FZ (MN)	-0.15	-0.30	-1.24	-2.21	-2.28	-2.31	-2.26	-2.08	-1.08	-0.25	-0.12

3U

2U-3U Z = 2550.2

Node#s	1433	1434	1430	1448	1449	1450	1451	1452	1442	1458	1456
DR (mm)	-0.16	-0.17	-0.18	-0.27	-0.36	-0.44	-0.53	-0.61	-0.70	-0.71	-0.72
DZ (mm)	2.25	2.23	2.21	2.10	2.04	2.01	2.00	1.96	1.89	1.87	1.86
FR (MN)	0.11	0.23	0.12	-0.67	-1.20	-1.13	-1.36	-0.80	0.11	0.23	0.11
FZ (MN)	0.17	0.32	1.28	2.26	2.30	2.32	2.27	2.06	1.06	0.24	0.11

Interface Force Distribution (continued)

Max Radial Normal Case Radial3A_R1 = Eq# 1

1L-2L Z = 1135.0

Node#s	1334	1335	1331	1349	1350	1351	1352	1353	1343	1359	1357
DR (mm)	-0.50	-0.51	-0.52	-0.61	-0.69	-0.77	-0.86	-0.94	-1.03	-1.04	-1.05
DZ (mm)	6.57	6.58	6.59	6.63	6.66	6.69	6.70	6.73	6.77	6.78	6.79
FR (MN)	0.04	0.07	0.01	-0.23	-0.39	-0.39	-0.45	-0.21	0.07	0.07	0.03
FZ (MN)	-0.19	-0.29	-1.02	-1.92	-2.13	-2.29	-2.39	-2.46	-1.43	-0.37	-0.23

2L

3L-2L Z = 727.1

Node#s	1301	1302	1298	1316	1317	1318	1319	1320	1310	1326	1324
DR (mm)	-0.12	-0.14	-0.15	-0.23	-0.31	-0.40	-0.48	-0.56	-0.65	-0.66	-0.67
DZ (mm)	8.48	8.48	8.48	8.47	8.47	8.46	8.45	8.45	8.44	8.44	8.44
FR (MN)	-0.01	-0.02	-0.03	0.00	0.04	0.06	0.05	-0.01	-0.04	-0.01	-0.01
FZ (MN)	0.28	0.46	1.75	3.32	3.54	3.62	3.57	3.40	1.82	0.46	0.28

2L-3L Z = 727.1 (Same as above with force signs reversed.)

Node#s	1301	1302	1298	1316	1317	1318	1319	1320	1310	1326	1324
DR (mm)	-0.12	-0.14	-0.15	-0.23	-0.31	-0.40	-0.48	-0.56	-0.65	-0.66	-0.67
DZ (mm)	8.48	8.48	8.48	8.47	8.47	8.46	8.45	8.45	8.44	8.44	8.44
FR (MN)	0.01	0.02	0.03	0.00	-0.04	-0.06	-0.05	0.01	0.04	0.01	0.01
FZ (MN)	-0.28	-0.46	-1.75	-3.32	-3.54	-3.62	-3.57	-3.40	-1.82	-0.46	-0.28

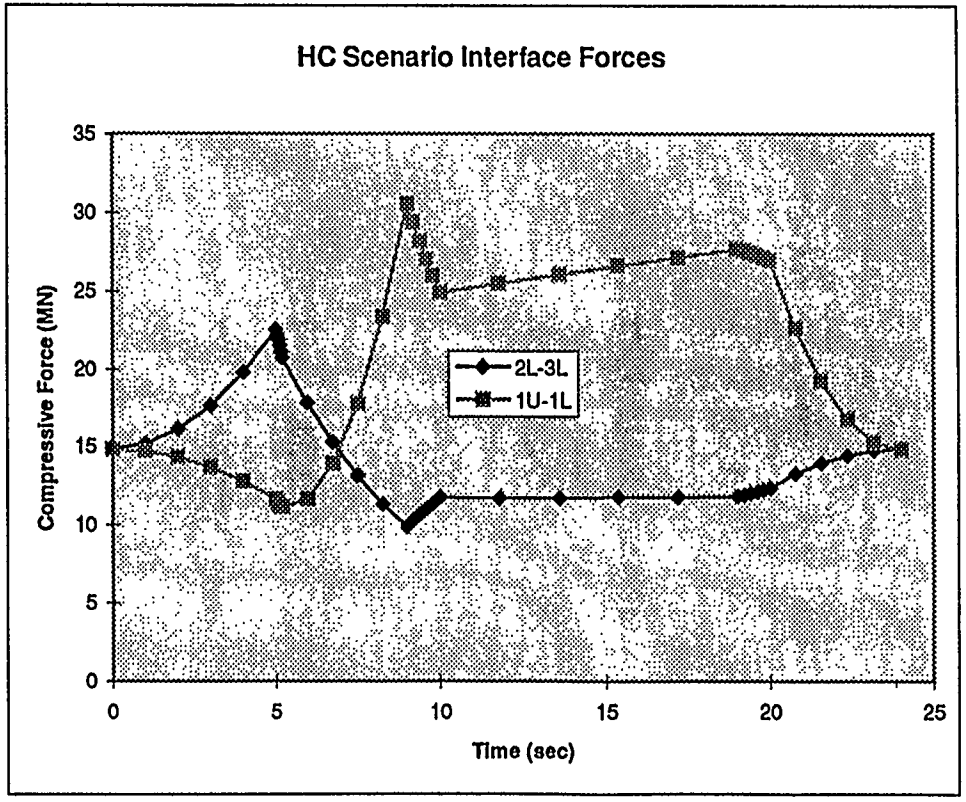
3L

4L-3L Z = 462.74

Node#s	1268	1269	1265	1283	1284	1285	1286	1287	1277	1293	1291
DR (mm)	-0.21	-0.22	-0.23	-0.31	-0.40	-0.48	-0.57	-0.65	-0.73	-0.75	-0.76
DZ (mm)	9.77	9.77	9.77	9.75	9.71	9.67	9.63	9.59	9.55	9.55	9.54
FR (MN)	0.00	-0.01	-0.12	-0.07	0.13	0.15	0.10	0.04	-0.01	-0.01	-0.01
FZ (MN)	0.23	0.39	1.59	2.98	3.10	3.09	2.98	2.77	1.46	0.37	0.22

Equilibria	Time	2L-3L	1U-1L	Load step of run# HC_R1	(* C4_R1)
	0	14.86813	14.83068	*	
	1	15.17513	14.70313	1	
	2	16.09612	14.32046	2	
	3	17.63112	13.68269	3	
	4	19.78011	12.7898	4	
#1	5	22.54311	11.6418	5	
	5.037	22.23213	11.45393	6	
	5.074	21.89476	11.30541	7	
	5.111	21.53102	11.19622	8	
	5.148	21.14089	11.12638	9	
#2	5.185	20.72438	11.09589	10	
	5.948	17.83514	11.64095	11	
	6.711	15.30657	13.86087	12	
	7.474	13.13867	17.75567	13	
	8.237	11.33144	23.32533	14	
#3	9	9.88488	30.56986	15	
	9.2	10.28861	29.33862	16	
	9.4	10.67699	28.15795	17	
	9.6	11.05004	27.02784	18	
	9.8	11.40775	25.94829	19	
#4	10	11.75011	24.9193	20	
	11.8	11.73383	25.47797	21	
	13.6	11.73298	26.03414	22	
	15.4	11.74754	26.58781	23	
	17.2	11.77753	27.13897	24	
#5	19	11.82294	27.68762	25	
	19.2	11.92381	27.56181	26	
	19.4	12.02821	27.4304	27	
	19.6	12.13615	27.2934	28	
	19.8	12.24761	27.1508	29	
#6	20	12.36261	27.00262	30	
	20.8	13.2646	22.62072	31	
	21.6	13.96614	19.21258	32	
	22.4	14.46724	16.77819	33	
	23.2	14.76791	15.31756	34	
	24	14.86813	14.83068	*	

NOTES:
1. Forces are in MN and are compressive. Forces are at the center of the 3/8" SS bearing plates between coils.
2. See other Notes from Int. Forces, Rev. 1, dated 5/12/95.
3. Input forces are from M. Krefta spreadsheet "atrns.xls" (i.e., from "Simple algebraic expressions ...", not from the Pillsbury spreadsheet of the 23 equilibria).



TPX Central Solenoid Assembly Structural Analysis

Al Corpuz
ESG TPX Design Engineering

August 11, 1995

TPX 14-950811-WEC-ACorpuz-02

APPROVED:

P.A. Sanger
Westinghouse TPX Chief Scientist

APPROVED:

D. R. Potter
Westinghouse TPX Engineering Manager

Westinghouse Electric Corporation
Electronic Systems Group

401 East Hendy Avenue, Sunnyvale, California 94088-3499

CS Assembly Structural Analysis

I. Overview and Summary

Previous Central Solenoid (CS) structural analysis efforts[1] focused on determining preload and providing input to detailed coil modeling and testing efforts. Subsequent analyses covered three areas:

1. Shipping and handling loads on the CS
2. Analysis refinements investigating assumptions made in reference 1:
   - Coil width and smeared properties
   - Force distribution in the coils
   - Changing from an angled link to a vertical CS-to-TF support
3. Feasibility analysis of the CPDR baseline "Flex Mount" (CS-to-TF support)

The first two items were investigated with modifications to the ANSYS 2D axisymmetric structural model described in reference 1. The results are comparable to the nominal worst case load sets defined in reference 1. Detailed coil analyses and testing results based on reference 1 input remain valid.

A 3D ANSYS model was developed for item 3 and showed the feasibility of a radially compliant mount design that does not use sliding surfaces. The mount allows radial motion while restraining lateral and vertical motions.

II. Shipping and Handling Loads on the CS

The reference 1 model was modified by eliminating the CS-to-TF support and fixing the ends of the preload structure to simulate handling rings. Shipping and handling loads were applied as if the CS were horizontal. Loads applied were 2 g's "vertically" (perpendicular to the CS axis) and 0.5 g's "laterally" (along the axis). Note that in this configuration, the only support that the coils receive is at each end from the room temperature preload (resulting from the prestrain applied to the preload structure). The concern was that the coils may require some intermediate support. However, the results show that the deflection in the middle of the CS was only 0.7 mm.

III. Analysis Refinements

Reference 1 results were used as input to detailed coil models. Both interface forces and deflections were provided as boundary conditions to allow cross checking. The input forces should provide similar deflections in both models, however initial results did not match. The difference was likely due to stiffness differences between the two models caused by: a) the differences in coil sizes; and b) the force distribution within the coil. The detailed model

[1] Corpuz, A., "CS Preload and Worst Coil Loads", 7/17/95. 14-950717-WEC-ACorpuz-01

was not affected by these issues since it used the proper coil size and applied loading on a turn-by-turn basis. The following describes the investigation of these issues for the CS structural model.

The CS structural model utilized coil widths corresponding to seven conductors wide (the maximum width of a six-turn wide spiral wound coil). The smeared properties used in reference 1 were developed with a six turn wide aligned ("regimented") coil pack. This assumption had the effect of stiffening the coil which was conservative for the purposes of reference 1. The worst case load sets in reference 1 were repeated using a six-wide coil and the results are summarized below.

The model also used a simplified force distribution which only considered net forces. There are internal forces within each coil which are proportional to the square of the current and which tend to compress each coil. Both force components were included in a second set of runs. Net forces were evenly distributed and internal forces were distributed using an approximation developed by Krefta[2]. Results are also summarized below.

The third analysis refinement was to replace the angled support link with a vertical link mounted directly above the coil center. This is more representative of the CPDR baseline design. Results for all three refinements are shown in table 1. Load cases are from reference 1.

Table 1. Analysis Results Summary

Load Case	Ref 1	7 to 6 Wide Coils	Add Internal Forces	Change to Vertical Link
• Room temp. preload	9.39	8.54	same	
• RT preload + cooldown	14.83	13.51	same	
• Min interface force	5.12	3.85	2.70	2.71
• Max radial fault load	4.36	4.27	4.81	4.79
• Max radial normal load	1.39	1.30	1.37	1.37
• Max compression	31.33	29.74	28.22	28.21

As could be expected, room temperature preload was lower for the same initial prestrain. The minimum interface load (from the max separation load case) also decreased. The ratio of radial to vertical load thus increases to 0.98/2.7 = 0.36 (minimum coefficient of friction required). The worst case maximum compression also decreases. In general, results are comparable with previous analyses. Detailed coil analyses and testing results remain valid.

The max vertical body force case was also run. As expected, the loads decreased as a result of changing to a vertical link. The CPDR baseline CS support approximates a vertical link

[2] Krefta, M., "Approximate expressions for internal EM forces acting throughout PF coil packs", 6/26/95, TPX.STC.MPK.STC.PS.M013.06.29.95

compliant in the lateral direction (without using sliding surfaces) while still providing resistance to lateral and vertical motions.

IV. Flex Mount Feasibility Analysis

A 3D ANSYS model of the flex mount was developed and is shown in figure 1. Differential lateral deflections were applied between the flex mount support (at the TF structure) and the hanger rod (attached to the top of the CS preload structure). Deflections of 0, 1.5, and 3 mm were applied. The 1.5 mm value is approximately the amount resulting from differential thermal contraction between the CS and TF. Note that this is conservative since the mount will likely be installed in the offset position and contract to near vertical.

The flex mount must be flexible in the lateral (radial) direction while surviving large vertical loads. The vertical body force on the CS resulting from EM loads is much larger than gravity loading. The mount is oriented as shown since the vertical upward load is larger than the vertical downward load (3.72 MN vs. 2.87 MN, respectively, total for the CS). The downward load is still significantly greater than gravity and would tend to make the mount buckle. For this analysis, the loads applied were the CS total vertical body load divided by 8 supports and multiplied by a 1.1 assumed load factor to account for uneven load sharing.

A nonlinear plastic analysis was performed and the results are shown in figure 2. There are actually three curves on the figure (corresponding to the three deflections) which lie almost on top of each other. The results show that the design meets the buckling safety factor. Figure 3 shows the load at the TF structure for the various deflections and both upward and downward loads. The results show that the loads are a low 16 KN at 1.5 mm differential and do not vary significantly over the loads and deflections examined.

Lateral loading was also applied in the direction perpendicular to the mount, simulating a seismic event in which the mount was loaded in parallel with the flex plates. The mount survived this event, performing its function of providing lateral restraint. However, additional work needs to be performed to optimize this design. Deflections in the rod were larger than anticipated. The rod diameter can be increased so that its stiffness relative to the plates is greater which would decrease deflections.

In conclusion, the flex mount has been shown to be a feasible design concept.

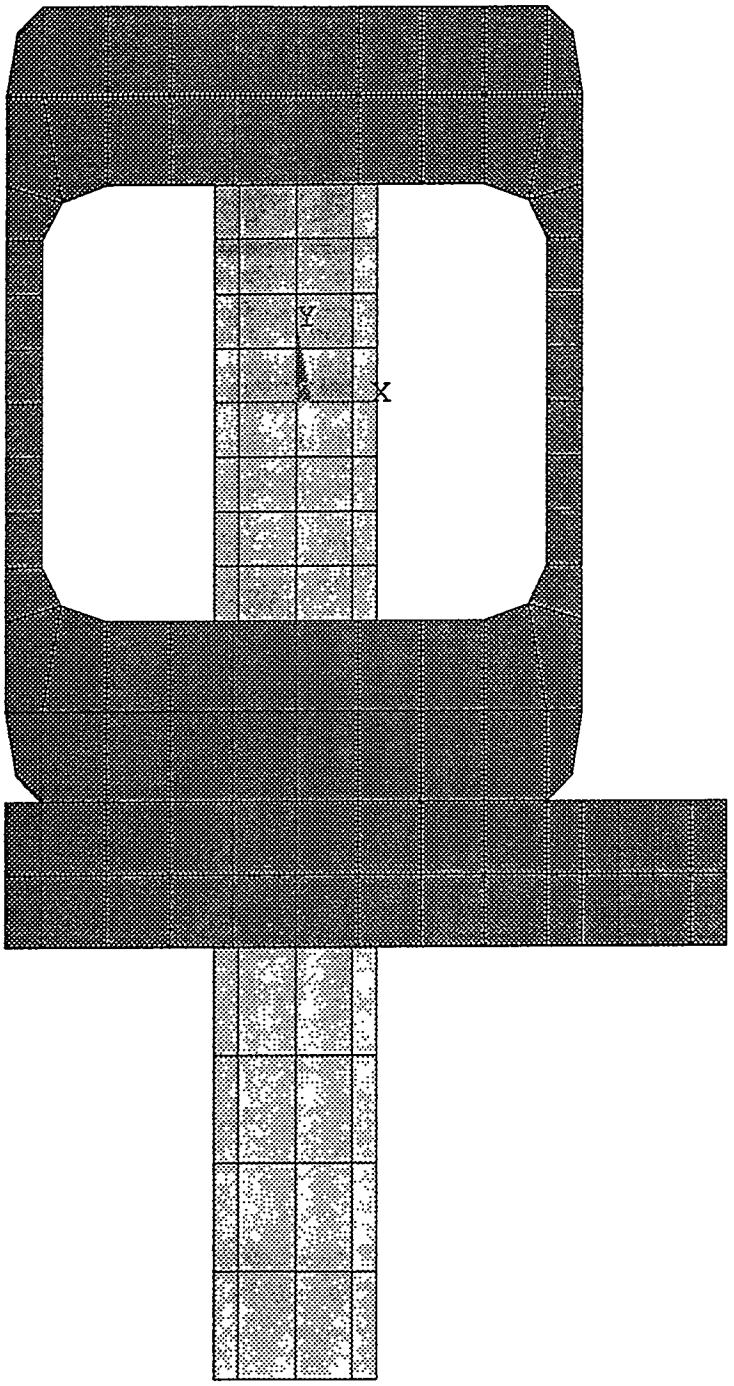


Figure 1. Flex Mount 3D ANSYS Model

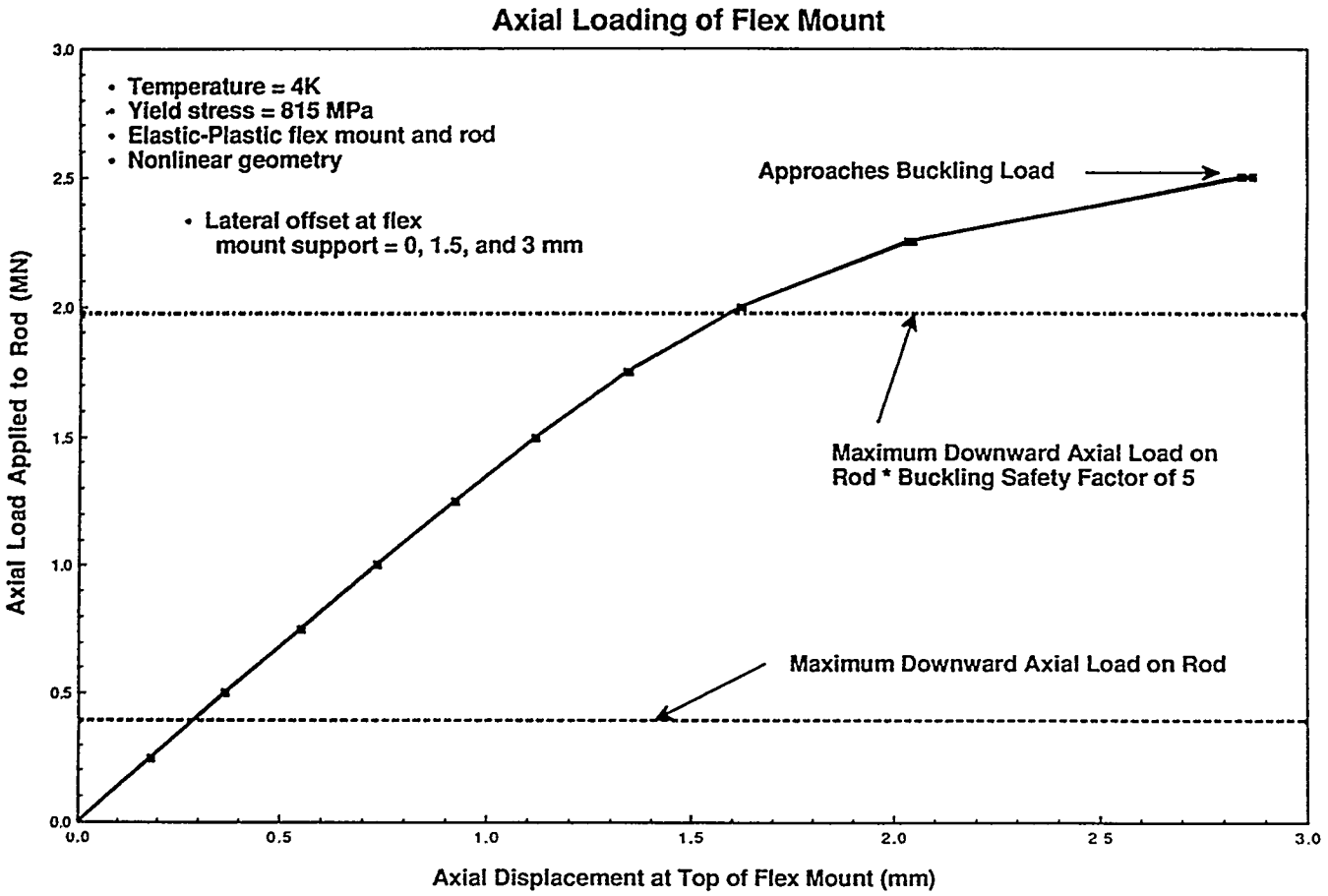


Figure 2. Flex Mount Buckling Analysis

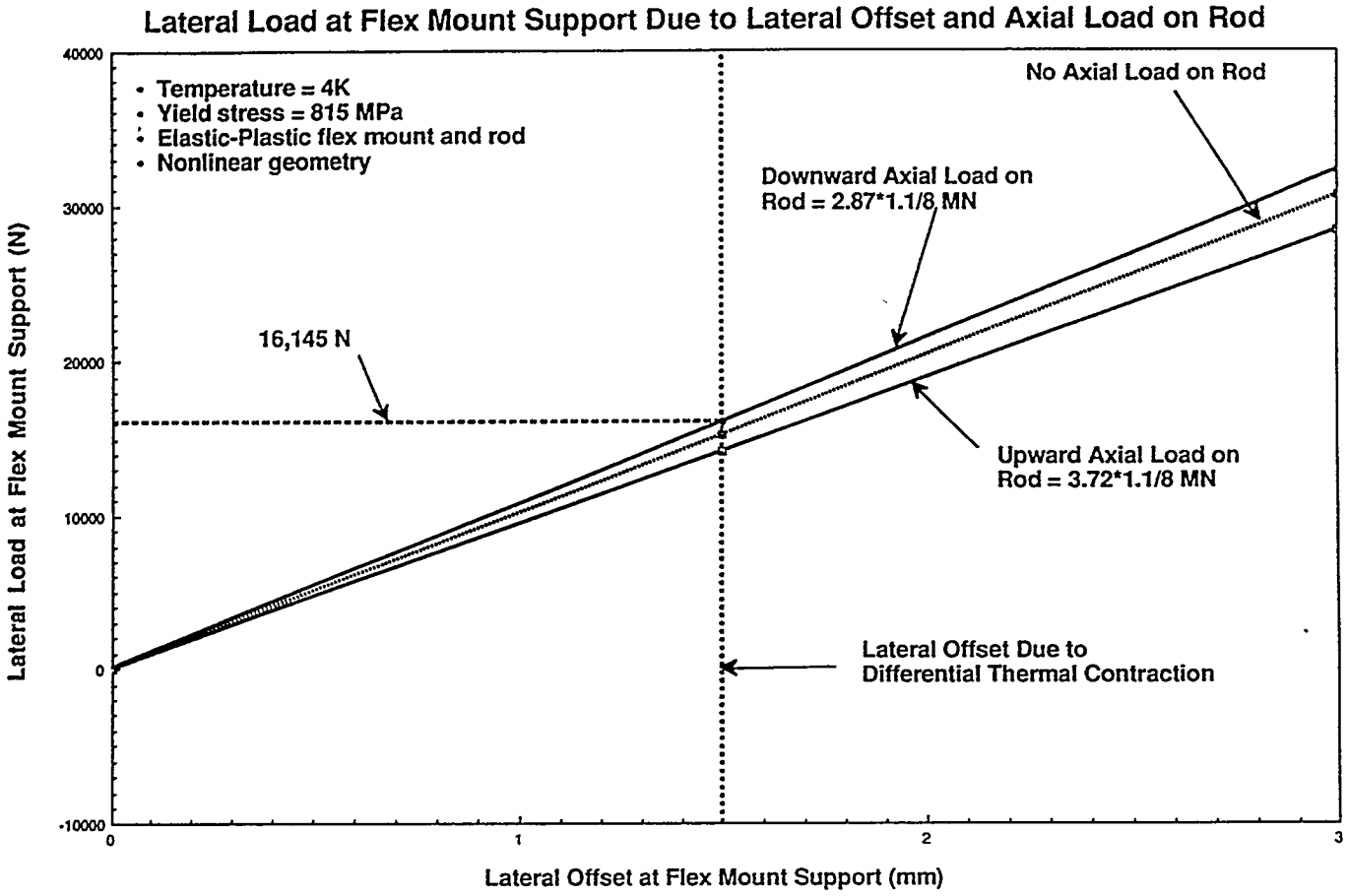


Figure 3. TF Structure Loading.

TPX PF 1 - 4 Coil Pack Structural Analysis

W. F. Hannon, J. Hillenbrand, and P. A. Sanger
STC Advanced Electromechanical Systems Department

August 8, 1995

TPX 14-950801-WEC-WHannon-01

APPROVED:

P.A. Sanger
Westinghouse TPX Chief Scientist

APPROVED:

D. R. Potter
Westinghouse TPX Engineering Manager

Westinghouse Electric Corporation
Electronic Systems Group

401 East Hendy Avenue, Sunnyvale, California 94088-3499

CONTENTS

LIST OF FIGURES vi

LIST OF TABLES vi

ABSTRACT viii

1. INTRODUCTION 1-1

2. FINITE ELEMENT ANSYS MODEL OF THE TPX CDR BASELINE CS COILS .2

2.1 CDR BASELINE MATERIAL PROPERTIES 3

2.2 MODELING PARAMETERS FOR THE CDR BASELINE DESIGN 3

2.3 RESULTS OF THE FEA ANALYSIS OF THE CDR BASELINE DESIGN 7

3. ANALYSIS OF THE CPDR BASELINE DESIGN 13

3.1 DESIGN CHANGES AND DESIGN PHILOSOPHY FOR THE DEVELOPMENT OF THE CPDR BASELINE 13

3.2 NEW CPDR MATERIAL PROPERTIES 14

3.3 THE CPDR ANSYS MODEL 17

3.4 DETERMINATION OF THE LOAD CASES 18

3.5 RESULTS OF FEA ANALYSIS OF THE CPDR CS BASELINE DESIGN 20
3.5.1 Conduit Wrap 21
3.5.2 Corner Filler or Roving 21
3.5.3 Spacer Block 22
3.5.4 Ground Wrap 22

4. COMPARISON OF THE CPDR BASELINE DESIGN WITH THE TPX DESIGN CRITERIA 24

4.1 SHEAR STRENGTH AS FUNCTION OF COMPRESSION AND TENSILE LOADING 25

4.2 ESTIMATE OF INSULATING MATERIAL PROPERTY LIMITS 27

4.3 INSULATION SHEAR UNDER COMPRESSION AND THROUGH THICKNESS TENSION 28
4.3.1 Insulation Compressive Stress 32

5. CONCLUSION 33

APPENDIX A A-1

APPENDIX B B-1

APPENDIX C C-1

ABSTRACT

This report presents the results of the finite element analysis of the TPX CS winding pack for the CDR and CPDR designs. Models were constructed and analyzed using ANSYS and give the stress fields for the conduit, conduit wrap, corner fillers, transition pieces and the ground wall insulation. For the CDR design, unacceptable shear and through thickness tensile stresses were found. Only 61% of the area of insulation passed the shear stress design criteria with 56% of the area experiencing through thickness tension, two thirds of which exceeded 50 Mpa. These stresses were driven by, in order of importance, the anisotropic properties, principally thermal contraction and modulus, of the insulating components, the thermal contraction mismatch between the Incoloy 908 conduit and the insulating system, and the concave deformation of the conduit under load. To improve the design, glass weaves providing more through thickness fibers were developed to better approach isotropic properties and reinforce the corner fillers against tension. The shear properties of the glass/epoxy components were measured both in compression and in tension. Finally a non-bonded insulation to conduit interface (also known as "slip plane") was adopted. The results are as follows:

1. 99.87% of the conduit wrap passes the design criteria.
2. 100% of the ground wall insulation passes the design criteria.
3. The corner fillers are still under very high combined tensile and shear stress with only 36% passing the criteria.
4. 4.90% of the transition pieces/spacer blocks pass the criteria.

Further work should be directed at stronger reinforcement of the corner fillers increasing the glass in the tips of the fillers from 1-2% to 10-12% and increase the through thickness glass of the spacer blocks particularly at the edges to reduce the stresses at the interface with the other insulating components.

1. INTRODUCTION

The primary tasks of this analysis are to determine the structural characteristics of the CS coil, to determine the component stresses expected to exist under a range of different operating scenarios, to utilize this analysis to guide design changes that improve performance and reliability and to assess this design relative to the requirements and the TPX design criteria.

The design of the TPX CS coils will be presented as it existed at two specific times. The starting point for this analysis is the coil design presented at the Conceptual Design Review (CDR). This configuration is referred to as the CDR Baseline Design. Subsequently the design was modified as a result of this analysis as well as the insulation R and D program particularly the 3x3 test results. These changes are embodied in the new baseline design for the Contractors Preliminary Design Review (CPDR) and is referred to as the CPDR Baseline.

This report presents the analysis by first describing the model used for both designs including the assumptions, boundary conditions, and material properties used, followed by the evaluation of both designs and finally an assessment of meeting the design criteria requirements.

2. FINITE ELEMENT ANSYS MODEL OF THE TPX CDR BASELINE CS COILS

There are four pairs of CS Coils. The drawings that define the coils are drawings TPX-E-1421-003 PO, PPL.LM.TPX.E-1425001, and PPL.LM.TPX.E-1426001. These drawings depict the spiral nature of the conductors, and show their placement within a coil. PF1 has 20 coil layers of 6 coils per layer. This will be referred to as a 6x20 coil buildup within this report. PF2 has a 6x16 coil buildup, and PF3 and PF4 both have a 6x10 coil buildup. The internal structure of all the CS coils is the same except for the variation in the number of coil layers.

The radial position of the conductors vary depending on the circumferential angle that is considered due to the continual spiral introduced to each conduit layer and 45 degree pancake to pancake rotations. The spirals occur in opposing pairs, with a clockwise layer following a counterclockwise layer. If we consider the relative placement that occurs between two conduit layers that are adjacent to each other but in different layers, we can find a variation in their relative positioning as we advance about the coil circumference. The coils will be aligned atop one another at one circumferential position, and they will move astride each other as the position changes. A 6x10 coil cross section was chosen to be fully modeled, since this represents either a PF3 or 4 and was expected to be the location of the highest stresses. A cross sectional cut was made in the coil at an angle of zero degrees as defined on drawing PPL.LM.TPX.E-1425001. This staggered geometry is chosen as representative of the relative conduit placement, and includes layers that align with each other, and layers that are misaligned to various degrees adequately capturing the effects of conduit stagger. Subsequent review of the stress plots suggest that this is the case.

2.1 CDR BASELINE MATERIAL PROPERTIES

The insulation materials used in the coil construction are orthotropic meaning that they have material properties that differ along each major axis. This is accounted for in the model by setting up proper element coordinate systems. The convention used is that the element X coordinate axis will always represent the through thickness normal direction. This corresponds to the fill direction in composite terminology. The z direction is always along the path or length of the conductor. The values used in the analysis of the CDR Baseline are taken from the report titled 'Preliminary Structural Evaluation of the (February '94) TPX TF Coil System" (13-940610-MIT/LMyatt-01) and shown in Table 1.

Table 2.1 - CDR CS Coil Material Properties

Material	Shear Modulus	Young's Modulus Transverse	Young's Modulus Longitudinal	Thermal Exp. Coef. Transverse	Thermal Exp. Coef. Longitudinal	Poisson Radio
Incoloy 908	71 GPa	184 GPa	184 GPa	5.56e-6/K	5.56e-6/K	0.299
316LN	81 GPa	205 GPa	205 GPa	10.3e-6/K	10.3e-6K	0.265
Conduct Wrap & Sheet Insul	11 GPa	22 GPa	33 GPa	24.8e-6/K	8.4e-6/K	0.21

2.2 MODELING PARAMETERS FOR THE CDR BASELINE DESIGN

The finite element model is axisymmetric, and as such, it doesn't account for non-axisymmetric effects or angular variations that arise from the spiral of the conductors. It is felt that the shallow spiral will not compromise this axisymmetric assumption. The spiral displaces the conduit radially by 23.93 mm (0.942 inch) over an arc of 315 degrees, and, since the average radius of a coil is given as 811.3 mm (31.94 inches), the spiral radius changes 24 mm over a distance of 2.2 m. The spiral is angled by only 0.6 degrees (0.01 radian) compared to the tangent of a circle

an arc of 315 degrees, and, since the average radius of a coil is given as 811.3 mm (31.94 inches), the spiral radius changes 24 mm over a distance of 2.2 m. The spiral is angled by only 0.6 degrees (0.01 radian) compared to the tangent of a circle centered about the coil center. This angle is believed to be small enough to justify the simplification to predict the stress behavior using axisymmetric elements.

The construction of the CDR Baseline coil starts with a cable in conduit (CIC) conductor that utilizes an Inconel 908 conduit about a superconducting cable. The cable is composed of 405 strands of 0.031 diameter (0.787 mm) Nb_3Sn encased in a nominally square Incoloy 908 Sheath. The Incoloy sheath is 0.095 inch (2.41 mm) thick (Drawing TPX E-1421005) The superconducting cable has a void fraction of approximately 38%, and is not expected to contribute significantly to the overall structure of the CS Coils. The cable is left out of the FEM Model entirely in these early investigations, and is only added at a later stage of the analysis in order to facilitate transfer of the electromagnetic loads to the structural model (reference 14-950630-WEC-MKrefta-01) The conduit is covered with a 0.81 mm (0.032 inch) insulating glass tape wrap. There is a 0.41 mm (0.016 inch) G11 spacer positioned between the cables in both the horizontal and the vertical directions. The rounded corners of the conduit introduce a void space that is filled with a roving material. The coil is vacuum impregnated to exclude void areas in the insulation system, and to achieve the structural integrity required.

The first step in building the finite element model is to define areas to represent each of the separate components. The use of an area as a primitive within ANSYS allows the default element size used in mesh generation of the model to be easily varied if necessary. The area buildup of one cable is shown as Figure 2-1.

This pattern is repeatedly translated and duplicated in order to represent a 6x10 coil buildup. This is accomplished by defining an array to describe the radial offset of each layer. Parameters are used to set the number of conduits per row, and the number of rows. This allows us to translate and duplicate the basic conduit pattern to represent any CS coil buildup at any circumferential location. The pattern results in overlapping nodes occurring between radially adjacent areas, but

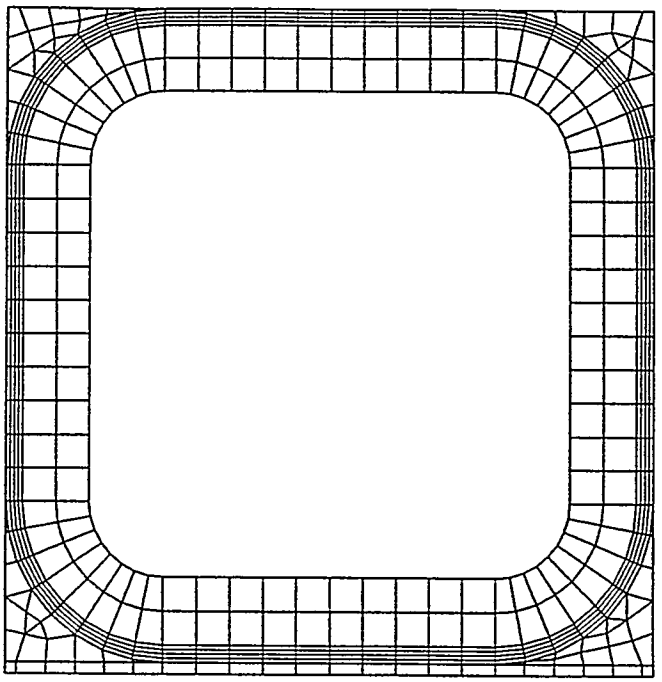


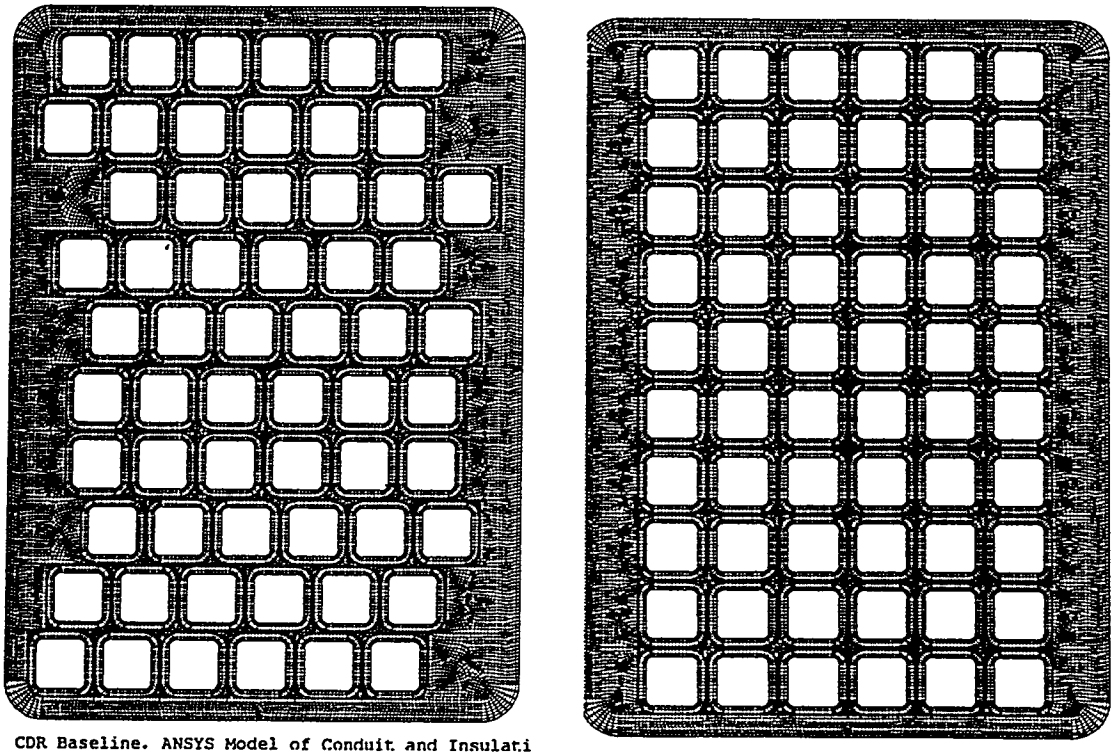
Figure 2-1 — Modeling mesh and the conduit, wrap, and roving pattern of a single conductor used to build the CS CDR FEM Model.

leaves a 0.41 mm (0.016 inch) gap to be filled with a G11 barrier between layers. The overlapping nodes are merged together. The 0.41 mm (0.016 inch) gap is filled with a continuous G11 barrier by creating an area using the perimeter nodes about this region. This effectively 'glues' the layers together resulting in a model with common nodes between adjacent areas, a model without 'seams' or gaps. The next step is the definition of the areas representing the spacer blocks. The last step is the addition of the 7.65 mm (0.301 inch) thick ground wall insulation.

The CDR model consists of 44355 nodes and 43067 elements and represents a moderately large sized ANSYS model. The construction of a three dimensional model with similar element feature sizing would increase the modeling complexity to such an extent as to overwhelm our computer capacity. The two ANSYS models of the CDR Baseline CS Coil with and without conduit stagger are shown as Figure 2.2.

The modeling of the CS coils involved several compromises in order to achieve a model that represents the final equipment while having adequate detail to avoid a model that could easily become so large as to exhaust computer resources. The

model as constructed has eight divisions along each conduit corner. This is repeated along the corners for the two conduit wrap layers that are local to the conduit. This imposes a reasonable aspect ratio on the brick elements that occur in an area of the model where peak stresses might be expected. The rest of the model uses a default element size of 1.27 mm (0.050 inch) during the element creation stage. This results in an element size within the flat portion of the conduit of 1.27 mm x 1.14 mm



. CDR Baseline. ANSYS Model of Conduit and Insulati

Figure 2.2 - The ANSYS Model used to describe the CS Aligned and Staggered Coil Construction.

(0.050" x 0.045). The model uses ANSYS element type 42 four node brick elements with the axisymmetric option enabled since there exists a complimentary electromagnetic ANSYS element and we anticipated complications would occur if we used a higher order element for the structural analysis than was available for the electromagnetic analysis. The default element size is 1.27 mm (0.050 inch), with the turn wrap divided into layers 0.008 inch (0.20 mm) thick. The model has elements with satisfactory shapes and aspect ratios except for the shallow triangular

elements formed in the roving material. The geometry of the roving is such that it is difficult to avoid an ill shaped element at the point where the conduit radius meets a line tangent to it. The model as shown is believed to be a reasonable choice. The peak stresses predicted in these long, thin roving triangles may be suspect.

The result is a moderately large ANSYS Model. The steering file used to create this model can be found in Appendix A and is called "srcs10.str". This file is used to create an ANSYS database file that holds the geometric and the material properties of the Finite element model. Each load case is defined with a steering file that specifies the operational temperature difference, the pressure applied at the top or bottom surface, the displacement of the top surface relative to the bottom surface, or the imposition of an Electromagnetic load as determined with a magnetic model built up from this structural geometry. The resulting force created by the nodal displacements was determined and saved to disk. Stress plots were produced, along with an estimate of the area that might fail the existing design criteria.

The CDR Baseline stress analysis started by considering the mechanical preload stresses in a CS coil when subjected to a 20 to 25 MNt preload. This was a relatively predictable loading, and it allowed us to begin creating the model as simply as possible. The intent was to determine the extent and magnitude of the thermal stresses, add the purely mechanical loading, and then add the electromagnetic loading to achieve the full operational range of the stresses. The preload level was provisionally chosen at 25 MNt based on the CDR work. The actual value was to be later optimized, and the stress results were to be modified accordingly.

2.3 RESULTS OF THE FEA ANALYSIS OF THE CDR BASELINE DESIGN

The load cases performed for the CDR Baseline were presented at the January 1995 TIM. The first series of runs were directed at separating the various overlapping effects of cooldown, preload and the effect of staggered vs. aligned conduit array. The preloadings were achieved by constraining the nodes at the top of the model in the Y direction. The nodes at the bottom were forced with an upward deflection an amount expected to result in a 25 MNt preload. The

differences in the constituent material properties and the aligned or staggered placement of the conduits resulted in differences in the achieved preload level. However the preload levels attained were close enough to the desired load levels for the investigation underway, and further iteration was not done for the CDR cases. The results for the CDR baseline case after cooldown, and with a 25 MN preload are summarized in Table 2-2. Typical property limits for through thickness tension and shear are both approximately 50 Mpa without the benefit of compressive loading to improve the shear stress. Therefore, with the through thickness stress approaching 140 Mpa and insulation shear stresses exceeding 100 Mpa, more detailed analysis was indicated.

The second series of runs used the following variations to explore the drivers in reducing these stresses and achieving the design criteria: a) artificially reducing the modulus of the Incoloy 908 conduit to zero so that internal stresses in the insulation system would be accentuated, b) replace the entire insulation matrix with an isotropic loaded epoxy-based putty with a thermal contraction similar to copper, and c) replace the Incoloy 908 with Type 316 stainless steel. All of these runs were performed for cooldown alone. A final run was made using a 316 stainless steel conduit with an isotropic insulation matrix and applying both cooldown and preload. The stresses of these runs have been evaluated against the design criteria and the percentage of the cross section passing the criteria for shear are shown in Table 2-3. The following conclusions are supported by these results:

1) The anisotropic modulus and thermal contraction of the glass/epoxy composite generates internal stresses from cooldown accounting for approximately 50% of the stress, primarily shear.

2) Thermal contraction mismatch between Incoloy 908 and the insulation matrix accounts for approximately 30% of the insulation stresses.

3) The concave deformation of the sheath under compressive loads accounts for the remaining 20% of the problem being the primary source of through thickness tension.

In addition, possible directions to be pursued were identified that could offer significant reduction in stresses. As a result of a focused development test program

supported by basic material measurements and FEA analysis, a new set of insulation materials and insulating approach was chosen for the CPDR design baseline. A description of the insulation system and the ramifications it has on the ANSYS modeling efforts will be described in the following sections.

Table 2-2. TPX CS Stress Analysis of the CDR Baseline-Peak Stress Summary

ALIGNED ARRAY

		Cooldown 908 Conduit Aligned	Cooldown Preload @ 25MNT 908 Conduit Aligned	Cooldown No Conduit Aligned	Cooldown 908 Conduit Isotropic Mat'l Aligned	Cooldown Isotropic Ins Mat'l 316LN Conduit Aligned	Cooldown Preload @ 27 MNt 316LN Conduit Aligned
		(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)
Conduit	SX	-307	-256		-173	-9	-127
		263	149		121	12	161
	SY	-494	-516		-232	-5	-378
		103	12		65	17	9
	SZ	-224	-205		-130	0	-97
		56	39		4	9	87
	SXY	-245	-250		-122	-9	-147
		245	249		122	9	147
	SINT	523	543		253	18	372
Insulation Material	SX	-101	-140	-44	-42	-2	-117
		133	141	127	32	3	27
	SY	-101	-144	-154	-39	-2	-82
		133	118	110	36	3	25
	SZ	0	-2	-34	14	-2	-55
		134	127	118	34	-1	16
	SXY	-74	-97	-35	-25	-2	-54
		74	97	38	25	2	54

STAGGER ARRAY		Cooldown 908 Conduit	Cooldown Preload @ 22MNt 908 Conduit	Cooldown No Conduit	Cooldown 908 Conduit Isotropic Mat'l	Cooldown Isotropic Ins Mat'l 316LN Conduit	Cooldown Preload @ 26 MNt 316LN Conduit Staggered
		(MPa)	(MPa)	(MPa)	(MPa)	(MPa)	(MPa)
Conduit	SX	-436	-331		-8	-195	-180
		299	300		14	112	227
	SY	-605	-642		-6	-211	-428
		345	237		15	86	19
	SZ	-282	-245		0	-127	-127
		77	81		9	1	96
	SXY	-328	-304		-7	-123	-155
		234	284		9	101	174
	SINT	673	633		18	249	427
Insulation Material	SX	-101	-145	-95	-2	-34	-124
		139	148	168	2	35	36
	SY	-167	-229	-180	-3	-31	-107
		215	1992	256	2	38	33
	SZ	-12	-50	-44	-2	0	-43
		70	70	62	0	31	13
	SXY	-96	-108	-63	-2	-29	-67
		90	103	75	2	29	71

Configuration	Load Condition	Pass Shear Margin	Pass Normal Tensile Stress at 1 MPa	Pass Normal Tensile Stress at 10 MPa	Pass Normal Tensile Stress at 20 MPa	Pass Normal Tensile Stress at 30 MPa	Pass Normal Tensile Stress at 40 MPa	Pass Normal Tensile Stress at 50 MPa
ALIGNED ARRAY								
Conduit Mat'l 908	Cooldown	66%	44%	59%	63%	66%	67%	69%
Conduit Mat'l 908	Cooldown, 25 MNt Preload	61%	56%	59%	67%	67%	68%	69%
No Conduit	Cooldown	85%	66%	68%	69%	72%	80%	88%
Conduit Mat'l 908,Isotropic Insulation	Cooldown	100%	49%	68%	88%	99%	100%	100%
Conduit Mat'l 316LN,Isotropic Insulation	Cooldown	100%	85%	100%	100%	100%	100%	100%
Conduit Mat'l 316LN,Isotropic Insulation	Cooldown, 27 MN Preload	97%	54%	83%	100%	100%	100%	100%
STAGGERED ARRAY								
Conduit Mat'l 908	Cooldown	64%	48%	59%	63%	66%	68%	68%
Conduit Mat'l 908	Cooldown, 22 MNt Preload	59%	58%	65%	67%	68%	68%	69%
No Conduit	Cooldown	78%	64%	68%	69%	70%	74%	80%
Conduit Mat'l 908,Isotropic Insulation	Cooldown	100%	93%	100%	100%	100%	100%	100%
Conduit Mat'l 316LN,Isotropic Insulation	Cooldown	100%	57%	70%	86%	100%	100%	100%
Conduit Mat'l 316LN,Isotropic Insulation	Cooldown, 26MN Preload	94%	75%	90%	98%	100%	100%	100%

Table 2-3. CDR Stress Analysis, Percentage of the Model Area That Passes the Design Criteria

3. ANALYSIS OF THE CPDR BASELINE DESIGN

3.1 DESIGN CHANGES AND DESIGN PHILOSOPHY FOR THE DEVELOPMENT OF THE CPDR BASELINE

The new CPDR baseline is described in the Winding Pack Design Report and thus will not be repeated here. However the development of the new baseline incorporated several features that significantly impacted the FEA modeling:

1) The G11 barrier between pancakes was removed in order to simplify the manufacturing process and because it was not necessary for the insulation integrity. This barrier however provided convenient hooks for the FEA model of the staggered baseline coil array. Extensive reconfiguring was required to circumvent the lack of this foundation.

2) In the new baseline kapton film is wrapped around the conductor as the primary insulating barrier. This wrapped insulation is not bonded to the conduit and is sometimes referred to as a "slip plane" or "non-bonded" configuration. This design change effectively eliminates tension on the conduit wrap insulation due to buckling of the conduit under compressive loads. In practice, we would expect significant friction between the kapton and the conduit against movement along the direction of the conductor due to the thermal mismatch and the loadings. However the friction factor to be used is open to conjecture and leads to a large uncertainty. In addition the size of the models and their running times would be excessive if friction factors were included. For the purposes of this analysis the CPDR model assumes zero friction or perfect slip.

3) Glass tapes and preforms were designed to better approach isotropic mechanical properties. The term "3D" has been used by the project to describe these weaves. For the tapes, more glass was needed in the direction of the tape thickness to reduce the thermal contraction and increase the modulus of the glass composite

For the corner fillers, reinforcement in the through thickness direction was needed. The impact to the model comes about in the material properties which have gone through several revisions in the past six months. The high stresses in the insulating materials have placed a stronger emphasis on refinement and confirmation of material properties and the present analysis indicates a high sensitivity to the property values still remains.

Besides the impact to the modeling itself, the high stresses in the CDR design also forced a different approach to the design assumptions used. For the CDR evaluation simplifying and conservative approaches were taken. Conservative design assumptions for the loading conditions were taken in CDR baseline evaluation. For example, all of the worse case EM loadings that occur in the CS coil array were applied to the one 6x10 array even though they may not have occurred simultaneously in time or in the same location or coil. The establishment of the preload was not optimized. Conservative assessments were made of the number of cycles on which to base fatigue life. In the light of the high insulation stresses, analyses were refined to remove cascading conservatism and the following changes were implemented:

1. Detailed structural analyses were expanded from the one accumulative loading case on the 6x10 array to the four worse coil loading on the specific coils in which they occur.

2. Using smeared properties, design optimization of the CS structural system and the preloading was completed (reported in the CS structural report).

3. A detailed analysis was performed on the temporal dependence of the CS loading profile using a rainflow counting method (14-950621-WEC-JHillenbrand-02)

3.2 NEW CPDR MATERIAL PROPERTIES

An expanded material property database was needed to support the analysis. Where possible, limited testing was performed to indicate the appropriate range for the properties. However in most cases, the properties were estimated based on existing data on similar materials. The insulation material properties that resulted and the process used for their estimation are given in 14-950605-WEC-FRoach-01

"Revision of Mechanical Properties Matrix of Insulation Materials for Structural/Thermal Analysis". It is included here as table 3-1. At first glance it would appear that the improvement in properties between the 2D glass designated as "conduit wrap" and "roving corner fill" and the new 3D weave and corner fill was minimal. However it must be recognized that the values taken for the 2D glass represent early estimates based on G11 properties and that were clearly not realistic for the configurations that the design was using. The most glaring example of this disconnect is in the CDR baseline roving corner fill where straight glass fibers along the axis of the conduit or z axis were placed in the corner gaps. No weaving was envisioned and thus glass in the x or y direction was not foreseen. Clearly the thermal contraction in the x or y direction for that case more closely approaches that of pure resin and certainly is not expected to be lower than high pressure laminate.

An important material property that the experimental program sought to improve was the shear strength under compressive loading and the through thickness tension for the glass composites selected in the CPDR design. The results of these measurements are described in 14-950718-WEC-PSanger-01 and are incorporated in the evaluation of the design with respect to the design criteria in the last section of this report. As will be seen later, the shear strength and tensile strength of the 3D corner fillers have not been measured. Very high tensile, compressive and shear stresses are being applied to this location. Development of an appropriate measurement technique is required for this component whose geometry will pose a challenge to any characterization testing program.

Table 3-1 TPX CPDR Material Property Data Base (4K) for use in Finite Element Modeling
(Superscripts are refer to references)

Material	E_x [GPa]	E_y [GPa]	E_z [GPa]	α_x [μ/K]	α_y [μ/K]	α_z [μ/K]	G_{xy} [GPa]	G_{xz} [GPa]	G_{yz} [GPa]	υ_{xy}	υ_{xz}	υ_{yz}
316LN SS	207[16]	207[16]	207[16]	10.4[16]	10.4[16]	10.3[1]	81[2]	81[2]	81[2]	0.282[2]	0.282[2]	0.282[2]
Incoloy 908	185[1]	185[1]	185[1]	5.92[16]	5.92[16]	5.92[16]	71[2]	71[2]	71[2]	0.299[2]	0.299[2]	0.299[2]
Conduit Wrap	19.7[1]	29.6[1]	29.6[1]	19.9[1]	6.7[1]	6.7[1]	7.6[3]	7.6[3]	10.7[3]	**0.26**[4]	**0.26**[4]	**0.26**[4]
Ground Wrap	19.7[1]	29.6[1]	29.6[1]	19.9[1]	6.7[1]	6.7[1]	7.6[3]	7.6[3]	10.7[3]	**0.26**[4]	**0.26**[4]	**0.26**[4]
Roving Corner Fill	19.7[1]	19.7[1]	29.6[1]	19.9[1]	19.9[1]	6.7[1]	**7.6**[4]	**7.6**[4]	**7.6**[4]	**0.26**[4]	**0.26**[4]	**0.26**[4]
HP Laminate (G11)	24.0[1]	35.0[16]	37.0[16]	24.9[1]	8.3[1]	8.3[1]	8.2[16]	9.7[16]	11.6[3]	**0.26**[4]	0.25(zx)	0.26[3]
Resin	8.0[16]	8.0[16]	8.0[16]	40[1]	40[1]	40[1]	2.9[16]	2.9[16]	2.9[16]	0.4[16]	0.4(zx)	0.4[16]
3D Weave (See notes 14,15)	23	32	25	19.2	8.25	16.2	8 (yx)	8	8 Av zy&yz	**0.26**	0.37 (zx)	0.35(zy) 0.25(yz)
3D Corner Fill (See notes 14,15)	22	25	31	20.3	16.2	7.56	8.5[11]	9 (zx)	8 Av zy&yz	**0.26**	0.38 (zx)	0.23(zy) 0.36(yz)
Araldite at 296K	18[8]	18[8]	18[8]	10[8]	10[8]	10[8]	6.9[5]	6.9[5]	6.9[5]	**0.3**	**0.3**	**0.3**
Kapton	4.8[12]	5.5[12]	5.5[12]	43.2[13]	13.0[10]	15.8[10]	0.37[10]	0.37[10]	0.37[10]	0.34[9]	**0.34**	**0.34**
SC Cable	0.6[7]	0.6[7]	60[7]	7.24[7]	7.24[7]	7.24[7]	0.23[5]	0.23[5]	0.23[5]	**0.3**[4]	**0.3**[4]	**0.3**[4]

3.3 THE CPDR ANSYS MODEL

The introduction of a kapton wrap about the Incoloy 908 conduit introduces a theoretical slip plane into the finite element model rendering the model non linear. The choice was made to consider only a friction coefficient of zero. This is expected to yield conduit stress values that will be higher, and should provide the 'softest' coils as compared to those with non zero friction coefficients and without slip planes. Friction is not expected to significantly affect the through thickness tension values. Future work must assess the impact of cyclic loading on locking in stresses into the winding pack as a result of this friction and on degrading the insulation by fretting.

The CPDR ANSYS model is built similarly to the CDR Model. The kapton wrap is added to the conduit, leaving a small gap (0.0025mm) to accommodate the gap elements. The 3D wrap layer is added next, then the roving. This pattern is translated and replicated forming the 6x10 array. At this point co-linear groups of nodes are aligned along the lines forming the layer boundaries. Half of the co-linear nodes belong to the lower conduit layer group and half belong to the top grouping. The nodes are at element edges, and these don't align. These disjointed nodes will cause difficulties as they form gaps that will not exist in the coil. The following procedure was used to achieve a properly joined model.

The lines forming the layer boundary were determined using their Y location. The areas that contain these lines were selected and cleared of their previously meshed elements. The ANSYS "area glue" command was invoked to build areas sharing common nodes. Of these areas, the 3D conduit wrap areas were reassigned their proper element coordinate systems and material type and then were meshed. The same was true for the roving material areas affected. The remaining model features are the same as the CDR model previously described.

The gap elements created between the conduit nodes and the kapton wrap nodes used ANSYS Type 52 elements which are 3D gap elements. They are used since the equivalent 2D elements require a convoluted method to assure that coordinate orientations are input, and this occurs automatically with the 3D elements. The use of a 3D element triggers another degree of freedom within the

entire model. The computational time was reduced by constraining all the nodes in the Z coordinate direction. The steering files needed to perform this analysis and runs the cases described in the next section are included in Appendix B.

The major difficulty in using the 3D gap elements is the determination of a contact stiffness. This stiffness should be the highest possible while allowing the model to converge. Hopefully this stiffness will be sufficient to prevent deflecting elements to overlap adjacent components, clearly a violation of the physical case. Using the recommended approach defined by ANSYS, a stiffness of 5e11 was selected as a starting point. This suggested value caused an ill conditioned matrix to occur and it failed to converge. The stiffness value was relaxed until a converged solution occurred. This value was at 5e10. The model was checked for overlapping components and none were found. This contact stiffness was successfully used for a time until during the investigation of the various worst case EM Loadings, a model failed to converge. The contact stiffness was relaxed to 1e10, and this value was used for the remaining investigations. The only load case using the 5e10 value is the worst case radial fault case, all others were rerun with the value of 1e10.

3.4 DETERMINATION OF THE LOAD CASES

The large number of operational modes of the TPX Magnet system, and most particularly the PF magnet system, could create a large number of cases to be structurally evaluated. In order to limit the scope of the mechanical investigation, the number of loadings were reduced to four worse case loading conditions. This process of culling and identification of the most severe loading cases is separately reported in 14-950707-WEC-MKrefta-01.

The specific electromagnetic load cases investigated are as follows:

- Max. Vertical Compression from Equilibria 16 on PF1L
- Max. Radial Operational Loading from Equilibria 1 on PF3U
- Max. Radial Operational Loading with Radial Shear Load from Equilibria 1 on PF3U
- Maximum Radial Fault from Equilibria 1 on PF3U

Furthermore additional cases were required to establish the actual cyclic loading. These cases were:

- Cooldown from the epoxy glass transition temperature of 100C to room temp
- Cooldown from room temperature to 4K
- Cooldown from the transition temperature to 4K with a preload of 11 MNt

This family of loadings was determined to be useful in demonstrating the maximum stress levels, the stress ranges, and the relative importance of thermal loading, electromagnetic loading, and the mechanical preloading. The model was always built so that the basic mechanical model could be changed to a magnetic model using the basic steering file. The rest of the magnetic model was built, the current loadings applied, and an ANSYS file created that held the resulting nodal forces. These loads were retrieved from the magnetic model, and were applied to the conductor nodes.

The next important consideration is the specification of the boundary loadings and constraints that develop within the CS coil assembly and specifically between individual coils. This model, described in 14-950717-WEC-ACorpuz-01, utilized smeared properties and considered radial loading to quantify the interaction occurring between the CS coils.

There is always a problem in taking a smeared model result and applying it to a detailed model. The global smeared model will produce nodal forces that are an average of what might occur in the more detailed models. If we apply these averaged forces across the top and bottom of the CS Coil, we are close to applying a pressure loading. The result will be that a concave surface will be predicted at the top and bottom of the CS Coils. It is impossible for a concave top of CS 1 to transmit a constant load to a concave bottom of a CS 2 Coil. The same argument could be made if the spacer blocks at the edges of the coil were weakened enough to produce a convex surface. From the CS assembly model and analysis the displacements that will occur between adjacent CS Coils were found to produce relatively linear displacements across the coil surface.

The boundary conditions that we wished to match between the global model and the detailed model were the slope that occurred atop the coil, the preload at the interfaces, and the radial force at the interfaces. This was accomplished in the following manner. The radial and axial displacement data was linearly interpolated to match the nodal positions of the detailed model. A data file was used to transfer these displacements explicitly to each node. The proper electromagnetic loadings were applied, and the model was solved. The resulting net preload and radial surface forces were extracted. The preload was too small, so a constant relative deflection was imposed between the top and bottom surfaces to achieve the desired preloading. A similar adjustment was made in the case applying the maximum tractive shear force.

Table 3-2. The net normal and the net radial forces that develop in the 2D global smeared model

	Surface Normal Force (MN) Global Model	Surface Normal Force (MN) Detailed Model	Surface Traction Force (MN) Global Model	Surface Traction Force (MN) Detailed Model
PF3U Radial Fault following LC#1	-14.29/14.40	-14.19/14.26	-4.36/-4.25	-4.76/-5.28
PF3U Radial Normal Operating LC#1	-19.18/22.5	-18.33/-22	0.19/-0.01	0/0
PF3U With PF2 Shear Normal Operating LC#1	-19.18/22.5	-18.56/22.22	0.01/-1.39	0/-1.43
PF1L Compressive Normal Operating LC#16	-31.33/17.95	-30.06/16.88	-0.02/-0.95	0/0

The net normal and the net radial forces that develop in the 2D global smeared model and used in the detailed coil models are shown in Table 3-2.

3.5 RESULTS OF FEA ANALYSIS OF THE CPDR CS BASELINE DESIGN

The peak stresses from the finite element analysis of the load cases are tabulated in Table 3-3 and the critical cases of maximum vertical compression and

thermal cooldown alone represented pictorially in Appendix C. A detailed comparison of these load cases reveals that the case of maximum vertical compression is the dominating operating case with the maximum radial fault case having the highest stresses as expected. We are treating the maximum fault case as a single life time event and not using it as a basis for evaluating the fatigue loads. The following assessment then focuses on the maximum vertical compression case.

While comparing these stress values, attention will be given to the existence of artifacts of geometrical modeling and boundary conditions. In addition, secondary and highly localized stresses are identified. Consideration of these factors have reduced several critical stresses.

3.5.1 Conduit Wrap

The through thickness stresses in the conduit wrap are still strongly influenced by cooldown as evidenced by a 50% increase in their stresses if cooled to 4K without preload which is unlikely to happen. The value of 19.5 Mpa is a very localized spot visible on the blowups of the area. The value of 8 Mpa is considered to be representative as the peak through thickness stress in the conduit wrap. Significant stress enhancing (+100%) is occurring at the conductors on the edge of the winding pack next to the spacer blocks or transition. This enhancement is apparent in the cooldown only case and is due to the orthotropic thermal contraction mismatch of the transition pieces and the conduit wrap. Without this enhancement, all conduit wrap through stresses are compressive.

The other critical stress for the conduit wrap is the shear stress. The value of 79.9 Mpa is extremely local and once again at the transition piece interface. A more representative shear value is 45.2 Mpa.

3.5.2 Corner Filler or Roving

The modeling of this area required extremely thin elements to be created at the tip or edges of the filler cross section and physically do not exist to the extent modeled. This artifact results in an increase of approximately 30% on the tensile stresses. Overall this piece remains the highest stressed component of the winding

pack which is confirmed by the occurrence of cracking of this component in the 5x5 test.

3.5.3 Spacer Block

Geometric modeling is responsible for a doubling of the reported shear stress in the spacer blocks. However it is clear that the orthotropic properties of the tape products is creating moderately high stress levels at the interface of the spacer blocks and all the adjacent components. Fortunately these are secondary stresses which do threaten the mechanical integrity of the winding pack. Further improvements in the construction and material properties of these pieces is indicated for phase II.

3.5.4 Ground Wrap

The highest stresses in the ground wall occur at the termination of Incoloy 908 separator plates between the coils. It is acknowledged that these stresses are very sensitive to the selection and geometry of the model boundary conditions and therefore the peak stresses are not expected to occur. Nevertheless attention must be given during the final design phase to minimize stress in this area. If the very localized stresses are put aside, the shear stresses are no greater than 100 Mpa and the through thickness tension do not exceed 58 MPa. Fortunately simultaneously high compressive stress make this stress tolerable.

The laminar tensile stress profile across the top and bottom of the coils shows the effect of the staggered array introducing tension as a result of tipping of the corner conduits. The transition pieces or spacer blocks appear to be responsible for enhancement of the ground wrap tensile stresses at the corners of the winding pack with a tipping of the corner conductors.

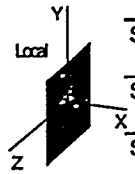
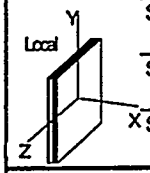
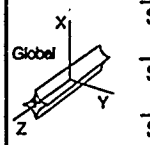
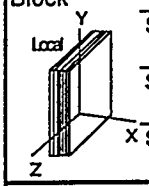
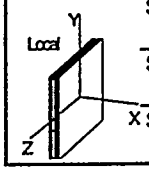
		FEA Load Case #8 Max Vert Compression (MPa)	FEA Load Case #4 Max. Rad. Oper.W /shear (MPa)	Max Rad. Oper. W O /Shear (MPa)	FEA Load Case #5 Max Radial Fault (MPa)	Effects of Cooldown		FEA Load Case #7 11MNt Vert ld cldwn GT to 4K (MPa)
						Cooldown GT to4K (MPa)	Cooldown GT to RT (MPa)	
Conduit	SX	-583	-481	-463	-882	-382	-127	-311
		479	380	361	756	229	76.4	265
	SY	-749	-619	-609	-892	-291	-97.2	-398
		354	301	290	460	204	67.9	210
	SZ	-186	-112	-68.8	-51.3	-238	-79.3	-224
		215	226	251	520	-5.66	-1.89	-1.39
	SXY	-289	-184	-180	-378	-133	-44.2	-156
		216	241	228	402	122	40.5	168
	SINT	740	612	602	941	375	125	389
Kapton	SX	-94.1	-70.6	-73.9	-137	-45.2	-15.1	-43.7
		12.3	10.8	9.57	17.4	7.24	2.41	7.92
	SY	-40.7	-26.5	-26.9	-79	-14.4	-4.8	-16.1
		61.3	58	56.4	65.6	59.3	19.8	54.6
	SZ	-3.62	5.99	6.54	-25.7	10.8	3.61	5.36
		41.5	42.4	43.9	51.1	43	14.3	36.2
	SXY	-2.75	-1.99	-2.09	-3.38	-1.53	-0.51	-1.41
		2.71	2.19	2.18	4.48	1.56	0.52	1.31
Conduit Wrap	SX	-84.8	-71.1	-71.5	-123	-37.4	-12.5	-46.9
		19.5	21.8	22.2	29	28.1	9.36	25.8
	SY	-306	-232	-234	-483	-145	-48.4	-116
		307	293	272	366	241	80.4	260
	SZ	40.5	65	-69.4	-19.7	59.2	19.7	64.2
		184	190	189	203	166	55.3	163
	SXY	-76.3	-75.7	-76	-79.5	-60.7	-20.2	-63
		79.9	68.9	69.4	54.4	62.2	20.7	65.2
Roving	SX	-65.5	-53.5	-54	-88.7	-25.2	-8.41	-36.2
		131	149	149	135	216	71.8	168
	SY	-37.5	-32.7	-32.7	-51.8	-33.9	-11.3	-28.4
		229	214	211	226	173	57.5	186
	SZ	9.64	19.3	19.9	30.9	-10.8	-3.61	-7.25
		87.1	95.6	97	117	84.1	28	67.7
	SXY	-70.9	-61.7	-58.2	-74.8	-58.6	-19.5	-53.3
		61.8	69.8	70.3	84.1	74.7	24.9	63.6
Spacer Block	SX	-33.8	-27.7	-27.7	-55.9	-24.6	-8.21	-26.1
		298	265	276	223	225	74.9	244
	SY	-183	-132	-140	-286	-90.9	-30.3	-106
		49.2	37.2	31.2	58.5	94.1	31.4	40.8
	SZ	65.6	85.7	90.1	16.7	82.3	27.4	76.3
		236	228	238	201	192	64.1	199
	SXY	-91.8	-76.5	-77	-71.6	-67.7	-22.6	-76.7
		83	93.7	87.7	74.4	72.1	24	82.7
Ground Wrap	SX	-242	-183	-190	-279	-13.1	-4.38	-101
		95.2	56.1	55.1	42.7	49.1	16.4	52.4
	SY	-303	-236	-247	-308	-124	-41.5	-179
		145	109	116	118	80.1	26.7	97
	SZ	-130	-86.3	-88.6	-119	-36.5	-12.2	-77.1
		49.8	54.7	56.9	67	20.3	6.77	27.1
	SXY	-107	-99.8	-106	-152	-38.2	-12.7	-63.3
		134	87.3	82.8	109	26.8	8.93	52.4

Table 3-3 - FEA Maximum Stress Result Summary for the CS Coil Assembly

4. COMPARISON OF THE CPDR BASELINE DESIGN WITH THE TPX DESIGN CRITERIA

The determination of the material property limits that are appropriate for the materials selected is an essential element in assessing the degree to which the CPDR CS design meets the TPX design criteria. This is particularly true of the CPDR baseline selected by the TPX program team of LLNL, MIT, B &W and Westinghouse where new and uncharacterized materials were chosen.

The composite materials utilized in the magnet are strong in compression, but are weak in shear and through thickness tension, that is, in the interlaminar direction. The design criteria document does not explicitly address the allowable through tension stress level. The peak value of the through tension stress developed in the 3D Conduit Wrap is estimated to range as high as 29 Mpa. The peak value of tension in the 3D Roving is expected to range as high as 229 MPa. The highest stress values are predicted to occur in the area of the roving where it is narrowing to a point. The present design criteria will not allow these values, and it appears as though they will be impossible to avoid.

Normally extensive testing and material characterization is performed to establish these property limits. In the TPX case, funding and schedule would not allow this approach in Phase I but this characterization must form an important part of the follow-on phases of the program. Nevertheless the approach taken for Phase I was to address the critical parameters of shear strength under compression and through thickness strength with limited exploratory measurements and estimate the remaining parameters based on related data. As will be shown in this section, the design does not meet all the requirements of the design criteria. Furthermore the results of the 3x3 program indicated that cracking in the winding pack is probable and a demonstration was needed that local cracks do not seriously impact the mechanical strength or the electrical integrity of the coil. Therefore a

Large Scale Verification Test Program was implemented to cover the uncertainty in the material property database, to verify design adequacy despite not meeting the design criteria, and to resolve concerns raised by the observation of cracking within the structure.

4.1 SHEAR STRENGTH AS FUNCTION OF COMPRESSION AND TENSILE LOADING

The 3D weave wrap material used as the outer wrapping of the conduit was one of the insulation systems tested by Composite Technology Development, Inc. and reported in reports titled "TPX Through Thickness Tension Testing" dated June 23, 1995 and "TPX Phase II Shear/Compression Testing" dated May 17,1995. These reports are contained in appendices in memo 14-950718-WEC-PSanger-01. The test results of interest are those utilizing the TTI 3D Weave material and the Shell 826 resin system.

The shear/compression testing of run # 163A Shell 826/3D Weave at a test angle of 15 degrees yielded a failure at 63.7 MPa in Shear Stress at a compressive stress of 17.1 MPa. The values obtained at a test angle of 45 degrees produced failure at 173.4 MPa shear stress at a compressive stress of 173.4 MPa. A straight line drawn between these two points would have a slope of 0.7 and a Y intercept of 52 MPa. The equation used to predict the failure for the 3D Weave components under shear and normal compression will be as follows:

Allowable Shear Stress (MPa) = 0.7 * Compressive Stress + 52 MPa

The results of the through thickness tension tests for the Shell 826 resin with TTI 3D weave reinforcement had an average failure at 46.12 MPa and a standard deviation of 10.02 MPa for samples with material reference TT1A tested 6/7/95. A second set of samples had an average failure at 46.36 MPa and a standard deviation of 6.66 for samples with material reference TT4A tested 6/22/95. The lower value of 46.12 MPa will be used to define the maximum tension that the insulation can develop under any circumstances. The extrapolation of the criteria to the case of normal tension will be handled by assuming a straight line fit between the predicted shear stress failure without normal stress (shear stress @ 52 MPa, normal stress @

develop under any circumstances. The extrapolation of the criteria to the case of normal tension will be handled by assuming a straight line fit between the predicted shear stress failure without normal stress (shear stress @ 52 MPa, normal stress @ Zero) and the failure point achieved for tension only (Shear stress @ Zero, Tension stress @ 46.12). The typical composite function is illustrated in figure 4-1.

Allowable Shear Stress (MPa) = -1.13 * Tension Stress + 52 Mpa

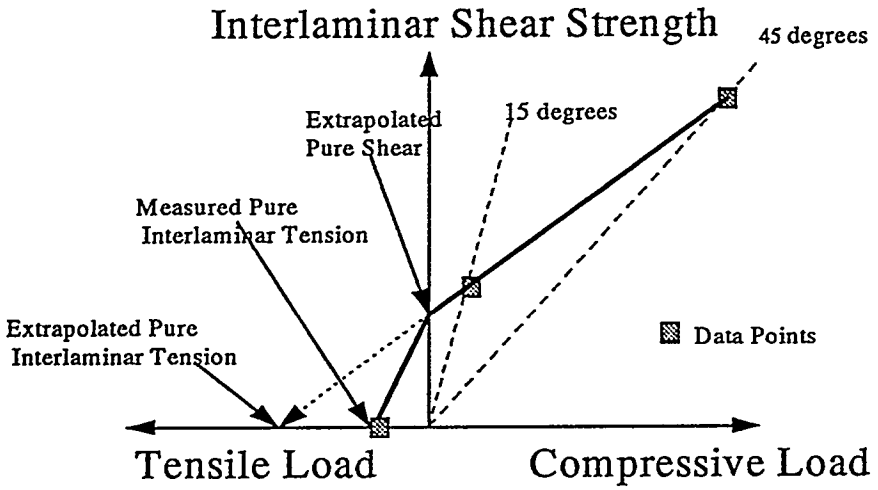


Figure 4-1 Combined Shear Compression and Tensile Strength Function used in the CPDR Design

The criteria will identify any of the 3D weave wrap material as failed if it develops greater than a 46.49 MPa tension or if it falls to the left and above either of the lines defined above.

Testing was also performed on material samples using a Satin weave and Shell 826 resin system. This material is representative of the ground wall insulation material. These results and the through thickness tension tests for the Shell 826 resin with TTI 3D have been reduced in a similar way to result in the following functions:

Allowable Shear Stress (MPa) = 0.5 * Compressive Stress + 96 Mpa

Allowable Shear Stress (MPa) = -1.55 * Tension Stress + 96 MPa

It is important to stress that the functions above are based on the limited test data available. Furthermore the values have not been modified to account for statistical scatter, or to account for fatigue.

4.2 ESTIMATE OF INSULATING MATERIAL PROPERTY LIMITS

In addition to the shear strength under compressive loading and the through thickness tensile strength, we have estimated values for the important ultimate strengths for composite materials which are shown in figure 4-2. The estimate is made by prorating the strength of glass reinforced epoxy composites like G10 by the percentage of glass projected for the various components of the insulation and tends to be conservative. For example of this conservatism is the interlaminar compressive strength for the conduit wrap and ground wall. From the shear/compression measurments made at 75 degree (14-950-718-WEC-PSanger-01), the compressive strength can be seen to exceed 900 Mpa instead of the 560 Mpa picked for the evaluation. For this reason, our intention is to not to use these values as black and white criteria until material properties for these composites have been determined in the next phase of the program. Nevertheless we feel that they can serve a guide to evaluating the stresses to be found in the CS winding pack.

Two factors have not been included in the analysis that will reduce the material capabilities: fatigue and radiation damage. As will be discussed later, the effects of fatigue have been included in the test parameters of the Large Scale Verification Program as provided for in the TPX Design Criteria. However the degradation resulting from radiation damage has not been considered and is deferred to Phase II.

3-D stress.xls	Fiber Dir or Laminar x Compressive Strength	Fiber Dir or Laminar x Tensile Strength	Laminar y Compressive Strength	Laminar y Tensile Strength
Material	(Mpa)	(Mpa)	(Mpa)	(Mpa)
Conduit Wrap	400	400	400	400
G10-cr	600	600	600	600
Resin	40	69		

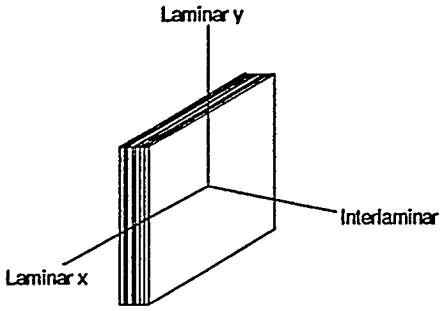


Figure 4.2 Approximate Single Cycle Material Limits at 4°K

4.3 INSULATION SHEAR UNDER COMPRESSION AND THROUGH THICKNESS TENSION

Using the function derived earlier for the shear and tensile in the insulation, the ANSYS output file was evaluated elementally to identify areas that do not meet the design criteria. The shear/tension function was applied to the corner fillers despite the fact that these functions do not apply to this component. In particular one of the improvement added to the CPDR design is reinforcement of the tips of the corner filler. With 4% parallel glass fibers extending out to the tips, better properties are expected than the data used which is for tape to tape flat contact with no through fiber.. The artifacts found earlier were not taken into account for this scan. The percentage of the cross sectional area of each component PASSING the shear criteria is given as follows:

Conduit Wrap	99.87%
Corner Filler	36%
Transition Pieces/Blocks	90%
Ground Wall	100%

As seen in the cross section plot, all failing areas on the conduit wrap are located at the edge of the winding pack where optimization of the transition pieces are expected to reduce these stresses. The failing areas of the ground wall are clearly due to boundary conditions in the model. It will be important to maintain a compliant interface at the interface between the coils.

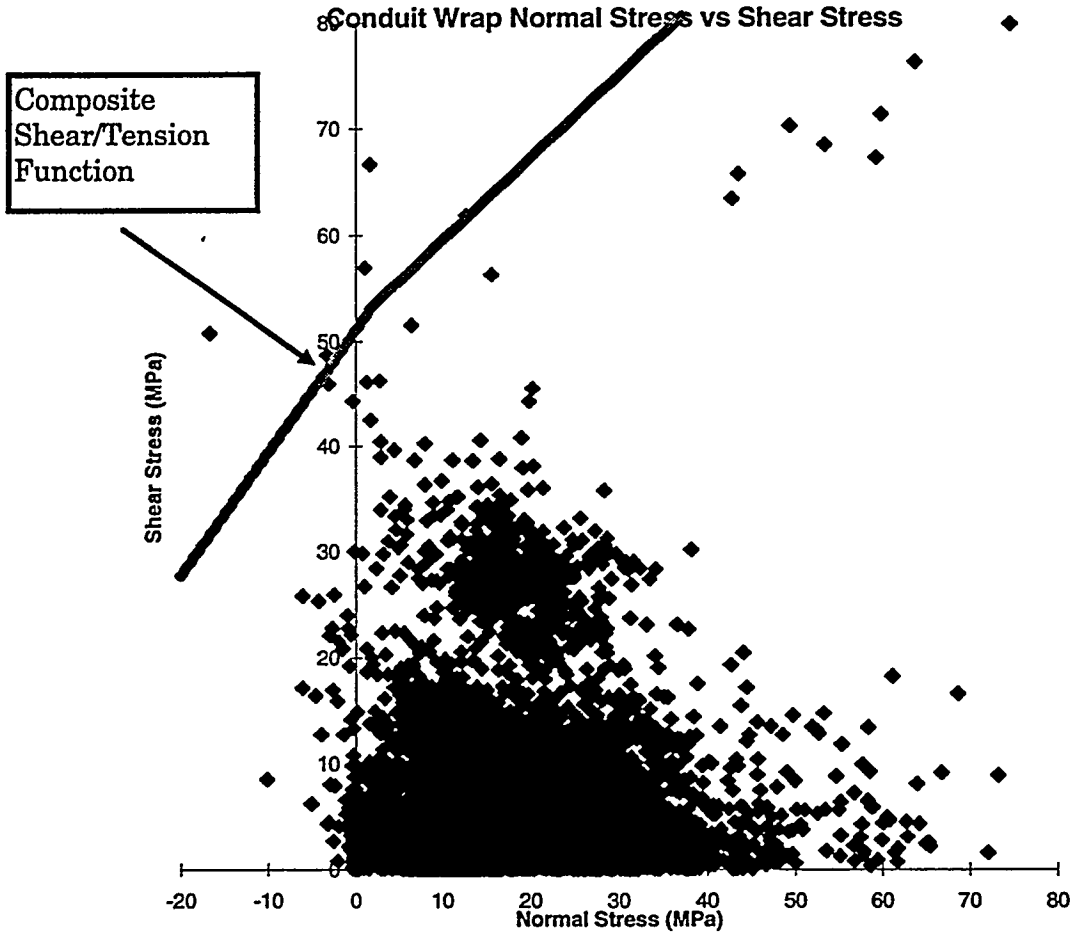


Figure 4.3 -Scatter plot of all elements containing conduit wrap.

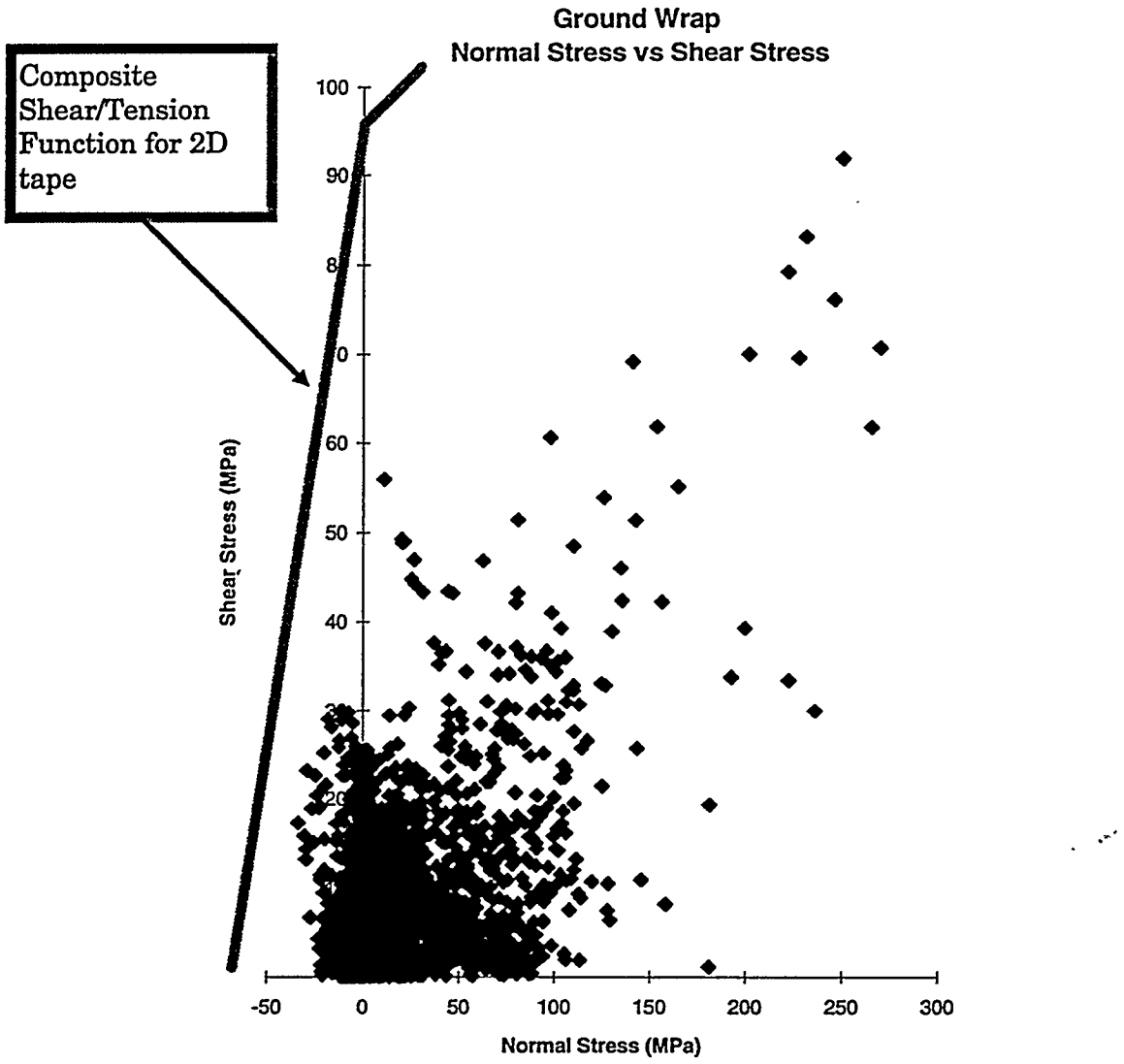


Figure 4.4 Scatter plot of all elements containing ground wall Insulation.

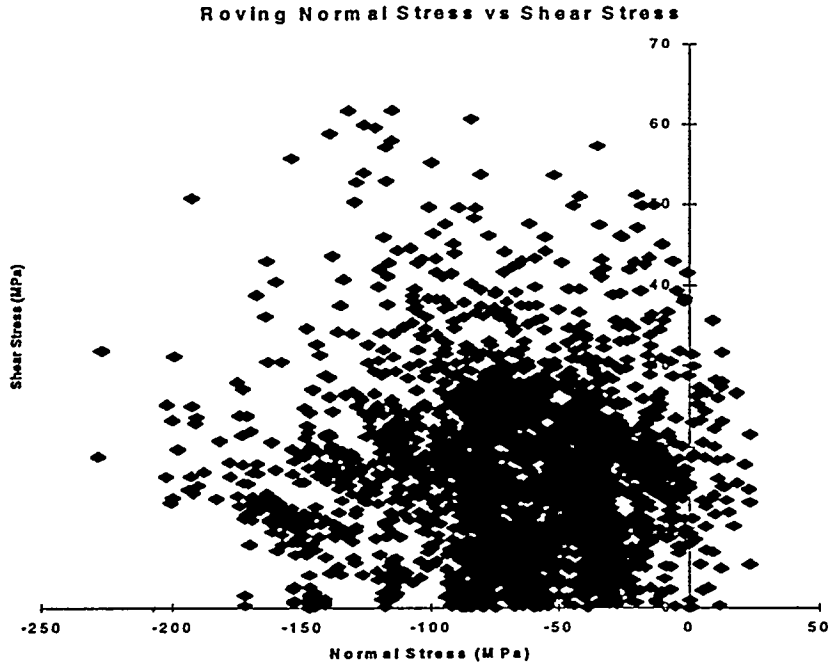


Figure 4.5 Scatter Plot of the Shear and Tensile Stresses of the Corner Filler.

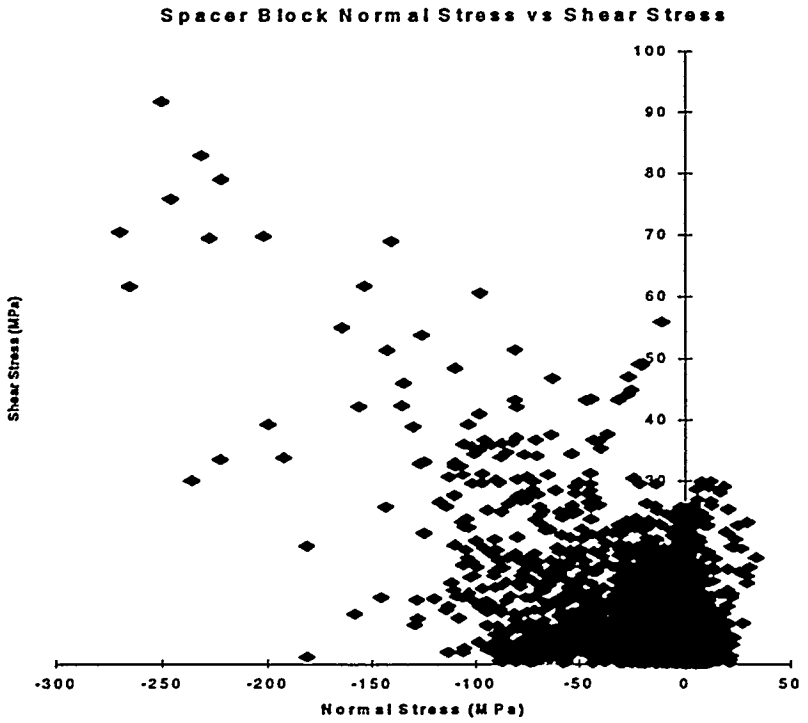


Figure 4.6 Scatter Plot of the Shear and Tensile Stresses in the Spacer Blocks.

In order to better clarify the problems that must be addressed in later phases of the design, scatter plots were made of the shear and tensile stresses for the parts

of the insulation system. The nodal stresses were averaged over the element and thus the values can be slightly lower than contained in Table 3.3. On the conduit wrap and the ground wall, the composite shear and tensile stress functions are overlayed on the data. In general these two components which play a vital role in providing the electrical integrity, meet the requirements. The spacer blocks and the corner fillers are being subjected to large values of tension simultaneous with significant shear stresses. Glass reinforcement to resist these stresses is definitely indicated.

4.3.1 Insulation Compressive Stress

The stress results were compared to the limits provided in section 4.2. For all components, the compressive allowables are not exceeded (306 vs 373 Mpa). However laminar tensile stresses satisfy the estimated ultimate capability of the material but do not maintain the 2/3 margin required by the design criteria in the conduit wrap (307 vs 267 Mpa). This deficiency must be investigated in the later phases particularly with measurement of the actual properties of the composites.

5. CONCLUSION

It is clear that the structural design of the CS coils cannot meet by analysis the allowable as defined in the TPX Design Criteria. However the design criteria provides for *Verification by Testing* in section I-4.1.4.4 "Stress Limits for Insulating Materials". The Large Scale Insulation Verification Test Program was designed to verify the design of the CS coil structural with the exception that irradiated materials were not available and the irradiation of a sample large enough to perform an adequate test was problematic. The results of this testing is presented in a separate report.

Besides identification that a verification test program is strongly indicated, two other conclusions can be made:

1. The transition pieces or spacer blocks are subjected to combined shear and tensile forces from thermal mismatches and property anisotropy. Reinforcement and further design refinements can improve this condition.

2. The corner fillers are highly stressed in tension and shear. The R &D program placed glass fibers in the through thickness direction but only achieved approximately 5% glass content. The same approach should be continued with a more radical shift in glass orientation from the 5% to approximately 30% in each direction. The filler pieces become essentially through thickness glass held together with longitudinal fibers instead of the present longitudinal bundles of glass held together with glass threads. The weaving process and configuration would remain the same. This shift in glass orientation simultaneously reducing the thermal contraction and decreasing the modulus.

APPENDIX A

This is the steering file used the analysis of the CDR Baseline design of the CS Coil.

```
/com FILE srcs10.str
/com William Hannan and Mark Krefta
/com Westinghouse STC
/com November 21, 1994

/prep7
ET, 1,42,,,1
local,11,0,0,0,0,0,90 $local,12,0 !rotated local coordinate
csys,0
/com
/com  PARAMETERS
*dim,pitch,array,20
rsm=.106      !inner radius of conduit
cw=.688       !cable width
fl=cw-2*rsm   !flat length of conduit wall
tc=.095       !conduit wall thickness
tins=.012     !insulation wrap thickness
rou=.201      !outer radius of conduit
r1=rou+tins   !outer radius of 1st insulating wrap
r2=r1+tins    !outer radius of 2nd insulating wrap
tg11=.016     !g11 sheet thickness
twrap=.301    !ground wall insulation thickness
csize=.942    !size of single turn cell i.e. offset in x,y
ric=28.237    !DWG 9414002B.DRW 6/28/94
innerrad=ric+twrap+2*tins+tc
xx=cw+tc+2*tins
r3=r2+twrap
nxt=6         !number of turns in a row
icsl=12       !last used coordinate system
ESIZE,.05     !default elem size
sml=.001      !a relatively small dimension
pitch(1)=0*csize,1/4*csize,3/4*csize,1/2*csize,1/2*csize
pitch(6)=3/4*csize,1/4*csize,1*csize,0*csize,1/4*csize
/com
/title,TPX CS Coil, 294K Cooldown, 908 Mat'l, Staggered Conduits, Rev'd Mat'l
```

```
/com /TITLE,TPX Central Solenoid coil stress analysis
/com  Young's modulus
mp,ex,1,26.83e6                          !material 1 incoloy
mp,ex,2,3.191e6  $mp,ey,2,4.787e6     $mp,ez,2,4.787e6 !material 2 insul.
mp,ex,3,3.191e6  $mp,ey,3,4.787e6     $mp,ez,3,4.787e6 !material 3 insul.
mp,ex,4,3.191e6  $mp,ey,4,4.787e6     $mp,ez,4,4.787e6 !material 4 insul.
mp,ex,5,3.191e6  $mp,ey,5,4.787e6     $mp,ez,5,4.787e6 !material 5 insul.
mp,ex,6,3.191e6  $mp,ey,6,4.787e6     $mp,ez,6,4.787e6 !material 6 insul.
mp,ex,7,1e6                          !material 7 insul.
mp,ex,8,3.191e6  $mp,ey,8,4.787e6     $mp,ez,8,4.787e6 !material 8 insul.
mp,ex,9,3.191e6  $mp,ey,9,4.787e6     $mp,ez,9,4.787e6 !material 9 insul.
mp,ex,10,3.191e6  $mp,ey,10,4.787e6    $mp,ez,10,4.787e6 !material 10 insul.
/com
/com  thermal contractions
mp,alpx,1,5.59e-6                          !material 1
mp,alpx,2,24.8e-6 $mp,alpy,2,8.4e-6   $mp,alpz,2,8.4e-6 !material 2
mp,alpx,3,24.8e-6 $mp,alpy,3,8.4e-6   $mp,alpz,3,8.4e-6 !material 3
mp,alpx,4,24.8e-6 $mp,alpy,4,24.80e-6  $mp,alpz,4,8.4e-6 !material 4
mp,alpx,5,24.8e-6 $mp,alpy,5,8.4e-6   $mp,alpz,5,8.4e-6 !material 5
mp,alpx,6,24.8e-6 $mp,alpy,6,8.4e-6   $mp,alpz,6,8.4e-6 !material 6
mp,alpx,7,24.8e-6                          !material 7
mp,alpx,8,24.8e-6 $mp,alpy,8,8.4e-6   $mp,alpz,8,8.4e-6 !material 8
mp,alpx,9,24.8e-6 $mp,alpy,9,8.4e-6   $mp,alpz,9,8.4e-6 !material 9
mp,alpx,10,24.8e-6 $mp,alpy,10,8.4e-6 $mp,alpz,10,8.4e-6 !material 10
/com
mp,gxy,2,1.596e6
mp,gxy,3,1.596e6
mp,gxy,4,1.596e6
mp,gxy,5,1.596e6
mp,gxy,6,1.596e6
mp,gxy,8,1.596e6
mp,gxy,9,1.596e6
mp,gxy,10,1.596e6
/com
mp,nuxy,2,.21
mp,nuxy,3,.21
mp,nuxy,4,.21
mp,nuxy,5,.21
mp,nuxy,6,.21
mp,nuxy,8,.21
mp,nuxy,9,.21
mp,nuxy,10,.21
/com   MAT #        DESCRIPTION
/com    1       INCOLOY CONDUIT
/com    2       CABLE WRAP  INNER
```

```
/com    3       CABLE WRAP  OUTER
/com    4       ROVING FILLER
/com    5       MID VERTICAL G11 SPACER
/com    6       UPPER/LOWER VERTICAL G11 SPACER
/com    7       EPOXY VOIDS
/com    8       G11 FILLER BLOCKS
/com    9       GROUNDWALL INSULATION
/com   10       HORIZONTAL G11 SHEETS
/com
/com  BEGIN LOOP OVER TURNS
ix=1
/com  ELEMENT COORDINATE SYSTEMS
local,icsl+1,1,rsm+(ix-1)*csize,rsm     !lower left corner
local,icsl+2,1,rsm+fl+(ix-1)*csize,rsm    !lower right
local,icsl+3,1,rsm+(ix-1)*csize,rsm+fl    !upper left
local,icsl+4,1,rsm+fl+(ix-1)*csize,rsm+fl !upper right
csys,0
/com  KEYPOINTS
*get,kst,kp,,num,max   !max kp number
*get,lst,line,,num,max   !max line number
*get,ast,area,,num,max   !max area number
K,kst+1,rsm+(ix-1)*csize                    !kp 1
K,kst+2,(ix-1)*csize,rsm                    !kp 2
KGEN,2,kst+1,,,fl  $KGEN,2,kst+2,,,,fl  $KGEN,2,kst+2,,,cw,fl !kp 3-5
KGEN,2,kst+2,,,cw   $KGEN,2,kst+1,,,,cw  $KGEN,2,kst+3,,,,cw !kp 6-8
KGEN,2,kst+6,,,tc  $KGEN,2,kst+5,,,tc  $KGEN,2,kst+7,,,,tc  !kp 9-11
KGEN,2,kst+8,,,,tc  $KGEN,2,kst+4,,,-tc  $KGEN,2,kst+2,,,-tc  !kp 12-14
KGEN,2,kst+1,,,,-tc $KGEN,2,kst+3,,,,-tc $KGEN,3,kst+9,,,tins !kp 15-18
KGEN,3,kst+10,,,tins $KGEN,3,kst+11,,,,tins  $KGEN,3,kst+12,,,,tins !kp 19-24
KGEN,3,kst+13,,,-tins $KGEN,3,kst+14,,,-tins  $KGEN,3,kst+15,,,,-tins !kp 25-30
KGEN,3,kst+16,,,,-tins $KGEN,2,kst+32,,,r2  $KGEN,2,kst+24,,,r2  !kp 31-34
KGEN,2,kst+30,,,-r2  $KGEN,2,kst+22,,,-r2  $KGEN,2,kst+33,,,,tg11 !kp 35-37
KGEN,2,kst+34,,,,-tg11 $KGEN,2,kst+33,,,tg11  $KGEN,2,kst+37,,,tg11  !kp 38-40
KGEN,2,kst+18,,,tg11  $KGEN,2,kst+20,,,tg11  $KGEN,2,kst+38,,,tg11  !kp 41-43
KGEN,2,kst+34,,,tg11  $KGEN,2,kst+36,,,,-tg11 $KGEN,2,kst+35,,,,tg11 !kp 44-46
k,,cw/2+(ix-1)*csize,cw/2   !keypoint for larc command  kp 47
*get,knm,kp,,num,max !kp number of larc command
/com
/com  LINES
L,kst+6,kst+5   $L,kst+8,kst+7   $L,kst+4,kst+2   $L,kst+1,kst+3   !lines 1-4
L,kst+9,kst+10  $L,kst+12,kst+11  $L,kst+13,kst+14  $L,kst+15,kst+16 !lines 5-8
L,kst+17,kst+19  $L,kst+23,kst+21  $L,kst+25,kst+27  $L,kst+29,kst+31 !lines 9-12
L,kst+18,kst+20  $L,kst+24,kst+22  $L,kst+26,kst+28  $L,kst+30,kst+32 !lines 13-
16
```

```
L,kst+39,kst+40  $L,kst+37,kst+33  $L,kst+33,kst+39  $L,kst+40,kst+37 !lines 17-
20
L,kst+40,kst+41  $L,kst+41,kst+42  $L,kst+42,kst+43  $L,kst+43,kst+44 !lines 21-
24
L,kst+37,kst+18  $L,kst+20,kst+38  $L,kst+38,kst+34  $L,kst+38,kst+43 !lines 25-
28
L,kst+44,kst+34  $L,kst+34,kst+24  $L,kst+22,kst+36  $L,kst+36,kst+45 !lines 29-
32
L,kst+45,kst+26  $L,kst+28,kst+46                    !lines 33-34
L,kst+46,kst+35  $L,kst+35,kst+30  $L,kst+3,kst+16  $L,kst+16,kst+31,2  !lines 35-
38
L,kst+31,kst+32,2  $L,kst+6,kst+9   $L,kst+9,kst+17,2  $L,kst+17,kst+18,2  !lines
39-42 thru thickness wrap
L,kst+18,kst+41  $L,kst+5,kst+10   $L,kst+10,kst+19,2  $L,kst+19,kst+20,2 !lines
43-46
L,kst+20,kst+42  $L,kst+8,kst+12   $L,kst+12,kst+23,2  $L,kst+23,kst+24,2 !lines
47-50
L,kst+7,kst+11   $L,kst+11,kst+21,2  $L,kst+21,kst+22,2 $L,kst+4,kst+13  !lines 51-
54
L,kst+13,kst+25,2  $L,kst+25,kst+26,2  $L,kst+2,kst+14  $L,kst+14,kst+27,2  !lines
55-58
L,kst+27,kst+28,2  $L,kst+1,kst+15   $L,kst+15,kst+29,2  $L,kst+29,kst+30,2 !lines
59-62
/com
/com  ARCS
LARC,kst+3,kst+6,knm,rsm    $LARC,kst+5,kst+8,knm,rsm   !lines 63-64
LARC,kst+7,kst+4,knm,rsm    $LARC,kst+2,kst+1,knm,rsm   !lines 65-66
LARC,kst+16,kst+9,knm,rou,8   $LARC,kst+10,kst+12,knm,rou,8 !lines 67-68 arc
length at corner
LARC,kst+11,kst+13,knm,rou,8  $LARC,kst+14,kst+15,knm,rou,8 !lines 69-70 for
wrap lines 67-78
LARC,kst+31,kst+17,knm,r1,8   $LARC,kst+19,kst+23,knm,r1,8  !lines 71-72
LARC,kst+21,kst+25,knm,r1,8   $LARC,kst+27,kst+29,knm,r1,8  !lines 73-74
LARC,kst+32,kst+18,knm,r2,8   $LARC,kst+20,kst+24,knm,r2,8  !lines 75-76
LARC,kst+22,kst+26,knm,r2,8   $LARC,kst+28,kst+30,knm,r2,8  !lines 77-78
L,kst+32,kst+33                  !line 79
/com
/com
/com   start areas
/com  Begin with outside wrap areas
/com    mesh outer wrap  AREAS 1-8
AL,lst+76,lst+50,lst+72,lst+46   $AL,lst+14,lst+53,lst+10,lst+50
AL,lst+77,lst+56,lst+73,lst+53
AL,lst+15,lst+59,lst+11,lst+56   $AL,lst+78,lst+62,lst+74,lst+59
AL,lst+16,lst+39,lst+12,lst+62
```

```
AL,lst+75,lst+42,lst+71,lst+39  $AL,lst+13,lst+46,lst+9,lst+42
/com
/com  second (inner)wrap layer  AREAS 9-16
AL,lst+72,lst+49,lst+68,lst+45  $AL,lst+10,lst+52,lst+6,lst+49
AL,lst+73,lst+55,lst+69,lst+52
AL,lst+11,lst+58,lst+7,lst+55  $AL,lst+74,lst+61,lst+70,lst+58
AL,lst+12,lst+38,lst+8,lst+61
AL,lst+71,lst+41,lst+67,lst+38  $AL,lst+9,lst+45,lst+5,lst+41
/com
/com  more areas  conduit regions  AREAS 17-24
AL,lst+2,lst+48,lst+6,lst+51  $AL,lst+65,lst+51,lst+69,lst+54
AL,lst+3,lst+54,lst+7,lst+57
AL,lst+66,lst+57,lst+70,lst+60  $AL,lst+4,lst+60,lst+8,lst+37
AL,lst+63,lst+37,lst+67,lst+40
AL,lst+1,lst+40,lst+5,lst+44  $AL,lst+64,lst+44,lst+68,lst+48
/com
/com  start roving areas  AREAS 25-28
AL,lst+77,lst+31,lst+32,lst+33  $AL,lst+78,lst+34,lst+35,lst+36
AL,lst+75,lst+79,lst+18,lst+25  $AL,lst+76,lst+26,lst+27,lst+30
/com
/com  bottom right corner area  AREA 29
AL,lst+18,lst+19,lst+17,lst+20
/com
/com  G11 spacers (3 total) AREA 30-32
AL,lst+25,lst+20,lst+21,lst+43  $AL,lst+13,lst+43,lst+22,lst+47
AL,lst+26,lst+47,lst+23,lst+28
/com
/com  top right corner area  AREA 33
AL,lst+27,lst+28,lst+24,lst+29
/com
/com  set area attributes and mesh
eshape,3
asel,s,,,ast+1  $mat,3  $type,1 $esys,icsl+4 $amesh,all
asel,s,,,ast+3  $mat,3  $type,1 $esys,icsl+3 $amesh,all
asel,s,,,ast+5  $mat,3  $type,1 $esys,icsl+1 $amesh,all
asel,s,,,ast+7  $mat,3  $type,1 $esys,icsl+2 $amesh,all
ASEL,s,,,ast+2,ast+6,4  $mat,3  $type,1 $esys,11 $amesh,all  !material 3 , elem type
2 (esys with i-j side)
ASEL,s,,,ast+4,ast+8,4  $mat,3  $type,1 $esys,12 $amesh,all  !material 3 , elem type
2 (esys with i-j side)
/com
asel,s,,,ast+9  $mat,2  $type,1 $esys,icsl+4 $amesh,all
asel,s,,,ast+11  $mat,2  $type,1 $esys,icsl+3 $amesh,all
asel,s,,,ast+13  $mat,2  $type,1 $esys,icsl+1 $amesh,all
asel,s,,,ast+15  $mat,2  $type,1 $esys,icsl+2 $amesh,all
```

```
ASEL,s,,,ast+10,ast+14,4  $mat,2  $type,1 $esys,11 $amesh,all  !material 3 , elem
type 2 (esys with i-j side)
ASEL,s,,,ast+12,ast+16,4  $mat,2  $type,1 $esys,12 $amesh,all  !material 3 , elem
type 2 (esys with i-j side)
/com
ASEL,s,,,ast+17,ast+24  $mat,1  $type,1 $esys,12 $amesh,all  ! material 1 , type 1
ASEL,S,,,ast+25,ast+28  $mat,4  $type,1 $esys,12 $amesh,all   !roving areas
ASEL,S,,,ast+31    $mat,5  $type,1 $esys,12   $amesh,all   !G11 spacer mat 5, type
2
ASEL,S,,,ast+30,ast+32,2 $mat,6 $type,1 $esys,12 $amesh,all   !G11 spacer mat 6,
type 1
ASEL,S,,,ast+29,ast+33,4 $mat,7 $type,1 $esys,11 $amesh,all   !corner areas epoxy,
mat 7, type 2
asel,all
icsl=icsl+4
/com  *enddo
/com
/com   translate in vertical direction
*get,ast,area,,num,max   !max area number
nrow=10
ncol=6
/com *do,COL,1,ncol
/com *get,ast,area,,num,max       !max area number
*do,ROW,1,nrow
*do,COL,1,ncol
*get,ast,area,,num,max
X=innerrad+csize*(COL-1)+pitch(ROW)
Y=csize*(ROW-1)
agen,2,1,33,,X,Y
local,icsl+1,1,X+rsm,Y+rsm
local,icsl+2,1,X+rsm+fl,Y+rsm
local,icsl+3,1,X+rsm,Y+rsm+fl
local,icsl+4,1,X+rsm+fl,Y+rsm+fl
asel,s,,,ast+5  $asel,a,,,ast+13  $earea  $emodif,all,esys,icsl+1
asel,s,,,ast+7  $asel,a,,,ast+15  $earea  $emodif,all,esys,icsl+2
asel,s,,,ast+11 $asel,a,,,ast+3   $earea  $emodif,all,esys,icsl+3
asel,s,,,ast+1  $asel,a,,,ast+9   $earea  $emodif,all,esys,icsl+4
asel,all
esel,all
icsl=icsl+4
csys,0
*enddo
*enddo
del=.02
aclear,1,33,1
```

```
L,290,8  $L,323,11
AL,494,546,549,551,553,453,5,6,4,452
AL,1018,1021,1023,1025,1027,457,11,12,10,456
L,594,19  $L,599,22  $L,870,31
L,875,34  $L,1146,43
AL,1018,1021,1023,1025,1027,457,11,12,10,456
AL,1492,1495,1497,1499,1501,531,17,18,16,485
L,1151,46  $L,1422,2816
AL,1966,1969,1971,1973,1975,535,23,24,22,532
L,1427,2819  $L,1698,2828
AL,2440,2443,2445,2447,2449,537,29,30,28,536
L,1703,2831
AL,2914,2917,2919,2921,2923,539,35,36,34,538
L,1974,2840
L,1979,2843
L,2250,2852
AL,3388,3391,3393,3395,3397,544,41,42,40,543
L,2255,2855
L,2526,2864
AL,3862,3865,3867,3869,3871,547,47,48,46,545
L,2531,2867
L,2802,2876
AL,4336,4339,4341,4343,4345,689,53,54,52,643
L,2763,3
AL,4810,4813,4815,4814,4741,693,1,60,58,690
aatt,8,,1,11
amesh,all
asel,none
*do,dum,0,nrow-2
lsel,s,loc,y,xx+dum*csize,xx+tg11+dum*csize
al,all
aplot
*enddo
aatt,10,,1,11
amesh,all
asel,none
ksel,s,kp,,6,83,77
kgen,2,all,,,-twrap
ksel,s,kp,,2,9,7
kgen,2,all,,,twrap
ksel,s,kp,,3,82,79
kgen,2,all,,,,twrap
ksel,s,kp,,8,315,307
kgen,2,all,,,,-twrap
ksel,all
```

```
l,83,10  $l,10,4  $l,4,6
l,9,17  $l,17,12  $l,12,2
l,82,23  $l,23,18  $l,3,18
l,29,315  $l,24,29  $l,8,24
lsel,s,,,722  $lsel,a,,,694  $lsel,a,,,55,57,2  $lsel,a,,,49,51
lsel,a,,,43,45  $lsel,a,,,37,39  $lsel,a,,,31,33  $lsel,a,,,25,27
lsel,a,,,19,21  $lsel,a,,,13,15  $lsel,a,,,7,9  $lsel,a,,,2,3
lsel,a,,,61,69  $lsel,a,,,768
al,all
lsel,s,,,5,6  $lsel,a,,,70,78  $lsel,a,,,10,12  $lsel,a,,,16,18
lsel,a,,,22,24  $lsel,a,,,28,30  $lsel,a,,,34,36  $lsel,a,,,40,42
lsel,a,,,46,48  $lsel,a,,,52,54  $lsel,a,,,58,60,2
lsel,a,,,772,773  $lsel,a,,,769
al,all
aatt,9,,1,12
amesh,all
asel,none
lsel,s,loc,y,xx+(nrow-1)*csize,xx+(nrow-1)*csize+twrap
/com lsel,a,,,801  $lsel,a,,,847,848
al,all
lsel,s,loc,y,xx-csize+tg11
lsel,a,,,851,852  $lsel,a,,,880
al,all
aatt,9,,1,11
amesh,all
asel,none
lsel,all
larc,4,29,10,r3
larc,10,23,18,r3
larc,18,12,17,r3
larc,17,24,29,r3
csys,17
clocal,5000,1,((pitch(1)-1)*csize)
csys,235
clocal,5001,1,((pitch(nrow)-1)*csize)
csys,38
clocal,5002,1,pitch(1)*csize
csys,256
clocal,5003,1,pitch(nrow)*csize
csys,0
al,926,59,768,851
aatt,9,,1,5000
amesh,all
asel,none
al,694,56,801,927
```

```
aatt,9,,1,5001
amesh,all
asel,none
al,4,769,880,931
aatt,9,,1,5002
amesh,all
asel,none
al,848,1,773,930
aatt,9,,1,5003
amesh,all
esel,all
asel,all
lsel,all
eplot
save,srcs10,db
```

APPENDIX B

This is primary steering file for running the CPDR case. Four other files are required and are contained in sequence in this appendix.

/com FILE cpdr.str

```
/com 2D Axisymetric Model of CS#3, Worst Case Vertical Compression Loading
/com William Hannan and Mark Krefta
/com Westinghouse STC
/com April 19, 1995
/prep7
et,1,plane42,,,1

/com ET,1,plane13,,,1
et,2,52
r,1,1e11,0,1e11
mp,mu,1,0
real,1
local,11,0,0,0,0,0,90 $local,12,0 !rotated local coordinate
csys,0
/com
/com  PARAMETERS
*dim,pitch,array,20
rsm=.106*.0254      !inner radius of conduit
cw=.688*.0254       !cable width
fl=cw-2*rsm         !flat length of conduit wall
tc=.095*.0254       !conduit wall thickness
tins1=.004*.0254    !insulation wrap thickness one
tins2=.028*.0254    !insulating wrap thickness two
rou=.201*.0254      !outer radius of conduit
r1=rou+tins1        !outer radius of 1st insulating wrap
r2=r1+tins2         !outer radius of 2nd insulating wrap
tg11=.016*.0254     !g11 sheet thickness
twrap=.301*.0254    !ground wall insulation thickness
csize=cw+2*tc+2*(tins1+tins2)  !size of single turn cell i.e. offset in x,y
ric=28.237*.0254    !DWG 9414002B.DRW 6/28/94
innerrad=ric+twrap+tins1+tins2+tc
xx=cw+tc+tins1+tins2
```

```
r3=r2+twrap
nxt=6           !number of turns in a row
icsl=12         !last used coordinate system
esize,.1*.0254
/com ESIZE,.05*.0254     !default elem size
sml=.001*.0254      !a relatively small dimension
rdiv=2          !radial divisions on thin bands
ldiv=8          !divisions of conduit and wrap along arc lengths
cn=.0005*.0254        !distance between nodes on slip elements
sp=0
del=.25/2*.0254     !adjusts width of spacer blocks
pitch(1)=0*csize,1/4*csize,3/4*csize,1/2*csize,1/2*csize
pitch(6)=3/4*csize,1/4*csize,1*csize,0*csize,1/4*csize
/com
/title,EM model of conductor pack
/com
/com  MAGNETIC PROPERTIES
emunit,mks      *mks units
mp,murx,1,1.0    *relative permeability
mp,murx,2,1.0     $mp,murx,3,1.0     $mp,murx,4,1.0     $mp,murx,5,1.0
mp,murx,6,1.0     $mp,murx,7,1.0     $mp,murx,8,1.0     $mp,murx,9,1.0
mp,murx,10,1.0     $mp,murx,11,1.0     $mp,murx,12,1.0     $mp,murx,13,1.0
mp,murx,14,1.0     $mp,murx,15,1.0     $mp,murx,16,1.0     $mp,murx,17,1.0
mp,murx,18,1.0     $mp,murx,19,1.0     $mp,murx,20,1.0
/com
/com   BH curve for incoloy conduit
/com tb,bh,1     !B-H table for Incoloy conduit
/com *dim,h,,20
/com *dim,b,,20
/com h(1)=17675.6,39798.2,66430.1,96481.4,127476.,156034. !first 6 H pts.
/com b(1)= 0.2032,0.38222,0.53714,0.66793,0.77460,0.85714 !first 6 B pts.
/com h(7)=178795.,193150.,197544.,201048.,210589.,229079. !next 6 H pts.
/com b(7)= 0.9155,0.9498,0.9600,0.9680,0.9893,1.0290 !next 6 B pts.
/com h(13)=259612.,305161.,368730.,453322.,697586. !next 5 H pts.
/com b(13)= 1.0907,1.1758,1.2851,1.4196,1.7737 !next 5 B pts.
/com h(18)=1000000.,2000000.,5000000.
/com b(18)=2.18,3.44,7.21
/com *do,i,1,20
/com tbpt,defi,h(i),b(i)
/com *enddo
/com
/com   MAT #        DESCRIPTION
/com    1       INCOLOY CONDUIT
/com    2       CABLE WRAP  INNER
/com    3       CABLE WRAP  OUTER
```

```
/com    4       ROVING FILLER
/com    5       MID VERTICAL G11 SPACER
/com    6       UPPER/LOWER VERTICAL G11 SPACER
/com    7       EPOXY VOIDS
/com    8       G11 FILLER BLOCKS
/com    9       GROUNDWALL INSULATION
/com   10       HORIZONTAL G11 SHEETS
/com   11       PF1 CONDUCTOR REGION
/com   12       PF2 CONDUCTOR REGION
/com   13       PF3 CONDUCTOR REGION
/com   14       PF4 CONDUCTOR REGION
/com   15       PF5 CONDUCTOR REGION
/com   16       PF6 CONDUCTOR REGION
/com   17       PF7 CONDUCTOR REGION
/com   18       PLASMA CONDUCTOR REGION
/com   19       TF INTERCONNECT CONDUCTOR REGION
/com   20       Free Space REGION
/com
/com
/com  DEFINE PF CURRENT SOURCE GEOMETRY (Dimensions in m)
pr1=.81   $pz1=.251   $pdr1=.144   $pdz1=.478
pr2=.81   $pz2=.7065  $pdr2=.144   $pdz2=.383
pr3=.81   $pz3=1.0415 $pdr3=.144   $pdz3=.239
pr4=.81   $pz4=1.3055 $pdr4=.144   $pdz4=.239
pr5=1.213 $pz5=2.35   $pdr5=.192   $pdz5=.382
pr6=3.7585 $pz6=2.144  $pdr6=.143   $pdz6=.478
pr7=4.297  $pz7=1.1135 $pdr7=.144   $pdz7=.335
/com   IC COIL GEOMETRY AND CURRENTS
pr8=2.9405  $pz8=0.6845 $pdr8=.045 $pdz8=.045
/com   PLASMA GEOMETRY AND CURRENTS
pr9=2.25  $pz9=0.0  $pdr9=1.0  $pdz9=1.0
/com   TF INTERCONNECT COIL
r10=3.1915  $z10=2.6924  $dr10=.023  $dz10=.027
/com  PF CURRENTS for HC Scenario at t=9sec
/com ni1=-2953000.  $ni2= -679000. $ni3=  115000. $ni4=  319000.
/com ni5= 3348000.  $ni6=-1699000. $ni7= -202000.
/com ni8=     000.  $ni9= 2000000.0
/com  PF CURRENTS for HC Scenario at t=5 sec., initiation
ni1= 934000. $ni2= 2318000.  $ni3= 1448000.  $ni4= 1406000.
ni5=2770000. $ni6=  144000.  $ni7=  120000.
ni8=     000.  $ni9=00.0
itf= 2814000.0       ! tf current level
/com   itf=0
ntrn=84
icon=itf/ntrn
```

```
/com
/com  TF CURRENT SOURCE GEOMETRY
/com  tdr1=.2138  $tdz1=.3037  $tr1=2.29108  $tz1=1.16586
/com  tdr2=.2138  $tdz2=.3037  $tr2=2.29108  $tz2=0.67564
/com  tdr3=.2138  $tdz3=.3037  $tr3=-1.9223  $tz3=0.0
/com  tdr4=.2138  $tdz4=.3037            $tz4=0.0
/com  tsa1=90.0  $tea1=180.0  $tin1=1.05156
/com  tsa2=9.11  $tea2=90.0  $tin2=1.5418
/com  tsa3=-9.11  $tea3=9.11  $tin3=5.809
/com  tlen=2.3317  $thl=tlen/2
/com  trm1=tin1+tdr1/2
/com  tr4=tr1-trm1
/com  trm2=tin2+tdr2/2
/com  trm3=tin3+tdr3/2
/com  ang=22.5  !meshed angular span of pf coils
/com  acc=.00005  !Biot-savart integration accuracy
/com
/com
/com  BEGIN LOOP OVER TURNS
ix=1
/com  ELEMENT COORDINATE SYSTEMS
local,icsl+1,1,rsm+(ix-1)*csize,rsm    !lower left corner
local,icsl+2,1,rsm+fl+(ix-1)*csize,rsm   !lower right
local,icsl+3,1,rsm+(ix-1)*csize,rsm+fl   !upper left
local,icsl+4,1,rsm+fl+(ix-1)*csize,rsm+fl !upper right
csys,0
/com  KEYPOINTS
*get,kst,kp,,num,max  !max kp number
*get,lst,line,,num,max  !max line number
*get,ast,area,,num,max  !max area number
K,kst+1,rsm+(ix-1)*csize                !kp 1
K,kst+2,(ix-1)*csize,rsm                !kp 2
KGEN,2,kst+1,,,fl  $KGEN,2,kst+2,,,,fl  $KGEN,2,kst+2,,,cw,fl !kp 3-5
KGEN,2,kst+2,,,,cw  $KGEN,2,kst+1,,,,cw  $KGEN,2,kst+3,,,,cw !kp 6-8
KGEN,2,kst+6,,,tc  $KGEN,2,kst+5,,,tc  $KGEN,2,kst+7,,,,tc  !kp 9-11
KGEN,2,kst+8,,,,tc  $KGEN,2,kst+4,,,-tc  $KGEN,2,kst+2,,,-tc  !kp 12-14
KGEN,2,kst+1,,,,-tc $KGEN,2,kst+3,,,,-tc
KGEN,2,kst+9,,,tins1   $kgen,2,kst+9,,,tins1+tins2 !kp 15-18
KGEN,2,kst+10,,,tins1  $kgen,2,kst+10,,,tins1+tins2
KGEN,2,kst+11,,,,tins1  $kgen,2,kst+11,,,,tins1+tins2
KGEN,2,kst+12,,,,tins1  $kgen,2,kst+12,,,,tins1+tins2 !kp 19-24
KGEN,2,kst+13,,,-tins1  $kgen,2,kst+13,,,-tins1-tins2
KGEN,2,kst+14,,,-tins1  $kgen,2,kst+14,,,-tins1-tins2
KGEN,2,kst+15,,,,-tins1 $kgen,2,kst+15,,,,-tins1-tins2 !kp 25-30
KGEN,2,kst+16,,,,-tins1 $kgen,2,kst+16,,,,-tins1-tins2
```

```
KGEN,2,kst+32,,,r2     $KGEN,2,kst+24,,,r2  !kp 31-34
KGEN,2,kst+30,,,-r2    $KGEN,2,kst+22,,,-r2  $KGEN,2,kst+33,,,,tg11 !kp 35-37
KGEN,2,kst+34,,,,-tg11  $KGEN,2,kst+33,,,tg11 $KGEN,2,kst+37,,,tg11  !kp 38-40
KGEN,2,kst+18,,,tg11   $KGEN,2,kst+20,,,tg11 $KGEN,2,kst+38,,,tg11  !kp 41-43
KGEN,2,kst+34,,,tg11  $KGEN,2,kst+36,,,,-tg11 $KGEN,2,kst+35,,,,tg11 !kp 44-46
kgen,2,kst+6,,,tc-cn  $kgen,2,kst+5,,,tc-cn   $kgen,2,kst+7,,,,tc-cn !kp 47,49
kgen,2,kst+8,,,,tc-cn $kgen,2,kst+4,,,-tc+cn  $kgen,2,kst+2,,,-tc+cn !kp 50,52
kgen,2,kst+1,,,,-tc+cn $kgen,2,kst+3,,,,-tc+cn                !kp 53,54
k,,cw/2+(ix-1)*csize,cw/2  !keypoint for larc command  kp 55
*get,knm,kp,,num,max !kp number of larc command
/com
/com  LINES
L,kst+6,kst+5   $L,kst+8,kst+7   $L,kst+4,kst+2   $L,kst+1,kst+3   !lines 1-4
/com L,kst+9,kst+10  $L,kst+12,kst+11  $L,kst+13,kst+14  $L,kst+15,kst+16 !lines
5-8
l,kst+47,kst+48  $l,kst+50,kst+49  $l,kst+51,kst+52  $l,kst+53,kst+54 !lines 5-8
L,kst+17,kst+19  $L,kst+23,kst+21  $L,kst+25,kst+27  $L,kst+29,kst+31 !lines 9-12
L,kst+18,kst+20  $L,kst+24,kst+22  $L,kst+26,kst+28  $L,kst+30,kst+32 !lines 13-
16
L,kst+39,kst+40  $L,kst+37,kst+33  $L,kst+33,kst+39  $L,kst+40,kst+37 !lines 17-
20
L,kst+40,kst+41  $L,kst+41,kst+42  $L,kst+42,kst+43  $L,kst+43,kst+44 !lines 21-
24
L,kst+37,kst+18  $L,kst+20,kst+38  $L,kst+38,kst+34  $L,kst+38,kst+43 !lines 25-
28
L,kst+44,kst+34  $L,kst+34,kst+24  $L,kst+22,kst+36  $L,kst+36,kst+45 !lines 29-
32
L,kst+45,kst+26  $L,kst+28,kst+46                !lines 33-34
L,kst+46,kst+35  $L,kst+35,kst+30
/com $L,kst+3,kst+16  $L,kst+16,kst+31,rdiv  !lines 35-38
l,kst+3,kst+54   $l,kst+16,kst+31,2
L,kst+31,kst+32,rdiv
/com $L,kst+6,kst+9 $L,kst+9,kst+17,rdiv $L,kst+17,kst+18,rdiv !lines 39-42 thru
thickness wrap
l,kst+6,kst+47   $l,kst+9,kst+17,rdiv    $l,kst+17,kst+18,rdiv
L,kst+18,kst+41
/com $L,kst+5,kst+10 $L,kst+10,kst+19,rdiv $L,kst+19,kst+20,rdiv !lines 43-46
l,kst+5,kst+48   $l,kst+10,kst+19,rdiv   $l,kst+19,kst+20,rdiv
L,kst+20,kst+42
/com  $L,kst+8,kst+12 $L,kst+12,kst+23,rdiv  $L,kst+23,kst+24,rdiv !lines 47-50
l,kst+8,kst+50   $l,kst+12,kst+23,rdiv   $l,kst+23,kst+24,rdiv
/com L,kst+7,kst+11  $L,kst+11,kst+21,rdiv $L,kst+21,kst+22,rdiv $L,kst+4,kst+13
!lines 51-54
l,kst+7,kst+49   $l,kst+11,kst+21,rdiv   $l,kst+21,kst+22,rdiv   $l,kst+4,kst+51
```

```
L,kst+13,kst+25,rdiv $L,kst+25,kst+26,rdiv $L,kst+2,kst+52 $L,kst+14,kst+27,rdiv
!lines 55-58
L,kst+27,kst+28,rdiv $L,kst+1,kst+53 $L,kst+15,kst+29,rdiv $L,kst+29,kst+30,rdiv
!lines 59-62
/com
/com  ARCS
lplot
LARC,kst+3,kst+6,knm,rsm    $LARC,kst+5,kst+8,knm,rsm   !lines 63-64
LARC,kst+7,kst+4,knm,rsm    $LARC,kst+2,kst+1,knm,rsm   !lines 65-66
LARC,kst+54,kst+47,knm,rou-cn,ldiv  $LARC,kst+48,kst+50,knm,rou-cn,ldiv !lines
67-68 arc length at corner
LARC,kst+49,kst+51,knm,rou-cn,ldiv  $LARC,kst+52,kst+53,knm,rou-cn,ldiv !lines
69-70 for wrap lines 67-78
LARC,kst+31,kst+17,knm,r1,ldiv  $LARC,kst+19,kst+23,knm,r1,ldiv  !lines 71-72
LARC,kst+21,kst+25,knm,r1,ldiv  $LARC,kst+27,kst+29,knm,r1,ldiv  !lines 73-74
LARC,kst+32,kst+18,knm,r2,ldiv  $LARC,kst+20,kst+24,knm,r2,ldiv  !lines 75-76
LARC,kst+22,kst+26,knm,r2,ldiv  $LARC,kst+28,kst+30,knm,r2,ldiv  !lines 77-78
L,kst+32,kst+33                 !line 79
/com
l,11,12  $l,10,9  $l,16,15  $l,14,13
larc,kst+16,kst+9,knm,rou,ldiv   $larc,kst+10,kst+12,knm,rou,ldiv
larc,kst+11,kst+13,knm,rou,ldiv  $larc,kst+14,kst+15,knm,rou,ldiv
/com
lsel,all
lcomb,32,33
lcomb,34,35
lcomb,26,27
lcomb,18,25
/com  start areas
/com  Begin with outside wrap areas
/com   mesh outer wrap  AREAS 1-8
AL,lst+76,lst+50,lst+72,lst+46
AL,lst+14,lst+53,lst+10,lst+50
AL,lst+77,lst+56,lst+73,lst+53
AL,lst+15,lst+59,lst+11,lst+56  $AL,lst+78,lst+62,lst+74,lst+59
AL,lst+16,lst+39,lst+12,lst+62
AL,lst+75,lst+42,lst+71,lst+39  $AL,lst+13,lst+46,lst+9,lst+42
/com
/com  second (inner)wrap layer  AREAS 9-16
AL,lst+72,lst+49,lst+85,lst+45  $AL,lst+10,lst+52,lst+80,lst+49
AL,lst+73,lst+55,lst+86,lst+52
AL,lst+11,lst+58,lst+83,lst+55  $AL,lst+74,lst+61,lst+87,lst+58
AL,lst+12,lst+38,lst+82,lst+61
AL,lst+71,lst+41,lst+84,lst+38  $AL,lst+9,lst+45,lst+81,lst+41
/com
```

```
/com  more areas  conduit regions  AREAS 17-24
AL,lst+2,lst+48,lst+6,lst+51   $AL,lst+65,lst+51,lst+69,lst+54
AL,lst+3,lst+54,lst+7,lst+57
AL,lst+66,lst+57,lst+70,lst+60  $AL,lst+4,lst+60,lst+8,lst+37
AL,lst+63,lst+37,lst+67,lst+40
AL,lst+1,lst+40,lst+5,lst+44   $AL,lst+64,lst+44,lst+68,lst+48
/com
/com  start roving areas  AREAS 25-28
AL,lst+77,lst+31,lst+32
AL,lst+78,lst+34,lst+36
AL,lst+75,lst+79,lst+35
AL,lst+76,lst+33,lst+30
/com
/com  bottom right corner area  AREA 29
AL,lst+18,lst+19,lst+17,lst+20
/com
/com   G11 spacers  (3 total)  AREA 30-32
AL,lst+25,lst+20,lst+21,lst+43  $AL,lst+13,lst+43,lst+22,lst+47
AL,lst+26,lst+47,lst+23,lst+28
/com
/com  top right corner area  AREA 33
AL,lst+27,lst+28,lst+24,lst+29
/com
/com  set area attributes and mesh
eshape,3
asel,s,,,ast+1  $mat,3  $type,1 $esys,icsl+4    $amesh,all
asel,s,,,ast+3  $mat,3  $type,1 $esys,icsl+3    $amesh,all
asel,s,,,ast+5  $mat,3  $type,1 $esys,icsl+1    $amesh,all
asel,s,,,ast+7  $mat,3  $type,1 $esys,icsl+2    $amesh,all
ASEL,s,,,ast+2,ast+6,4  $mat,3  $type,1 $esys,11 $amesh,all  !material 3 , elem type
2 (esys with i-j side)
ASEL,s,,,ast+4,ast+8,4  $mat,3  $type,1 $esys,12 $amesh,all  !material 3 , elem type
2 (esys with i-j side)
/com
asel,s,,,ast+9   $mat,2  $type,1 $esys,icsl+4     $amesh,all
asel,s,,,ast+11  $mat,2  $type,1 $esys,icsl+3     $amesh,all
asel,s,,,ast+13  $mat,2  $type,1 $esys,icsl+1     $amesh,all
asel,s,,,ast+15  $mat,2  $type,1 $esys,icsl+2     $amesh,all
ASEL,s,,,ast+10,ast+14,4  $mat,2  $type,1 $esys,11 $amesh,all  !material 3 , elem
type 2 (esys with i-j side)
ASEL,s,,,ast+12,ast+16,4  $mat,2  $type,1 $esys,12 $amesh,all  !material 3 , elem
type 2 (esys with i-j side)
/com
ASEL,s,,,ast+17,ast+24  $mat,1  $type,1 $esys,12 $amesh,all  ! material 1 , type 1
ASEL,S,,,ast+25,ast+28  $mat,4  $type,1 $esys,12 $amesh,all   !roving areas
```

```
ASEL,S,,,ast+31    $mat,5  $type,1 $esys,12    $amesh,all   !G11 spacer mat 5, type
2
ASEL,S,,,ast+30,ast+32,2 $mat,6 $type,1 $esys,12 $amesh,all   !G11 spacer mat 6,
type 1
ASEL,S,,,ast+29,ast+33,4 $mat,7 $type,1 $esys,11 $amesh,all   !corner areas epoxy,
mat 7, type 2
asel,all
icsl=icsl+4
nsel,all
esel,none
esel,all
csys,0
/com
/com   translate in radial and vertical direction
*get,ast,area,,num,max   !max area number
z1=pz3-pdz3/2
nrow=10
ncol=6
*do,ROW,1,nrow
*do,COL,1,ncol
*get,ast,area,,num,max
X=innerrad+csize*(COL-1)+pitch(ROW)
Y=z1+(csize+sp)*(ROW-1)
agen,2,1,28,1,X,Y,0,0,0,0
local,icsl+1,1,X+rsm,Y+rsm
local,icsl+2,1,X+rsm+fl,Y+rsm
local,icsl+3,1,X+rsm,Y+rsm+fl
local,icsl+4,1,X+rsm+fl,Y+rsm+fl
asel,s,,,ast+5  $asel,a,,,ast+13  $earea  $emodif,all,esys,icsl+1
asel,s,,,ast+7  $asel,a,,,ast+15  $earea  $emodif,all,esys,icsl+2
asel,s,,,ast+11 $asel,a,,,ast+3   $earea  $emodif,all,esys,icsl+3
asel,s,,,ast+1  $asel,a,,,ast+9   $earea  $emodif,all,esys,icsl+4
asel,all
esel,all
icsl=icsl+4
csys,0
*enddo
*enddo
aclear,1,33,1  $adele,1,33,1,1   *delete original areas
/com
asel,s,,,59 $asel,a,,,1570 $asel,a,,,1713 $asel,a,,,200
aclear,all
adele,all,,,1
esel,s,mat,,1,2
nsle
```

```
type,2
eintf,2*cn
esel,none
type,1
esel,s,mat,,3,4
nsel,all
nummrg,node,.0254*1e-4  $nummrg,kpoi,.0254*1e-4
btol,.01
asel,all
/com
/Com Merge Areas At 1-2 layer interface
/com
lsel,s,loc,y,z1+xx-sml,z1+xx+sml
asll        $asel,u,,,58    $asel,u,,,368
aclear,all   $aglue,all
/com Select Roving Areas And Mesh
asel,s,,,1,10   $asel,a,,,227,367,28   $asel,a,,,61,201,28
mat,4   $type,1   $esys,12   $amesh,all
/com Select outerwrap areas and mesh
asel,s,,,11,22
mat,3   $type,1   $esys,11   $amesh,all
/com
/Com Merge Areas At 2-3 Layer Interface
/com
lsel,s,loc,y,z1+xx-sml+csize,z1+xx+sml+csize
asll        $asel,u,,,226   $asel,u,,,536
aclear,all   $aglue,all
/com Select roving areas and mesh
asel,s,,,395,535,28   $asel,a,,,396,508,28   $asel,a,,,229,369,28
asel,a,,,254,366,28
mat,4   $type,1   $esys,12   $amesh,all
/com Select outer wrap areas and mesh
asel,s,,,23,33    $asel,a,,,35
mat,3   $type,1   $esys,11   $amesh,all
/com
/com Merge Areas At 3-4 Layer Interface
/com
lsel,s,loc,y,z1+xx-sml+2*csize,z1+xx+sml+2*csize
asll        $asel,u,,,563    $asel,u,,,537
aclear,all   $aglue,all
/com Select Roving Areas and Mesh
asel,s,,,394,534,28   $asel,a,,,564,704,28
asel,a,,,59,63,4    $asel,a,,,86,91,5    $ asel,a,,,114,119,5
asel,a,,,142,147,5   $asel,a,,,170,175,5
mat,4   $type,1    $esys,12   $amesh,all
```

```
/com Select Outer Wrap Areas and Mesh
asel,s,,,200,284,28  $asel,a,,,203,287,28
asel,a,,,207,263,28  $asel,a,,,198
mat,3    $type,1    $esys,11  $amesh,all
/com
/com Merge Areas At 4-5 Layer Interface
/com
/com Nothing Needed, They have equal offsets
/com
/com Merge Areas At 5-6 Layer Interface
/com
lsel,s,loc,y,z1+xx-sml+4*csize,z1+xx+sml+4*csize
asll
asel,u,,,730   $asel,u,,,1040
aclear,all     $aglue,all
/com Select Roving Areas and Mesh
/com
asel,s,,,899,1039,28  $asel,a,,,733,873,28
asel,a,,,343,347,4    $asel,a,,,371,375,4    $asel,a,,,291
asel,a,,,397          $asel,a,,,312,315,3    $asel,a,,,319,341,21
mat,4    $type,1      $esys,12    $amesh,all
/com Select Outer Wrap Areas and Mesh
asel,s,,,399,455,28   $asel,a,,,403,487,28
asel,a,,,425,509,28   $asel,a,,,483
mat,3    $type,1      $esys,11    $amesh,all
/com Merge Areas At 6-7 Layer Interface
lsel,s,loc,y,z1+xx-sml+5*csize,z1+xx+sml+5*csize
asll
asel,u,,,1067   $asel,u,,,1041
aclear,all      $aglue,all
/com Select Roving Areas and Mesh
asel,s,,,898,1038,28    $asel,a,,,1068,1208,28
asel,a,,,1095,1207,28   $asel,a,,,901,1013,28
mat,4    $type,1        $esys,12    $amesh,all
/com Select Outer Wrap Areas and Mesh
asel,s,,,515,683,28   $asel,a,,,591,675,28   $asel,a,,,511
mat,3    $type,1      $esys,11    $amesh,all
/com Merge Areas At 7-8 Layer Interface
lsel,s,loc,y,z1+xx-sml+6*csize,z1+xx+sml+6*csize
asll
asel,u,,,1066   $asel,u,,,1376
aclear,all      $aglue,all
/com Select Roving Areas and Mesh
asel,s,,,707,847,28     $asel,a,,,758,870,28
asel,a,,,1236,1348,28   $asel,a,,,1094,1206,28
```

```
asel,a,,,703
mat,4   $type,1       $esys,12   $amesh,all
/com Select Outer Wrap Areas and Mesh
asel,s,,,875,959,28     $asel,a,,,879,963,28
asel,a,,,900,984,28
mat,3    $type,1       $esys,11  $amesh,all
/com Merge Areas At 8-9 Layer
/com Nothing Needed, They are 1 Pitch Offsett, KP Align OK
/com Merge Areas At 9-10 Layer
lsel,s,loc,y,z1+xx-sml+8*csize,z1+xx+sml+8*csize
asll
asel,u,,,1402          $asel,u,,,1712
aclear,all            $aglue,all
/com Select Roving Areas and Mesh
asel,s,,,987,1071,28    $asel,a,,,991,1075,28
asel,a,,,1571,1711,28   $asel,a,,,1405,1545,28
asel,a,,,1012          $asel,a,,,1069
mat,4   $type,1       $esys,12   $amesh,all
/com Select Outer Wrap Areas and Mesh
asel,s,,,1099,1183,28   $asel,a,,,1097,1181,28
asel,a,,,1103,1187,28
mat,3   $type,1       $esys,11   $amesh,all
/com
/com Create Spacer Blocks
/com
csys,0
lsel,all
lgen,2,98,152,54,-pitch(1)-del,0
lgen,2,101,,,-pitch(1)-del,0
lgen,2,584,587,3,-pitch(2)-del,0
lgen,2,530,,,-pitch(2)-del,0
lgen,2,3986,4043,57,-pitch(10)-del,0
lgen,2,3983,,,-pitch(10)-del,0
lgen,2,98,152,54,-pitch(1)+del+(ncol+1)*csize
lgen,2,467,,,csize-pitch(1)+del
lgen,2,948,951,3,-pitch(2)+del+csize
lgen,2,902,,,-pitch(2)+del+csize
lgen,2,3986,4043,57,-pitch(10)+del+(ncol+1)*csize
lgen,2,4336,,,csize-pitch(10)+del
lsel,s,,,944,947,3   $lsel,a,,,1091,1094,3
lsel,a,,,896         $lsel,a,,,1088
lgen,8,all,,,,csize
lsel,all             $ksll
nummrg,kp            $asel,none
l,5,64        $l,2,62        $l,94,3        $l,358,6
```

```
l,887,33      $l,886,47      $l,1150,139    $l,1679,271
l,1678,446    $l,2207,578    $l,14,2206     $l,15,2434
l,12,2436     $l,20,286      $l,580,19      $l,844,25
l,845,42      $l,1109,104    $l,1636,236    $l,1637,403
l,2164,535    $l,711,2165    $l,2692,30     $l,28,2650
l,32,2651     $l,288,18
al,101,1760,890,1808
al,98,1808,877,884,1810,152
al,17,587,530,584,1811,896,947,944,1810,153
lsel,s,,,25     $lsel,a,,,53    $lsel,a,,,1166  $lsel,a,,,1019
lsel,a,,,1450   $lsel,a,,,1163  $lsel,a,,,962   $lsel,a,,,1820
lsel,a,,,1811   $lsel,a,,,1016  $lsel,a,,,1160  $lsel,a,,,585
al,all
lsel,all
al,1232,1238,1235,1820,1451,1394,1448,1832
al,1304,1310,1307,1832,1883,1826,1880,1882
lsel,s,,,76,84,8 $lsel,a,,,1400  $lsel,a,,,2315       $lsel,a,,,2746
lsel,a,,,1379   $lsel,a,,,2258  $lsel,a,,,1882,1885,3  $lsel,a,,,2312
lsel,a,,,1376   $lsel,a,,,1881
al,all
lsel,all
al,1522,1538,1523,1885,2747,2690,2744,1892
lsel,s,,,513
lsel,a,,,3176,3179,3          $lsel,a,,,3122       $lsel,a,,,3613
lsel,a,,,3560  $lsel,a,,,3610  $lsel,a,,,1892,1898,6  $lsel,a,,,1595
lsel,a,,,1616  $lsel,a,,,1610  $lsel,a,,,2745
al,all
lsel,all
al,1682,1736,1688,1898,3611,3554,3608,1904
al,803,4043,3986,1953,956,968,1904,3609
al,1022,1953,3983,1952
al,467,2042,1040,1954
al,23,949,1955,1034,1028,2042,470,519
al,27,1381,1957,1091,1094,1088,1955,948,902,951
al,1172,1184,1178,1964,1383,1334,1380,1957
al,58,1812,1766,1815,1970,1250,1256,1244,1964,1382
al,82,2677,1976,1322,1328,1316,1970,2244,2198,2247
al,1466,1520,1472,2024,2679,2630,2676,1976
lsel,s,,,85     $lsel,a,,,3108   $lsel,a,,,3062   $lsel,a,,,3111
lsel,a,,,515    $lsel,a,,,3541   $lsel,a,,,2025   $lsel,a,,,1592
lsel,a,,,1594   $lsel,a,,,1544   $lsel,a,,,2024   $lsel,a,,,2678
al,all
lsel,all
al,1664,1667,1666,2026,3543,3494,3540,2025
lsel,s,,,875    $lsel,a,,,4405   $lsel,a,,,2027   $lsel,a,,,1739
```

```
lsel,a,,,1754    $lsel,a,,,1738   $lsel,a,,,2026   $lsel,a,,,3542
lsel,a,,,3476    $lsel,a,,,3537   $lsel,a,,,3972   $lsel,a,,,3926
lsel,a,,,3975
al,all
lsel,all
al,1100,1106,2027,4404,4358,2029
al,1112,2036,4336,2029
/com Choice of esys 12 sets the weak dir of spacer block in Global X
/com Direction
aatt,8,,1,12
esize,.12*0.0254
amesh,all
asel,none
/com
/com   MESH STRAIGHT SECTIONS OF GROUND WRAP
ESIZE,.19*.0254     !default elem size
asel,none
ksel,s,kp,,2,12,10      $kgen,2,all,,,-twrap
ksel,s,kp,,18,28,10     $kgen,2,all,,,twrap
ksel,s,kp,,15,32,17     $kgen,2,all,,,,twrap
ksel,s,kp,,5,20,15      $kgen,2,all,,,,-twrap
ksel,all
l,4,9          $l,4,2          $l,9,12         $l,15,16
l,16,21         $l,21,32        $l,28,11        $l,11,10
l,10,18         $l,26,20        $l,26,22        $l,22,5
lsel,s,,,877,884,7
lsel,a,,,956,968,12             $lsel,a,,,1688   $lsel,a,,,1522
lsel,a,,,1400    $lsel,a,,,1307   $lsel,a,,,1160   $lsel,a,,,944,947,3
lsel,a,,,2096    $lsel,a,,,1595   $lsel,a,,,1538   $lsel,a,,,1379
lsel,a,,,1232    $lsel,a,,,1166   $lsel,a,,,2048   $lsel,a,,,1682
lsel,a,,,1616    $lsel,a,,,1523   $lsel,a,,,1304   $lsel,a,,,1238
lsel,a,,,1163    $lsel,a,,,2097   $lsel,a,,,1736   $lsel,a,,,1610
lsel,a,,,1376    $lsel,a,,,1310   $lsel,a,,,1235   $lsel,a,,,896
al,all
lsel,s,,,1028    $lsel,a,,,1100   $lsel,a,,,1738   $lsel,a,,,1592
lsel,a,,,1520    $lsel,a,,,1316   $lsel,a,,,1178   $lsel,a,,,1094
lsel,a,,,2120    $lsel,a,,,1106   $lsel,a,,,1666   $lsel,a,,,1594
lsel,a,,,1466    $lsel,a,,,1250   $lsel,a,,,1184   $lsel,a,,,1088
lsel,a,,,2114    $lsel,a,,,1739   $lsel,a,,,1667   $lsel,a,,,1544
lsel,a,,,1322    $lsel,a,,,1256   $lsel,a,,,1172   $lsel,a,,,1034
lsel,a,,,2108    $lsel,a,,,1754   $lsel,a,,,1664   $lsel,a,,,1472
lsel,a,,,1328    $lsel,a,,,1244   $lsel,a,,,1091
al,all
aatt,9,,1,12
amesh,all
```

```
asel,none
lsel,s,,,104    $lsel,a,,,229   $lsel,a,,,370   $lsel,a,,,392
lsel,a,,,1954   $lsel,a,,,1760  $lsel,a,,,157   $lsel,a,,,298
lsel,a,,,320    $lsel,a,,,445   $lsel,a,,,2168  $lsel,a,,,226
lsel,a,,,248    $lsel,a,,,373   $lsel,a,,,514   $lsel,a,,,2169
lsel,a,,,176    $lsel,a,,,301   $lsel,a,,,442   $lsel,a,,,464
lsel,a,,,2170
al,all
lsel,s,,,1952   $lsel,a,,,4052  $lsel,a,,,4190  $lsel,a,,,4329
lsel,a,,,4340   $lsel,a,,,2098  $lsel,a,,,3980  $lsel,a,,,4118
lsel,a,,,4257   $lsel,a,,,4268  $lsel,a,,,2036  $lsel,a,,,4046
lsel,a,,,4185   $lsel,a,,,4196  $lsel,a,,,4334  $lsel,a,,,2101
lsel,a,,,4113   $lsel,a,,,4124  $lsel,a,,,4262  $lsel,a,,,4401
lsel,a,,,2099
al,all
aatt,9,,1,11
amesh,all
asel,none
lsel,all
larc,4,22,84,r3   $larc,9,16,2458,r3
larc,21,11,28,r3  $larc,26,10,18,r3
csys,17
clocal,5000,1,-(del+pitch(1))
csys,235
clocal,5001,1,-(del+pitch(nrow))
csys,38
clocal,5002,1,(1-pitch(1))*csize+del
csys,256
clocal,5003,1,(1-pitch(nrow))*csize+del
csys,0
asel,none
al,890,2170,2171,2096
aatt,9,,1,5000
amesh,all
asel,none
al,1022,2097,2173,2098
aatt,9,,1,5001
amesh,all
asel,none
al,1112,2101,2180,2108
aatt,9,,1,5002
amesh,all
asel,none
al,1040,2120,2186,2168
aatt,9,,1,5003
```

```
amesh,all
esel,all
/com
/com   Mesh current region
asel,none
lsel,all
ksel,all
*do,ROW,1,nrow
*do,COL,1,ncol
iof=((row-1)*ncol+col-1)*72
/com lsel,s,,,132+iof,150+iof,3
/com lsel,a,,,128+iof
lsel,none
lcomb,128,150
lcomb,147,144
lcomb,141,138
lcomb,135,132
al,all
lsel,all
/PREP7
kgen,2,16,,,3/8/2*.0254
kgen,2,16,,,,3/8/2*.0254
FLST,5,2,3,ORDE,2
FITEM,5,27
FITEM,5,31
KSEL,U, , ,P51X
kgen,2,16,,,,3/8/2*.0254
kgen,2,21,,,,3/8/2*.0254
kgen,2,22,,,,-3/8/2*.0254
kgen,2,26,,,,-3/8/2*.0254
LSTR,     16,     36
LSTR,     36,     37
LSTR,     37,     21
LSTR,     38,     22
LSTR,     38,     39
LSTR,     39,     26
lsel,all
asel,none
FLST,2,4,4,ORDE,4
FITEM,2,2099
FITEM,2,2192
FITEM,2,2240
FITEM,2,-2241
AL,P51X
FLST,2,4,4,ORDE,4
```

```
FITEM,2,2169
FITEM,2,2242
FITEM,2,-2243
FITEM,2,2245
AL,P51X
mat,1
amesh,all
save,sl2dmr,db
/eof


/eof
/com


/com File coord1.csv
/com The model was mirrored in y, The elem coord systems were not
/com This will place them where they belong

csys,0 $clocal,13,1,2.69E-03,-0.00269,0,0,0,0
csys,0 $clocal,14,1,1.48E-02,-0.00269,0,0,0,0
csys,0 $clocal,15,1,2.69E-03,-0.01478,0,0,0,0
csys,0 $clocal,16,1,1.48E-02,-0.01478,0,0,0,0
csys,0 $clocal,17,1,0.73078,-0.92469,0,0,0,0
csys,0 $clocal,18,1,0.74287,-0.92469,0,0,0,0
csys,0 $clocal,19,1,0.73078,-0.93678,0,0,0,0
csys,0 $clocal,20,1,0.74287,-0.93678,0,0,0,0
csys,0 $clocal,21,1,0.75471,-0.92469,0,0,0,0
csys,0 $clocal,22,1,0.7668,-0.92469,0,0,0,0
csys,0 $clocal,23,1,0.75471,-0.93678,0,0,0,0
csys,0 $clocal,24,1,0.7668,-0.93678,0,0,0,0
csys,0 $clocal,25,1,0.77864,-0.92469,0,0,0,0
csys,0 $clocal,26,1,0.79073,-0.92469,0,0,0,0
csys,0 $clocal,27,1,0.77864,-0.93678,0,0,0,0
csys,0 $clocal,28,1,0.79073,-0.93678,0,0,0,0
csys,0 $clocal,29,1,0.80256,-0.92469,0,0,0,0
csys,0 $clocal,30,1,0.81465,-0.92469,0,0,0,0
csys,0 $clocal,31,1,0.80256,-0.93678,0,0,0,0
csys,0 $clocal,32,1,0.81465,-0.93678,0,0,0,0
csys,0 $clocal,33,1,0.82649,-0.92469,0,0,0,0
csys,0 $clocal,34,1,0.83858,-0.92469,0,0,0,0
csys,0 $clocal,35,1,0.82649,-0.93678,0,0,0,0
csys,0 $clocal,36,1,0.83858,-0.93678,0,0,0,0
csys,0 $clocal,37,1,0.85042,-0.92469,0,0,0,0
```

```
csys,0 $clocal,38,1,0.86251,-0.92469,0,0,0,0
csys,0 $clocal,39,1,0.85042,-0.93678,0,0,0,0
csys,0 $clocal,40,1,0.86251,-0.93678,0,0,0,0
csys,0 $clocal,41,1,0.73677,-0.94862,0,0,0,0
csys,0 $clocal,42,1,0.74886,-0.94862,0,0,0,0
csys,0 $clocal,43,1,0.73677,-0.96071,0,0,0,0
csys,0 $clocal,44,1,0.74886,-0.96071,0,0,0,0
csys,0 $clocal,45,1,0.76069,-0.94862,0,0,0,0
csys,0 $clocal,46,1,0.77278,-0.94862,0,0,0,0
csys,0 $clocal,47,1,0.76069,-0.96071,0,0,0,0
csys,0 $clocal,48,1,0.77278,-0.96071,0,0,0,0
csys,0 $clocal,49,1,0.78462,-0.94862,0,0,0,0
csys,0 $clocal,50,1,0.79671,-0.94862,0,0,0,0
csys,0 $clocal,51,1,0.78462,-0.96071,0,0,0,0
csys,0 $clocal,52,1,0.79671,-0.96071,0,0,0,0
csys,0 $clocal,53,1,0.80855,-0.94862,0,0,0,0
csys,0 $clocal,54,1,0.82064,-0.94862,0,0,0,0
csys,0 $clocal,55,1,0.80855,-0.96071,0,0,0,0
csys,0 $clocal,56,1,0.82064,-0.96071,0,0,0,0
csys,0 $clocal,57,1,0.83247,-0.94862,0,0,0,0
csys,0 $clocal,58,1,0.84456,-0.94862,0,0,0,0
csys,0 $clocal,59,1,0.83247,-0.96071,0,0,0,0
csys,0 $clocal,60,1,0.84456,-0.96071,0,0,0,0
csys,0 $clocal,61,1,0.8564,-0.94862,0,0,0,0
csys,0 $clocal,62,1,0.86849,-0.94862,0,0,0,0
csys,0 $clocal,63,1,0.8564,-0.96071,0,0,0,0
csys,0 $clocal,64,1,0.86849,-0.96071,0,0,0,0
csys,0 $clocal,65,1,0.74873,-0.97255,0,0,0,0
csys,0 $clocal,66,1,0.76082,-0.97255,0,0,0,0
csys,0 $clocal,67,1,0.74873,-0.98464,0,0,0,0
csys,0 $clocal,68,1,0.76082,-0.98464,0,0,0,0
csys,0 $clocal,69,1,0.77266,-0.97255,0,0,0,0
csys,0 $clocal,70,1,0.78475,-0.97255,0,0,0,0
csys,0 $clocal,71,1,0.77266,-0.98464,0,0,0,0
csys,0 $clocal,72,1,0.78475,-0.98464,0,0,0,0
csys,0 $clocal,73,1,0.79658,-0.97255,0,0,0,0
csys,0 $clocal,74,1,0.80867,-0.97255,0,0,0,0
csys,0 $clocal,75,1,0.79658,-0.98464,0,0,0,0
csys,0 $clocal,76,1,0.80867,-0.98464,0,0,0,0
csys,0 $clocal,77,1,0.82051,-0.97255,0,0,0,0
csys,0 $clocal,78,1,0.8326,-0.97255,0,0,0,0
csys,0 $clocal,79,1,0.82051,-0.98464,0,0,0,0
csys,0 $clocal,80,1,0.8326,-0.98464,0,0,0,0
csys,0 $clocal,81,1,0.84444,-0.97255,0,0,0,0
csys,0 $clocal,82,1,0.85653,-0.97255,0,0,0,0
```

```
csys,0 $clocal,83,1,0.84444,-0.98464,0,0,0,0
csys,0 $clocal,84,1,0.85653,-0.98464,0,0,0,0
csys,0 $clocal,85,1,0.86836,-0.97255,0,0,0,0
csys,0 $clocal,86,1,0.88045,-0.97255,0,0,0,0
csys,0 $clocal,87,1,0.86836,-0.98464,0,0,0,0
csys,0 $clocal,88,1,0.88045,-0.98464,0,0,0,0
csys,0 $clocal,89,1,0.74275,-0.99647,0,0,0,0
csys,0 $clocal,90,1,0.75484,-0.99647,0,0,0,0
csys,0 $clocal,91,1,0.74275,-1.0086,0,0,0,0
csys,0 $clocal,92,1,0.75484,-1.0086,0,0,0,0
csys,0 $clocal,93,1,0.76667,-0.99647,0,0,0,0
csys,0 $clocal,94,1,0.77876,-0.99647,0,0,0,0
csys,0 $clocal,95,1,0.76667,-1.0086,0,0,0,0
csys,0 $clocal,96,1,0.77876,-1.0086,0,0,0,0
csys,0 $clocal,97,1,0.7906,-0.99647,0,0,0,0
csys,0 $clocal,98,1,0.80269,-0.99647,0,0,0,0
csys,0 $clocal,99,1,0.7906,-1.0086,0,0,0,0
csys,0 $clocal,100,1,0.80269,-1.0086,0,0,0,0
csys,0 $clocal,101,1,0.81453,-0.99647,0,0,0,0
csys,0 $clocal,102,1,0.82662,-0.99647,0,0,0,0
csys,0 $clocal,103,1,0.81453,-1.0086,0,0,0,0
csys,0 $clocal,104,1,0.82662,-1.0086,0,0,0,0
csys,0 $clocal,105,1,0.83845,-0.99647,0,0,0,0
csys,0 $clocal,106,1,0.85054,-0.99647,0,0,0,0
csys,0 $clocal,107,1,0.83845,-1.0086,0,0,0,0
csys,0 $clocal,108,1,0.85054,-1.0086,0,0,0,0
csys,0 $clocal,109,1,0.86238,-0.99647,0,0,0,0
csys,0 $clocal,110,1,0.87447,-0.99647,0,0,0,0
csys,0 $clocal,111,1,0.86238,-1.0086,0,0,0,0
csys,0 $clocal,112,1,0.87447,-1.0086,0,0,0,0
csys,0 $clocal,113,1,0.74275,-1.0204,0,0,0,0
csys,0 $clocal,114,1,0.75484,-1.0204,0,0,0,0
csys,0 $clocal,115,1,0.74275,-1.0325,0,0,0,0
csys,0 $clocal,116,1,0.75484,-1.0325,0,0,0,0
csys,0 $clocal,117,1,0.76667,-1.0204,0,0,0,0
csys,0 $clocal,118,1,0.77876,-1.0204,0,0,0,0
csys,0 $clocal,119,1,0.76667,-1.0325,0,0,0,0
csys,0 $clocal,120,1,0.77876,-1.0325,0,0,0,0
csys,0 $clocal,121,1,0.7906,-1.0204,0,0,0,0
csys,0 $clocal,122,1,0.80269,-1.0204,0,0,0,0
csys,0 $clocal,123,1,0.7906,-1.0325,0,0,0,0
csys,0 $clocal,124,1,0.80269,-1.0325,0,0,0,0
csys,0 $clocal,125,1,0.81453,-1.0204,0,0,0,0
csys,0 $clocal,126,1,0.82662,-1.0204,0,0,0,0
csys,0 $clocal,127,1,0.81453,-1.0325,0,0,0,0
```

```
csys,0 $clocal,128,1,0.82662,-1.0325,0,0,0,0
csys,0 $clocal,129,1,0.83845,-1.0204,0,0,0,0
csys,0 $clocal,130,1,0.85054,-1.0204,0,0,0,0
csys,0 $clocal,131,1,0.83845,-1.0325,0,0,0,0
csys,0 $clocal,132,1,0.85054,-1.0325,0,0,0,0
csys,0 $clocal,133,1,0.86238,-1.0204,0,0,0,0
csys,0 $clocal,134,1,0.87447,-1.0204,0,0,0,0
csys,0 $clocal,135,1,0.86238,-1.0325,0,0,0,0
csys,0 $clocal,136,1,0.87447,-1.0325,0,0,0,0
csys,0 $clocal,137,1,0.74873,-1.0443,0,0,0,0
csys,0 $clocal,138,1,0.76082,-1.0443,0,0,0,0
csys,0 $clocal,139,1,0.74873,-1.0564,0,0,0,0
csys,0 $clocal,140,1,0.76082,-1.0564,0,0,0,0
csys,0 $clocal,141,1,0.77266,-1.0443,0,0,0,0
csys,0 $clocal,142,1,0.78475,-1.0443,0,0,0,0
csys,0 $clocal,143,1,0.77266,-1.0564,0,0,0,0
csys,0 $clocal,144,1,0.78475,-1.0564,0,0,0,0
csys,0 $clocal,145,1,0.79658,-1.0443,0,0,0,0
csys,0 $clocal,146,1,0.80867,-1.0443,0,0,0,0
csys,0 $clocal,147,1,0.79658,-1.0564,0,0,0,0
csys,0 $clocal,148,1,0.80867,-1.0564,0,0,0,0
csys,0 $clocal,149,1,0.82051,-1.0443,0,0,0,0
csys,0 $clocal,150,1,0.8326,-1.0443,0,0,0,0
csys,0 $clocal,151,1,0.82051,-1.0564,0,0,0,0
csys,0 $clocal,152,1,0.8326,-1.0564,0,0,0,0
csys,0 $clocal,153,1,0.84444,-1.0443,0,0,0,0
csys,0 $clocal,154,1,0.85653,-1.0443,0,0,0,0
csys,0 $clocal,155,1,0.84444,-1.0564,0,0,0,0
csys,0 $clocal,156,1,0.85653,-1.0564,0,0,0,0
csys,0 $clocal,157,1,0.86836,-1.0443,0,0,0,0
csys,0 $clocal,158,1,0.88045,-1.0443,0,0,0,0
csys,0 $clocal,159,1,0.86836,-1.0564,0,0,0,0
csys,0 $clocal,160,1,0.88045,-1.0564,0,0,0,0
csys,0 $clocal,161,1,0.73677,-1.0683,0,0,0,0
csys,0 $clocal,162,1,0.74886,-1.0683,0,0,0,0
csys,0 $clocal,163,1,0.73677,-1.0803,0,0,0,0
csys,0 $clocal,164,1,0.74886,-1.0803,0,0,0,0
csys,0 $clocal,165,1,0.76069,-1.0683,0,0,0,0
csys,0 $clocal,166,1,0.77278,-1.0683,0,0,0,0
csys,0 $clocal,167,1,0.76069,-1.0803,0,0,0,0
csys,0 $clocal,168,1,0.77278,-1.0803,0,0,0,0
csys,0 $clocal,169,1,0.78462,-1.0683,0,0,0,0
csys,0 $clocal,170,1,0.79671,-1.0683,0,0,0,0
csys,0 $clocal,171,1,0.78462,-1.0803,0,0,0,0
csys,0 $clocal,172,1,0.79671,-1.0803,0,0,0,0
```

```
csys,0 $clocal,173,1,0.80855,-1.0683,0,0,0,0
csys,0 $clocal,174,1,0.82064,-1.0683,0,0,0,0
csys,0 $clocal,175,1,0.80855,-1.0803,0,0,0,0
csys,0 $clocal,176,1,0.82064,-1.0803,0,0,0,0
csys,0 $clocal,177,1,0.83247,-1.0683,0,0,0,0
csys,0 $clocal,178,1,0.84456,-1.0683,0,0,0,0
csys,0 $clocal,179,1,0.83247,-1.0803,0,0,0,0
csys,0 $clocal,180,1,0.84456,-1.0803,0,0,0,0
csys,0 $clocal,181,1,0.8564,-1.0683,0,0,0,0
csys,0 $clocal,182,1,0.86849,-1.0683,0,0,0,0
csys,0 $clocal,183,1,0.8564,-1.0803,0,0,0,0
csys,0 $clocal,184,1,0.86849,-1.0803,0,0,0,0
csys,0 $clocal,185,1,0.75471,-1.0922,0,0,0,0
csys,0 $clocal,186,1,0.7668,-1.0922,0,0,0,0
csys,0 $clocal,187,1,0.75471,-1.1043,0,0,0,0
csys,0 $clocal,188,1,0.7668,-1.1043,0,0,0,0
csys,0 $clocal,189,1,0.77864,-1.0922,0,0,0,0
csys,0 $clocal,190,1,0.79073,-1.0922,0,0,0,0
csys,0 $clocal,191,1,0.77864,-1.1043,0,0,0,0
csys,0 $clocal,192,1,0.79073,-1.1043,0,0,0,0
csys,0 $clocal,193,1,0.80256,-1.0922,0,0,0,0
csys,0 $clocal,194,1,0.81465,-1.0922,0,0,0,0
csys,0 $clocal,195,1,0.80256,-1.1043,0,0,0,0
csys,0 $clocal,196,1,0.81465,-1.1043,0,0,0,0
csys,0 $clocal,197,1,0.82649,-1.0922,0,0,0,0
csys,0 $clocal,198,1,0.83858,-1.0922,0,0,0,0
csys,0 $clocal,199,1,0.82649,-1.1043,0,0,0,0
csys,0 $clocal,200,1,0.83858,-1.1043,0,0,0,0
csys,0 $clocal,201,1,0.85042,-1.0922,0,0,0,0
csys,0 $clocal,202,1,0.86251,-1.0922,0,0,0,0
csys,0 $clocal,203,1,0.85042,-1.1043,0,0,0,0
csys,0 $clocal,204,1,0.86251,-1.1043,0,0,0,0
csys,0 $clocal,205,1,0.87434,-1.0922,0,0,0,0
csys,0 $clocal,206,1,0.88643,-1.0922,0,0,0,0
csys,0 $clocal,207,1,0.87434,-1.1043,0,0,0,0
csys,0 $clocal,208,1,0.88643,-1.1043,0,0,0,0
csys,0 $clocal,209,1,0.73078,-1.1161,0,0,0,0
csys,0 $clocal,210,1,0.74287,-1.1161,0,0,0,0
csys,0 $clocal,211,1,0.73078,-1.1282,0,0,0,0
csys,0 $clocal,212,1,0.74287,-1.1282,0,0,0,0
csys,0 $clocal,213,1,0.75471,-1.1161,0,0,0,0
csys,0 $clocal,214,1,0.7668,-1.1161,0,0,0,0
csys,0 $clocal,215,1,0.75471,-1.1282,0,0,0,0
csys,0 $clocal,216,1,0.7668,-1.1282,0,0,0,0
csys,0 $clocal,217,1,0.77864,-1.1161,0,0,0,0
```

```
csys,0 $clocal,218,1,0.79073,-1.1161,0,0,0,0
csys,0 $clocal,219,1,0.77864,-1.1282,0,0,0,0
csys,0 $clocal,220,1,0.79073,-1.1282,0,0,0,0
csys,0 $clocal,221,1,0.80256,-1.1161,0,0,0,0
csys,0 $clocal,222,1,0.81465,-1.1161,0,0,0,0
csys,0 $clocal,223,1,0.80256,-1.1282,0,0,0,0
csys,0 $clocal,224,1,0.81465,-1.1282,0,0,0,0
csys,0 $clocal,225,1,0.82649,-1.1161,0,0,0,0
csys,0 $clocal,226,1,0.83858,-1.1161,0,0,0,0
csys,0 $clocal,227,1,0.82649,-1.1282,0,0,0,0
csys,0 $clocal,228,1,0.83858,-1.1282,0,0,0,0
csys,0 $clocal,229,1,0.85042,-1.1161,0,0,0,0
csys,0 $clocal,230,1,0.86251,-1.1161,0,0,0,0
csys,0 $clocal,231,1,0.85042,-1.1282,0,0,0,0
csys,0 $clocal,232,1,0.86251,-1.1282,0,0,0,0
csys,0 $clocal,233,1,0.73677,-1.14,0,0,0,0
csys,0 $clocal,234,1,0.74886,-1.14,0,0,0,0
csys,0 $clocal,235,1,0.73677,-1.1521,0,0,0,0
csys,0 $clocal,236,1,0.74886,-1.1521,0,0,0,0
csys,0 $clocal,237,1,0.76069,-1.14,0,0,0,0
csys,0 $clocal,238,1,0.77278,-1.14,0,0,0,0
csys,0 $clocal,239,1,0.76069,-1.1521,0,0,0,0
csys,0 $clocal,240,1,0.77278,-1.1521,0,0,0,0
csys,0 $clocal,241,1,0.78462,-1.14,0,0,0,0
csys,0 $clocal,242,1,0.79671,-1.14,0,0,0,0
csys,0 $clocal,243,1,0.78462,-1.1521,0,0,0,0
csys,0 $clocal,244,1,0.79671,-1.1521,0,0,0,0
csys,0 $clocal,245,1,0.80855,-1.14,0,0,0,0
csys,0 $clocal,246,1,0.82064,-1.14,0,0,0,0
csys,0 $clocal,247,1,0.80855,-1.1521,0,0,0,0
csys,0 $clocal,248,1,0.82064,-1.1521,0,0,0,0
csys,0 $clocal,249,1,0.83247,-1.14,0,0,0,0
csys,0 $clocal,250,1,0.84456,-1.14,0,0,0,0
csys,0 $clocal,251,1,0.83247,-1.1521,0,0,0,0
csys,0 $clocal,252,1,0.84456,-1.1521,0,0,0,0
csys,0 $clocal,253,1,0.8564,-1.14,0,0,0,0
csys,0 $clocal,254,1,0.86849,-1.14,0,0,0,0
csys,0 $clocal,255,1,0.8564,-1.1521,0,0,0,0
csys,0 $clocal,256,1,0.86849,-1.1521,0,0,0,0
csys,0 $clocal,5000,1,0.72761,-0.92469,0,180,0,0
csys,0 $clocal,5001,1,0.72761,-1.1521,0,180,0,0
csys,0 $clocal,5002,1,0.88961,-0.92469,0,0,0,0
csys,0 $clocal,5003,1,0.89545,-1.1521,0,0,0,0
/eof
/BATCH
```

```
/com File mcv.str
/com This file must be run after the file cpdr.str
/com File cpdr.str creates the database called sl2dmr.db that is used in this file
/com File mcv.str
/com This File will create the worst case vertical compression FEM Model
/com This file calls the following files, which must be in the same directory
/com coord1.csv   This file holds element coordinate system locations needed
because
/com              the magnetic model was mirrored to represent a lower CS Coil
/com revmat1.str  This file inputs the material properties
/com sdout        This file creates and stores stress plots
/nerr,2,200000
resume,sl2dmr,db
asel,all
esel,all
nsel,all
finish
/prep7
r,1,1e10,0,0,1e10
arsym,y,all,,,,0,1
/com Mirroring in Y doesnot get element coordinate systems
/com This file does it
/input,coord1,csv
/com clear all dof constraints to control and re- apply
nsel,all
ddele,all
/com apply constraint to Z dir, due to 3D contact elements
d,all,uz,0
/com constrain bottom line in y dir
lsel,s,,,2240
nsll
d,all,uy,0
/com Constrain top line to remain line, add preload force of 31.33 MNt
/com Inner Radius of Spacer Plate @ .7276 meter
/com Outer Radius of Spacer Plate @ .8896 Meter
/com This Defines an Area Equal To .8230 Sq Meter
/com The net force exerted between 1u and 1l is 31.33MNt
/com this results in a pressure of 31.33e6MNt/.8230 sq. meter or
/com 38.07 MNt
lsel,s,line,,2243
nsll,,1
sfl,2243,press,38.07e6
cp,1,uy,all
esel,s,mat,,13
nsle
```

```
ldread,forc,,,,,maxvc,rmg
/com save,sl2dmvc,db
/input,revmat1,str
mp,ex,13,1e9
mp,alpx,13,5.59e-6
FINISH
/SOLU
esel,all
nsel,all
asel,all
/com This Model Is To Have Thermal Stresses Calculated Based On The Epoxy
/com "Glass Transition" Temperature. This Temperature Was Estimated @ 100deg
/com C or K Above Room Temp. The Expansion Coefficients Are Estimated By
/com Phil Sanger To Be 147% Higher Thaan The Average Value Of The RT To
/com 4K Values. The Equivalent Contraction is achieved by
/com inflating the cooldown Temp By 147 deg.
tunif,-294-147
eqslv,pcg
solve
finish
/title,TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT
Zero Stress
/post1
/show,mcv1e10,plt,0,8
/input,sdout
/com Select Top And Bottom Lines to Determinne Forces
lsel,s,line,,2240   $nsll,s,1
fsum
/com Store Results
*get,frx1,fsum,,item,fx   $*get,fry1,fsum,,item,fy
lsel,s,line,,2243   $nsll,s,1
fsum
*get,frx2,fsum,,item,fx   $*get,fry2,fsum,,item,fy
/com save results
/output,mcve10,dat
lsel,s,line,,2240   $nsll,s,1
prnsol,u,x
prnsol,u,y
lsel,s,line,,2243   $nsll,s,1
prnsol,u,x
prnsol,u,y
*status
finish
/output
save,mcv,db
```

```
/com FILE revmat1.str
/com William Hannan
/com Westinghouse STC
/com June 9, 1995
/com Analysis done in Metric
/com 2D Model with slip planes at conduit OD
/com Mat'l per J.F Roach, Rev 2 to table assembled by L Myatt ,MIT/PFC
/com Dated 3/15/95,5/24/95
/com
/com  Young's modulus
mp,ex,1,185e9                          !material 1 incoloy
mp,ex,2,4.8e9  $mp,ey,2,5.5e9    $mp,ez,2,5.5e9 !material 2 insul. Kapton
mp,ex,3,23e9   $mp,ey,3,32e9     $mp,ez,3,25e9  !material 3 insul. 3D Weave
mp,ex,4,22e9   $mp,ey,4,25e9     $mp,ez,4,31e9  !material 4 insul. 3D corner fill
mp,ex,8,23e9   $mp,ey,8,32e9     $mp,ez,8,25e9  !material 8 insul. 3D Weave
mp,ex,9,19.7e9   $mp,ey,9,29.6e9     $mp,ez,9,29.6e9  !material 9 insul. 3D Weave
/com
mp,gxy,1,71e9   $mp,gxz,1,71e9    $mp,gyz,1,71e9
mp,gxy,2,.37e9  $mp,gxz,2,.37e9   $mp,gyz,2,.37e9
mp,gxy,3,8e9  $mp,gxz,3,8e9   $mp,gyz,3,8e9
mp,gxy,4,8.5e9  $mp,gxz,4,9e9   $mp,gyz,4,8e9
mp,gxy,8,8e9  $mp,gxz,8,8e9   $mp,gyz,8,8e9
mp,gxy,9,7.6e9  $mp,gxz,9,7.6e9   $mp,gyz,9,10.7e9
/com
mp,nuxy,1,.299  $mp,nuxz,1,.299   $mp,nuyz,1,.299
mp,nuxy,2,.34   $mp,nuxz,2,.34    $mp,nuyz,2,.34
mp,nuxy,3,.26   $mp,nuxz,3,.37    $mp,nuyz,3,.25
mp,nuxy,4,.26   $mp,nuxz,4,.38    $mp,nuyz,4,.23
mp,nuxy,8,.26   $mp,nuxz,8,.37    $mp,nuyz,8,.25
mp,nuxy,9,.26   $mp,nuxz,9,.37    $mp,nuyz,9,.25
/com
/com  thermal contractions
mp,alpx,1,5.92e-6 $mp,alpy,1,5.92e-6   $mp,alpz,1,5.92e-6 !Material 1
!material 1
mp,alpx,2,43.2e-6 $mp,alpy,2,13.0e-6   $mp,alpz,2,15.8e-6 !material 2
mp,alpx,3,19.2e-6   $mp,alpy,3,8.25e-6    $mp,alpz,3,16.2e-6   !material 3
mp,alpx,4,20.3e-6   $mp,alpy,4,16.2e-6    $mp,alpz,4,7.56e-6   !material 4
mp,alpx,8,19.2e-6   $mp,alpy,8,8.25e-6    $mp,alpz,8,16.2e-6   !material 8
mp,alpx,9,19.9e-6   $mp,alpy,9,6.7e-6    $mp,alpz,9,6.7e-6   !material 9
/com
/com The Mat'l are taken from full Ansys Model, not all ten Mat'ls are used.
/com    MAT #          DESCRIPTION
```

```
/com    1       INCOLOY CONDUIT
/com    2       CABLE WRAP  INNER
/com    3       CABLE WRAP  OUTER
/com    4       ROVING FILLER
/com    5       MID VERTICAL G11 SPACER
/com    6       UPPER/LOWER VERTICAL G11 SPACER
/com    7       EPOXY VOIDS
/com    8       G11 FILLER BLOCKS
/com    9       GROUNDWALL INSULATION
/com   10       HORIZONTAL G11 SHEETS
/com
```

/com File sdout

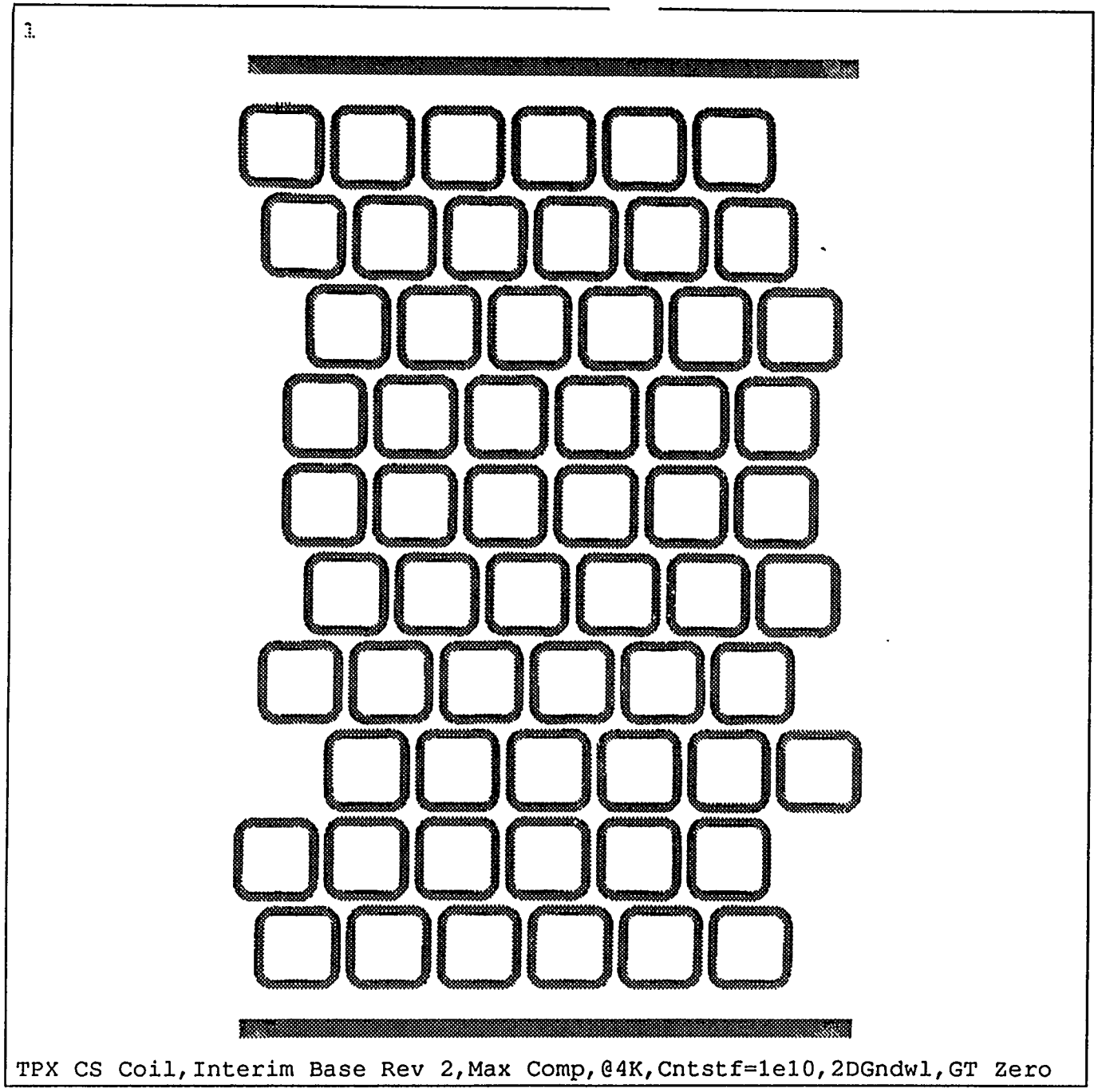
/com This file creates and stores output for later retrieval

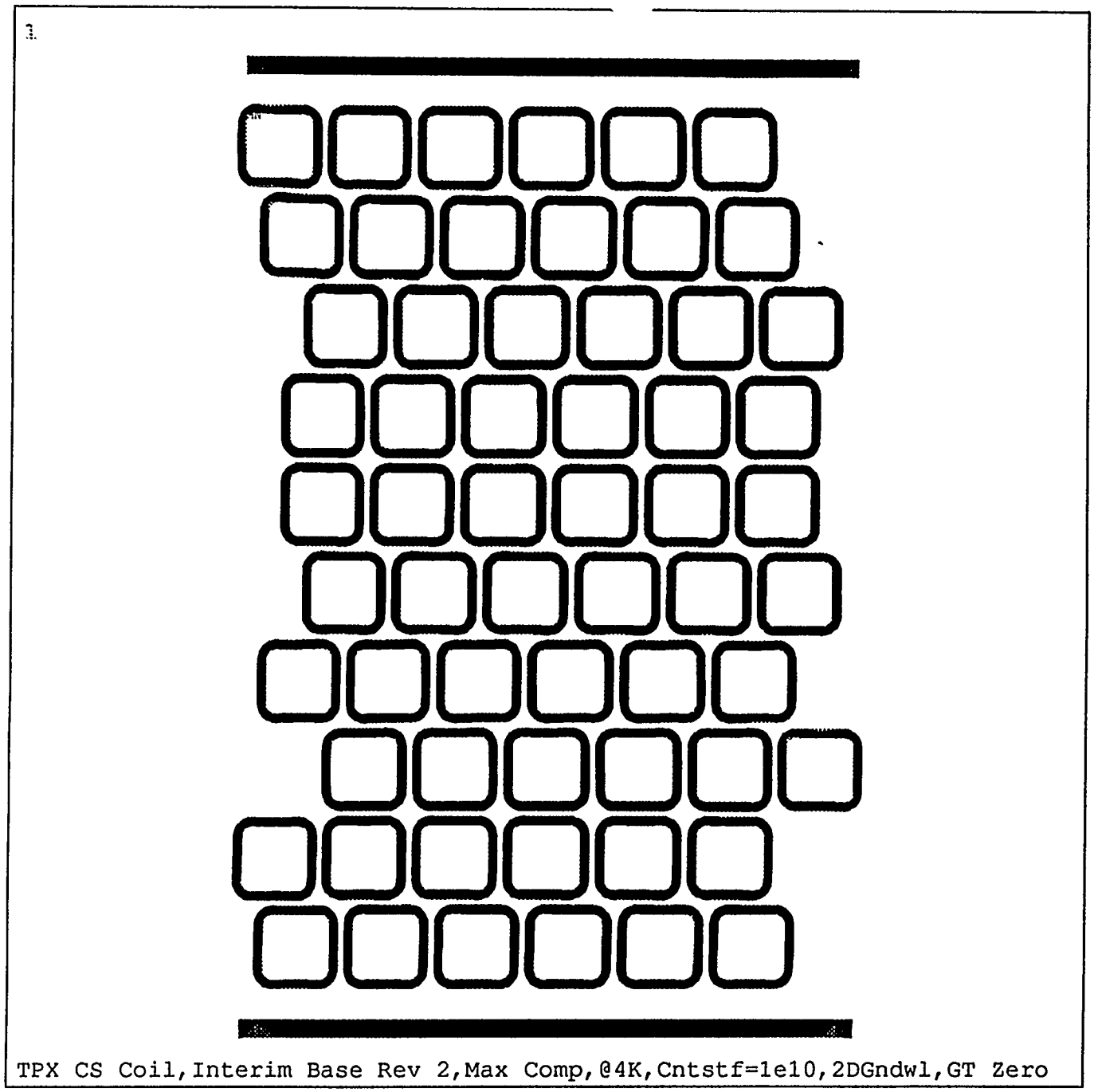
```
finish
/post1
/auto
/edge,all,1,45
/glin,all,-1
esel,s,mat,,2,10
esel,u,type,,2
rsys,solu
plesol,s,x
plesol,s,y
plesol,s,z
plesol,s,xy
plesol,s,int
esel,s,mat,,1
esel,u,type,,2
PLESOL,S,X
plesol,s,y
plesol,s,z
plesol,s,xy
plesol,s,int
plesol,s,1
plesol,s,3
plesol,epel,x
plesol,epel,y
plesol,epel,z
esel,s,mat,,2
esel,u,type,,2
plesol,s,x
plesol,s,y
```

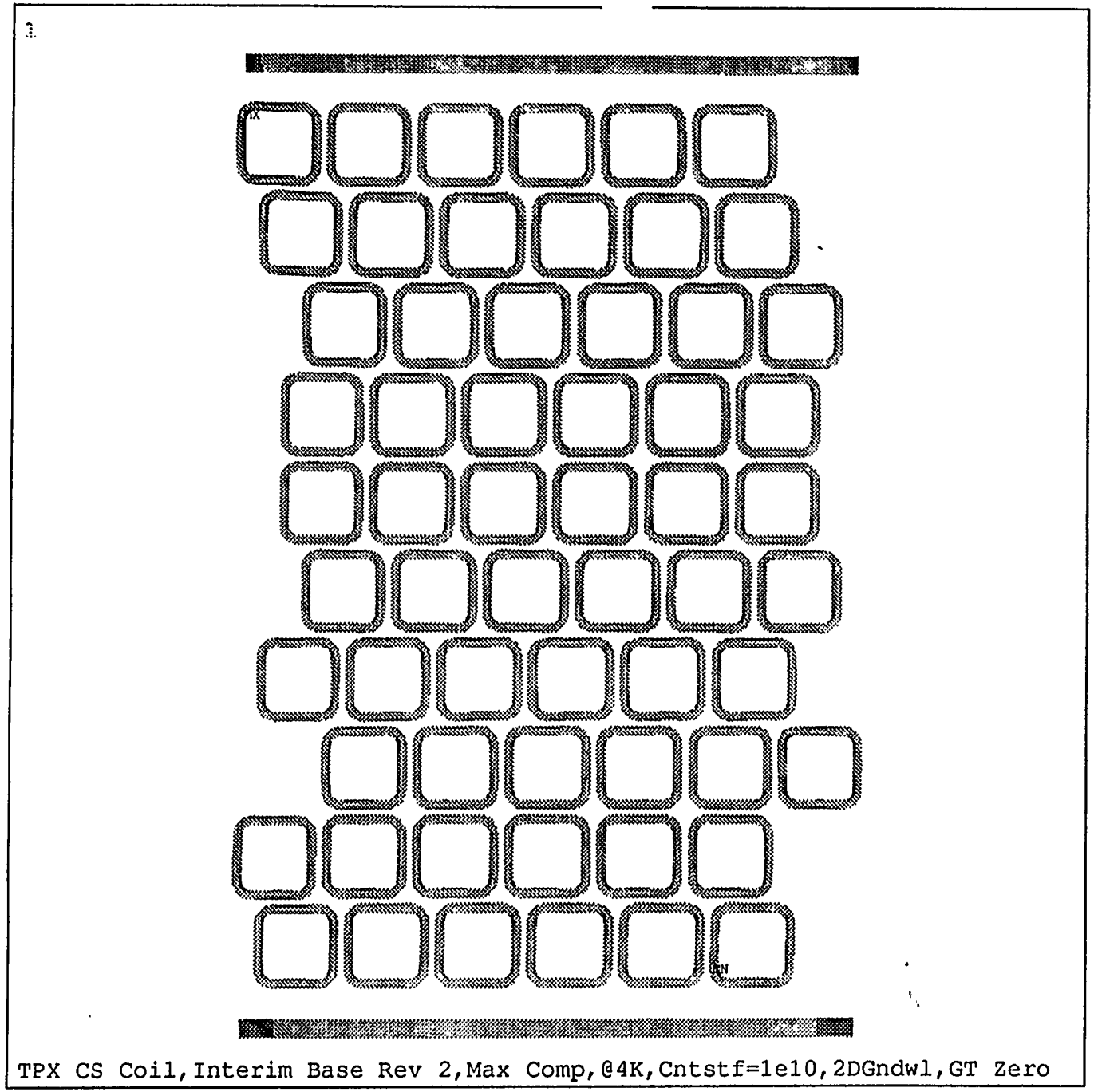
```
plesol,s,z
plesol,s,xy
plesol,s,int
esel,s,mat,,3
esel,u,type,,2
plesol,s,x
plesol,s,y
plesol,s,z
plesol,s,xy
plesol,s,int
esel,s,mat,,4
esel,u,type,,2
plesol,s,x
plesol,s,y
plesol,s,z
plesol,s,xy
plesol,s,int
esel,s,mat,,8
esel,u,type,,2
plesol,s,x
plesol,s,y
plesol,s,z
plesol,s,xy
plesol,s,int
esel,s,mat,,9
esel,u,type,,2
plesol,s,x
plesol,s,y
plesol,s,z
plesol,s,xy
plesol,s,int
/eof
```

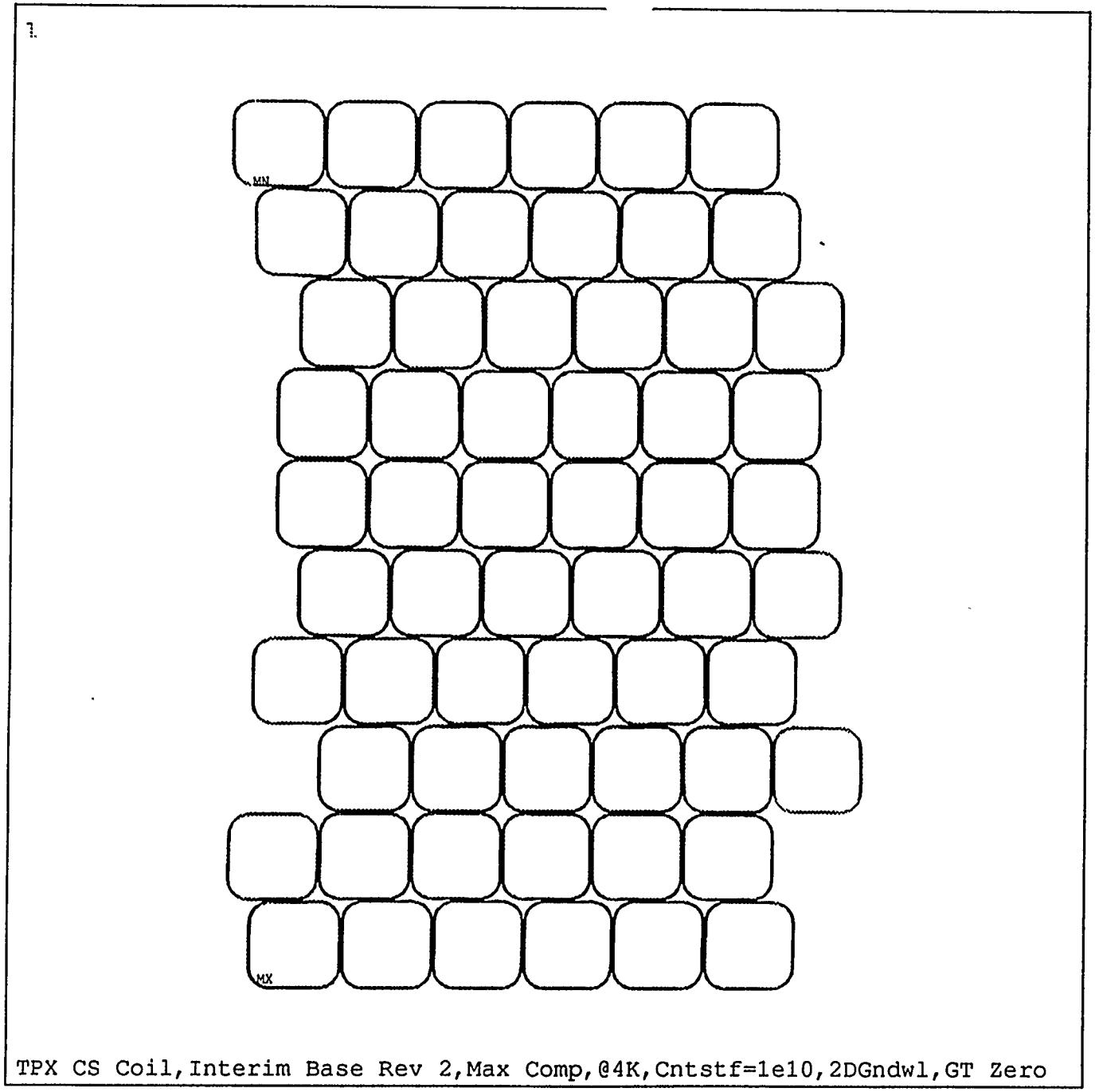
APPENDIX C

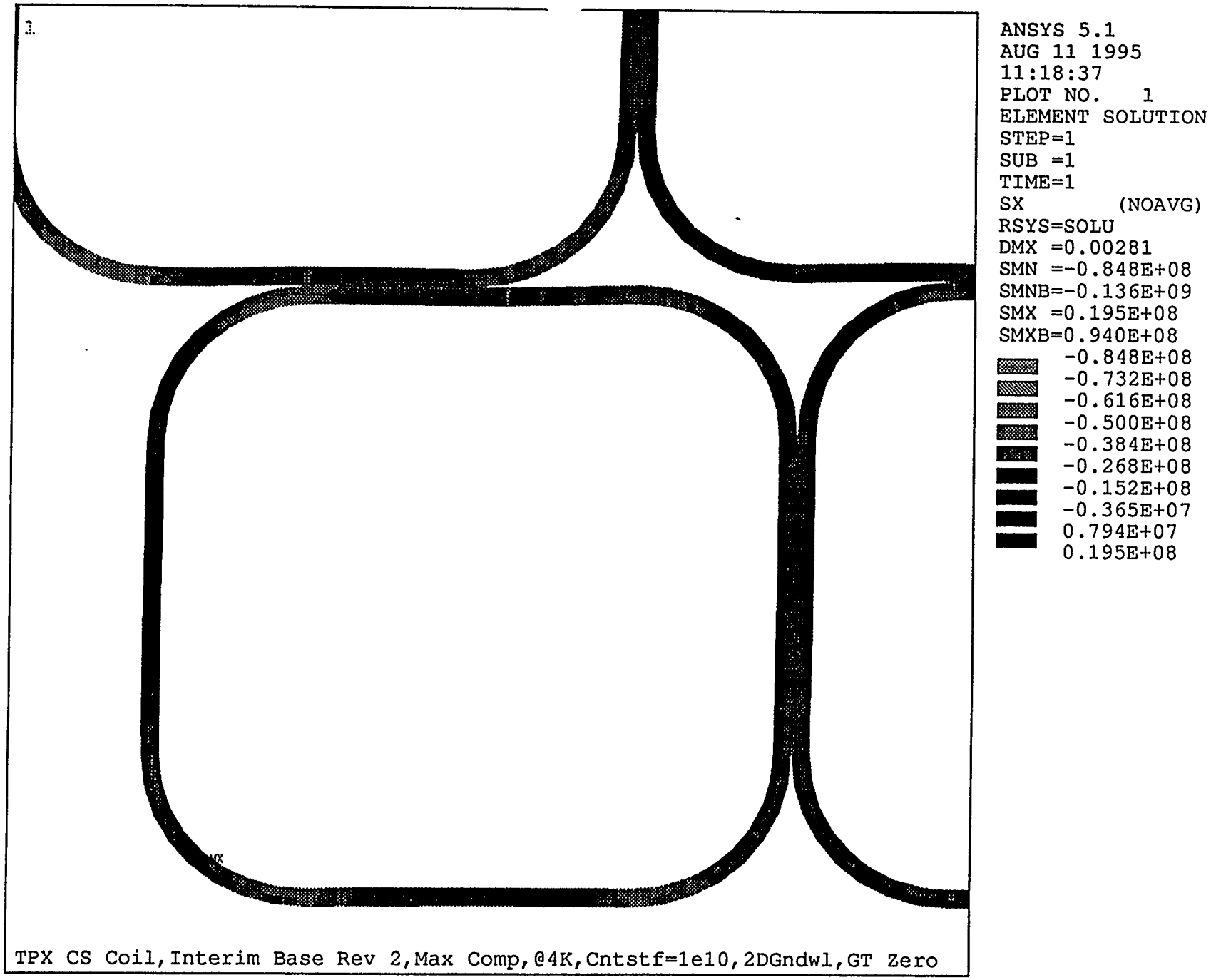
In the following 20 pages, the results of the FEA analyis of the CPDR for the maximum compressive case are given. All charts are labeled in the right upper corner for the stress state being presented. Each component is presented individually on separate graphs.

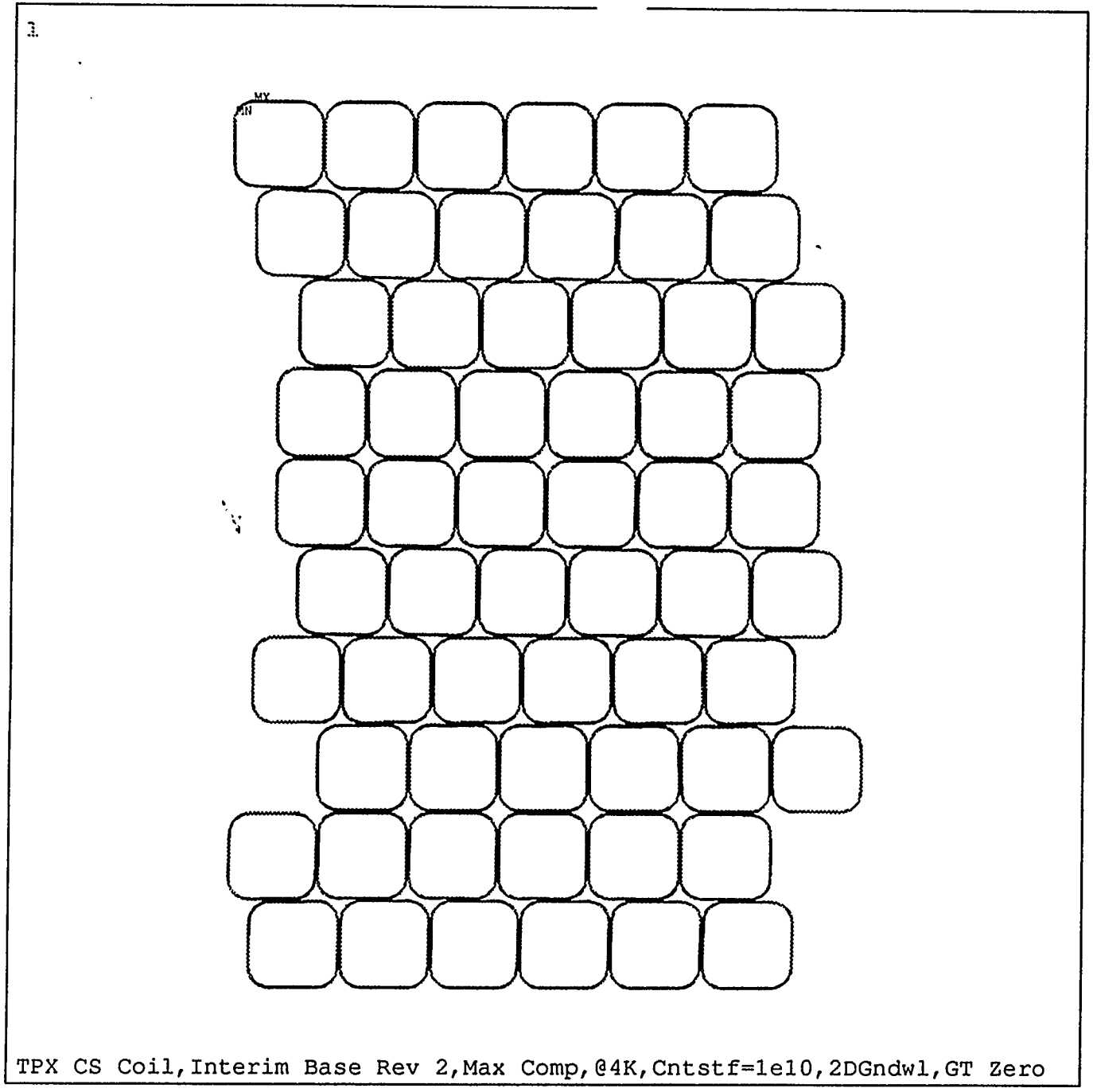

ANSYS 5.1
JUL 10 1995
15:22:56
PLOT NO. 11
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S1 (NOAVG)
DMX =0.00281
SMN =-0.146E+09
SMNB=-0.245E+09
SMX =0.479E+09
SMXB=0.512E+09
-0.146E+09
-0.763E+08
-0.689E+07
0.625E+08
0.132E+09
0.201E+09
0.271E+09
0.340E+09
0.410E+09
0.479E+09
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero

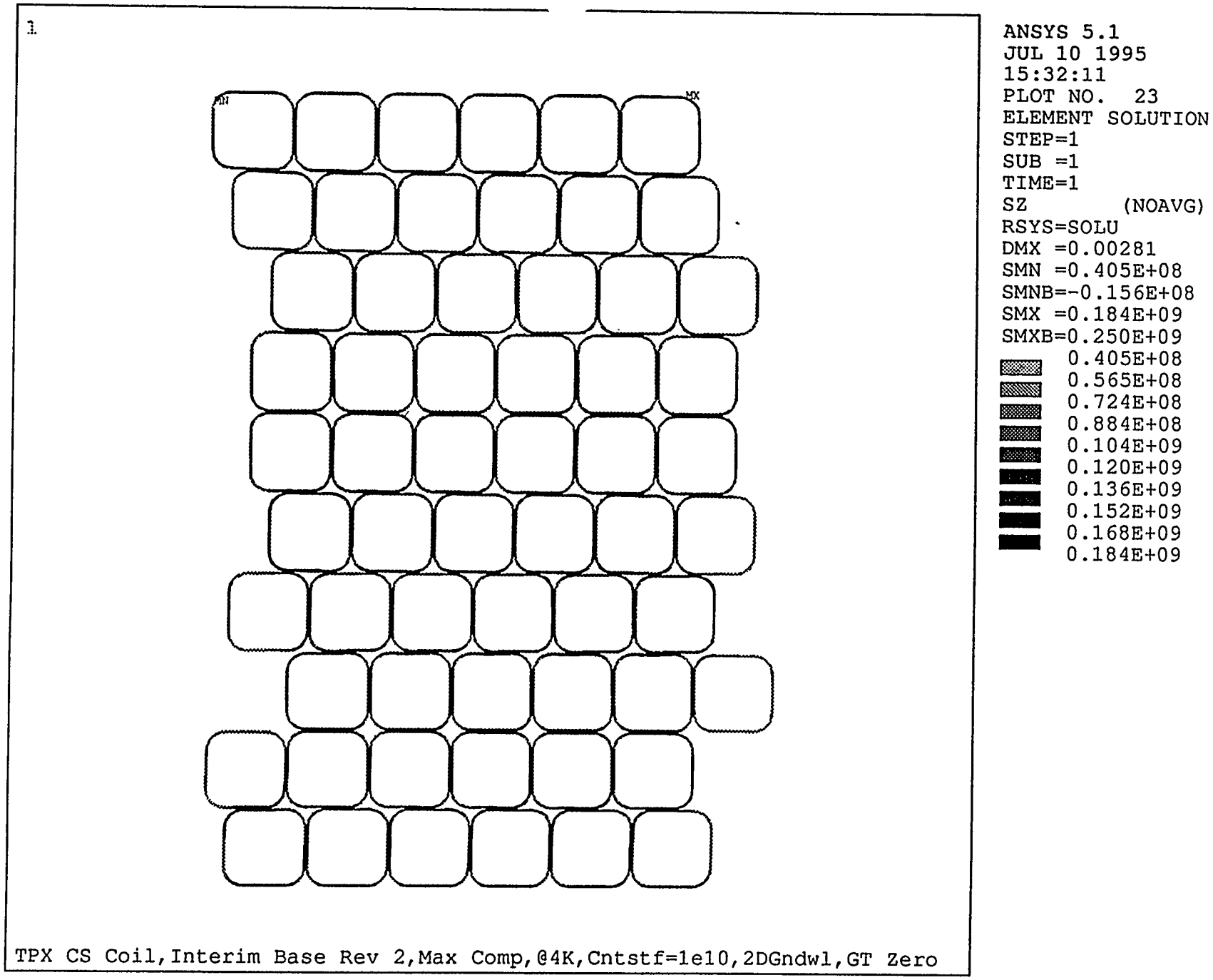

ANSYS 5.1
JUL 10 1995
15:23:51
PLOT NO. 12
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
S3 (NOAVG)
DMX =0.00281
SMN =-0.782E+09
SMNB=-0.849E+09
SMX =0.872E+07
SMXB=0.129E+09
-0.782E+09
-0.694E+09
-0.606E+09
-0.519E+09
-0.431E+09
-0.343E+09
-0.255E+09
-0.167E+09
-0.792E+08
0.872E+07
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero

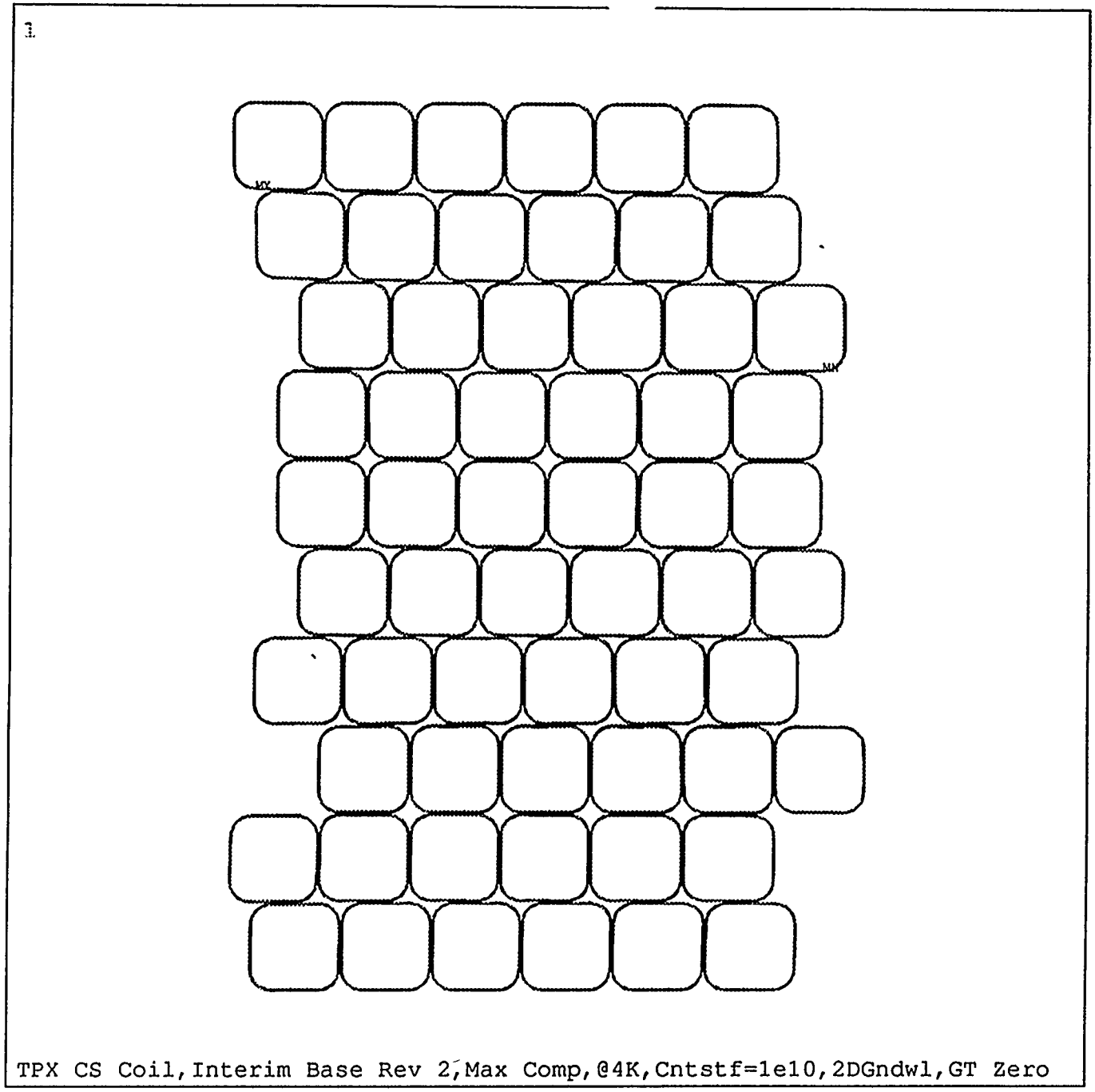

ANSYS 5.1
JUL 10 1995
15:22:02
PLOT NO. 10
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SINT (NOAVG)
DMX =0.00281
SMN =0.635E+08
SMNB=-0.734E+07
SMX =0.740E+09
SMXB=0.787E+09
0.635E+08
0.139E+09
0.214E+09
0.289E+09
0.364E+09
0.439E+09
0.514E+09
0.589E+09
0.665E+09
0.740E+09
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero

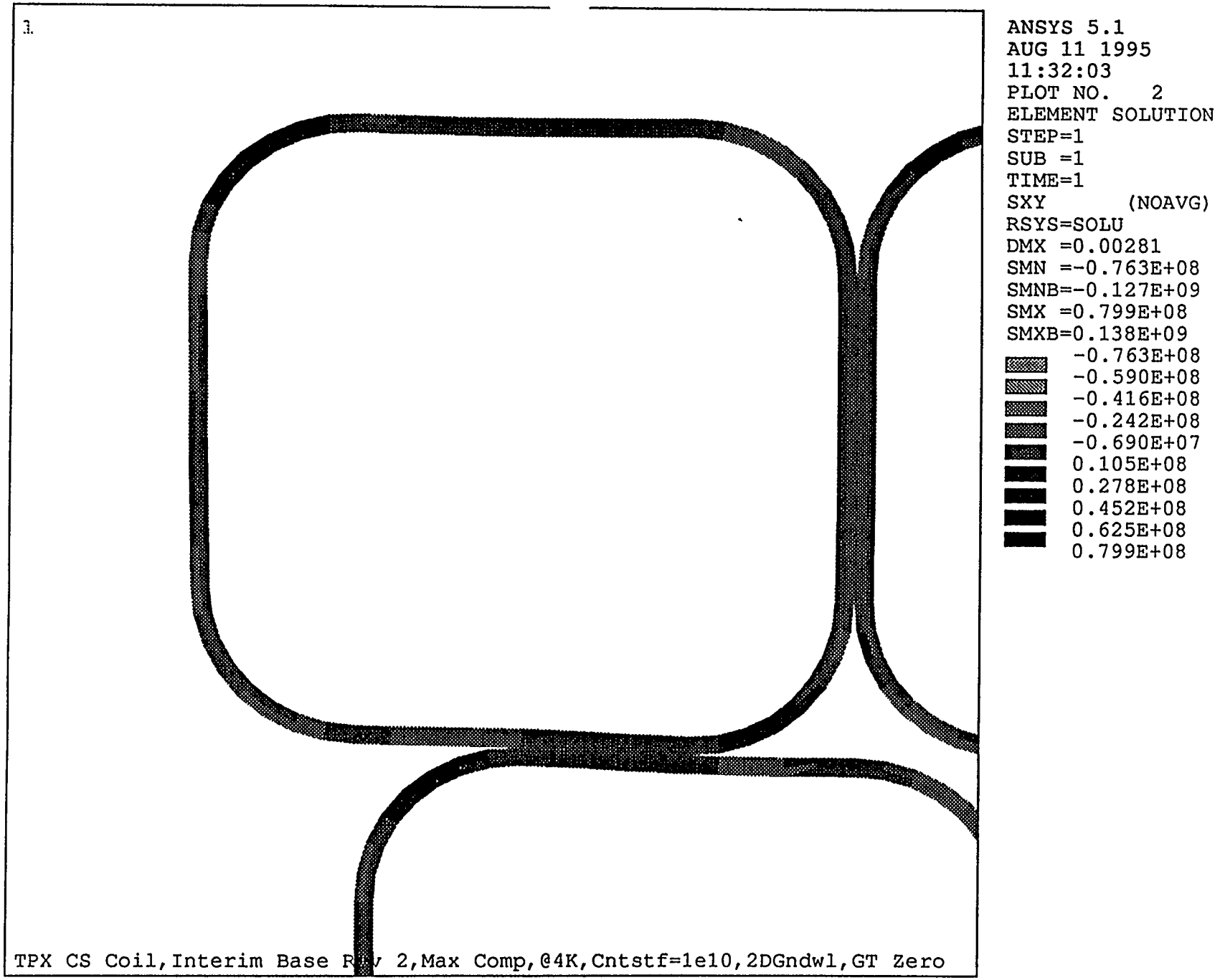

1
MN
MX
ANSYS 5.1
JUL 10 1995
15:30:36
PLOT NO. 21
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SX (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =-0.848E+08
SMNB=-0.136E+09
SMX =0.195E+08
SMXB=0.940E+08
-0.848E+08
-0.732E+08
-0.616E+08
-0.500E+08
-0.384E+08
-0.268E+08
-0.152E+08
-0.365E+07
0.794E+07
0.195E+08
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero

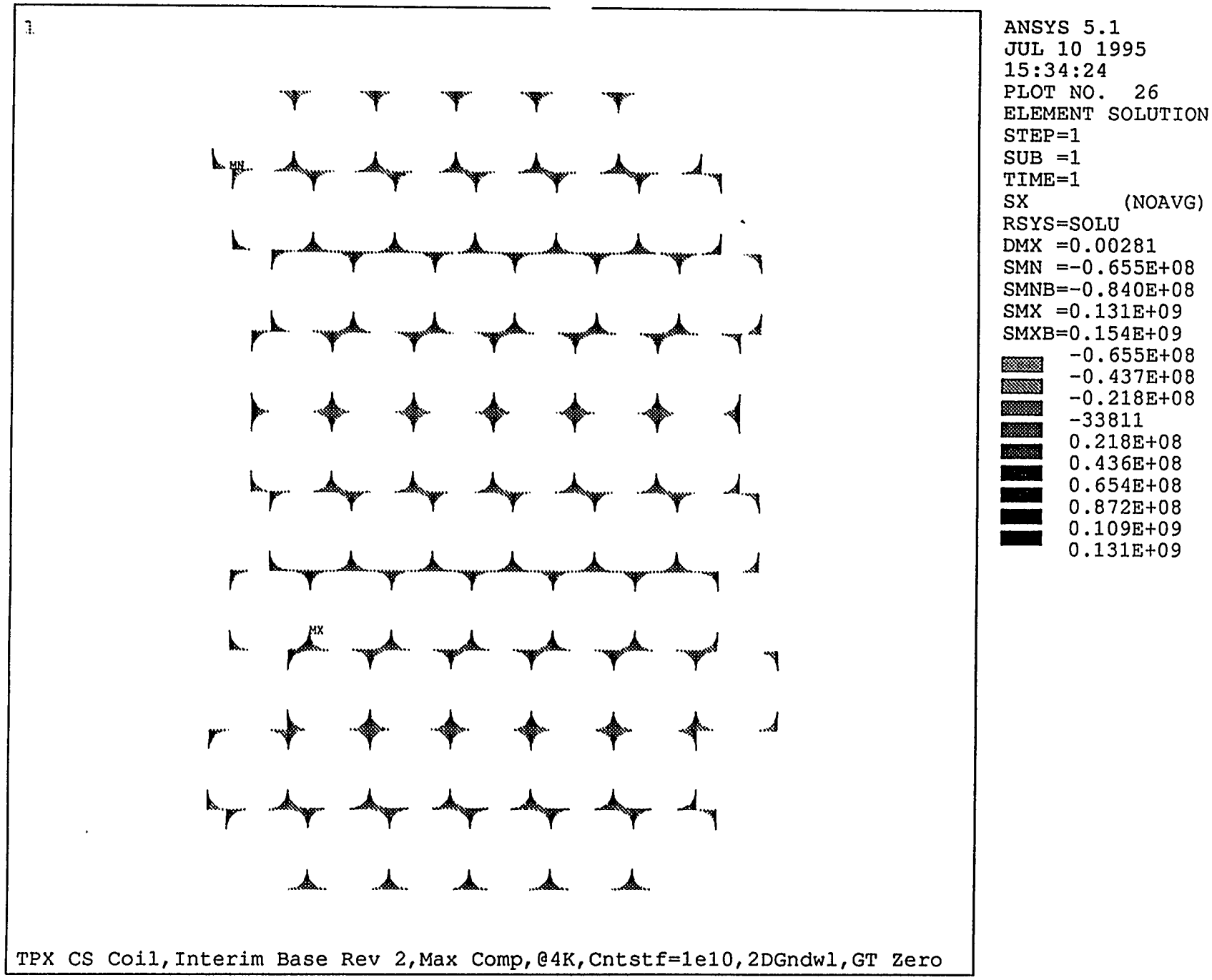

ANSYS 5.1
AUG 11 1995
11:18:37
PLOT NO. 1
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SX (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =-0.848E+08
SMNB=-0.136E+09
SMX =0.195E+08
SMXB=0.940E+08
-0.848E+08
-0.732E+08
-0.616E+08
-0.500E+08
-0.384E+08
-0.268E+08
-0.152E+08
-0.365E+07
0.794E+07
0.195E+08
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero

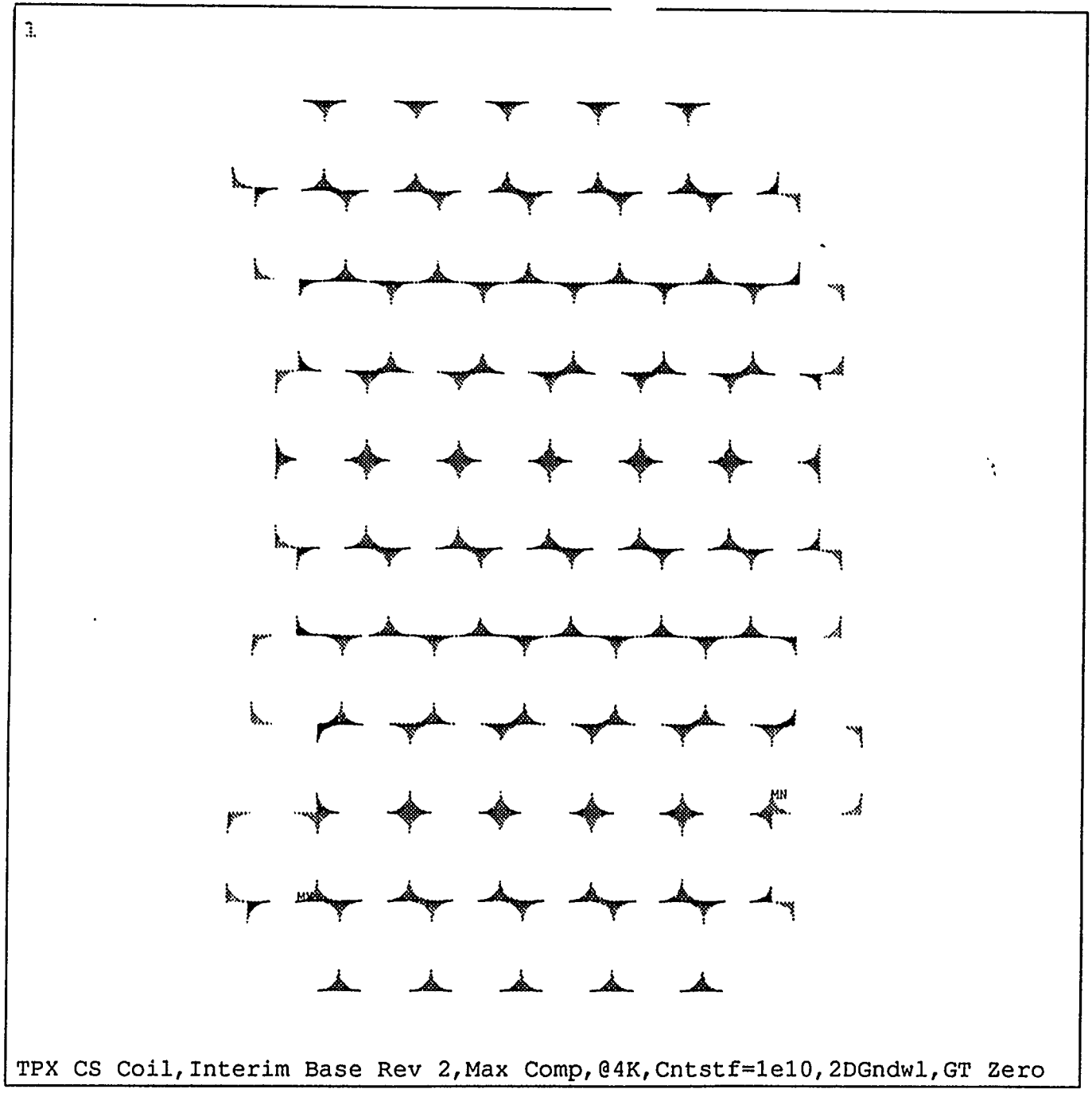

MY
MN
ANSYS 5.1
JUL 10 1995
15:31:23
PLOT NO. 22
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SY (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =-0.306E+09
SMNB=-0.346E+09
SMX =0.307E+09
SMXB=0.352E+09
-0.306E+09
-0.238E+09
-0.170E+09
-0.101E+09
-0.332E+08
0.349E+08
0.103E+09
0.171E+09
0.239E+09
0.307E+09
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero

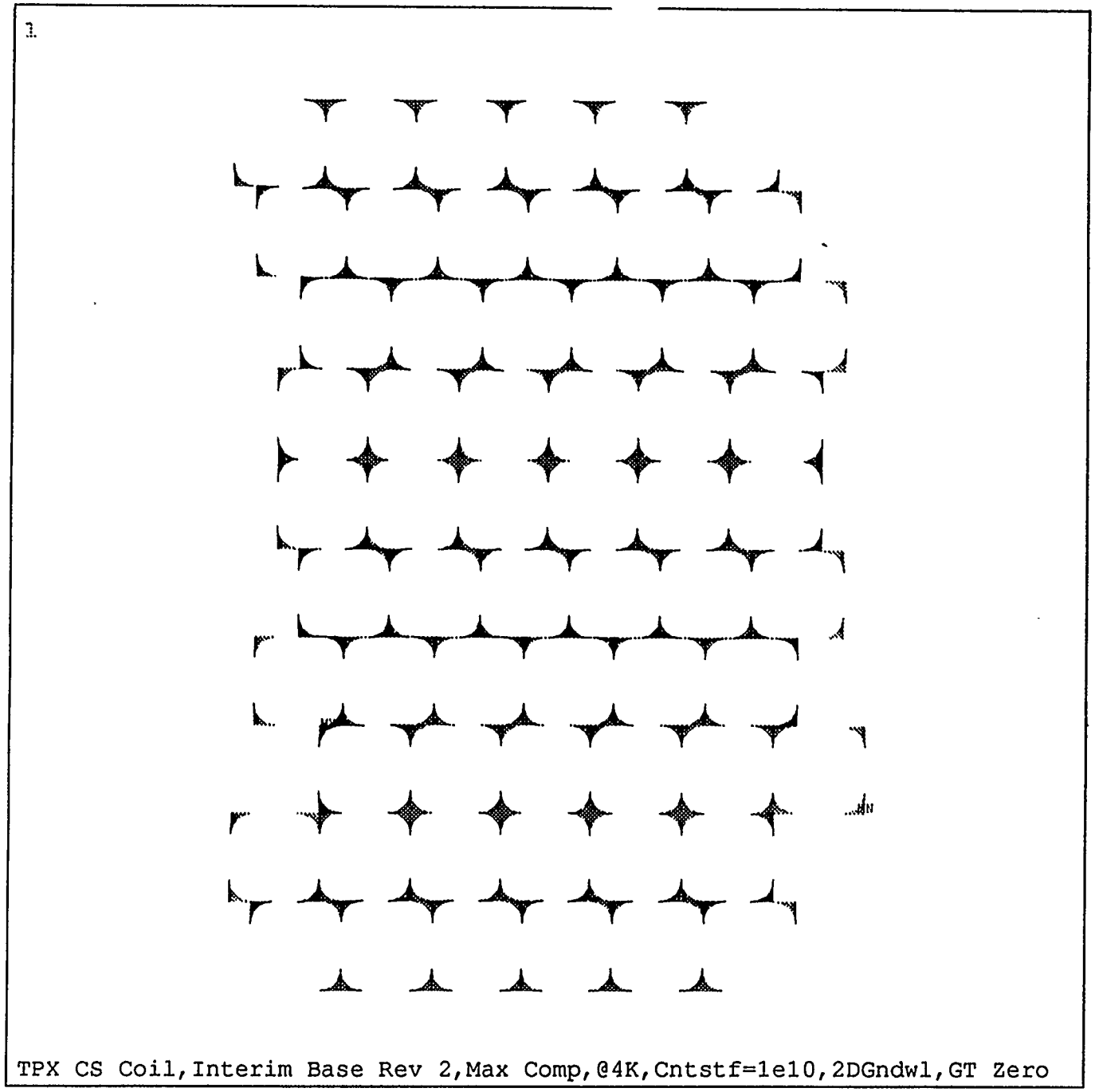

1
MN
MX
ANSYS 5.1
JUL 10 1995
15:32:11
PLOT NO. 23
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SZ (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =0.405E+08
SMNB=-0.156E+08
SMX =0.184E+09
SMXB=0.250E+09
0.405E+08
0.565E+08
0.724E+08
0.884E+08
0.104E+09
0.120E+09
0.136E+09
0.152E+09
0.168E+09
0.184E+09
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero

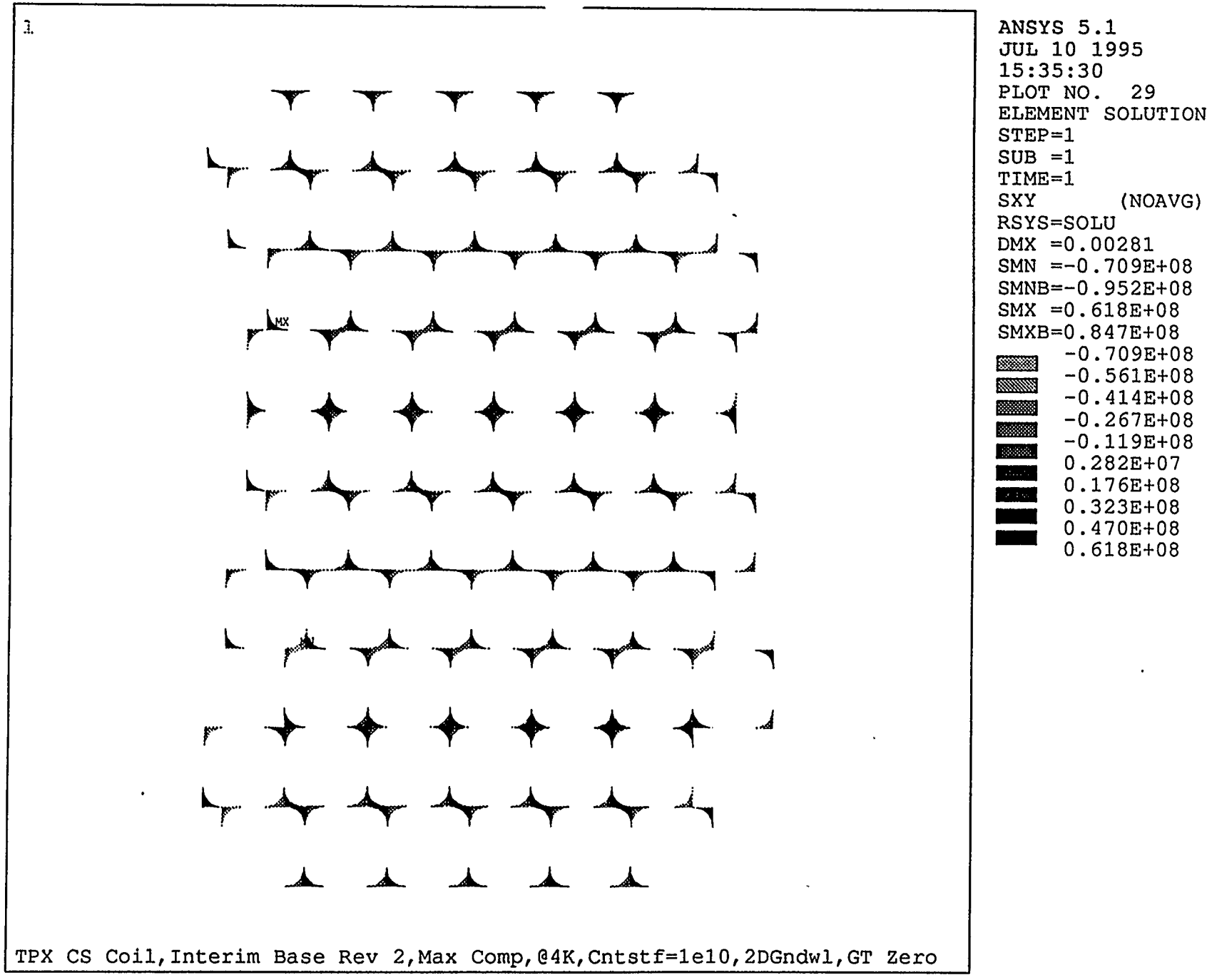

1
MX
MN
ANSYS 5.1
JUL 10 1995
15:32:59
PLOT NO. 24
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SXY (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =-0.763E+08
SMNB=-0.127E+09
SMX =0.799E+08
SMXB=0.138E+09
-0.763E+08
-0.590E+08
-0.416E+08
-0.242E+08
-0.690E+07
0.105E+08
0.278E+08
0.452E+08
0.625E+08
0.799E+08
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero

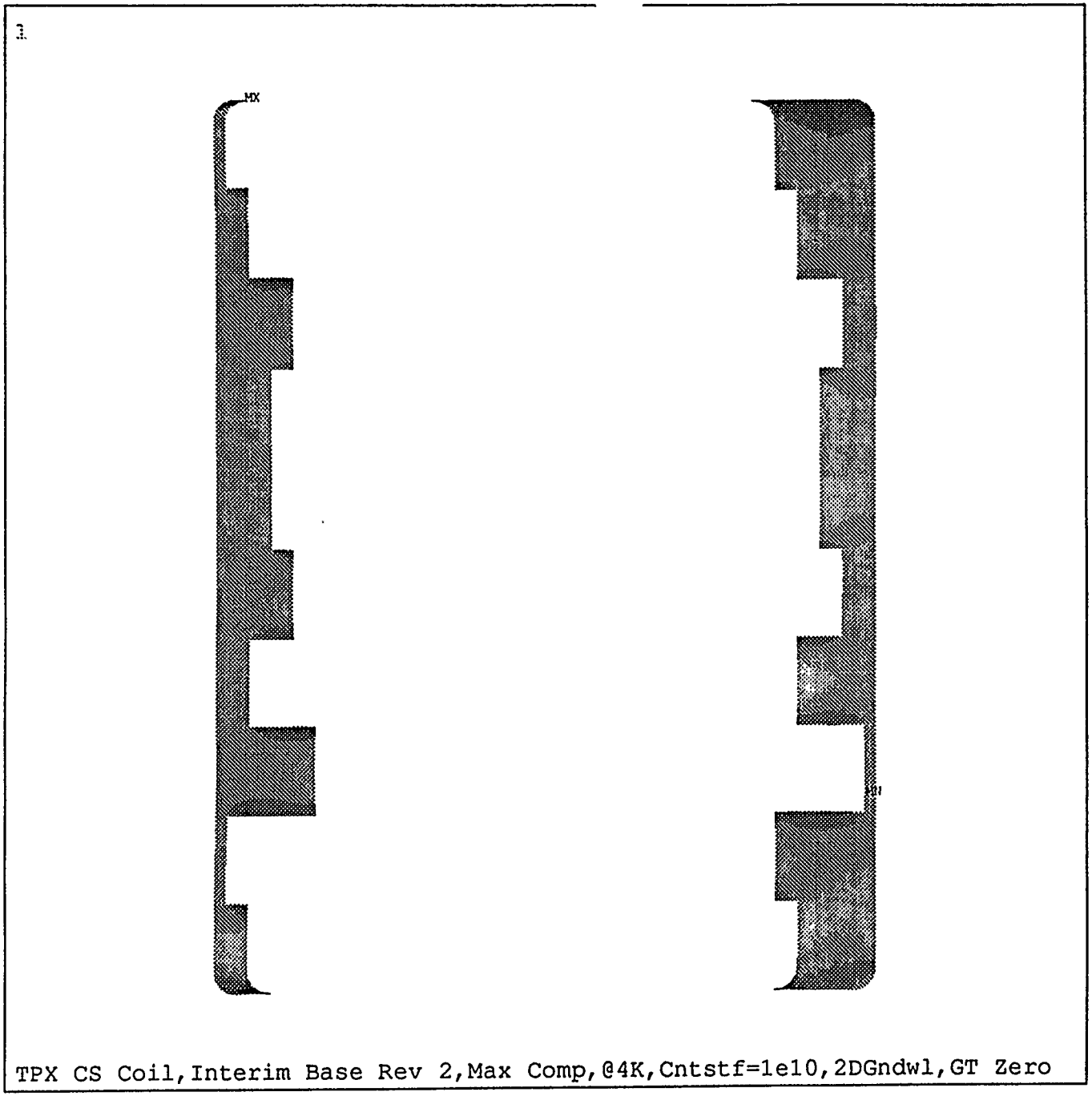

1
ANSYS 5.1
AUG 11 1995
11:32:03
PLOT NO. 2
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SXY (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =-0.763E+08
SMNB=-0.127E+09
SMX =0.799E+08
SMXB=0.138E+09
-0.763E+08
-0.590E+08
-0.416E+08
-0.242E+08
-0.690E+07
0.105E+08
0.278E+08
0.452E+08
0.625E+08
0.799E+08
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero

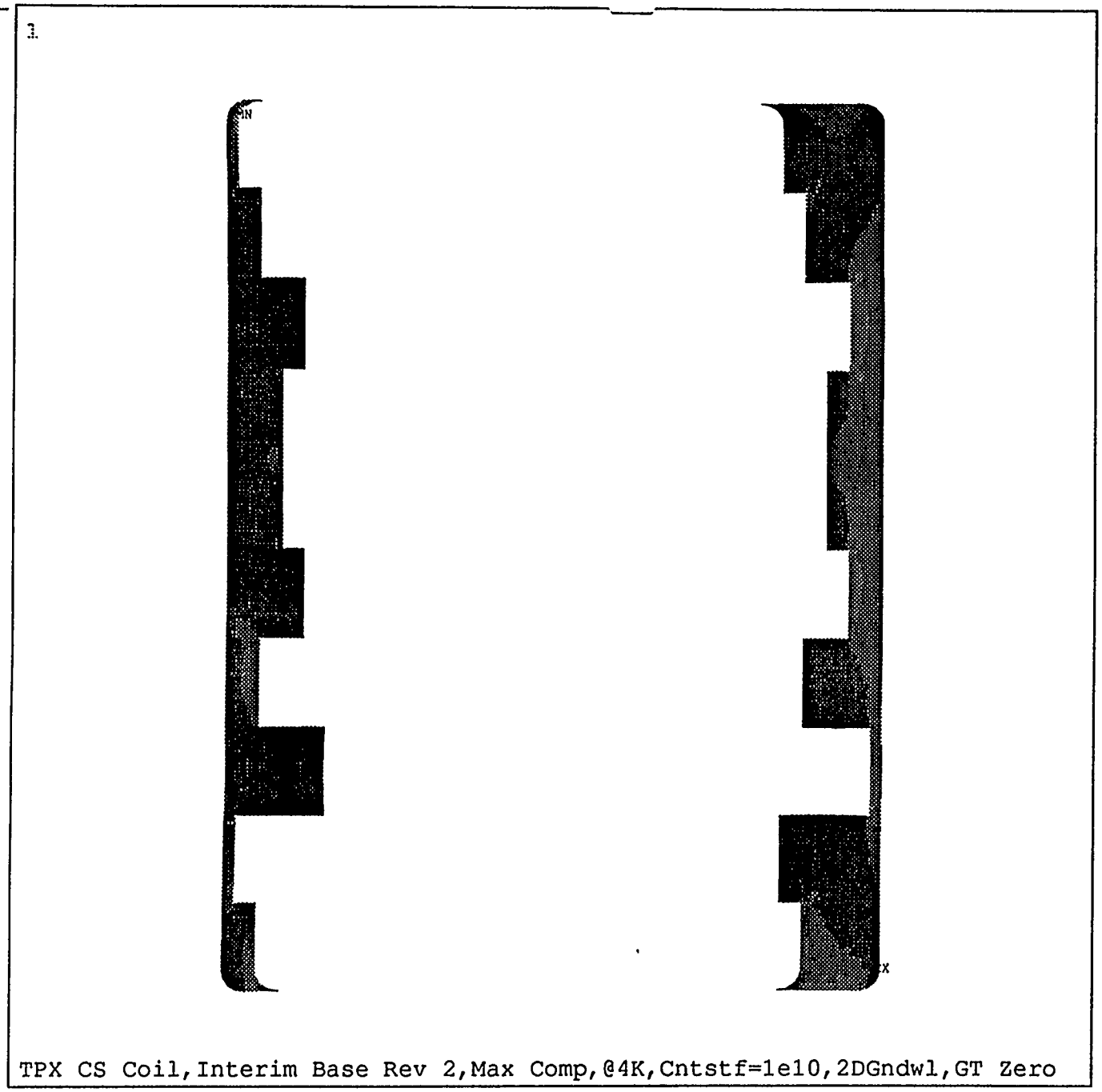

MN
MX
ANSYS 5.1
JUL 10 1995
15:34:24
PLOT NO. 26
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SX (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =-0.655E+08
SMNB=-0.840E+08
SMX =0.131E+09
SMXB=0.154E+09
-0.655E+08
-0.437E+08
-0.218E+08
-33811
0.218E+08
0.436E+08
0.654E+08
0.872E+08
0.109E+09
0.131E+09
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero

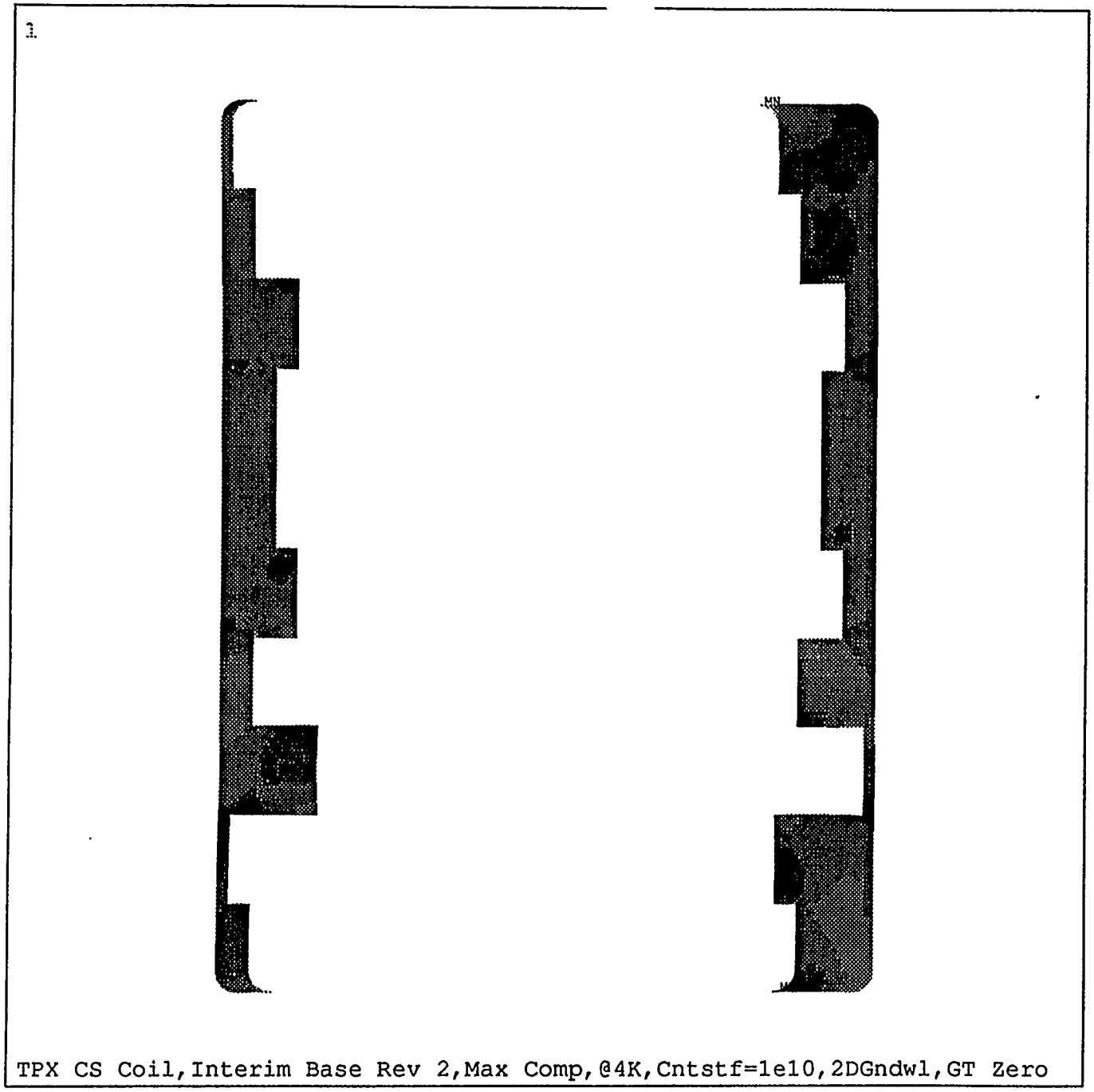

ANSYS 5.1
JUL 10 1995
15:34:46
PLOT NO. 27
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SY (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =-0.375E+08
SMNB=-0.639E+08
SMX =0.229E+09
SMXB=0.254E+09
-0.375E+08
-0.794E+07
0.216E+08
0.512E+08
0.808E+08
0.110E+09
0.140E+09
0.169E+09
0.199E+09
0.229E+09
MN
MX
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero

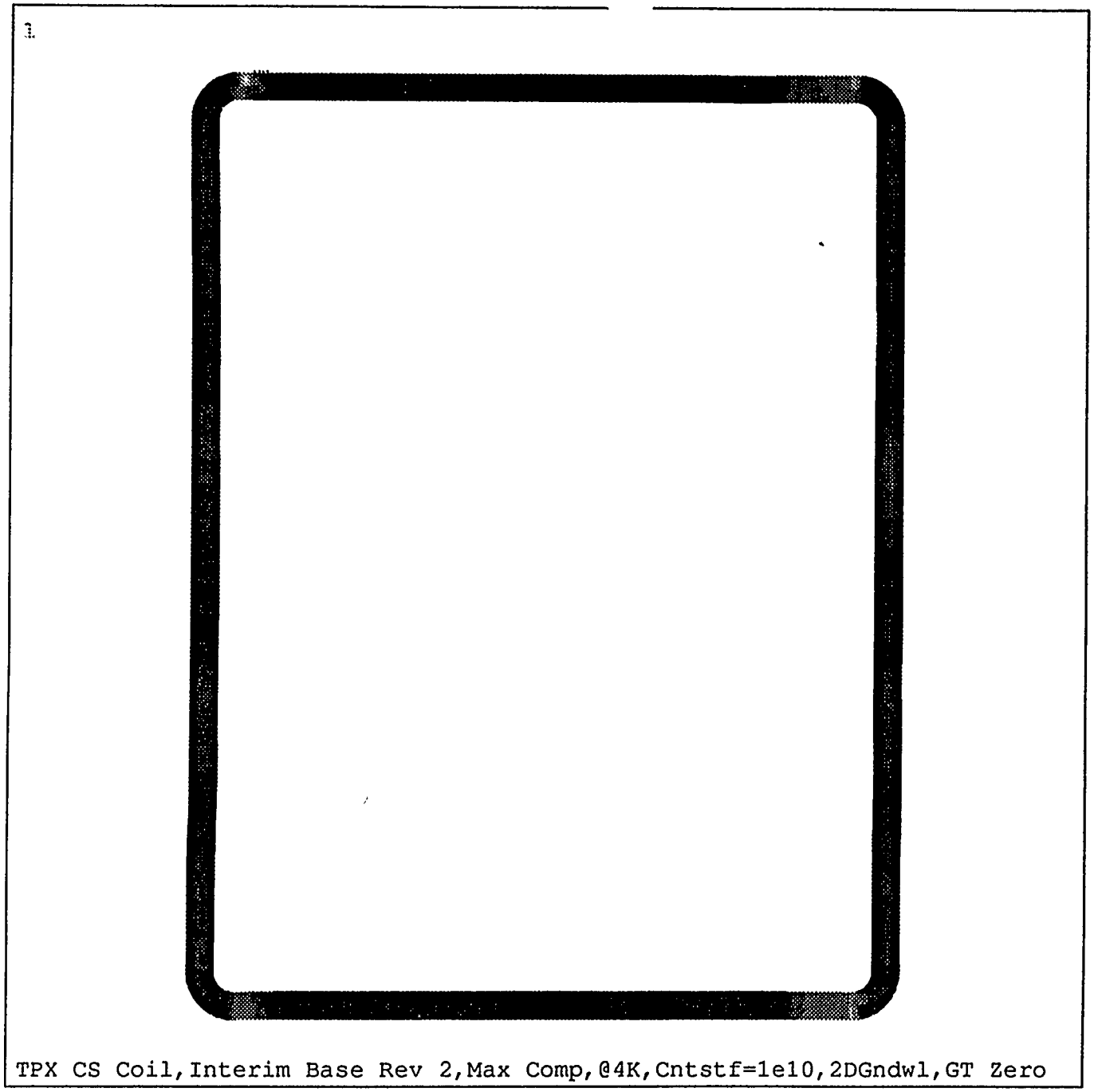

1
ANSYS 5.1
JUL 10 1995
15:35:08
PLOT NO. 28
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SZ (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =0.964E+07
SMNB=-0.165E+07
SMX =0.871E+08
SMXB=0.104E+09
0.964E+07
0.182E+08
0.269E+08
0.355E+08
0.441E+08
0.527E+08
0.613E+08
0.699E+08
0.785E+08
0.871E+08
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero

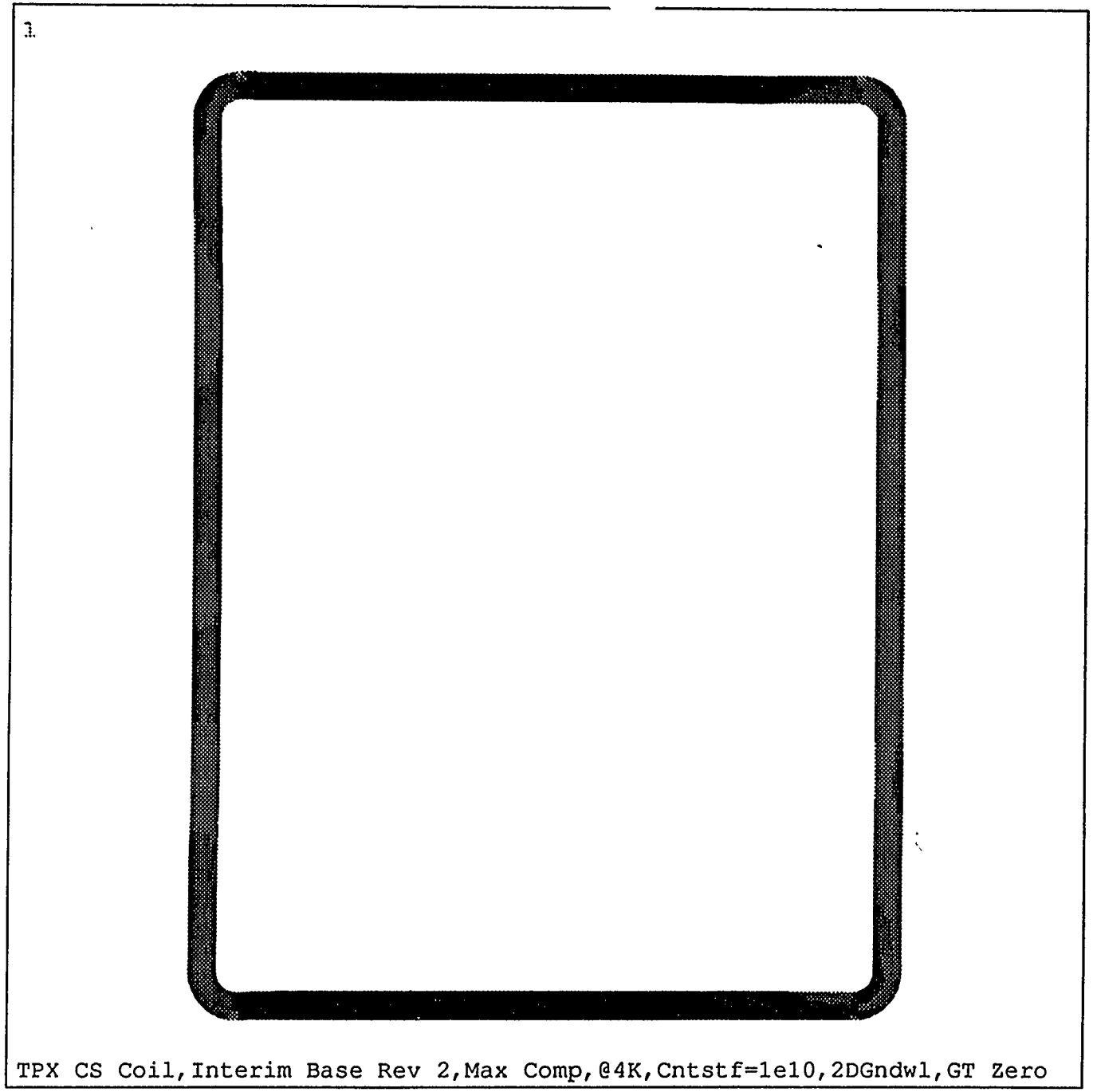

1
MX
ANSYS 5.1
JUL 10 1995
15:35:30
PLOT NO. 29
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SXY (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =-0.709E+08
SMNB=-0.952E+08
SMX =0.618E+08
SMXB=0.847E+08
-0.709E+08
-0.561E+08
-0.414E+08
-0.267E+08
-0.119E+08
0.282E+07
0.176E+08
0.323E+08
0.470E+08
0.618E+08
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero

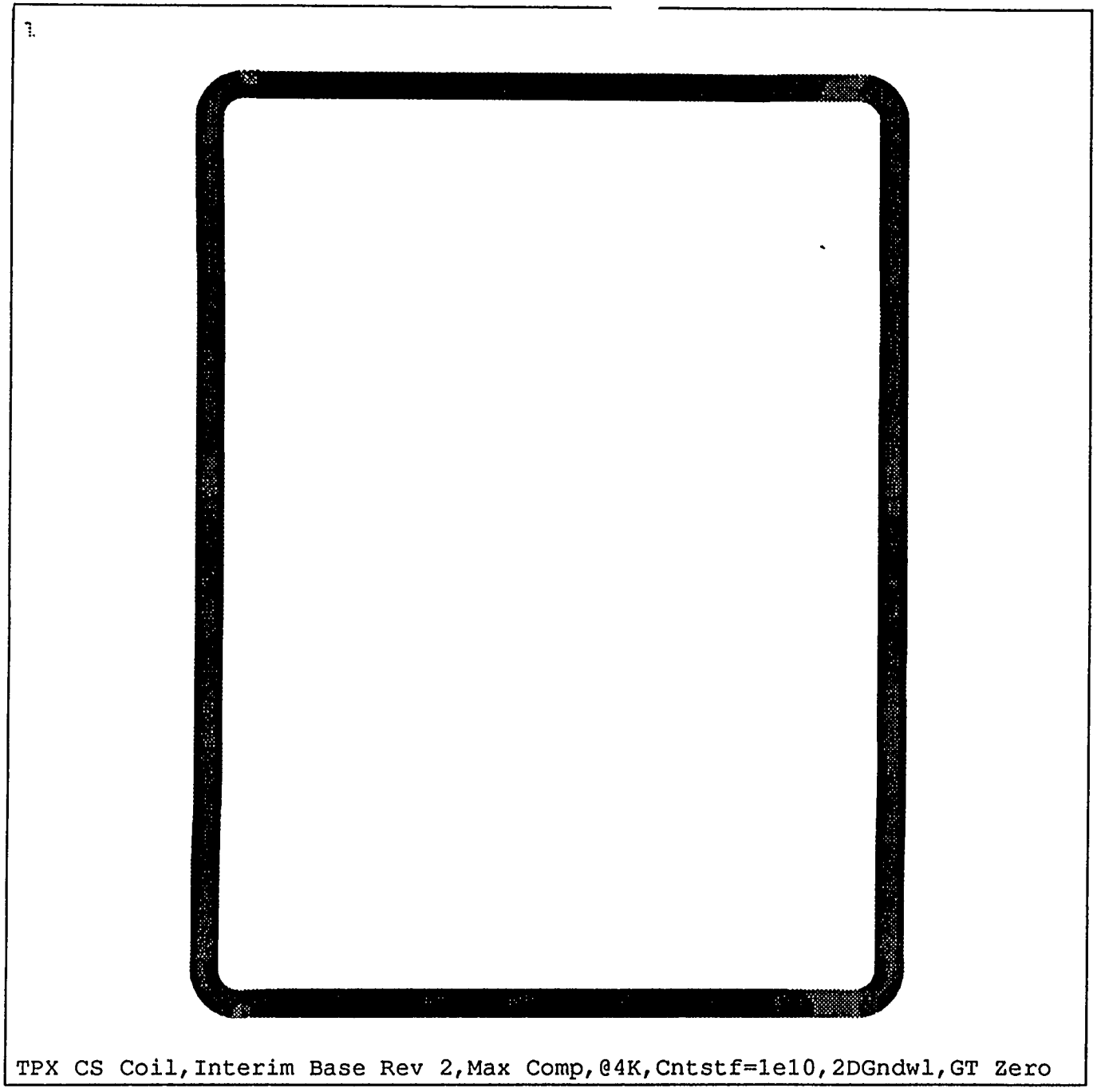

MX
ANSYS 5.1
JUL 10 1995
15:36:16
PLOT NO. 31
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SX (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =-0.338E+08
SMNB=-0.588E+08
SMX =0.298E+09
SMXB=0.407E+09
-0.338E+08
0.298E+07
0.398E+08
0.766E+08
0.113E+09
0.150E+09
0.187E+09
0.224E+09
0.261E+09
0.298E+09
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero

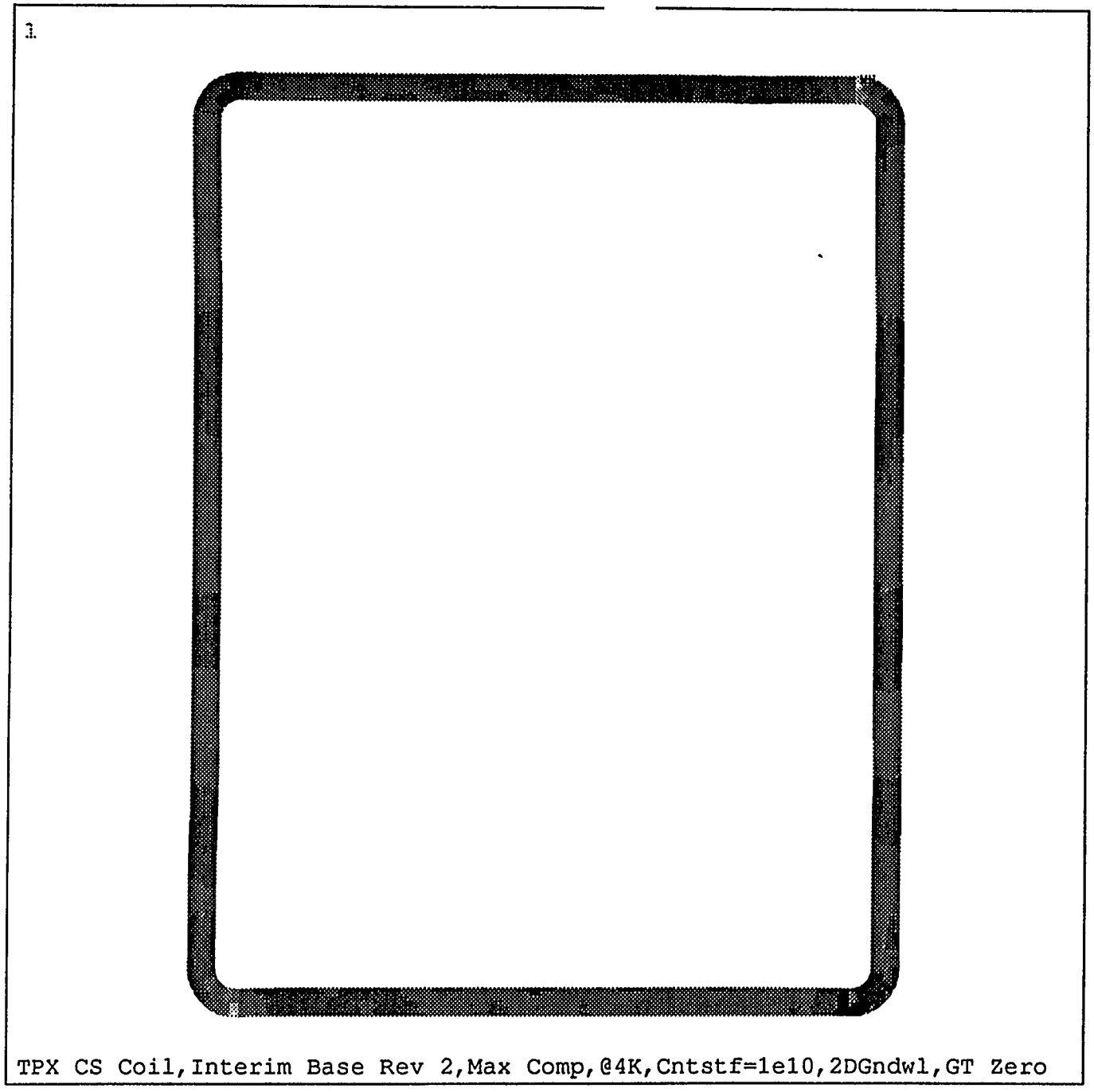

ANSYS 5.1
JUL 10 1995
15:36:36
PLOT NO. 32
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SY (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =-0.183E+09
SMNB=-0.286E+09
SMX =0.492E+08
SMXB=0.122E+09
-0.183E+09
-0.157E+09
-0.131E+09
-0.106E+09
-0.798E+08
-0.540E+08
-0.282E+08
-0.238E+07
0.234E+08
0.492E+08
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero


1
MN
ANSYS 5.1
JUL 10 1995
15:37:18
PLOT NO. 34
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SXY (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =-0.918E+08
SMNB=-0.136E+09
SMX =0.830E+08
SMXB=0.151E+09
-0.918E+08
-0.723E+08
-0.529E+08
-0.335E+08
-0.141E+08
0.534E+07
0.248E+08
0.442E+08
0.636E+08
0.830E+08
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero


1
ANSYS 5.1
JUL 10 1995
15:38:00
PLOT NO. 36
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SX (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =-0.242E+09
SMNB=-0.369E+09
SMX =0.952E+08
SMXB=0.136E+09
-0.242E+09
-0.204E+09
-0.167E+09
-0.129E+09
-0.920E+08
-0.545E+08
-0.171E+08
0.203E+08
0.578E+08
0.952E+08
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero


1
ANSYS 5.1
JUL 10 1995
15:38:18
PLOT NO. 37
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SY (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =-0.303E+09
SMNB=-0.433E+09
SMX =0.145E+09
SMXB=0.163E+09
-0.303E+09
-0.254E+09
-0.204E+09
-0.154E+09
-0.104E+09
-0.541E+08
-0.425E+07
0.456E+08
0.955E+08
0.145E+09
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero


ANSYS 5.1
JUL 10 1995
15:38:36
PLOT NO. 38
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SZ (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =-0.130E+09
SMNB=-0.260E+09
SMX =0.498E+08
SMXB=0.117E+09
-0.130E+09
-0.110E+09
-0.901E+08
-0.702E+08
-0.502E+08
-0.302E+08
-0.102E+08
0.980E+07
0.298E+08
0.498E+08
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero


1
ANSYS 5.1
JUL 10 1995
15:38:54
PLOT NO. 39
ELEMENT SOLUTION
STEP=1
SUB =1
TIME=1
SXY (NOAVG)
RSYS=SOLU
DMX =0.00281
SMN =-0.107E+09
SMNB=-0.217E+09
SMX =0.134E+09
SMXB=0.263E+09
-0.107E+09
-0.798E+08
-0.532E+08
-0.265E+08
211790
0.269E+08
0.536E+08
0.803E+08
0.107E+09
0.134E+09
TPX CS Coil,Interim Base Rev 2,Max Comp,@4K,Cntstf=1e10,2DGndwl,GT Zero

Structural Analysis of TPX PF 5 Coil Pack

Mark P. Krefta
STC Advanced Electromagnetic Systems Department

June 30, 1995

TPX 14-950818-WEC-MKrefta-03

APPROVED:

P.A. Sanger
Westinghouse TPX Chief Scientist

APPROVED:

D. R. Potter
Westinghouse TPX Engineering Manager

Westinghouse Electric Corporation
Electronic Systems Group

401 East Hendy Avenue, Sunnyvale, California 94088-3499

CONTENTS

Page

CONTENTS iii

LIST OF FIGURES iv

LIST OF TABLES iv

ABSTRACT v

1. INTRODUCTION 1

2. ANSYS THREE-DIMENSIONAL PF5 STRUCTURAL MODEL 3

2.1 GEOMETRY DESCRIPTION 3
2.2 MATERIAL CHARACTERISTICS 10
2.3 BOUNDARY CONDITIONS AND LOADINGS 11

3. .ANALYSIS RESULTS 15

3.1 COIL PACK DEFORMATIONS 15
3.2 COIL PACK STRESSES 19

4. DISCUSSION OF RESULTS 25

5. REFERENCES 26

6. APPENDIX A - ANSYS 3-D COMMAND FILE 27

7. APPENDIX B - ANSYS AXISYMMETRIC PF5 COMMAND FILE 28

LIST OF FIGURES

Page

FIGURE 2-1THREE-DIMENSIONAL VIEW OF PF5 STRUCTURAL MODEL ILLUSTRATING 45 DEGREE SECTION OF COIL BEING MODELED AND VERTICAL AND ANGULAR CONSTRAINTS APPLIED TO THE CONDUCTOR PACK. 6
FIGURE 2-2CROSS SECTION SHOWING PRINCIPLE DIRECTIONS ASSOCIATED WITH FINITE ELEMENTS IN THE CONDUIT, THREE-DIMENSIONAL WRAP AND ROVING CORNER FILL REGIONS OF THE CONDUCTOR PACK. ..7
FIGURE 2-3CROSS-SECTIONAL CUT OF PF5 FINITE ELEMENT MESH SHOWING BUILD-UP OF CONDUCTOR PACK FROM 128 TURNS AND SURROUNDING FILLER MATERIAL AND GROUND WRAP INSULATION. 8
FIGURE 2-4- CROSS SECTION SHOWING PRINCIPLE DIRECTIONS ASSOCIATED WITH FINITE ELEMENTS IN THE PF5 CONDUCTOR PACK 3-D WEAVE FILLER REGIONS. 9
FIGURE 2-5 CROSS SECTION SHOWING PRINCIPLE DIRECTIONS ASSOCIATED WITH FINITE ELEMENTS IN THE GROUND WRAP REGIONS OF THE CONDUCTOR PACK. 10
FIGURE 2-6 ELECTROMAGNETIC FORCE DISTRIBUTION THROUGHOUT PF5U CROSS SECTION DURING EQUILIBRIA #1 AT A LOCATION DIRECTLY ABOVE A TF SUPPORT.. 13
FIGURE 2-7 ELECTROMAGNETIC FORCE VARIATION ALONG PF5U CONDUCTOR PATH DUE TO INTERACTION OF PF5 CURRENT WITH TF GENERATED MAGNETIC FIELDS. A NODE ASSOCIATED WITH THE INNERMOST LOWER TURN IN THE PF5U CONDUCTOR PACK IS SHOWN IN THIS PLOT 14
FIGURE 3-1-THREE-DIMENSIONAL VIEW OF DEFORMED PF5 COIL ILLUSTRATING HOOP CONTRACTION DUE TO COOLDOWN AND VERTICAL COMPRESSION RESULTING FROM ELECTROMAGNETIC LOADING 16
FIGURE 3-2 SIDE VIEW OF DEFORMED PF5 COIL ILLUSTRATING SAG BETWEEN VERTICAL SUPPORT POINTS DUE TO DOWNWARD VERTICAL LORENTZ LOADING. 17
FIGURE 3-3 CROSS SECTION OF PF5 CONDUCTOR PACK DIRECTLY ABOVE TF SUPPORT POINT ILLUSTRATING DEFORMED SHAPE OF PACK DUE TO COOLDOWN AND LORENTZ FORCE LOADING. 18
FIGURE 3-4 BLOWUP OF CONDUIT ELEMENTS SHOWING DEFORMATION WHICH IS EVIDENT EVEN WITH THE COARSE MODEL. 19
FIGURE 3-5 CONTOURS OF CONSTANT STRESS INTENSITY THROUGHOUT THE INCOLOY CONDUITS IN CONDUCTOR PACK PF5 AT AN ANGULAR LOCATION DIRECTLY ABOVE A TF SUPPORT POINT. THE MAXIMUM STRESS (315 MPA) OCCURS IN THE UPPER LEFT CORNER 22
FIGURE 3-6 BLOWUP OF STRESS INTENSITY DISTRIBUTION IN UPPERMOST LEFT CONDUIT OF PF5 CONDUCTOR PACK 23
FIGURE 3-7 ILLUSTRATION OF DEFORMED SHAPE RESULTING FROM PF5U AXISYMMETRIC MODEL 24

LIST OF TABLES

TABLE 2-1 - DIMENSIONS USED IN THE PF5 STRUCTURAL MODEL FOR A SINGLE TURN IN THE CONDUCTOR PACK 6
TABLE 2-2 MATERIAL PROPERTIES AND ORIENTATIONS ASSUMED IN PF5 STRUCTURAL MODEL 11
TABLE 3-1-SUMMARY OF MAXIMUM AND MINIMUM STRESS COMPONENTS THROUGHOUT THE PF5 CONDUCTOR PACK 21

ABSTRACT

A three-dimensional structural model of the Tokamak Physics eXperiment (TPX) superconducting Poloidal Field (PF) coil PF5 has been established for investigating the stress state of the coil pack and the mechanisms which impact the stress levels. The coil loadings include thermal cooldown from glass transition temperature to 4K and electromagnetic forces from a worst case electromagnetic event. The coil is supported by 8 vertical restraints located uniformly about the coil periphery. A single 45 degree section is modeled and periodic boundary conditions are applied to simulate the effect of the remainder of the coil. The model contains three-dimensional solid brick elements along with a series of contact elements which allow a sliding interface between the conduits and surrounding insulation. A static analysis is performed and the results are presented in this report.

This work was performed for Westinghouse Marine Division in Sunnyvale, California under contract No. B254501. It partially fulfills the deliverable requirements of the TPX Technical Scope of Work (TSOW), TPX Magnet System Rev. 5, Section 2.3.

1. INTRODUCTION

Westinghouse Science & Technology Center (WSTC) is providing structural analysis of the Tokamak Physics eXperiment (TPX) superconducting Poloidal Field (PF) coils in partial fulfillment of Section 2.3 (PF coil structural analysis) of the TPX Technical Scope of Work[1]. The particular focus of this work is the structural analysis of poloidal coil PF5 and its restraining system. The analysis performed by WSTC has been based on the baseline coil pack design for the Contractual Preliminary Design Review (CPDR) referred to as the CPDR Baseline. Additional information concerning the location of the coil restraints has been based on information received at the Design Information Technical Transfer Meeting (DIT-8/94) including the TPX conceptual design drawing package and the general documentation package for the superconducting magnet system[2]

The main focus of this report is to provide static structural analysis of coil PF5 which is restrained at eight discrete points around the ring and subjected to spatially periodic variations in the electromagnetic loading due to interaction with the 16 discrete TF coils. The ANSYS computer program has been used to establish a finite element model in order to determine the coil deformations and conductor pack stresses resulting from cooldown and electromagnetic loading. This model and it's loading is described in detail in Section 2 of this report.

At the outset of this modeling effort a decision was made to attempt to model the conductor pack in terms of its individual components, rather than as an equivalent "smeared properties" region. It quickly became clear that in order to model the coil at this level of detail with the computer resources that were available (i.e., a Sun Sparcstation 20 with 512 Mb RAM), a compromise would have to be made in the level of spatial discretization. In order to "fit" the model within our computer environment while retaining the detailed structure of the conductor pack, a very coarse mesh was used. It is recognized that the consequence of using such a coarse mesh is that the localized stresses reported in this work will possess substantial error, but the gross deformations of the geometry will be

reasonably accurate. The obvious solution to this problem is the use of submodeling in regions where the local stress are a concern. However, due to time and budget constraints no submodeling has been performed to date. The overall philosophy is to report the stress levels associated with the coarse model, and if concerns arise due to excessive stress levels, refined models will be established in a later phase of the program. This qualification is stated upfront so that the reader understands that the stress values reported in Section 3.2 are not meant to be precise values of the localized peak stress, but indicators to whether a more refined analysis is warranted.

2. ANSYS THREE-DIMENSIONAL PF5 STRUCTURAL MODEL

A three-dimensional structural model of the TPX PF5U has been established using the computer program ANSYS. The model has been constructed so that the effects of Lorentz forces, differential thermal contraction, and reaction of the vertical loading using eight discrete support points can be investigated. Of primary concern is the level of stress enhancement in the conductor pack resulting from nonaxisymmetric loading and vertical constraints.

2.1 GEOMETRY DESCRIPTION

A three-dimensional finite element model of conductor pack PF5 was created using ANSYS structural solid elements STIF45 and point-to-point contact elements STIF52. The entire array of 128 turns was modeled throughout a 45 degree angular span at the ends of which the coil is supported in the vertical direction. It has been assumed in the modeling that the coil is free to move in the radial direction. An overall view of the structure is shown in fig. 2.1. A coarse, two-dimensional mesh of the coil cross section was first created and the three-dimensional structure was formed by extruding the mesh into the third dimension along the length of the coil. In order to limit the degrees of freedom and form elements with reasonable aspect ratios, the cross section was discretized using a very coarse mesh. Ten element divisions were used along the angular length in an attempt to represent the effects of nonuniform loading and the discrete support of coil pack PF5. The contact elements were placed between the conduits and the surrounding insulation to allow sliding between the two.

The initial cross section of the coil pack was constructed from a single elementary cell shown in fig. 2.2. Here, an incoloy conduit is shown surrounded by a layer of insulation (referred to as the 3-D weave thin tape). The superconducting cable inside the incoloy conduit is not included in the model because its stiffness is assumed to be negligible. Also, the thin layer of kapton conduit wrap which immediately surrounds the conduit has not been included. It is reasoned that neglecting the material possessing such a small

thickness (i.e., .004 in) will have a minimal impact on the structure, while significantly increasing the model complexity. The 3-D weave and conduit regions are not directly connected to each other, but are connected through contact elements which allow sliding along the interface, but restrict the elements from interfering with each other. The rounded corner regions of the conduit and surrounding 3-D weave appear as angled straight lines since only a single element was used to span the corner. Unfortunately, due to limitations in computational power, the mesh was constructed using a minimal number of nodes and elements, usually at the expense of spatial resolution. However, more detailed two-dimensional meshes of conductor packs have been formed where the primary focus is on the internal stresses in this region. In this modeling effort, the effects of conductor pack axial bending and shear resulting from load variations along the conductor length are a primary focus. Figure 2.2 also illustrates the numerical material identifiers used by ANSYS along with the principle directions associated with the materials. The corner regions of the cell are filled with a roving corner fill identified as material 4. The dimensions used in constructing this cell are given in Table 2.1.

A matrix of 8 radial by 16 vertical cells is formed to represent the 128 turns of PF5. The mean radial and vertical location of this coil pack was taken to be 1.213 m and 2.35 m, respectively. The individual rows of turns were assumed to be aligned as shown in fig. 2.3. Because the coil is constructed by spirally winding eight pancakes (two rows of turns), the actual cross section changes at different angular locations throughout the coil. The individual rows will only be aligned as shown in fig. 2.3 at a single angular location. The effect of this slight shift in the precise location of the individual turns was shown to produce an enhancement in the localized stress internal to the coil pack in reference 3, but is ignored in this work since the added complexity is too great to handle in a large scale, three-dimensional model. These localized effects can be accurately represented by establishing a submodel of the region of interest including the added detail which contributes to the stress enhancement. The deflections or forces from the global model can be used to establish boundary conditions for the submodel. At this point in time such a refined model of PF5 has not been constructed.

A thin radial strip of material has been applied on the inside and outside radial edges of the coil to represent 3-D weave filler blocks which are used to fill space left empty as a result the spiral winding. The thickness of the filler strips was taken to be 13.43 mm.

This thickness results in a total coil radial build (after including the groundwall insulation) of 0.2336 m which is consistent with data given on drawing from TPX drawing F-9414002B (in millimeters) from the section of the table entitled "nominal winding pack geometry (at operating temperature)" for coil PF5. Figure 2.4 shows a cross-sectional cut of the finite elements which form the filler material radial bands. Also superimposed on the plot are the 1 and 2 principle directions associated with the elements since the material is orthotropic, and a numeric material identifier (i.e., 8) used by the ANSYS program. The third principle direction is normal to the plane of the cut (i.e., the angular direction).

Finally the outer ground wrap is modeled using a thin layer of elements which surround the coil as shown in fig. 2.5. The thickness of this wrap is taken as 7.645 mm. Again the material is modeled with orthotropic characteristics so that the principle directions associated with the elements must be properly identified.

Table 2-1 - Dimensions used in the PF5 structural model for a single turn in the conductor pack.

DIMENSION	LENGTH (mm)
Cable width	17.47
Inside conduit corner radius	2.692
3-D wrap build	0.813
Overall cell size	23.93 by 23.93

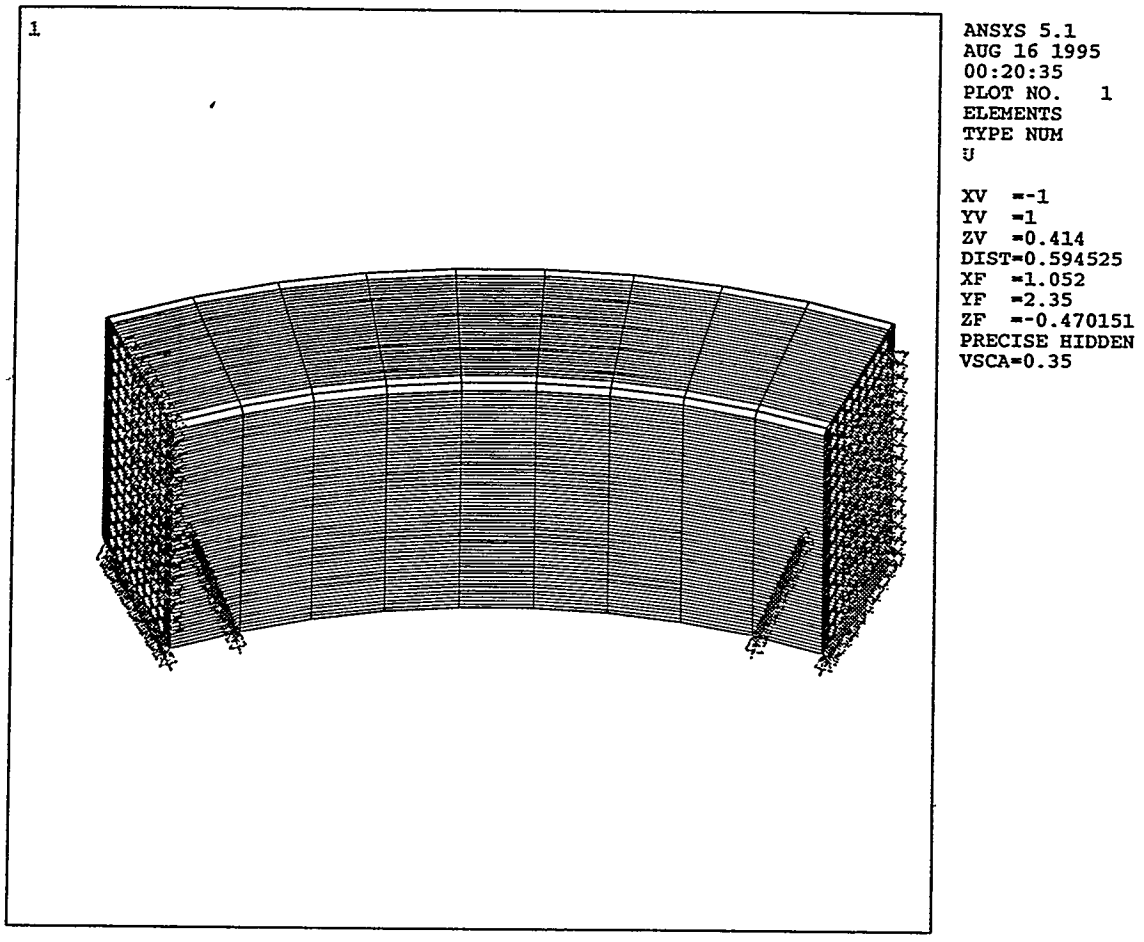


Figure 2-1Three-dimensional view of PF5 structural model illustrating 45 degree section of coil being modeled and vertical and angular constraints applied to the conductor pack.

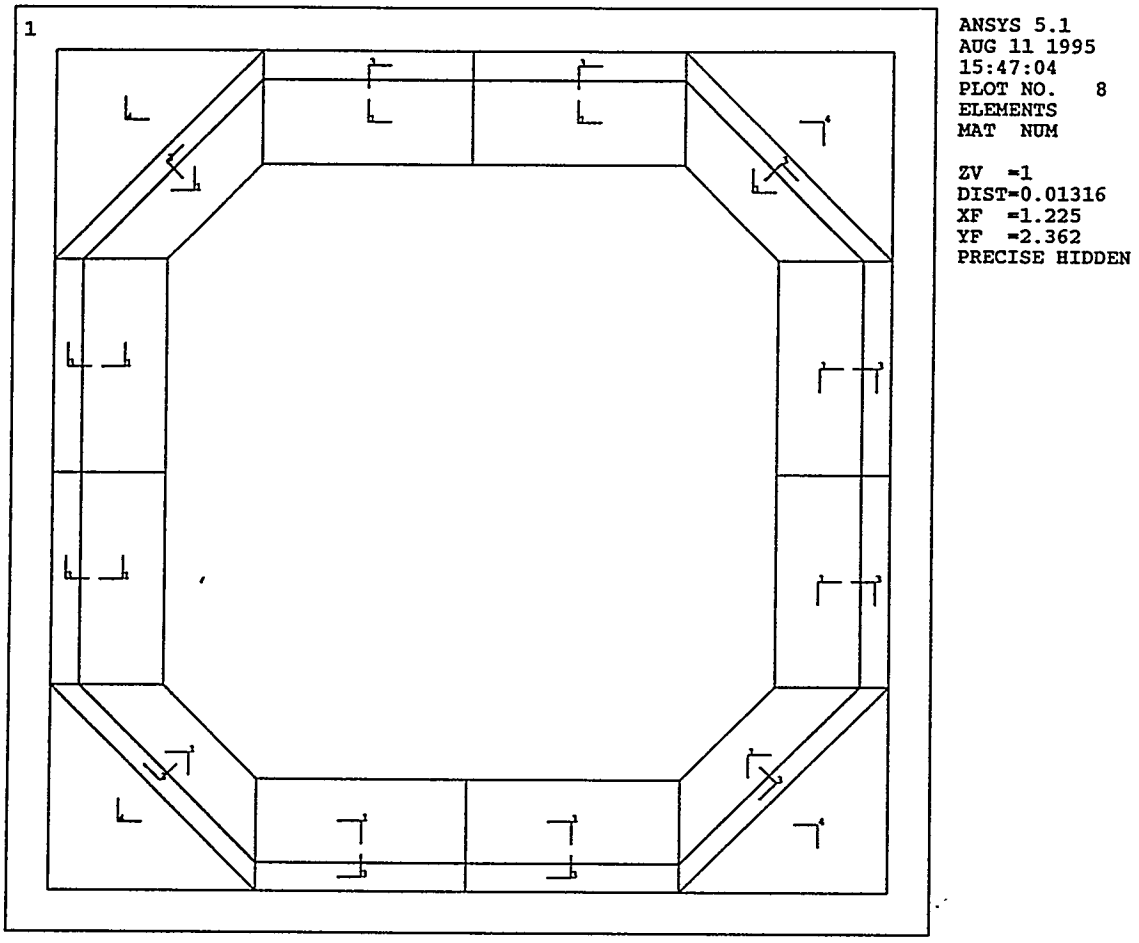


Figure 2-2Cross section showing principle directions associated with finite elements in the conduit, three-dimensional wrap and roving corner fill regions of the conductor pack.

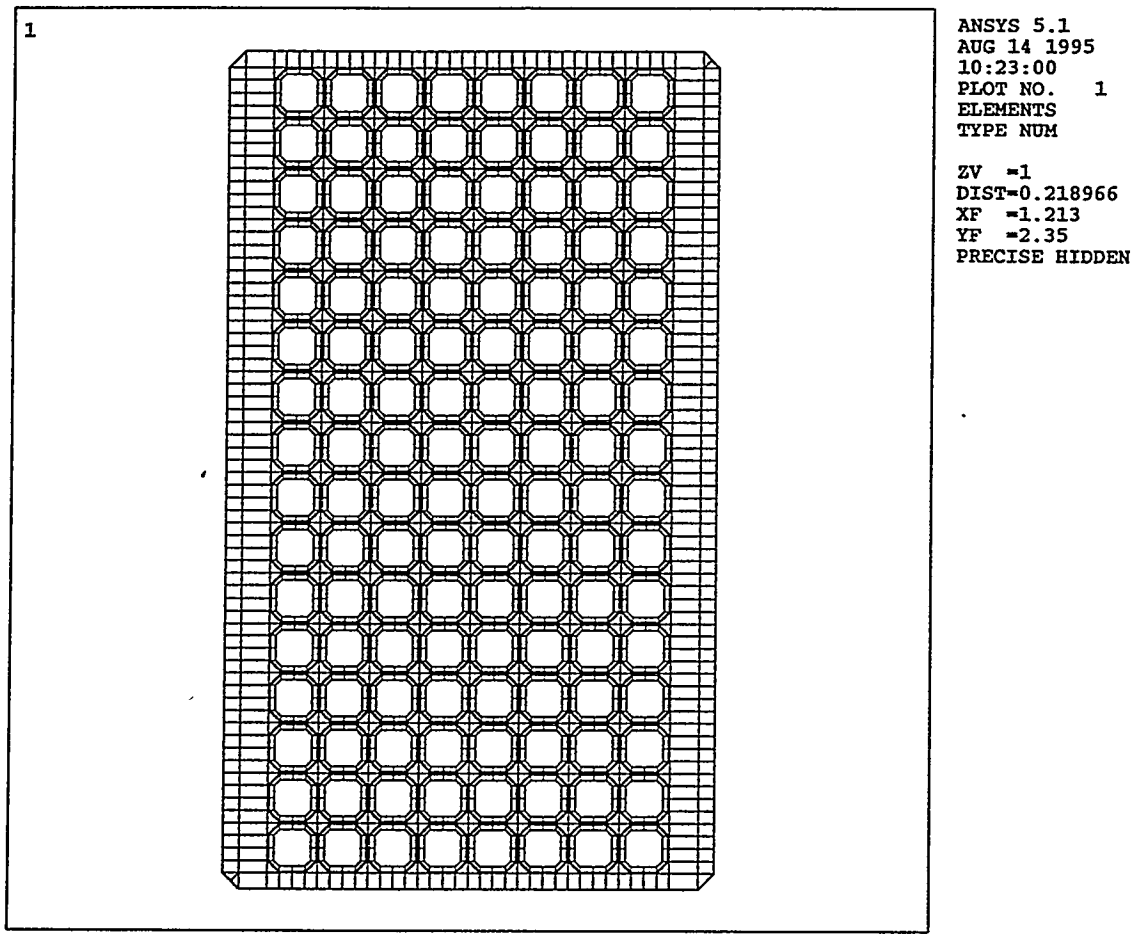


Figure 2-3Cross-sectional cut of PF5 finite element mesh showing build-up of conductor pack from 128 turns and surrounding filler material and ground wrap insulation.

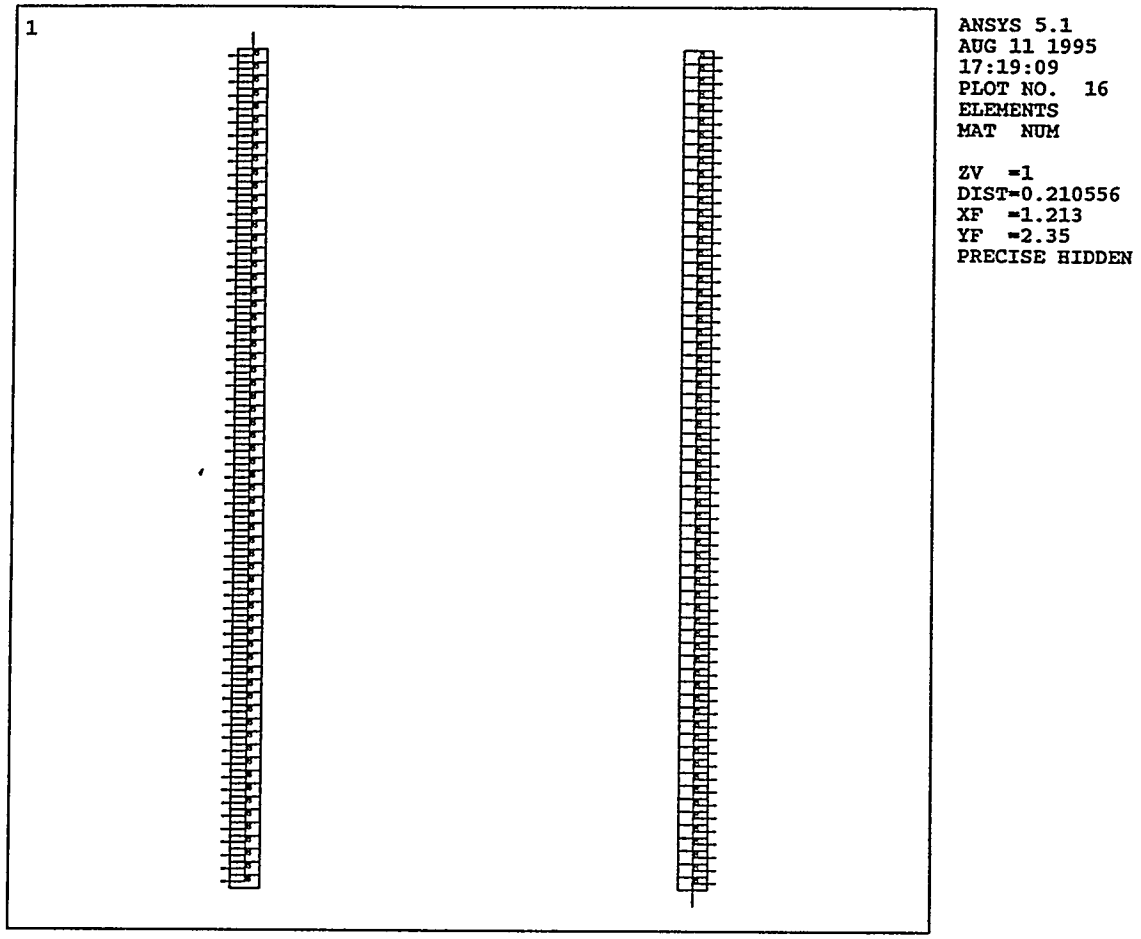


Figure 2-4- Cross section showing principle directions associated with finite elements in the PF5 conductor pack 3-D weave filler regions.

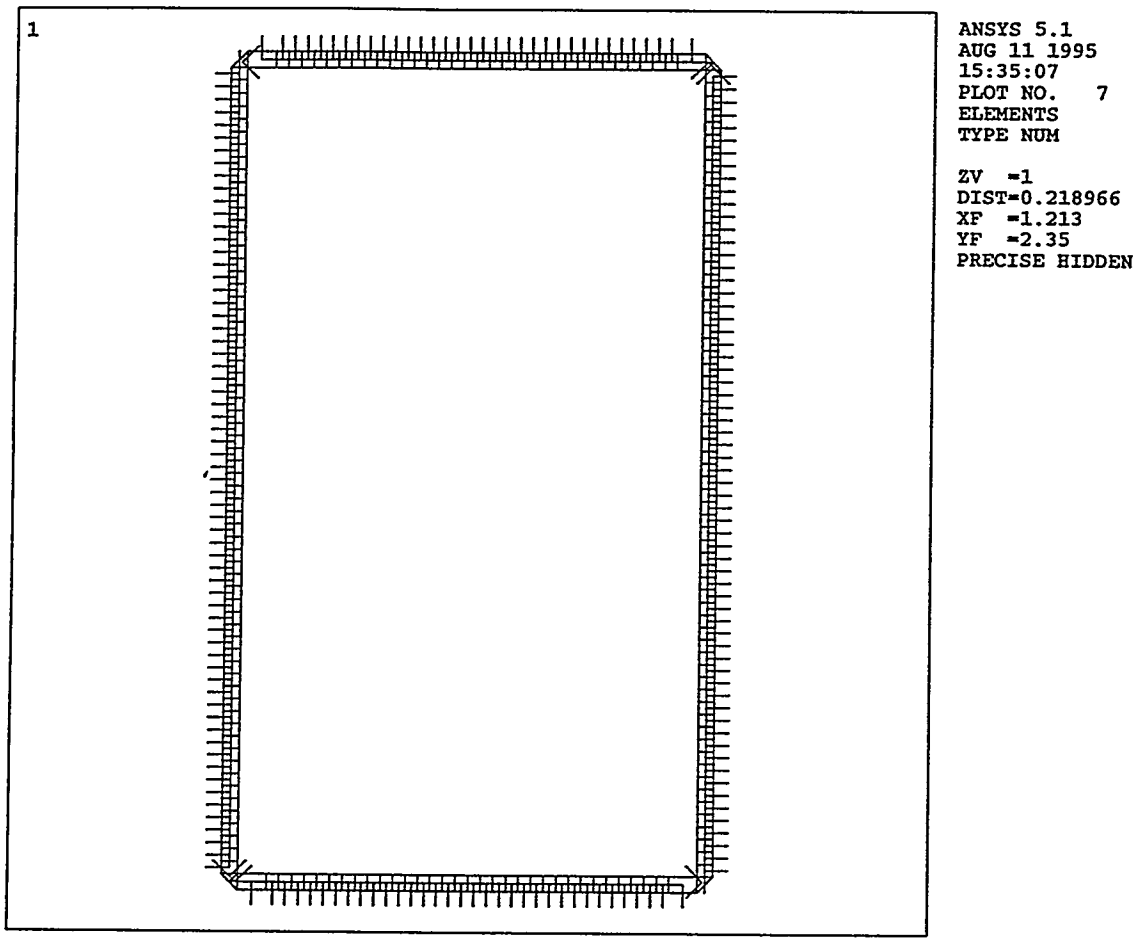


Figure 2-5 Cross section showing principle directions associated with finite elements in the ground wrap regions of the conductor pack.

2.2 MATERIAL CHARACTERISTICS

The structural material properties for the PF5 model were taken from reference 4. The properties that were appropriate to this analysis and their orientation in the PF5 coil pack are summarized in Table 2.2. These properties are very similar to those assumed by Hannan[3]. One notable exception is that the x and y principle directions have been switched in the case of material id 3 (i.e., the 3-D weave thin tape).

Table 2-2 Material properties and orientations assumed in PF5 structural model

Material ID	Material Type	E_x (GPa)	E_y (GPa)	E_z (GPa)	α_x(μ/K)	α_y(μ/K)	α_z(μ/K)	G_{xy} (GPa)	G_{yz} (GPa)	G_{xz} (GPa)	υ_{xy}	υ_{yz}	υ_{xz}
1	Incoloy	185	185	185	5.92	5.92	5.92	71	71	71	.299	.299	.299
3	3-D weave thin tape	32	23	25	8.25	19.2	16.2	8.0	8.0	8.0	.186	.34	.34
4	3-D corner fill	22	25	31	20.3	16.2	7.56	8.5	9.0	8.0	.26	.38	.23
8	3-D weave filler blocks	23	32	25	19.6	8.25	16.2	8.0	8.0	8.0	.26	.37	.25
9	Ground wrap	19.7	29.6	29.6	19.9	6.7	6.7	7.6	7.6	10.7	.26	.26	.26

Material ID	ORIENTATION
1	Not an issue - material is isotropic
3	x is along wrap direction, y is through thickness, z is along conductor direction (i.e., angular)
4	x is vertical, y is radial, z is along conductor direction (i.e., angular)
8	x is radial, y is vertical, z is along conductor direction (i.e., angular)
9	x is through thickness, y is along wrap direction, z is along conductor direction (i.e., angular)

2.3 BOUNDARY CONDITIONS AND LOADINGS

The boundary conditions placed on the PF5 model include periodicity constraints in the form of coupled degrees of freedom and angular and vertical displacement constraints. Since the electromagnetic loading pattern repeats every 22.5 degrees (i.e. 1/16'th of 360 degree) and the external support loading is periodic over 45 degree intervals, a 45 degree section is required for the analysis. The periodicity is enforced by coupling the deflections (i.e., U_r, U_ϕ, U_z) throughout the coil pack at zero degrees (the angle being the toriodal angle,ϕ) to defections throughout the coil pack at 45 degrees. This connects the ends of the coil so that essentially a full hoop is being analyzed (i.e., $U(\phi)=U(\phi\pm45)$ for any node). Further, the coil is vertically supported at 16 angular locations throughout a 10 degree span (i.e. .212 m) centered about the TF coils. This is modeled by fixing the vertical deflections at the bottom surface of the coil pack near the two ends of the 45 degree section actually modeled. That is, the nodes on the bottom surface of the coil pack that lie in the range $0\leq\phi\leq5$ and $40\leq\phi\leq45$ are constrained to have $U_z=0$ as indicated in the three-dimensional plot in fig. 2.1. Lastly, some form of hoop constraints must be applied to restrict the coil pack and conduits from spinning about the vertical axis. Therefore, a single node associated with each of the 128 conduits along with a single node in the insulation region of the conductor pack is fixed in its angular degree of freedom (i.e., $U_\phi=0$). Since these constraints were applied at an angular location of zero degrees, it follows since these nodes are constrained that the angular deflections at 45 degrees are also constrained as

illustrated in fig. 2.1. The coil was not externally restrained in the radial direction so that is free to expand or contract during warm-up or cooldown.

The applied loading consists of two different forms. The first is due to contraction as a result of thermal cooldown. ANSYS accounts for this automatically with the only user input being the thermal contraction coefficients for each of the materials which are given in Table 2.2 and the temperature excursion (ΔT) which is being simulated. The ΔT has been taken to be 416 K. This is obtained from a 125 K cooldown from glass transition temperature plus a 290 K cooldown from ambient to cryogenic operating temperature (i.e., 4K).

The second form of loading is electromagnetic which varies depending upon the way the tokamak is being operated. A worst case electromagnetic loading[5] identified as Pillsbury's equilibria #1[6,7] (i.e., prebias) and has used for this study. This load case corresponds to worst case radial and vertical body centering forces being applied to PF5 during normal operating conditions. In addition to the net body forces, spatial variations both throughout the coil cross section and along the coil path length have been taken from reference 5 for this load case. The resulting electromagnetic loading is shown as a vector plot throughout the cross section in fig. 2.6. Here, a particularly large compressive force can be observed due to the interaction of the self field and the PF5 current. The loads are specified as nodal forces uniformly distributed on the inside surfaces of the conduits.

The variation of the electromagnetic loading along the conductor path is shown in fig. 2.7 for both the radial and vertical forces. In this case, a single node of the innermost lower conduit is shown. The variation with angle is relatively small for PF5 when compared with the larger radius coils PF6 and PF7. Further, the variation in fig. 2.7 appears even smaller for the particular conduit chosen, because the internal compressive effect from the self field contributes a large, radially outward and vertically up directed force component that is invariant with position and tends to dominate the much smaller variation due to TF interaction.

The net integrated body forces from this distribution is obtained by performing a summation on all the applied nodal forces. The result of this is a net outward radial force of 2.75 MN and net downward vertical force of 0.79 MN for a 45 degree section of the PF5U coil. A listing of the EM forces applied to each node of the model can be found in Appendix A along with other commands used in forming the three-dimensional model.

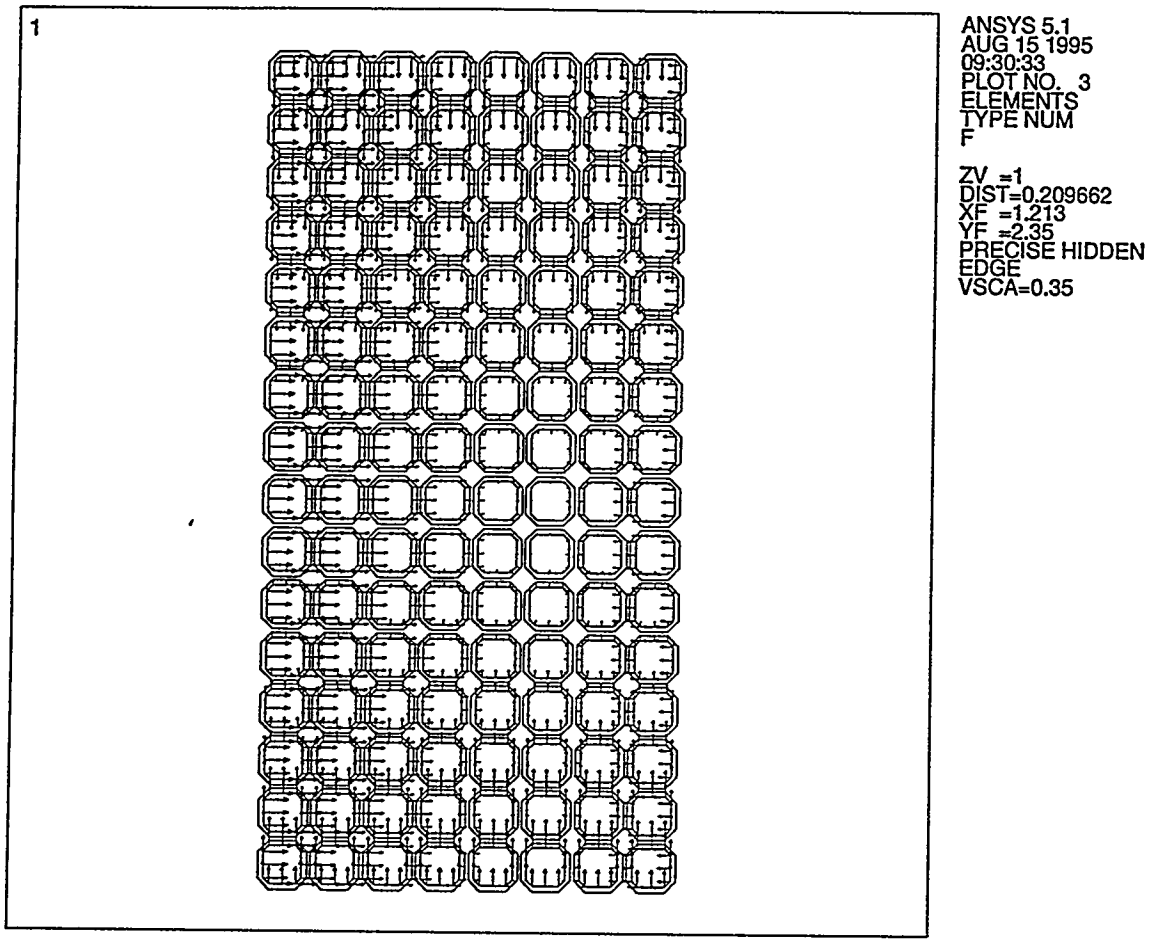


Figure 2-6 Electromagnetic force distribution throughout PF5U cross section during equilibria #1 at a location directly above a TF support..

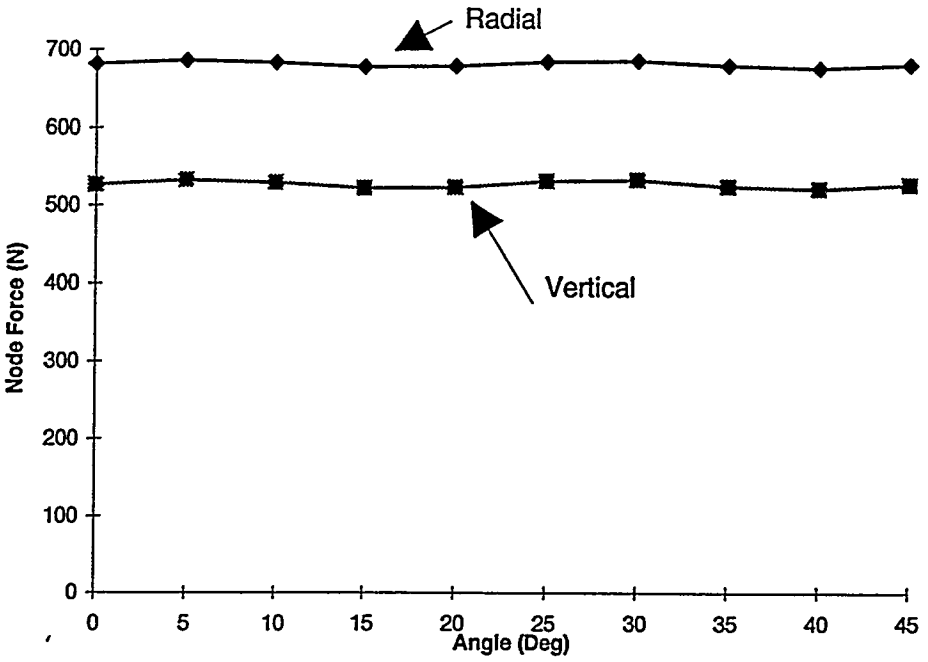


Figure 2-7 Electromagnetic force variation along PF5U conductor path due to interaction of PF5 current with TF generated magnetic fields. A node associated with the innermost lower turn in the PF5U conductor pack is shown in this plot

3. .ANALYSIS RESULTS

3.1 COIL PACK DEFORMATIONS

The most obvious effect of cooldown is the reduction of the coil diameter (3.7 mm) as a result of the thermal contraction. This is apparent in the deformed plot given in fig. 3.1. Also apparent is a vertical compression of the coil due to electromagnetic loading. Both of these effects were observed in the analysis of the central solenoid coils[3]. The electromagnetic loading actually tends to counteract the hoop contraction, but the magnitude of the thermal contraction is roughly 4 times greater than the hoop expansion from radial electromagnetic forces.

If the nodal displacements are amplified by a factor of 50, rather than a factor of 12.4 as in fig. 3.1, then other modes of deformation become apparent. Figure 3.2 shows the coil shape when viewed looking radially outward at the coil inner radial surface. A slight sag in the coil between the two vertical support points can be detected. This bending is a result of reacting the vertical electromagnetic force at the two ends of the 45 degree section. The effect of the electromagnetic force variations along the path of the conductor is not apparent in fig. 3.2. Similarly, when the radial deflections are viewed from above, variations in the radial deflection are not observed. Evidently the structural bending stiffness is very large for PF5 given the small distance between peak positive and negative locations of the alternating component of electromagnetic force.

Figure 3.3 illustrates the shape of the coil cross section directly above the TF support structure. Here it can be observed that the deformations are particularly severe at the top inner and outer radial edges of the coil pack. Many of the peak stresses are observed in these locations. Figure 3.4 shows the deformation associated with a single conduit. Although the mesh is very coarse, the inward bending of the top and bottom

portions of the conduits is apparent. This is consistent with results predicted by others using refined models[3].

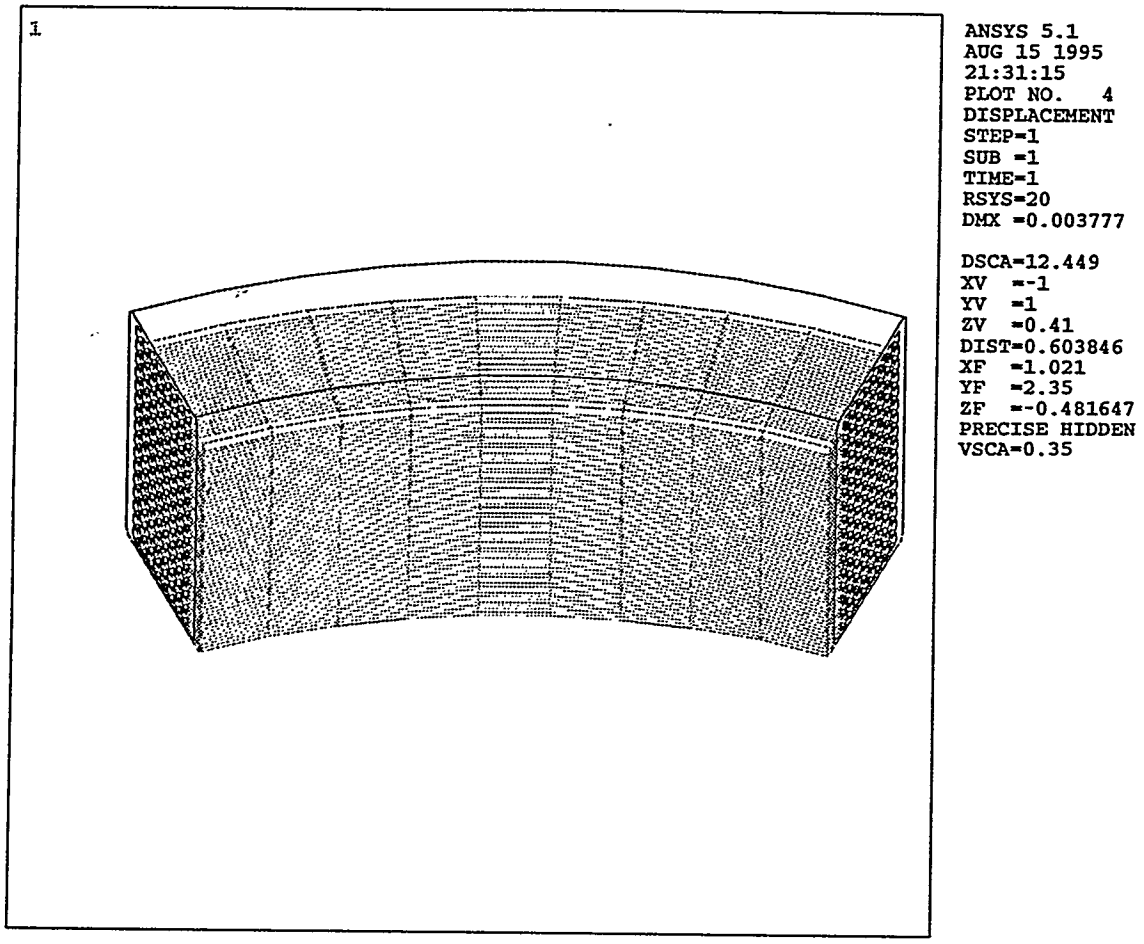


Figure 3-1-Three-dimensional view of deformed PF5 coil illustrating hoop contraction due to cooldown and vertical compression resulting from electromagnetic loading.

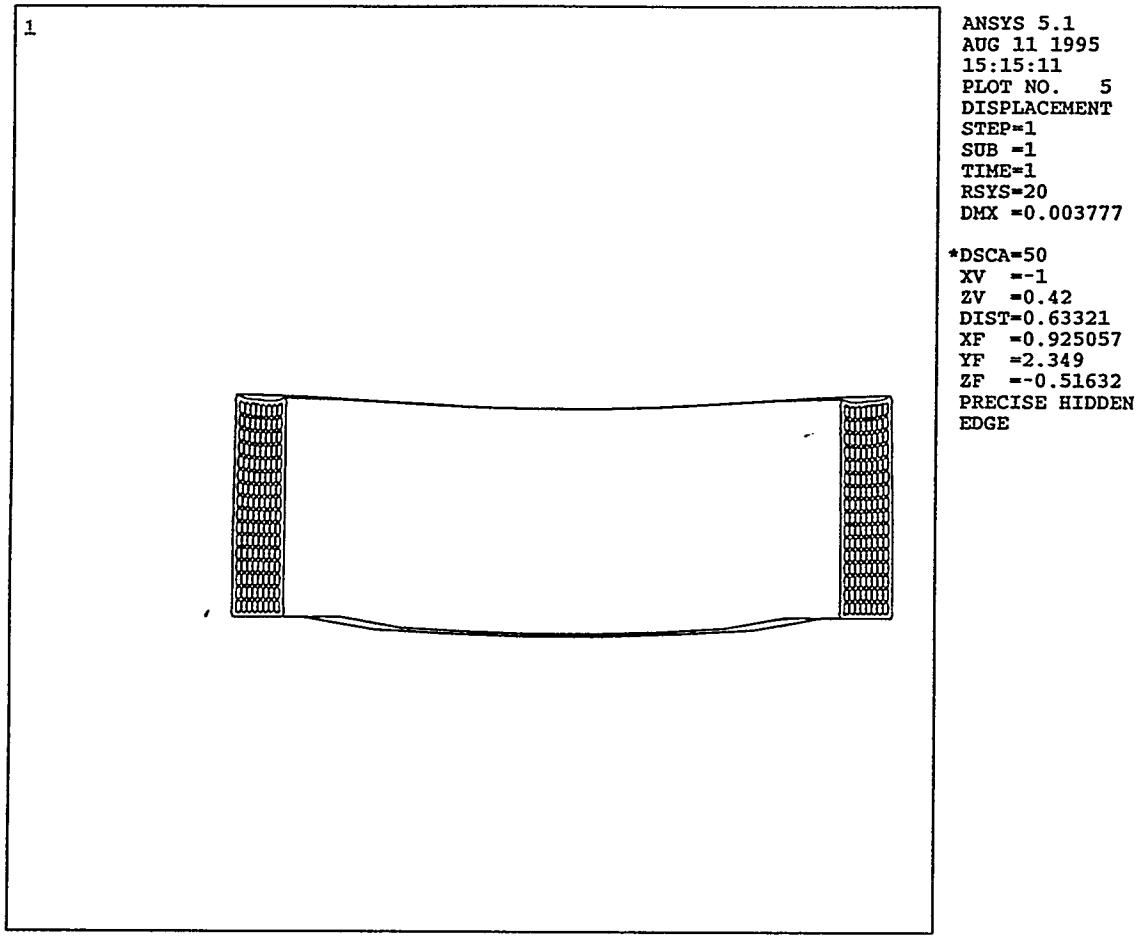


Figure 3-2 Side view of deformed PF5 coil illustrating sag between vertical support points due to downward vertical Lorentz loading.

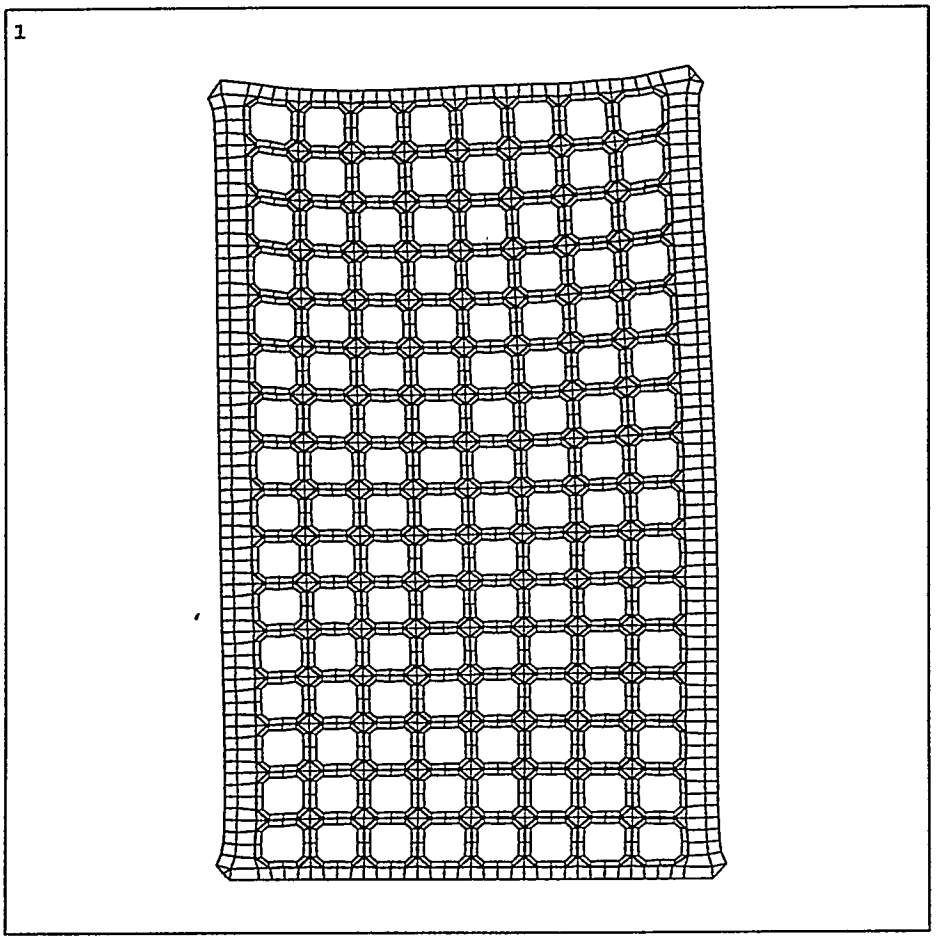


Figure 3-3 Cross section of PF5 conductor pack directly above TF support point illustrating deformed shape of pack due to cooldown and Lorentz force loading.

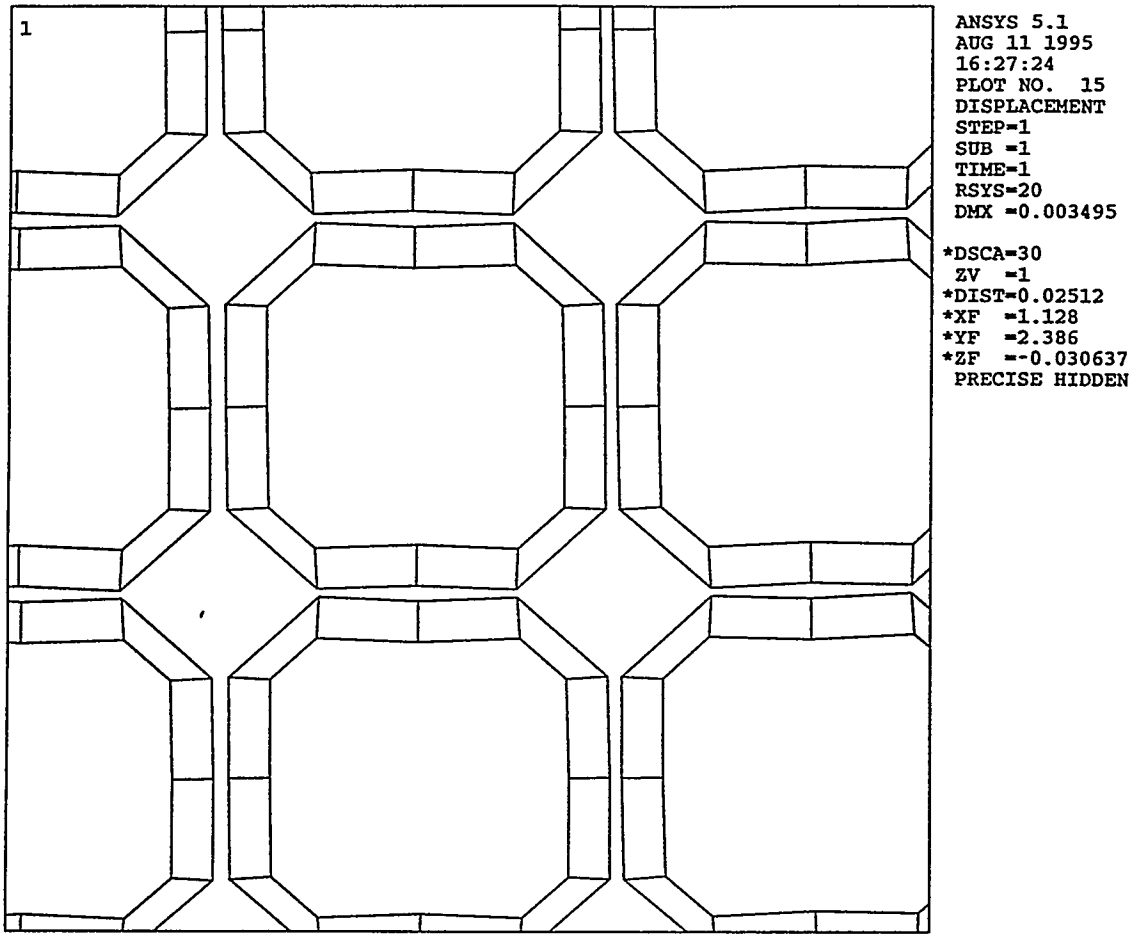


Figure 3-4 Blowup of conduit elements showing deformation which is evident even with the coarse model.

3.2 COIL PACK STRESSES

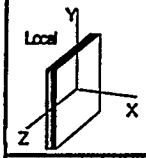
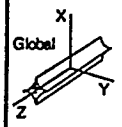
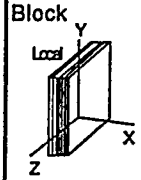
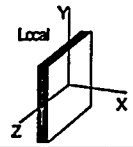
The coil pack stresses are summarized by evaluating their magnitude along each of the materials three major axes. Contour plots of the element stresses were obtained for each of the materials in the coil pack insulation system. The individual stress components show a great deal of variation due to the localized bending that exists as illustrated by the contour plot in fig. 3.5. These plots are useful for locating the region of peak stress, then zooming in on this region for a more detailed examination as illustrated in fig. 3.6. In general, the peak stresses occur above the support points at the two ends of the 45 degree

section, usually at the 5 and 40 degree locations. Further, the peaks are often observed in the top of the coil pack near the inside and outside radial edges.

The first column of Table 3.1 gives the coordinate directions in which the component stresses are presented. These directions are along the materials principle axes in all cases except for the incoloy conduit. Since the conduit is modeled as isotropic, the direction in which the component stresses are evaluated is not of great concern. In the case of the conduit, the x direction is radial, the y direction is vertical, and the z direction is angular along the conductor path. The stress results are presented in this way to be consistent with those presented in reference 3. The case of the 3-D weave thin tape, in particular, may be somewhat confusing. Here the x-directed stress is through the thickness of the tape; whereas, in the local coordinate system associated with the 3-D model this is actually the y-direction (see Table 2.2). In order to be consistent with reference 3, the x and y directed stress results obtained from ANSYS have been interchanged when they were recorded in Table 3.2.

The second column in Table 3.1 gives the values of component stresses which result from the three-dimensional analysis. Here, both the effects of cooldown and the Lorentz loading is applied simultaneously. In order to judge whether or not the variations along the length of the conductor are important, a third column of results is added that corresponds to a purely axisymmetric analysis. The exact same mesh was used for the axisymmetric model as was used for the three-dimensional model, except that the axisymmetric elements sweep a full 360 degrees, whereas the solid three-dimensional elements span only 5 degrees. In the axisymmetric model the electromagnetic force possesses no alternating component along the length of the conductor. Also, the downward vertical force is reacted by a plane placed at the bottom of the coil. Again, the effects of both cooldown and electromagnetic loading is included in the stress results. Figure 3.7 illustrates the deformed coil pack for the case of the axisymmetric solution

Table 3-1-Summary of maximum and minimum stress components throughout the PF5 conductor pack.

		Three-Dimensional Model Cooldown and Lorentz Loads (MPa)	Axisymmetric Model Cooldown and Lorentz loads (MPa)
Conduit	SX	-248 197	-188 130
	SY	-65.4 171	-213 96.1
	SZ	-327 174	-26 120
	SXY	-62.5 127	-117 117
	SINT	369	238
3-D Weave Thin Tape 	SX	-88 55.8	-92 30.5
	SY	-106 154	-87.5 147
	SZ	75.1 170	86 165
	SXY	-54.8 50.2	-21 21
Roving 	SX	11.4 111	30.8 108
	SY	25.4 90.7	31.8 91.9
	SZ	33.5 102	52.2 90.5
	SXY	-38.6 36.3	-39 39.7
Spacer Block 	SX	-18.6 132	-11 120
	SY	-86.4 89.5	-44 63
	SZ	87.4 194	103 175
	SXY	-15.8 15.3	-11.7 10.6
Ground Wrap 	SX	-77.8 53.3	-19 41
	SY	-106 24	-1.02 27.5
	SZ	-25.3 48.7	-14.8 36.2
	SXY	-24.2 26.4	-19.7 19.9

* Positive values signify tension & negative numbers indicate compression.
Material properties reflect CPDR baseline properties.

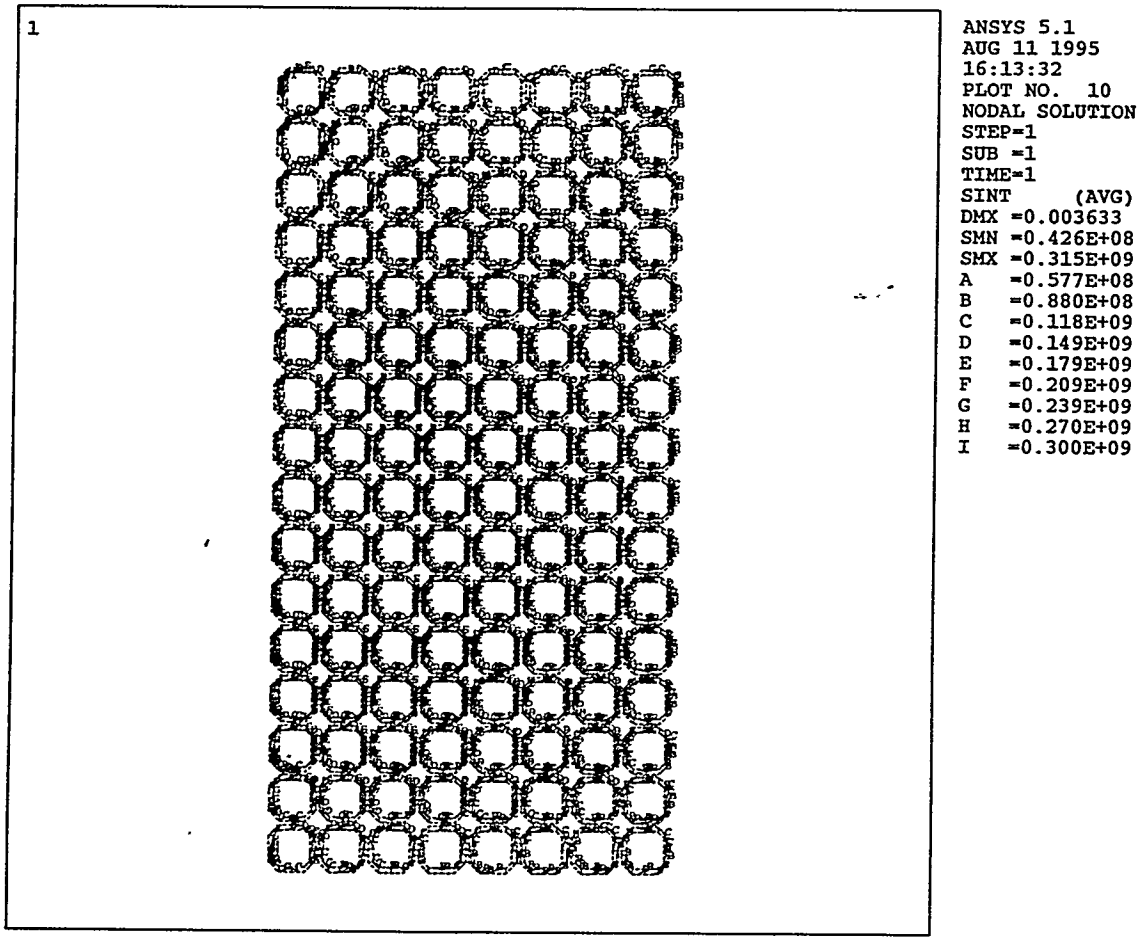


Figure 3-5 Contours of constant stress intensity throughout the incoloy conduits in conductor pack PF5 at an angular location directly above a TF support point. The maximum stress (315 Mpa) occurs in the upper left corner

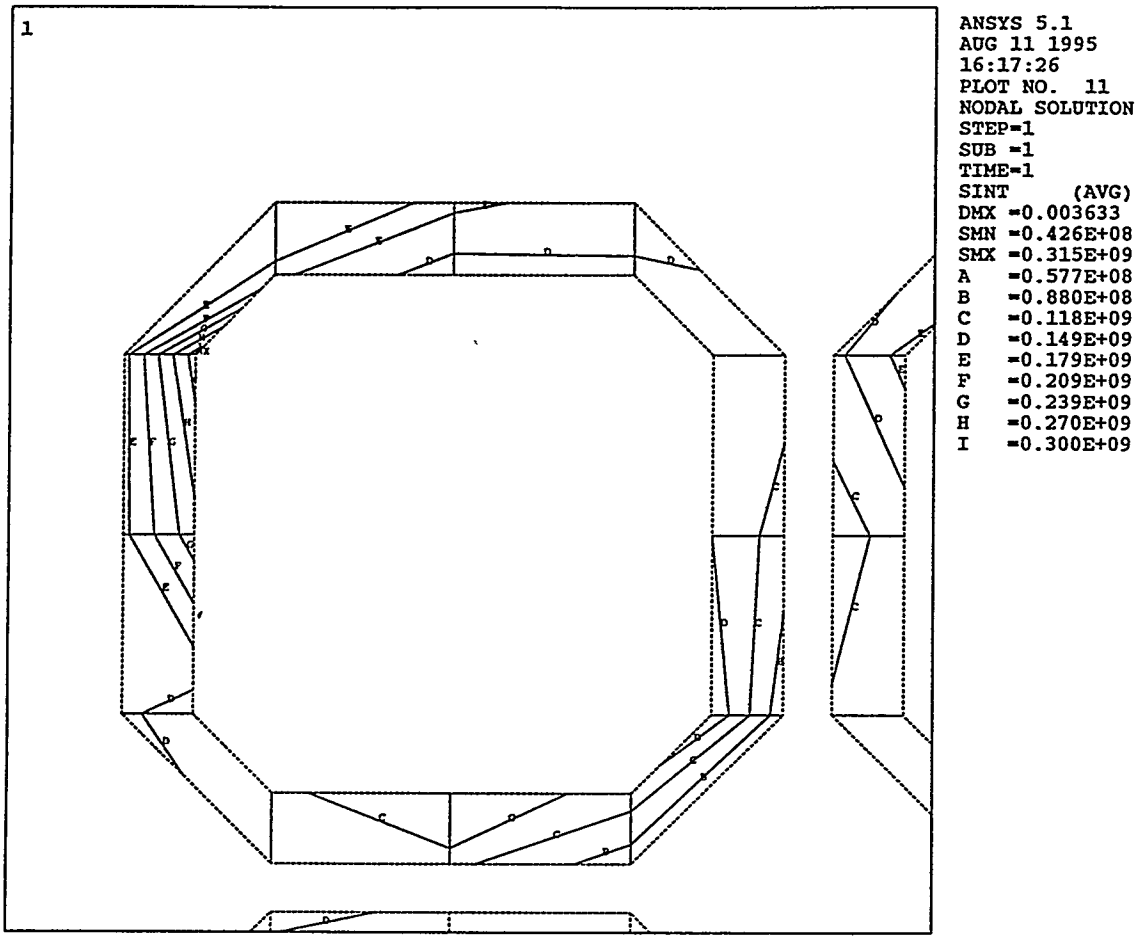


Figure 3-6 Blowup of stress intensity distribution in uppermost left conduit of PF5 conductor pack.

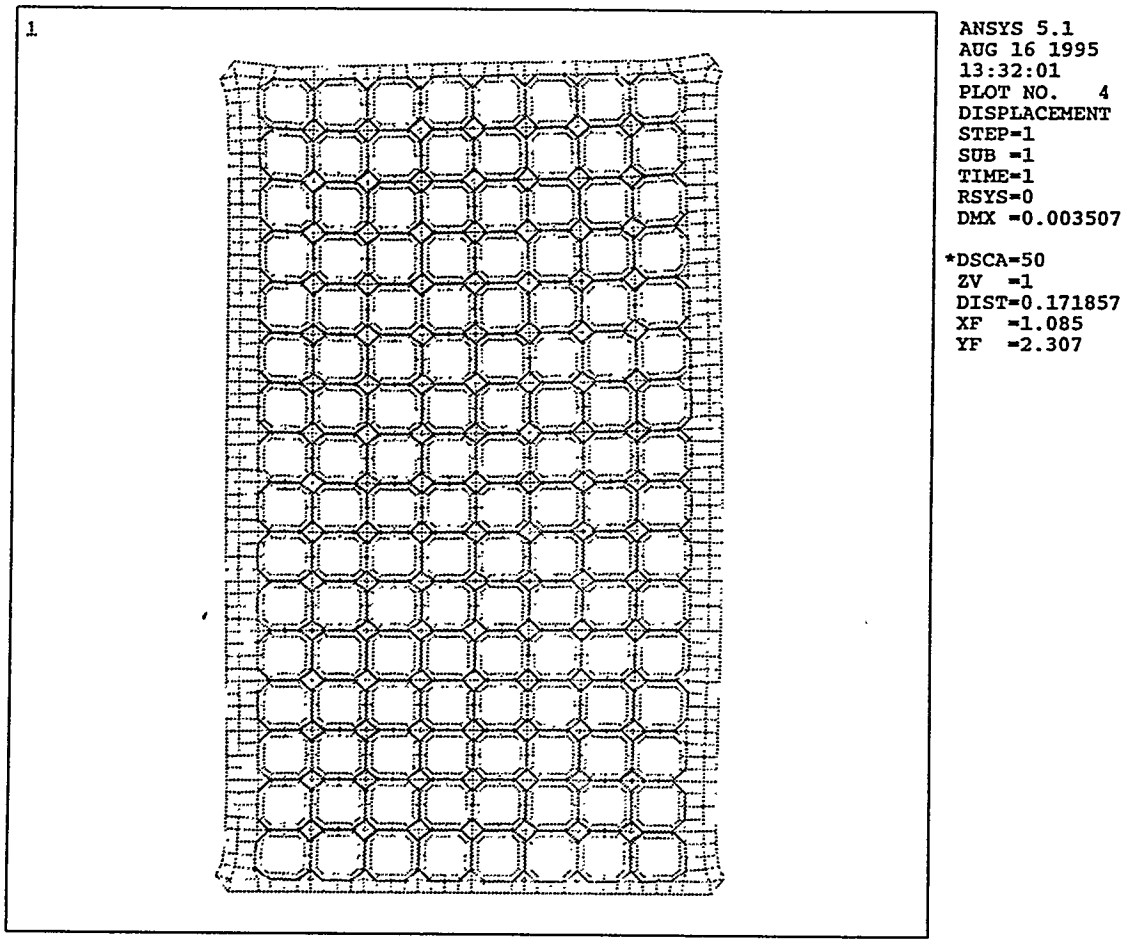


Figure 3-7 Illustration of deformed shape resulting from PF5U axisymmetric model.

4. DISCUSSION OF RESULTS

Several observations have been made based on xamination of the deformation and stress results. These are summarized below:

1. A limited amount of bending occurs as a result of the discrete support points based on the deformation plots.
2. The electromagnetic force variations along the path of the conductor are very small in PF5. Further, deformations as a result of these forces cannot even be observed in the results.
3. A large internal compressive force exists in PF5 due to the interaction of the PF5 current and its self field.
4. Surprisingly, a large change in the conduit stresses (see Table 3.2) is observed in the 3-D model indicating the conduit plays a major role in limiting the bending, rather than the insulation.
5. Credence is given to the 3-D solution since the effects of bending can be observed by examining differences in hoop stress (SZ) between axisymmetric and 3-D solutions. For each material in the coil, the spread in the hoop stress (i.e., max-min) is larger in the 3-D as would be expected.
6. Overall, the stresses in the insulation system appear lower for PF5U than in the CS. One exception is the 3-D weave thin tape through thickness stress which is 55.8 MPa for the PF5 model. Perhaps a refined model of this region would be appropriate.
7. The conduit stresses are substantially lower in PF5U compared with the CS, even with the bending effects included.

5. REFERENCES

1. Pedrotti, L., Jackson, M.C., and Deis, G.A., "Tokamak Physics Experiment Technical Scope of Work - TPX Magnet System," Revision 5, Lawrence Livermore National Laboratory TPX SOW document, 7/6/95.

2. Zbasnik, J. and Lang, D., "Tokamak Physics Experiment Superconducting Magnet System Design Documentation List," TPX #91-940815-LLNL-DLang, Aug. 15, 1994.

3. Hannan, W. F., "Structural Analysis of the CS Winding Pack," TPX Report # 14-950909-WEC-WHannan-01, 8/95.

4. Roach, J., F., "Revision of Mechanical Properties Matrix of Insulation Materials for Structural/Thermal Analyses," TPX memo #14-12210.3-WSTC/JFROACH-M12-06-05-95, June 5, 1995.

5. Krefta, M. P., "Electromagnetic Analysis of TPX Poloidal Field Coils," TPX Report # 14-950630-WEC-MKrefta-01, Table 4.10, page 4-41, June 30, 1995.

6. Pillsbury, R.D., "Poloidal Field Coil System Current Requirements for TPX," TPX #14-941007-MIT-RPillsbury-01, Oct. 7, 1994

7. Pillsbury, R. D., Jr., "Poloidal Field Coil System Static Forces for the Twenty-three Equilibria in TPX," 11/17/94, TPX Document #14-941117-MIT-RPillsbury-01.

6. APPENDIX A - ANSYS 3-D COMMAND FILE

The following are ANSYS commands used to establish the three-dimensional structural model of PF5U.

7. APPENDIX B - ANSYS AXISYMMETRIC PF5 COMMAND FILE

The following are ANSYS commands used to establish the axisymmetric structural model of PF5U.

```
/com 2D Axisymetric Model of PF5 coil
/com Mark Krefta
/com Westinghouse STC
/com July 26, 1995
et,1,plane42,1,,1
et,2,52
et,3,45,,,,1
r,1,5e11,0,0,5e11
real,1
/com
/com  PARAMETERS        ,
*dim,pitch,array,20             ,
rsm=.106*.0254      !inner radius of conduit
cw=.688*.0254       !cable width
fl=cw-2*rsm         !flat length of conduit wall
tc=.095*.0254       !conduit wall thickness
tins1=.004*.0254    !insulation wrap thickness
one
tins2=.028*.0254    !insulating wrap thickness
two
rou=.201*.0254      !outer radius of conduit
r1=rou+tins1        !outer radius of 1st insulating
wrap
r2=r1+tins2         !outer radius of 2nd insulating
wrap
tg11=.016*.0254     !g11 sheet thickness
twrap=.301*.0254    !ground wall insulation
thickness
csize=cw+2*tc+2*(tins1+tins2)  !size of single
turn cell i.e. offset in x,y
r3=r2+twrap
sml=.001*.0254      !a relatively small
dimension
cn=.0005*.0254      !distance between nodes
on slip elements
del=.25/2*.0254     !adjusts width of spacer
blocks
pitch(1)=0*csize,1/4*csize,3/4*csize,1/2*csize,
1/2*csize
pitch(6)=3/4*csize,1/4*csize,1*csize,0*csize,1/
4*csize
/com
/com
/com  MAT #        DESCRIPTION
/com   1       INCOLOY CONDUIT
/com   2       CABLE WRAP  INNER
/com   3       CABLE WRAP  OUTER
/com   4       ROVING FILLER
/com   5       MID VERTICAL G11 SPACER
/com   6       UPPER/LOWER VERTICAL
G11 SPACER
/com   7       EPOXY VOIDS
/com   8       G11 FILLER BLOCKS
/com   9       GROUNDWALL
INSULATION
/com  10       HORIZONTAL G11 SHEETS
/com
/com
/com DEFINE PF CURRENT SOURCE
GEOMETRY (Dimensions in m)
pr5=1.213 $pz5=2.35   $pdr5=.192
$pdz5=.382
/com Westinghouse STC
/com June 9, 1995
/com Analysis done in Metric
/com 2D Model with slip planes at conduit OD
/com Mat'l per J.F Roach, Rev 2 to table
assembled by L Myatt ,MIT/PFC
/com Dated 3/15/95,5/24/95
/com
/com  Young's modulus
ex2=5.5e9  $ey2=4.8e9  $yx2=.34
$xy2=yx2*ey2/ex2
ex3=32e9   $ey3=23e9  $yx3=.26
$xy3=yx3*ey3/ex3
ex9=29.6e9  $ey9=19.7e9 $yx9=.26
$xy9=yx9*ey9/ex9
mp,ex,1,185e9                    !material 1
incoloy
mp,ey,2,4.8e9  $mp,ex,2,5.5e9
$mp,ez,2,5.5e9 !material 2 insul. Kapton
mp,ey,3,23e9   $mp,ex,3,32e9    $mp,ez,3,25e9
!material 3 insul. 3D Weave
mp,ex,4,22e9   $mp,ey,4,25e9    $mp,ez,4,31e9
!material 4 insul. 3D corner fill
mp,ex,8,23e9   $mp,ey,8,32e9    $mp,ez,8,25e9
!material 8 insul. 3D Weave
mp,ey,9,19.7e9  $mp,ex,9,29.6e9
$mp,ez,9,29.6e9  !material 9 insul. 3D Weave
/com
mp,gxy,1,71e9  $mp,gxz,1,71e9
$mp,gyz,1,71e9
mp,gxy,2,.37e9  $mp,gyz,2,.37e9
$mp,gxz,2,.37e9
mp,gxy,3,8e9   $mp,gyz,3,8e9
$mp,gxz,3,8e9
mp,gxy,4,8.5e9  $mp,gxz,4,9e9   $mp,gyz,4,8e9
mp,gxy,8,8e9  $mp,gxz,8,8e9   $mp,gyz,8,8e9
mp,gxy,9,7.6e9  $mp,gyz,9,7.6e9
$mp,gxz,9,10.7e9
/com
mp,nuxy,1,.299  $mp,nuxz,1,.299
$mp,nuyz,1,.299
mp,nuxy,2,xy2  $mp,nuyz,2,.34
$mp,nuxz,2,.34
mp,nuxy,3,xy3  $mp,nuyz,3,.37
$mp,nuxz,3,.25
mp,nuxy,4,.26  $mp,nuxz,4,.38
$mp,nuyz,4,.23
mp,nuxy,8,.26  $mp,nuxz,8,.37
$mp,nuyz,8,.25
mp,nuxy,9,xy9  $mp,nuyz,9,.26
$mp,nuxz,9,.26
/com
/com thermal contractions
mp,alpx,1,5.92e-6  $mp,alpy,1,5.92e-6
$mp,alpz,1,5.92e-6 !Material 1
!material 1
mp,alpy,2,43.2e-6  $mp,alpx,2,13.0e-6
$mp,alpz,2,15.8e-6 !material 2
mp,alpy,3,19.2e-6  $mp,alpx,3,8.25e-6
$mp,alpz,3,16.2e-6  !material 3
mp,alpx,4,20.3e-6  $mp,alpy,4,16.2e-6
$mp,alpz,4,7.56e-6  !material 4
mp,alpx,8,19.2e-6  $mp,alpy,8,8.25e-6
$mp,alpz,8,16.2e-6  !material 8
mp,alpy,9,19.9e-6  $mp,alpx,9,6.7e-6
$mp,alpz,9,6.7e-6  !material 9
/com
/com The Mat'l are taken from full Ansys
Model, not all ten Mat'ls are used.
/com  MAT #        DESCRIPTION
/com   1       INCOLOY CONDUIT
/com   2       CABLE WRAP  INNER
/com   3       CABLE WRAP  OUTER
/com   4       ROVING FILLER
/com   5       MID VERTICAL G11 SPACER
/com   6       UPPER/LOWER VERTICAL
G11 SPACER
/com   7       EPOXY VOIDS
/com   8       G11 FILLER BLOCKS
/com   9       GROUNDWALL
INSULATION
/com  10       HORIZONTAL G11 SHEETS
/com
/com
/com ROW #1
iy=-7
/com
/com  BEGIN SINGLE CELL
ix=-3   ! CELL #1
*do,iy,-7,8
*do,ix,-3,4
/com DEFINE ELEMENT SHAPE AND SIZE
eshape,3
esize,0.3*.0254
/com  DEFINE ELEMENT COORDINATE
SYSTEMS
rcs1=pr5+tins2+tins1+tc+rsm+(ix-1)*csize
ycs1=pz5+tins2+tins1+tc+rsm+(iy-1)*csize
csys,0
/com  KEYPOINTS
*get,lst,line,,num,max   !max line number
*get,ast,area,,num,max   !max area number
/com
/com  KPOINT IN CENTER OF CELL  KP1
rclc=pr5+csize/2+(ix-1)*csize
yclc=pz5+csize/2+(iy-1)*csize
k,,rclc,yclc  !keypoint for larc command  kp1
*get,knm,kp,,num,max !kp number of larc
command
kst=knm
/com
/com  CONDUIT
/com  Conduit geometry  inside edges
K,kst+1,rcs1,ycs1-rsm          ! kp 2
K,kst+2,rcs1-rsm,ycs1     !kp 3
KGEN,2,kst+1,,,fl  SKGEN,2,kst+2,,,,fl
$KGEN,2,kst+2,,,cw,fl !kp 4-6
```

```
KGEN,2,kst+2,,,cw  $KGEN,2,kst+1,,,,cw
$KGEN,2,kst+3,,,,cw !kp 7-9
/com Conduit outside edges  KP10 thru kp117
kgen,2,kst+6,,,tc-cn  $kgen,2,kst+5,,,tc-cn
$kgen,2,kst+7,,,,tc-cn
kgen,2,kst+8,,,,tc-cn $kgen,2,kst+4,,,-tc+cn
$kgen,2,kst+2,,,,-tc+cn
kgen,2,kst+1,,,,-tc+cn $kgen,2,kst+3,,,,-tc+cn
/com  Conduit lines
L,kst+6,kst+5  $L,kst+8,kst+7
$L,kst+4,kst+2  $L,kst+1,kst+3
LARC,kst+3,kst+6,knm,rsm,1
$LARC,kst+5,kst+8,knm,rsm,1
LARC,kst+7,kst+4,knm,rsm,1
$LARC,kst+2,kst+1,knm,rsm,1
L,kst+9,kst+10  $L,kst+12,kst+11
$L,kst+13,kst+14  $L,kst+15,kst+16
larc,kst+16,kst+9,knm,rou-cn
$larc,kst+10,kst+12,knm,rou-cn
larc,kst+11,kst+13,knm,rou-cn
$larc,kst+14,kst+15,knm,rou-cn
/com  Conduit Areas
mat,1  $type,1
a,kst+5,kst+6,kst+9,kst+10
$a,kst+8,kst+5,kst+10,kst+12
a,kst+7,kst+8,kst+12,kst+11
$a,kst+4,kst+7,kst+11,kst+13
a,kst+2,kst+4,kst+13,kst+14
$a,kst+1,kst+2,kst+14,kst+15
a,kst+3,kst+1,kst+15,kst+16
$a,kst+6,kst+3,kst+16,kst+9
amesh,ast+1,ast+8
/com
/com  INSULATION LAYERS
/com  1ST LAYER INSULATION
/com  inside edges  KP18 thru KP25
KGEN,2,kst+6,,,tc  $KGEN,2,kst+5,,,tc
$KGEN,2,kst+7,,,,tc
KGEN,2,kst+8,,,,tc  $KGEN,2,kst+4,,,-tc
$KGEN,2,kst+2,,,,-tc
KGEN,2,kst+1,,,,-tc $KGEN,2,kst+3,,,,-tc
LARC,kst+22,kst+23,knm,rou,1
$LARC,kst+24,kst+17,knm,rou,1
LARC,kst+18,kst+20,knm,rou,1
$LARC,kst+19,kst+21,knm,rou,1
/com
/com  SECOND LAYER INSULATION
/com  Inner layer        Outer Layer KP26-KP33
kgen,2,kst+17,,,tins1+tins2
kgen,2,kst+18,,,tins1+tins2
kgen,2,kst+19,,,,tins1+tins2
kgen,2,kst+20,,,,tins1+tins2
kgen,2,kst+21,,,-tins1-tins2
kgen,2,kst+22,,,-tins1-tins2
kgen,2,kst+23,,,,-tins1-tins2
kgen,2,kst+24,,,,-tins1-tins2
/com  lines
LARC,kst+30,kst+31,knm,r2,1
$LARC,kst+32,kst+25,knm,r2,1
LARC,kst+26,kst+28,knm,r2,1
$LARC,kst+27,kst+29,knm,r2,1
/com  Insulation Areas  (inner layer)
mat,3  $type,1
a,kst+18,kst+17,kst+25,kst+26
$a,kst+22,kst+21,kst+29,kst+30
amesh,ast+9,ast+10
mat,3  $type,1
a,kst+19,kst+20,kst+28,kst+27
$a,kst+24,kst+23,kst+31,kst+32
amesh,ast+11,ast+12
mat,3  $type,1    !lower left corner
a,kst+23,kst+22,kst+30,kst+31  $amesh,ast+13
mat,3  $type,1    !lower right corner
a,kst+17,kst+24,kst+32,kst+25  $amesh,ast+14
mat,3  $type,1    !upper right corner
a,kst+20,kst+18,kst+26,kst+28  $amesh,ast+15
mat,3  $type,1    !upper left corner
a,kst+21,kst+19,kst+27,kst+29  $amesh,ast+16
/com
/com  OUTERMOST CORNERS KP34-37
KGEN,2,kst+28,,,r2    $KGEN,2,kst+32,,,r2
KGEN,2,kst+31,,,-r2    $KGEN,2,kst+27,,,-r2
/com
/com  ROVING AREAS
mat,4  $type,1
a,kst+30,kst+35,kst+31    !lower left
a,kst+34,kst+25,kst+32    !lower right
a,kst+26,kst+33,kst+28    !upper right
a,kst+36,kst+29,kst+27    !upper left
amesh,ast+17,ast+20
/com
*enddo
*enddo
/com
/com
/com
/com
/com
/com  Merge nodes and kpoints on cell
interfaces
arsel,mat,3,4  $lsar  $kpls
earea
nsel,ext
nummrg,node,sml
nummrg,kpoi,sml
nall  $eall  $kpall  $arall  $lsall
numcmp,kpoi  $numcmp,line  $numcmp,node
/com
/com
spcr=.529*.0254
esize,.6*.0254
*get,afst,area,,num,max
/com
/com  FORM LEFT FILLER REGION BY
DRAGGING LINES
/com  Get uppermost left node
insd=pr5-4*csize
uppr=pz5+8*csize
ksel,s,loc,x,insd-sml,insd+sml
ksel,r,loc,y,uppr-sml,uppr+sml
*get,k1,kp,,num,max
kgen,2,all,,,-spcr
*get,kmx,kp,,num,max
1,kmx,k1
*get,ldrg,line,,num,max    !get the drag line
number
/com  drag areas one by one
ksel,s,loc,x,insd-sml,insd+sml
/com
/com  upper most set of two cells
*do,idex,1,8
lskp,1
lsel,r,loc,y,uppr-sml-2*(idex-1)*csize,uppr-
2*idex*csize
*get,l1,line,,num,max
lsel,u,,,l1
*get,l2,line,,num,max
lsel,u,,,l2
*get,l3,line,,num,max
lsel,u,,,l3
*get,l4,line,,num,max
lsel,u,,,l4
*get,l5,line,,num,max
lsel,u,,,l5
*get,l6,line,,num,max
lskp,1
lsel,r,loc,y,uppr-sml-2*(idex-1)*csize,uppr-
2*idex*csize
lsel,a,,,ldrg
adrag,l1,l3,l2,l4,l6,l5,ldrg
*enddo
/com
/com
/com
/com  FORM RIGHT FILLER REGION BY
DRAGGING LINES
/com  Get uppermost RIGHT node
insd=pr5+4*csize
uppr=pz5+8*csize
ksel,s,loc,x,insd-sml,insd+sml
ksel,r,loc,y,uppr-sml,uppr+sml
*get,k1,kp,,num,max
kgen,2,all,,,spcr
*get,kmx,kp,,num,max
1,k1,kmx
*get,ldrg,line,,num,max    !get the drag line
number
/com  drag areas one by one
ksel,s,loc,x,insd-sml,insd+sml
/com
/com  upper most set of two cells
*do,idex,1,8
lskp,1
lsel,r,loc,y,uppr-sml-2*(idex-1)*csize,uppr-
2*idex*csize
lsel,a,,,ldrg
adrag,l5,l6,l4,l2,l3,l1,ldrg
*enddo
/com
/com
/com
*get,alst,area,,num,max
mat,8  $type,1
amesh,afst+1,alst

*get,afst,area,,num,max
/com
/com  FORM LEFT GROUND WRAP
REGION BY DRAGGING LINES
/com  Get uppermost left node
insd=pr5-4*csize-spcr
uppr=pz5+8*csize
ksel,s,loc,x,insd-sml,insd+sml
ksel,r,loc,y,uppr-sml,uppr+sml
*get,k1,kp,,num,max
kgen,2,all,,,-twrap
*get,kmx,kp,,num,max
1,k1,kmx
*get,ldrg,line,,num,max    !get the drag line
number
/com  drag areas one by one
ksel,s,loc,x,insd-sml,insd+sml
/com
/com  upper most set of two cells
*do,idex,1,8
lskp,1
lsel,r,loc,y,uppr-sml-2*(idex-1)*csize,uppr-
2*idex*csize
*get,l1,line,,num,max
lsel,u,,,l1
*get,l2,line,,num,max
lsel,u,,,l2
*get,l3,line,,num,max
lsel,u,,,l3
*get,l4,line,,num,max
lsel,u,,,l4
*get,l5,line,,num,max
lsel,u,,,l5
*get,l6,line,,num,max
lskp,1
lsel,r,loc,y,uppr-sml-2*(idex-1)*csize,uppr-
2*idex*csize
lsel,a,,,ldrg
```

```
adrag,l1,l2,l3,l4,l5,l6,ldrg
*enddo
/com
/com
/com
/com  FORM RIGHT GROUND WRAP
REGION BY DRAGGING LINES
/com  Get uppermost right node
insd=pr5+4*csize+spcr
uppr=pz5+8*csize
ksel,s,loc,x,insd-sml,insd+sml
ksel,r,loc,y,uppr-sml,uppr+sml
*get,k1,kp,,num,max
kgen,2,all,,,twrap
*get,kmx,kp,,num,max
l,k1,kmx
*get,ldrg,line,,num,max    !get the drag line
number
/com   drag areas one by one
ksel,s,loc,x,insd-sml,insd+sml
/com
/com   upper most set of two cells
*do,idex,1,8
lskp,1
lsel,r,loc,y,uppr-sml-2*(idex-1)*csize,uppr-
2*idex*csize
*get,l1,line,,num,max
lsel,u,,l1
*get,l2,line,,num,max
lsel,u,,l2
*get,l3,line,,num,max
lsel,u,,l3
*get,l4,line,,num,max
lsel,u,,l4
*get,l5,line,,num,max
lsel,u,,l5
*get,l6,line,,num,max
lskp,1
lsel,r,loc,y,uppr-sml-2*(idex-1)*csize,uppr-
2*idex*csize
lsel,a,,ldrg
adrag,l1,l2,l3,l4,l5,l6,ldrg
*enddo
/com
/com
*get,alst,area,,num,max
mat,9  $type,1
amesh,afst+1,alst
/com
/com
/com
/com  FORM TOP GROUND WRAP REGION
BY DRAGGING LINES
/com  Get uppermost Left node
afst=alst
insd=pr5-4*csize-spcr
uppr=pz5+8*csize
ksel,s,loc,x,insd+spcr-sml,insd+spcr+sml
ksel,r,loc,y,uppr-sml,uppr+sml
*get,k1,kp,,num,max
kgen,2,all,,,,twrap
*get,kmx,kp,,num,max
l,k1,kmx
*get,ldrg,line,,num,max    !get the drag line
number
/com   drag top-of-spacer area
ksel,s,loc,y,uppr-sml,uppr+sml
/com
/com  left most region on top of spacer
lskp,1
lsel,r,loc,x,insd+sml,insd+spcr
*get,l1,line,,num,max
lsel,a,,ldrg
adrag,l1,,,,,,ldrg
*get,abad,area,,num,max
/com
/com  first set of 2 cells
*do,idex,1,4
lskp,1
lsel,r,loc,x,insd+spcr+sml+2*(idex-
1)*csize,insd+spcr+2*idex*csize
*get,l1,line,,num,max
lsel,u,,l1
*get,l2,line,,num,max
lsel,u,,l2
*get,l3,line,,num,max
lsel,u,,l3
*get,l4,line,,num,max
lsel,u,,l4
*get,l5,line,,num,max
lsel,u,,l5
*get,l6,line,,num,max
lskp,1
lsel,r,loc,x,insd+spcr+sml+2*(idex-
1)*csize,insd+spcr+2*idex*csize
lsel,a,,ldrg
adrag,l4,l6,l5,l1,l3,l2,ldrg
*enddo
/com
/com  right most region on top of spacer
lskp,1
lsel,r,loc,x,insd+spcr+sml+2*4*csize,insd+2*sp
cr+2*4*csize
*get,l1,line,,num,max
lsel,a,,ldrg
adrag,l1,,,,,,ldrg
/com
/com
/com
/com
/com  FORM BOTTOM GROUND WRAP
REGION BY DRAGGING LINES
/com  Get uppermost Left node
insd=pr5-4*csize-spcr
uppr=pz5-8*csize
ksel,s,loc,x,insd-sml,insd+sml
ksel,r,loc,y,uppr-sml,uppr+sml
*get,k1,kp,,num,max
kgen,2,all,,,,-twrap
*get,kmx,kp,,num,max
l,k1,kmx
*get,ldrg,line,,num,max    !get the drag line
number
/com   drag top-of-spacer area
ksel,s,loc,y,uppr-sml,uppr+sml
/com
/com  left most region on top of spacer
idex=1
lskp,1
lsel,r,loc,x,insd+sml,insd+spcr
*get,l1,line,,num,max
lsel,a,,ldrg
adrag,l1,,,,,,ldrg
/com
/com  first set of 2 cells
*do,idex,1,4
lskp,1
lsel,r,loc,x,insd+spcr+sml+2*(idex-
1)*csize,insd+spcr+2*idex*csize
*get,l1,line,,num,max
lsel,u,,l1
*get,l2,line,,num,max
lsel,u,,l2
*get,l3,line,,num,max
lsel,u,,l3
*get,l4,line,,num,max
lsel,u,,l4
*get,l5,line,,num,max
lsel,u,,l5
*get,l6,line,,num,max
lskp,1
lsel,r,loc,x,insd+spcr+sml+2*(idex-
1)*csize,insd+spcr+2*idex*csize
lsel,a,,ldrg
adrag,l1,l3,l2,l4,l6,l5,ldrg
*enddo
/com
/com  right most region on top of spacer
lskp,1
lsel,r,loc,x,insd+spcr+sml+2*4*csize,insd+2*sp
cr+2*4*csize
*get,l1,line,,num,max
lsel,a,,ldrg
adrag,l1,,,,,,ldrg
*get,ab2,area,,num,max
/com
/com
*get,alst,area,,num,max
mat,9  $type,1
amesh,afst+1,alst
/com
/com
/com  Merge common nodes and kpoints
arsel,mat,8  $arasel,mat,9
lsar  $kpls  $area  $nelem
nummrg,node,sml
nummrg,kpoi,sml
arall  $lsall  $kpall
nall  $eall
/com
/com
/com  GET FOUR CORNERS
/com  Get uppermost Left region
esize,,1
insd=pr5-4*csize-spcr
uppr=pz5+8*csize
ksel,s,loc,x,insd-sml,insd+sml
ksel,r,loc,y,uppr-sml,uppr+twrap+sml
ksel,a,loc,y,uppr-sml,uppr+sml
ksel,r,loc,x,insd-sml-twrap,insd+sml
nummrg,kpoi,sml
*get,k1,kp,,num,min
ksel,u,,k1
*get,k2,kp,,num,min
*get,k3,kp,,num,max
ksel,a,,k1
a,k3,k1,k2
*get,alst,area,,num,max
mat,9  $type,1
amesh,alst
/com
/com  Get lowermost left region
lwr=pz5-8*csize
ksel,s,loc,x,insd-sml,insd+sml
ksel,r,loc,y,lwr-twrap-sml,lwr+sml
ksel,a,loc,y,lwr-sml,lwr+sml
ksel,r,loc,x,insd-sml-twrap,insd+sml
nummrg,kpoi,sml
*get,k1,kp,,num,min
ksel,u,,k1
*get,k2,kp,,num,min
*get,k3,kp,,num,max
ksel,a,,k1
a,k2,k3,k1
*get,alst,area,,num,max
mat,9  $type,1
amesh,alst
/com
/com  Get lowermost right region
otsd=pr5+4*csize+spcr
ksel,s,loc,x,otsd-sml,otsd+sml
ksel,r,loc,y,lwr-twrap-sml,lwr+sml
ksel,a,loc,y,lwr-sml,lwr+sml
ksel,r,loc,x,otsd-sml,otsd+sml+twrap
nummrg,kpoi,sml
*get,k1,kp,,num,min
ksel,u,,k1
*get,k2,kp,,num,min
*get,k3,kp,,num,max
ksel,a,,k1
a,k3,k1,k2
*get,alst,area,,num,max
mat,9  $type,1
amesh,alst
/com
/com  Get uppermost right region
ksel,s,loc,x,otsd-sml,otsd+sml
```

```
ksel,r,loc,y,uppr-sml,uppr+twrap+sml
ksel,a,loc,y,uppr-sml,uppr+sml
ksel,r,loc,x,otsd-sml,otsd+sml+twrap
nummrg,kpoi,sml
*get,k1,kp,,num,min
ksel,u,,,k1
*get,k2,kp,,num,min
*get,k3,kp,,num,max
ksel,a,,,k1
a,k2,k3,k1
*get,alst,area,,num,max
mat,9  $type,1
amesh,alst
/com
/com
/com  MODIFY ELEMENT COORDINATE
SYSTEM FOR TOP LEFT
kpall  $lsall
aclear,abad
k1=3914
k2=3703
k3=4145
k4=4146
a,k1,k2,k3,k4
mat,9  $type,1
amesh,abad
aclear,ab2
k1=4021
k2=268
k3=4201
k4=4209
a,k1,k2,k3,k4
mat,9  $type,1
amesh,ab2
/com  Gap elements
esel,s,mat,,1,3
nelem
type,2
eintf,2*cn
/com
/com  EM LOADING  Radial and vertical forces
on inside of conduit
eall  $nall $ksel,all  $lsall
konst=2.77*2.77*.192*.382*2*3.14159265/(12
8)
cr=19.3e6*konst
cz=20.1e6*konst
*do,irow,-7,8
*do,icol,-3,4
rclc=pz5+csize/2+(icol-1)*csize
yclc=pz5+csize/2+(irow-1)*csize
ksel,s,loc,x,rclc-cw/2-sml,rclc+cw/2+sml
ksel,r,loc,y,yclc-cw/2-sml,yclc+cw/2+sml
lskp,1
nline,1
*get,nx,node,,count
fr=27400.0*2*3.14159265/nx
fz=6320000.0/(nx*128)
rnorm=2*(1.213-rclc)/.192
znorm=2*(2.35-yclc)/.382
dfr=cr*rnorm/nx
dfz=cz*znorm/nx
fr=fr+dfr
fz=-fz+dfz
f,all,fx,fr
f,all,fy,fz
*enddo
*enddo
/com
/com
/com  Fix vert deflection on lower boundary
yc=pz5-8*csize-twrap
ksel,s,loc,y,yc-sml,yc+sml
lskp,1
nline,1
d,all,uy,0
nall
eall
```

APPENDIX A - ANSYS 3-D COMMAND FILE

The following are ANSYS commands used to establish the three-dimensional structural model of PF5U.

```
/com 3D Model of PF5U
/com Mark Krefta
/com Westinghouse STC
/com July 26, 1995
et,1,plane42,1,,1
et,2,52
et,3,45,,,1
r,1,1e7,0,0,1e7
real,1
/com
/com PARAMETERS
*dim,pitch,array,20
rsm=.106*.0254 !inner radius of conduit
cw=.688*.0254 !cable width
fl=cw-2*rsm !flat length of conduit wall
tc=.095*.0254 !conduit wall thickness
tins1=.004*.0254 !insulation wrap thickness one
tins2=.028*.0254 !insulating wrap thickness two
rou=.201*.0254 !outer radius of conduit
r1=rou+tins1 !outer radius of 1st insulating wrap
r2=r1+tins2 !outer radius of 2nd insulating wrap
tg11=.016*.0254 !g11 sheet thickness
twrap=.301*.0254 !ground wall insulation thickness
csize=cw+2*tc+2*(tins1+tins2) !size of single turn cell i.e. offset in x,y
r3=r2+twrap
sml=.001*.0254 !a relatively small dimension
cn=.0005*.0254 !distance between nodes on slip elements
del=.25/2*.0254 !adjusts width of spacer blocks
pitch(1)=0*csize,1/4*csize,3/4*csize,1/2*csize,1/2*csize
pitch(6)=3/4*csize,1/4*csize,1*csize,0*csize,1/4*csize
/com
/com
/com MAT #
DESCRIPTION
/com 1 INCOLOY CONDUIT
/com 2 CABLE WRAP INNER
/com 3 CABLE WRAP OUTER
/com 4 ROVING FILLER
/com 5 MID VERTICAL G11 SPACER
/com 6 UPPER/LOWER VERTICAL G11 SPACER
/com 7 EPOXY VOIDS
/com 8 G11 FILLER BLOCKS
/com 9 GROUNDWALL INSULATION
/com 10 HORIZONTAL G11 SHEETS
/com
/com Young's modulus
ex2=5.5e9 $ey2=4.8e9
$yx2=.34 $xy2=yx2*ey2/ex2
ex3=32e9 $ey3=23e9
$yx3=.26 $xy3=yx3*ey3/ex3
ex11=29.6e9 $ey11=19.7e9
$yx11=.26
$xy11=yx11*ey11/ex11
mp,ex,1,185e9
!material 1 incoloy
mp,ey,2,4.8e9 $mp,ex,2,5.5e9
$mp,ez,2,5.5e9 !material 2 insul. Kapton
mp,ey,3,23e9 $mp,ex,3,32e9
$mp,ez,3,25e9 !material 3 insul. 3D Weave
mp,ex,4,22e9 $mp,ey,4,25e9
$mp,ez,4,31e9 !material 4 insul. 3D corner fill
mp,ex,8,23e9 $mp,ey,8,32e9
$mp,ez,8,25e9 !material 8 insul. 3D Weave
mp,ex,9,19.7e9 $mp,ey,9,29.6e9
$mp,ez,9,29.6e9 !material 9 insul. 3D Weave
mp,ey,11,19.7e9
$mp,ex,11,29.6e9
$mp,ez,11,29.6e9 !material 9 insul. 3D Weave
/com
mp,gxy,1,71e9 $mp,gxz,1,71e9
$mp,gyz,1,71e9
mp,gxy,2,,37e9 $mp,gyz,2,,37e9
$mp,gxz,2,,37e9
mp,gxy,3,8e9 $mp,gyz,3,8e9
$mp,gxz,3,8e9
mp,gxy,4,8.5e9 $mp,gxz,4,9e9
$mp,gyz,4,8e9
mp,gxy,8,8e9 $mp,gxz,8,8e9
$mp,gyz,8,8e9
mp,gxy,9,7.6e9 $mp,gxz,9,7.6e9
$mp,gyz,9,10.7e9
mp,gxy,11,7.6e9
$mp,gyz,11,7.6e9
$mp,gxz,11,10.7e9
/com
mp,nuxy,1,,299 $mp,nuxz,1,,299
$mp,nuyz,1,,299
mp,nuxy,2,xy2 $mp,nuyz,2,,34
$mp,nuxz,2,,34
mp,nuxy,3,xy3 $mp,nuyz,3,,37
$mp,nuxz,3,,25
mp,nuxy,4,,26 $mp,nuxz,4,,38
$mp,nuyz,4,,23
mp,nuxy,8,,26 $mp,nuxz,8,,37
$mp,nuyz,8,,25
mp,nuxy,9,,26 $mp,nuxz,9,,26
$mp,nuyz,9,,26
mp,nuxy,11,xy9
$mp,nuyz,11,,26
$mp,nuxz,11,,26
/com
/com thermal contractions
mp,alpx,1,5.92e-6
$mp,alpy,1,5.92e-6
$mp,alpz,1,5.92e-6 !Material 1 !material 1
mp,alpy,2,43.2e-6
$mp,alpx,2,13.0e-6
$mp,alpz,2,15.8e-6 !material 2
mp,alpy,3,19.2e-6
$mp,alpx,3,8.25e-6
$mp,alpz,3,16.2e-6 !material 3
mp,alpx,4,20.3e-6
$mp,alpy,4,16.2e-6
$mp,alpz,4,7.56e-6 !material 4
mp,alpx,8,19.2e-6
$mp,alpy,8,8.25e-6
$mp,alpz,8,16.2e-6 !material 8
mp,alpx,9,19.9e-6
$mp,alpy,9,6.7e-6
$mp,alpz,9,6.7e-6 !material 9
mp,alpy,11,19.9e-6
$mp,alpx,11,6.7e-6
$mp,alpz,11,6.7e-6 !material 9
/com
/com The Mat'l are taken from full Ansys Model, not all ten Mat'ls are used.
/com MAT #
DESCRIPTION
/com 1 INCOLOY CONDUIT
/com 2 CABLE WRAP INNER
/com 3 CABLE WRAP OUTER
/com 4 ROVING FILLER
/com 5 MID VERTICAL G11 SPACER
/com 6 UPPER/LOWER VERTICAL G11 SPACER
/com 7 EPOXY VOIDS
/com 8 G11 FILLER BLOCKS
/com 9 GROUNDWALL INSULATION
/com 10 HORIZONTAL G11 SHEETS
/com
/com
/com DEFINE PF CURRENT SOURCE GEOMETRY
(Dimensions in m)
pr5=1.213 $pz5=2.35
$pdr5=.192 $pdz5=.382
/com
/com ROW #1
iy=7
/com
/com BEGIN SINGLE CELL
ix=3 ! CELL #1
*do,iy,-7,8
*do,ix,-3,4
/com DEFINE ELEMENT SHAPE AND SIZE
eshape,3
esize,0.3*.0254
/com DEFINE ELEMENT COORDINATE SYSTEMS
rcs1=pr5+tins2+tins1+tc+rsm+(ix-1)*csize
ycs1=pz5+tins2+tins1+tc+rsm+(iy-1)*csize
csys,0
/com KEYPOINTS
*get,kst,line,,num,max !max line number
*get,ast,area,,num,max !max area number
/com
/com KPOINT IN CENTER OF CELL KP1
rclc=pr5+csize/2+(ix-1)*csize
yclc=pz5+csize/2+(iy-1)*csize
k,,rclc,yclc !keypoint for larc command kp1
*get,knm,kp,,num,max !kp number of larc command
kst=knm
/com
/com CONDUIT
/com Conduit geometry inside edges
K,kst+1,rcs1,ycs1-rsm !kp 2
K,kst+2,rcs1-rsm,ycs1 !kp 3
KGEN,2,kst+1,,,fl
$KGEN,2,kst+2,,,fl
$KGEN,2,kst+2,,,cw,fl !kp 4-6
KGEN,2,kst+2,,,cw
$KGEN,2,kst+1,,,cw
$KGEN,2,kst+3,,,cw !kp 7-9
/com Conduit outside edges
KP10 thru kp117
kgen,2,kst+6,,,tc-cn
$kgen,2,kst+5,,,tc-cn
$kgen,2,kst+7,,,tc-cn
kgen,2,kst+8,,,tc-cn
$kgen,2,kst+4,,,-tc+cn
$kgen,2,kst+2,,,-tc+cn
kgen,2,kst+1,,,-tc+cn
$kgen,2,kst+3,,,-tc+cn
/com Conduit lines
L,kst+6,kst+5 $L,kst+8,kst+7
$L,kst+4,kst+2 $L,kst+1,kst+3
LARC,kst+3,kst+6,knm,rsm,1
$LARC,kst+5,kst+8,knm,rsm,1
LARC,kst+7,kst+4,knm,rsm,1
$LARC,kst+2,kst+1,knm,rsm,1
L,kst+9,kst+10
$L,kst+12,kst+11
$L,kst+13,kst+14
$L,kst+15,kst+16
larc,kst+16,kst+9,knm,rou-cn
$larc,kst+10,kst+12,knm,rou-cn
larc,kst+11,kst+13,knm,rou-cn
$larc,kst+14,kst+15,knm,rou-cn
/com Conduit Areas
mat,1 $type,1
a,kst+5,kst+6,kst+9,kst+10
$a,kst+8,kst+5,kst+10,kst+12
a,kst+7,kst+8,kst+12,kst+11
$a,kst+4,kst+7,kst+11,kst+13
a,kst+2,kst+4,kst+13,kst+14
$a,kst+1,kst+2,kst+14,kst+15
a,kst+3,kst+1,kst+15,kst+16
$a,kst+6,kst+3,kst+16,kst+9
amesh,ast+1,ast+8
/com
```

```
/com INSULATION LAYERS
/com 1ST LAYER
INSULATION
/com inside edges KP18 thru
KP25
KGEN,2,kst+6,,,tc
$KGEN,2,kst+5,,,tc
$KGEN,2,kst+7,,,tc
KGEN,2,kst+8,,,tc
$KGEN,2,kst+4,,,-tc
$KGEN,2,kst+2,,,-tc
KGEN,2,kst+1,,,-tc
$KGEN,2,kst+3,,,-tc
LARC,kst+22,kst+23,knm,rou,1
SLARC,kst+24,kst+17,knm,rou,1
LARC,kst+18,kst+20,knm,rou,1
SLARC,kst+19,kst+21,knm,rou,1
/com
/com SECOND LAYER
INSULATION
/com Inner layer Outer
Layer KP26-KP33
kgen,2,kst+17,,,tins1+tins2
kgen,2,kst+18,,,tins1+tins2
kgen,2,kst+19,,,tins1+tins2
kgen,2,kst+20,,,tins1+tins2
kgen,2,kst+21,,,-tins1-tins2
kgen,2,kst+22,,,-tins1-tins2
kgen,2,kst+23,,,-tins1-tins2
kgen,2,kst+24,,,-tins1-tins2
/com lines
LARC,kst+30,kst+31,knm,r2,1
SLARC,kst+32,kst+25,knm,r2,1
LARC,kst+26,kst+28,knm,r2,1
SLARC,kst+27,kst+29,knm,r2,1
/com Insulation Areas (inner
layer)
mat,3 $type,1
a,kst+26,kst+18,kst+17,kst+25
$a,kst+30,kst+22,kst+21,kst+29
amesh,ast+9,ast+10
mat,3 $type,1
a,kst+27,kst+19,kst+20,kst+28
$a,kst+32,kst+24,kst+23,kst+31
amesh,ast+11,ast+12
mat,3 $type,1 !lower left
corner
a,kst+31,kst+23,kst+22,kst+30
$amesh,ast+13
mat,3 $type,1 !lower right
corner
a,kst+25,kst+17,kst+24,kst+32
$amesh,ast+14
mat,3 $type,1 !upper right
corner
a,kst+28,kst+20,kst+18,kst+26
$amesh,ast+15
mat,3 $type,1 !upper left
corner
a,kst+29,kst+21,kst+19,kst+27
$amesh,ast+16
/com
/com OUTERMOST CORNERS
KP34-37
KGEN,2,kst+28,,,r2
$KGEN,2,kst+32,,,r2
KGEN,2,kst+31,,,-r2
$KGEN,2,kst+27,,,-r2
/com
/com ROVING AREAS
mat,4 $type,1
a,kst+30,kst+35,kst+31 !lower
left
a,kst+34,kst+25,kst+32 !lower
right
a,kst+26,kst+33,kst+28 !upper
right
a,kst+36,kst+29,kst+27 !upper
left
amesh,ast+17,ast+20
/com
*enddo
*enddo
/com
/com
/com
/com
/com
/com Merge nodes and kpoints
on cell interfaces
ansel,mat,3,4 $ksar $kpls
earea
nsel,ext
nummrg,node,sml
nummrg,kpoi,sml
nall $eall $kpall $aall $lall
numcmp,kpoi $numcmp,line
$numcmp,node
/com
/com
spcr=.529*.0254
esize,.6*.0254
*get,afst,area,,num,max
/com
/com FORM LEFT FILLER
REGION BY DRAGGING
LINES
/com Get uppermost left node
insd=pr5-4*csize
uppr=pz5+8*csize
ksel,s,loc,x,insd-sml,insd+sml
ksel,r,loc,y,uppr-sml,uppr+sml
*get,k1,kp,,num,max
kgen,2,all,,,-spcr
*get,kmx,kp,,num,max
1,kmx,k1
*get,ldrg,line,,num,max !get
the drag line number
/com drag areas one by one
ksel,s,loc,x,insd-sml,insd+sml
/com
/com upper most set of two
cells
*do,idex,1,8
lskp,1
ksel,r,loc,y,uppr-sml-2*(idex-
1)*csize,uppr-2*idex*csize
*get,l1,line,,num,max
lsel,u,,l1
*get,l2,line,,num,max
lsel,u,,l2
*get,l3,line,,num,max
lsel,u,,l3
*get,l4,line,,num,max
lsel,u,,l4
*get,l5,line,,num,max
lsel,u,,l5
*get,l6,line,,num,max
lskp,1
lsel,r,loc,y,uppr-sml-2*(idex-
1)*csize,uppr-2*idex*csize
lsel,a,,ldrg
adrag,l5,l6,l4,l2,l3,l1,ldrg
*enddo
/com
/com
/com
/com FORM RIGHT FILLER
REGION BY DRAGGING
LINES
/com Get uppermost RIGHT
node
insd=pr5+4*csize
uppr=pz5+8*csize
ksel,s,loc,x,insd-sml,insd+sml
ksel,r,loc,y,uppr-sml,uppr+sml
*get,k1,kp,,num,max
kgen,2,all,,,spcr
*get,kmx,kp,,num,max
1,k1,kmx
*get,ldrg,line,,num,max !get
the drag line number
/com drag areas one by one
ksel,s,loc,x,insd-sml,insd+sml
/com
/com upper most set of two
cells
*do,idex,1,8
lskp,1
lsel,r,loc,y,uppr-sml-2*(idex-
1)*csize,uppr-2*idex*csize
*get,l1,line,,num,max
lsel,u,,l1
*get,l2,line,,num,max
lsel,u,,l2
*get,l3,line,,num,max
lsel,u,,l3
*get,l4,line,,num,max
lsel,u,,l4
*get,l5,line,,num,max
lsel,u,,l5
*get,l6,line,,num,max
lskp,1
lsel,r,loc,y,uppr-sml-2*(idex-
1)*csize,uppr-2*idex*csize
lsel,a,,ldrg
adrag,l1,l3,l2,l4,l6,l5,ldrg
*enddo
/com
/com
/com
*get,alst,area,,num,max
mat,8 $type,1
amesh,afst+1,alst

*get,afst,area,,num,max
/com
/com FORM LEFT GROUND
WRAP REGION BY
DRAGGING LINES
/com Get uppermost left node
insd=pr5-4*csize-spcr
uppr=pz5+8*csize
ksel,s,loc,x,insd-sml,insd+sml
ksel,r,loc,y,uppr-sml,uppr+sml
*get,k1,kp,,num,max
kgen,2,all,,,-twrap
*get,kmx,kp,,num,max
1,k1,kmx
*get,ldrg,line,,num,max !get
the drag line number
/com drag areas one by one
ksel,s,loc,x,insd-sml,insd+sml
/com
/com upper most set of two
cells
*do,idex,1,8
lskp,1
lsel,r,loc,y,uppr-sml-2*(idex-
1)*csize,uppr-2*idex*csize
*get,l1,line,,num,max
lsel,u,,l1
*get,l2,line,,num,max
lsel,u,,l2
*get,l3,line,,num,max
lsel,u,,l3
*get,l4,line,,num,max
lsel,u,,l4
*get,l5,line,,num,max
lsel,u,,l5
*get,l6,line,,num,max
lskp,1
lsel,r,loc,y,uppr-sml-2*(idex-
1)*csize,uppr-2*idex*csize
lsel,a,,ldrg
adrag,l6,l5,l4,l3,l2,l1,ldrg
*enddo
/com
/com
/com
/com FORM RIGHT GROUND
WRAP REGION BY
DRAGGING LINES
/com Get uppermost right node
insd=pr5+4*csize+spcr
uppr=pz5+8*csize
ksel,s,loc,x,insd-sml,insd+sml
ksel,r,loc,y,uppr-sml,uppr+sml
*get,k1,kp,,num,max
kgen,2,all,,,twrap
*get,kmx,kp,,num,max
1,k1,kmx
*get,ldrg,line,,num,max !get
the drag line number
/com drag areas one by one
ksel,s,loc,x,insd-sml,insd+sml
/com
/com upper most set of two
cells
*do,idex,1,8
lskp,1
lsel,r,loc,y,uppr-sml-2*(idex-
1)*csize,uppr-2*idex*csize
*get,l1,line,,num,max
lsel,u,,l1
*get,l2,line,,num,max
lsel,u,,l2
*get,l3,line,,num,max
lsel,u,,l3
*get,l4,line,,num,max
lsel,u,,l4
*get,l5,line,,num,max
```

```
lsel,u,,15
*get,l6,line,,num,max
lskp,1
lsel,r,loc,x,insd+spcr+sml+2*(ide
x-
1)*csize,insd+spcr+2*idex*csize
lsel,a,,kdrg
adrag,l4,l6,l5,l1,l3,l2,kdrg
*enddo
/com
/com right most region on top of
spacer
lskp,1
lsel,r,loc,x,insd+spcr+sml+2*4*c
size,insd+2*spcr+2*4*csize
*get,l1,line,,num,max
lsel,a,,kdrg
adrag,l1,,,,,kdrg
/com
/com
/com
/com
/com FORM BOTTOM
GROUND WRAP REGION BY
DRAGGING LINES
/com  Get uppermost Left node
insd=pr5-4*csize-spcr
uppr=pz5-8*csize
ksel,s,loc,x,insd-sml,insd+sml
ksel,r,loc,y,uppr-sml,uppr+sml
*get,k1,kp,,num,max
kgen,2,all,,,,-twrap
*get,kmx,kp,,num,max
l,k1,kmx
*get,ldrg,line,,num,max   !get
the drag line number
/com  drag top-of-spacer area
ksel,s,loc,y,uppr-sml,uppr+sml
/com
/com  left most region on top of
spacer
idex=1
lskp,1
lsel,r,loc,x,insd+sml,insd+spcr
*get,l1,line,,num,max
lsel,a,,kdrg
adrag,l1,,,,,kdrg
/com
/com  first set of 2 cells
*do,idex,1,4
lskp,1
lsel,r,loc,x,insd+spcr+sml+2*(ide
x-
1)*csize,insd+spcr+2*idex*csize
*get,l1,line,,num,max
lsel,u,,l1
*get,l2,line,,num,max
lsel,u,,l2
*get,l3,line,,num,max
lsel,u,,l3
*get,l4,line,,num,max
lsel,u,,l4
*get,l5,line,,num,max
lsel,u,,l5
*get,l6,line,,num,max
lskp,1
lsel,r,loc,x,insd+spcr+sml+2*(ide
x-
1)*csize,insd+spcr+2*idex*csize
lsel,a,,kdrg
adrag,l1,l3,l2,l4,l6,l5,kdrg
*enddo
/com
/com  right most region on top of
spacer
lskp,1
lsel,r,loc,x,insd+spcr+sml+2*4*c
size,insd+2*spcr+2*4*csize
*get,l1,line,,num,max
lsel,a,,kdrg
adrag,l1,,,,,kdrg
*get,ab2,area,,num,max
/com
/com
*get,alst,area,,num,max
mat,9  $type,1
amesh,afst+1,alst
/com
/com
/com  Merge common nodes and
kpoints
arsel,mat,8  $arsel,mat,9
kar  $kpls  $area  $nelem
nummrg,node,sml
nummrg,kpoi,sml
arall  $lsall  $kpall
nall  $eall
/com
/com
/com  GET FOUR CORNERS
/com  Get uppermost Left region
esize,,1
insd=pr5-4*csize-spcr
uppr=pz5+8*csize
ksel,s,loc,x,insd-sml,insd+sml
ksel,r,loc,y,uppr-
sml,uppr+twrap+sml
ksel,a,loc,y,uppr-sml,uppr+sml
ksel,r,loc,x,insd-sml-
twrap,insd+sml
nummrg,kpoi,sml
*get,k1,kp,,num,min
ksel,u,,k1
*get,k2,kp,,num,min
*get,k3,kp,,num,max
ksel,a,,k1
a,k3,k1,k2
*get,alst,area,,num,max
mat,11  $type,1
amesh,alst
/com
/com  Get lowermost left region
lwr=pz5-8*csize
ksel,s,loc,x,insd-sml,insd+sml
ksel,r,loc,y,lwr-twrap-
sml,lwr+sml
ksel,a,loc,y,lwr-sml,lwr+sml
ksel,r,loc,x,insd-sml-
twrap,insd+sml
nummrg,kpoi,sml
*get,k1,kp,,num,min
ksel,u,,k1
*get,k2,kp,,num,min
*get,k3,kp,,num,max
ksel,a,,k1
a,k2,k3,k1
*get,alst,area,,num,max
mat,11  $type,1
amesh,alst
/com
/com  Get lowermost right region
otsd=pr5+4*csize+spcr
ksel,s,loc,x,otsd-sml,otsd+sml
ksel,r,loc,y,lwr-twrap-
sml,lwr+sml
ksel,a,loc,y,lwr-sml,lwr+sml
ksel,r,loc,x,otsd-
sml,otsd+sml+twrap
nummrg,kpoi,sml
*get,k1,kp,,num,min
ksel,u,,k1
*get,k2,kp,,num,min
*get,k3,kp,,num,max
ksel,a,,k1
a,k3,k1,k2
*get,alst,area,,num,max
mat,11  $type,1
amesh,alst
/com
/com  Get uppermost right region
ksel,s,loc,x,otsd-sml,otsd+sml
ksel,r,loc,y,uppr-
sml,uppr+twrap+sml
ksel,a,loc,y,uppr-sml,uppr+sml
ksel,r,loc,x,otsd-
sml,otsd+sml+twrap
nummrg,kpoi,sml
*get,k1,kp,,num,min
ksel,u,,k1
*get,k2,kp,,num,min
*get,k3,kp,,num,max
ksel,a,,k1
a,k2,k3,k1
*get,alst,area,,num,max
mat,11  $type,1
amesh,alst
/com
/com
/com  MODIFY ELEMENT
COORDINATE SYSTEM FOR
TOP LEFT
kpall  $lsall
aclear,abad
k1=3914
k2=3703
k3=4145
k4=4146
a,k1,k2,k3,k4
mat,9  $type,1
amesh,abad
aclear,ab2
k1=4027
k2=268
k3=4201
k4=4209
a,k1,k2,k3,k4
mat,9  $type,1
amesh,ab2

csys,0
lsall  $kpall  $nall  $eall
ndp=9
esize,,ndp      !nine elements
deep
deep=45      !45 degrees deep
k,10000,0,0,0  !keypoints form
axis for vrotat
k,10001,0,1,0
/com
/com
arsel,mat,1
type,3  $mat,1
vrotat,all,,,,,10000,10001,deep
/com
/com
arsel,mat,3
type,3  $mat,3
vrotat,all,,,,,10000,10001,deep
/com
/com
/com
arsel,mat,4
type,3  $mat,4
vrotat,all,,,,,10000,10001,deep
/com
/com
arsel,mat,8
type,3  $mat,8
vrotat,all,,,,,10000,10001,deep
/com
/com
nall
arsel,mat,9
type,3  $mat,9
vrotat,all,,,,,10000,10001,deep
/com
/com
arsel,mat,11
type,3  $mat,11
vrotat,all,,,,,10000,10001,deep
/com
/com
nall  $eall
arsel,type,1  $aclear,all
/com
/com
vlsel,mat,3,11
evolu  $nelem  $arvl  $lsar  $kpls
nummrg,node,sml
nummrg,kp,sml
kpall  $lsall  $arall  $vlall
nall  $eall
/com
/com  Gap elements
esel,s,mat,,1,3
nelem
type,2
eintf,2*cn
/com
/com  Local cylindrical
coordinate system
eall  $nall  $lsel,all  $lsall
/com  Rotate nodes into
cylindrical cs
local,20,1,0,0,0,0,0,-90
csys,20
nrotat,all
/com
/com
/com  Fix vert deflection on
lower boundary
yc=pz5-8*csize-twrap
csys,20
ang=0
nsel,s,loc,z,yc-sml,yc+sml
nsel,r,loc,y,ang-sml,ang+sml
d,all,uz,0
ang=5
nsel,s,loc,z,yc-sml,yc+sml
nsel,r,loc,y,ang-sml,ang+sml
d,all,uz,0
ang=40
nsel,s,loc,z,yc-sml,yc+sml
nsel,r,loc,y,ang-sml,ang+sml
d,all,uz,0
ang=45
nsel,s,loc,z,yc-sml,yc+sml
nsel,r,loc,y,ang-sml,ang+sml
d,all,uz,0
/com
/com Fix gross angular rotation
on conduits
*do,irow,-7,8
*do,icol,-3,4
rclc=pr5+csize/2+(icol-1)*csize
yclc=pz5+csize/2+(irow-1)*csize
ksel,s,loc,x,rclc-cw/2-
sml,rclc+cw/2+sml
ksel,r,loc,z,yclc-cw/2-
sml,yclc+cw/2+sml
ksel,r,loc,y,-sml,sml
lskp,1  $nline,1
*get,nx,node,,num,max
xx=nx(nx)  $yy=ny(nx)
$zz=nz(nx)
nall
nw=node(xx,deep,zz)
d,nx,uy,0
d,nw,uy,0
*enddo
*enddo
/com Fix gross angular rotation
on epoxy mess
esel,mat,3
nelem
nsel,r,loc,y,-sml,sml
*get,nx,node,,num,max
xx=nx(nx)  $yy=ny(nx)
$zz=nz(nx)
nall
nw=node(xx,deep,zz)
d,nx,uy,0
d,nw,uy,0
/com
/com  activate all nodes
nall
eall
/com

cp,1,ux,5930,66714
cp,2,ux,5931,66715
cp,3,ux,5938,66850
```

cp,4,ux,5939,66851
cp,5,ux,5937,66831
cp,6,ux,5936,66813
cp,7,ux,5934,66778
cp,8,ux,5935,66779
cp,9,ux,5932,66742
cp,10,ux,5933,66743
cp,11,ux,5947,66994
cp,12,ux,5948,66995
cp,13,ux,5946,66975
cp,14,ux,5945,66957
cp,15,ux,5943,66922
cp,16,ux,5944,66923
cp,17,ux,5941,66886
cp,18,ux,5942,66887
cp,19,ux,5956,67138
cp,20,ux,5957,67139
cp,21,ux,5955,67119
cp,22,ux,5954,67101
cp,23,ux,5952,67066
cp,24,ux,5953,67067
cp,25,ux,5950,67030
cp,26,ux,5951,67031
cp,27,ux,5965,67282
cp,28,ux,5966,67283
cp,29,ux,5964,67263
cp,30,ux,5963,67245
cp,31,ux,5961,67210
cp,32,ux,5962,67211
cp,33,ux,5959,67174
cp,34,ux,5960,67175
cp,35,ux,5968,67316
cp,36,ux,5970,67354
cp,37,ux,5810,64790
cp,38,ux,5666,62450
cp,39,ux,49,55005
cp,40,ux,47,33786
cp,41,ux,48,33787
cp,42,ux,43,33782
cp,43,ux,50,55031
cp,44,ux,96,33975
cp,45,ux,97,33976
cp,46,ux,92,33971
cp,47,ux,98,55121
cp,48,ux,143,34164
cp,49,ux,144,34165
cp,50,ux,139,34160
cp,51,ux,145,55193
cp,52,ux,190,34353
cp,53,ux,191,34354
cp,54,ux,186,34349
cp,55,ux,192,55265
cp,56,ux,237,34542
cp,57,ux,238,34543
cp,58,ux,233,34538
cp,59,ux,239,55337
cp,60,ux,284,34731
cp,61,ux,285,34732
cp,62,ux,280,34727
cp,63,ux,286,55409
cp,64,ux,331,34920
cp,65,ux,332,34921
cp,66,ux,327,34916
cp,67,ux,333,55481
cp,68,ux,378,35109
cp,69,ux,379,35110
cp,70,ux,374,35105
cp,71,ux,380,55553
cp,72,ux,5745,63744
cp,73,ux,5889,66084
cp,74,ux,20,6135
cp,75,ux,45,33784
cp,76,ux,24,6155
cp,77,ux,46,33785
cp,78,ux,23,6154
cp,79,ux,44,33783
cp,80,ux,72,6351
cp,81,ux,94,33973
cp,82,ux,76,6371
cp,83,ux,95,33974
cp,84,ux,75,6370
cp,85,ux,93,33972
cp,86,ux,119,6567
cp,87,ux,141,34162
cp,88,ux,123,6587
cp,89,ux,142,34163
cp,90,ux,122,6586
cp,91,ux,140,34161
cp,92,ux,166,6783
cp,93,ux,188,34351
cp,94,ux,170,6803
cp,95,ux,189,34352
cp,96,ux,169,6802
cp,97,ux,187,34350
cp,98,ux,213,6999
cp,99,ux,235,34540
cp,100,ux,217,7019
cp,101,ux,236,34541
cp,102,ux,216,7018
cp,103,ux,234,34539
cp,104,ux,260,7215
cp,105,ux,282,34729
cp,106,ux,264,7235
cp,107,ux,283,34730
cp,108,ux,263,7234
cp,109,ux,281,34728
cp,110,ux,307,7431
cp,111,ux,329,34918
cp,112,ux,311,7451
cp,113,ux,330,34919
cp,114,ux,310,7450
cp,115,ux,328,34917
cp,116,ux,354,7647
cp,117,ux,376,35107
cp,118,ux,358,7667
cp,119,ux,377,35108
cp,120,ux,357,7666
cp,121,ux,375,35106
cp,122,ux,19,6134
cp,123,ux,22,6153
cp,124,ux,21,6152
cp,125,ux,71,6350
cp,126,ux,74,6369
cp,127,ux,73,6368
cp,128,ux,118,6566
cp,129,ux,121,6585
cp,130,ux,120,6584
cp,131,ux,165,6782
cp,132,ux,168,6801
cp,133,ux,167,6800
cp,134,ux,212,6998
cp,135,ux,215,7017
cp,136,ux,214,7016
cp,137,ux,259,7214
cp,138,ux,262,7233
cp,139,ux,261,7232
cp,140,ux,306,7430
cp,141,ux,309,7449
cp,142,ux,308,7448
cp,143,ux,353,7646
cp,144,ux,356,7665
cp,145,ux,355,7664
cp,146,ux,5809,64789
cp,147,ux,5665,62449
cp,148,ux,31,33674
cp,149,ux,17,33675
cp,150,ux,32,6100
cp,151,ux,15,6098
cp,152,ux,1,5972
cp,153,ux,4,5975
cp,154,ux,27,33622
cp,155,ux,29,33624
cp,156,ux,69,33890
cp,157,ux,83,6316
cp,158,ux,67,6314
cp,159,ux,53,6188
cp,160,ux,56,6191
cp,161,ux,79,33838
cp,162,ux,81,33840
cp,163,ux,116,34079
cp,164,ux,130,6532
cp,165,ux,114,6530
cp,166,ux,100,6404
cp,167,ux,103,6407
cp,168,ux,126,34027
cp,169,ux,128,34029
cp,170,ux,163,34268
cp,171,ux,177,6748
cp,172,ux,161,6746
cp,173,ux,147,6620
cp,174,ux,150,6623
cp,175,ux,173,34216
cp,176,ux,175,34218
cp,177,ux,210,6964
cp,178,ux,224,34457
cp,179,ux,208,6962
cp,180,ux,194,6836
cp,181,ux,197,6839
cp,182,ux,220,34405
cp,183,ux,222,34407
cp,184,ux,271,34646
cp,185,ux,257,7180
cp,186,ux,255,7178
cp,187,ux,241,7052
cp,188,ux,244,7055
cp,189,ux,267,34594
cp,190,ux,269,34596
cp,191,ux,304,34835
cp,192,ux,318,7396
cp,193,ux,302,7394
cp,194,ux,288,7268
cp,195,ux,291,7271
cp,196,ux,314,34783
cp,197,ux,316,34785
cp,198,ux,351,35024
cp,199,ux,365,7612
cp,200,ux,349,7610
cp,201,ux,335,7484
cp,202,ux,338,7487
cp,203,ux,361,34972
cp,204,ux,363,34974
cp,205,ux,5743,63709
cp,206,ux,5887,66049
cp,207,ux,5812,64826
cp,208,ux,5668,62486
cp,209,ux,36,33679
cp,210,ux,18,33677
cp,211,ux,34,6101
cp,212,ux,16,6099
cp,213,ux,3,5974
cp,214,ux,6,5977
cp,215,ux,28,33623
cp,216,ux,30,33625
cp,217,ux,70,33892
cp,218,ux,85,6317
cp,219,ux,68,6315
cp,220,ux,55,6190
cp,221,ux,58,6193
cp,222,ux,80,33839
cp,223,ux,82,33841
cp,224,ux,117,34081
cp,225,ux,132,6533
cp,226,ux,115,6531
cp,227,ux,102,6406
cp,228,ux,105,6409
cp,229,ux,127,34028
cp,230,ux,129,34030
cp,231,ux,164,34270
cp,232,ux,179,6749
cp,233,ux,162,6747
cp,234,ux,149,6622
cp,235,ux,152,6625
cp,236,ux,174,34217
cp,237,ux,176,34219
cp,238,ux,211,6965
cp,239,ux,226,34459
cp,240,ux,209,6963
cp,241,ux,196,6838
cp,242,ux,199,6841
cp,243,ux,221,34406
cp,244,ux,223,34408
cp,245,ux,273,34648
cp,246,ux,258,7181
cp,247,ux,256,7179
cp,248,ux,243,7054
cp,249,ux,246,7057
cp,250,ux,268,34595
cp,251,ux,270,34597
cp,252,ux,305,34837
cp,253,ux,320,7397
cp,254,ux,303,7395
cp,255,ux,290,7270
cp,256,ux,293,7273
cp,257,ux,315,34784
cp,258,ux,317,34786
cp,259,ux,352,35026
cp,260,ux,367,7613
cp,261,ux,350,7611
cp,262,ux,337,7486
cp,263,ux,340,7489
cp,264,ux,362,34973
cp,265,ux,364,34975
cp,266,ux,5744,63710
cp,267,ux,5888,66050
cp,268,ux,5811,64825
cp,269,ux,5667,62485
cp,270,ux,35,33678
cp,271,ux,14,33676
cp,272,ux,33,6081
cp,273,ux,13,6080
cp,274,ux,2,5973
cp,275,ux,5,5976
cp,276,ux,26,33621
cp,277,ux,25,33620
cp,278,ux,66,33891
cp,279,ux,84,6297
cp,280,ux,65,6296
cp,281,ux,54,6189
cp,282,ux,57,6192
cp,283,ux,78,33837
cp,284,ux,77,33836
cp,285,ux,113,34080
cp,286,ux,131,6513
cp,287,ux,112,6512
cp,288,ux,101,6405
cp,289,ux,104,6408
cp,290,ux,125,34026
cp,291,ux,124,34025
cp,292,ux,160,34269
cp,293,ux,178,6729
cp,294,ux,159,6728
cp,295,ux,148,6621
cp,296,ux,151,6624
cp,297,ux,172,34215
cp,298,ux,171,34214
cp,299,ux,207,6945
cp,300,ux,225,34458
cp,301,ux,206,6944
cp,302,ux,195,6837
cp,303,ux,198,6840
cp,304,ux,219,34404
cp,305,ux,218,34403
cp,306,ux,272,34647
cp,307,ux,254,7161
cp,308,ux,253,7160
cp,309,ux,242,7053
cp,310,ux,245,7056
cp,311,ux,266,34593
cp,312,ux,265,34592
cp,313,ux,301,34836
cp,314,ux,319,7377
cp,315,ux,300,7376
cp,316,ux,289,7269
cp,317,ux,292,7272
cp,318,ux,313,34782
cp,319,ux,312,34781
cp,320,ux,348,35025
cp,321,ux,366,7593
cp,322,ux,347,7592
cp,323,ux,336,7485
cp,324,ux,339,7488
cp,325,ux,360,34971
cp,326,ux,359,34970
cp,327,ux,5742,63690
cp,328,ux,5886,66030
cp,329,ux,9,6044
cp,330,ux,10,6045
cp,331,ux,7,6026
cp,332,ux,61,6260
cp,333,ux,62,6261
cp,334,ux,59,6242
cp,335,ux,108,6476

cp,336,ux,109,6477
cp,337,ux,106,6458
cp,338,ux,155,6692
cp,339,ux,156,6693
cp,340,ux,153,6674
cp,341,ux,202,6908
cp,342,ux,203,6909
cp,343,ux,200,6890
cp,344,ux,249,7124
cp,345,ux,250,7125
cp,346,ux,247,7106
cp,347,ux,296,7340
cp,348,ux,297,7341
cp,349,ux,294,7322
cp,350,ux,343,7556
cp,351,ux,344,7557
cp,352,ux,341,7538
cp,353,ux,11,6046
cp,354,ux,38,33729
cp,355,ux,12,6047
cp,356,ux,40,33731
cp,357,ux,8,6027
cp,358,ux,39,33730
cp,359,ux,63,6262
cp,360,ux,87,33918
cp,361,ux,64,6263
cp,362,ux,89,33920
cp,363,ux,60,6243
cp,364,ux,88,33919
cp,365,ux,110,6478
cp,366,ux,134,34107
cp,367,ux,111,6479
cp,368,ux,136,34109
cp,369,ux,107,6459
cp,370,ux,135,34108
cp,371,ux,157,6694
cp,372,ux,181,34296
cp,373,ux,158,6695
cp,374,ux,183,34298
cp,375,ux,154,6675
cp,376,ux,182,34297
cp,377,ux,204,6910
cp,378,ux,228,34485
cp,379,ux,205,6911
cp,380,ux,230,34487
cp,381,ux,201,6891
cp,382,ux,229,34486
cp,383,ux,251,7126
cp,384,ux,275,34674
cp,385,ux,252,7127
cp,386,ux,277,34676
cp,387,ux,248,7107
cp,388,ux,276,34675
cp,389,ux,298,7342
cp,390,ux,322,34863
cp,391,ux,299,7343
cp,392,ux,324,34865
cp,393,ux,295,7323
cp,394,ux,323,34864
cp,395,ux,345,7558
cp,396,ux,369,35052
cp,397,ux,346,7559
cp,398,ux,371,35054
cp,399,ux,342,7539
cp,400,ux,370,35053
cp,401,ux,5813,64860
cp,402,ux,5669,62520
cp,403,ux,52,55085
cp,404,ux,37,33728
cp,405,ux,42,33733
cp,406,ux,41,33732
cp,407,ux,51,55059
cp,408,ux,86,33917
cp,409,ux,91,33922
cp,410,ux,90,33921
cp,411,ux,99,55149
cp,412,ux,133,34106
cp,413,ux,138,34111
cp,414,ux,137,34110
cp,415,ux,146,55221
cp,416,ux,180,34295
cp,417,ux,185,34300
cp,418,ux,184,34299
cp,419,ux,193,55293
cp,420,ux,227,34484
cp,421,ux,232,34489
cp,422,ux,231,34488
cp,423,ux,240,55365
cp,424,ux,274,34673
cp,425,ux,279,34678
cp,426,ux,278,34677
cp,427,ux,287,55437
cp,428,ux,321,34862
cp,429,ux,326,34867
cp,430,ux,325,34866
cp,431,ux,334,55509
cp,432,ux,368,35051
cp,433,ux,373,35056
cp,434,ux,372,35055
cp,435,ux,381,55581
cp,436,ux,5741,63672
cp,437,ux,5885,66012
cp,438,ux,401,7863
cp,439,ux,425,35322
cp,440,ux,405,7883
cp,441,ux,426,35323
cp,442,ux,404,7882
cp,443,ux,424,35321
cp,444,ux,448,8079
cp,445,ux,469,35484
cp,446,ux,452,8099
cp,447,ux,470,35485
cp,448,ux,451,8098
cp,449,ux,468,35483
cp,450,ux,491,8295
cp,451,ux,512,35646
cp,452,ux,495,8315
cp,453,ux,513,35647
cp,454,ux,494,8314
cp,455,ux,511,35645
cp,456,ux,534,8511
cp,457,ux,555,35808
cp,458,ux,538,8531
cp,459,ux,556,35809
cp,460,ux,537,8530
cp,461,ux,554,35807
cp,462,ux,577,8727
cp,463,ux,598,35970
cp,464,ux,581,8747
cp,465,ux,599,35971
cp,466,ux,580,8746
cp,467,ux,597,35969
cp,468,ux,620,8943
cp,469,ux,641,36132
cp,470,ux,624,8963
cp,471,ux,642,36133
cp,472,ux,623,8962
cp,473,ux,640,36131
cp,474,ux,663,9159
cp,475,ux,684,36294
cp,476,ux,667,9179
cp,477,ux,685,36295
cp,478,ux,666,9178
cp,479,ux,683,36293
cp,480,ux,706,9375
cp,481,ux,727,36456
cp,482,ux,710,9395
cp,483,ux,728,36457
cp,484,ux,709,9394
cp,485,ux,726,36455
cp,486,ux,400,7862
cp,487,ux,403,7881
cp,488,ux,402,7880
cp,489,ux,447,8078
cp,490,ux,450,8097
cp,491,ux,449,8096
cp,492,ux,490,8294
cp,493,ux,493,8313
cp,494,ux,492,8312
cp,495,ux,533,8510
cp,496,ux,536,8529
cp,497,ux,535,8528
cp,498,ux,576,8726
cp,499,ux,579,8745
cp,500,ux,578,8744
cp,501,ux,619,8942
cp,502,ux,622,8961
cp,503,ux,621,8960
cp,504,ux,662,9158
cp,505,ux,665,9177
cp,506,ux,664,9176
cp,507,ux,705,9374
cp,508,ux,708,9393
cp,509,ux,707,9392
cp,510,ux,5814,64878
cp,511,ux,5670,62538
cp,512,ux,412,35213
cp,513,ux,398,35214
cp,514,ux,413,7828
cp,515,ux,396,7826
cp,516,ux,382,7700
cp,517,ux,385,7703
cp,518,ux,408,35161
cp,519,ux,410,35163
cp,520,ux,445,35402
cp,521,ux,459,8044
cp,522,ux,443,8042
cp,523,ux,429,7916
cp,524,ux,432,7919
cp,525,ux,455,35350
cp,526,ux,457,35352
cp,527,ux,488,35564
cp,528,ux,502,8260
cp,529,ux,486,8258
cp,530,ux,472,8132
cp,531,ux,475,8135
cp,532,ux,498,35512
cp,533,ux,500,35514
cp,534,ux,531,35726
cp,535,ux,545,8476
cp,536,ux,529,8474
cp,537,ux,515,8348
cp,538,ux,518,8351
cp,539,ux,541,35674
cp,540,ux,543,35676
cp,541,ux,574,8692
cp,542,ux,588,35888
cp,543,ux,572,8690
cp,544,ux,558,8564
cp,545,ux,561,8567
cp,546,ux,584,35836
cp,547,ux,586,35838
cp,548,ux,631,36050
cp,549,ux,617,8908
cp,550,ux,615,8906
cp,551,ux,601,8780
cp,552,ux,604,8783
cp,553,ux,627,35998
cp,554,ux,629,36000
cp,555,ux,660,36212
cp,556,ux,674,9124
cp,557,ux,658,9122
cp,558,ux,644,8996
cp,559,ux,647,8999
cp,560,ux,670,36160
cp,561,ux,672,36162
cp,562,ux,703,36374
cp,563,ux,717,9340
cp,564,ux,701,9338
cp,565,ux,687,9212
cp,566,ux,690,9215
cp,567,ux,713,36322
cp,568,ux,715,36324
cp,569,ux,5739,63637
cp,570,ux,5883,65977
cp,571,ux,5816,64898
cp,572,ux,5672,62558
cp,573,ux,417,35218
cp,574,ux,399,35216
cp,575,ux,415,7829
cp,576,ux,397,7827
cp,577,ux,384,7702
cp,578,ux,387,7705
cp,579,ux,409,35162
cp,580,ux,411,35164
cp,581,ux,446,35404
cp,582,ux,461,8045
cp,583,ux,444,8043
cp,584,ux,431,7918
cp,585,ux,434,7921
cp,586,ux,456,35351
cp,587,ux,458,35353
cp,588,ux,489,35566
cp,589,ux,504,8261
cp,590,ux,487,8259
cp,591,ux,474,8134
cp,592,ux,477,8137
cp,593,ux,499,35513
cp,594,ux,501,35515
cp,595,ux,532,35728
cp,596,ux,547,8477
cp,597,ux,530,8475
cp,598,ux,517,8350
cp,599,ux,520,8353
cp,600,ux,542,35675
cp,601,ux,544,35677
cp,602,ux,575,8693
cp,603,ux,590,35890
cp,604,ux,573,8691
cp,605,ux,560,8566
cp,606,ux,563,8569
cp,607,ux,585,35837
cp,608,ux,587,35839
cp,609,ux,633,36052
cp,610,ux,618,8909
cp,611,ux,616,8907
cp,612,ux,603,8782
cp,613,ux,606,8785
cp,614,ux,628,35999
cp,615,ux,630,36001
cp,616,ux,661,36214
cp,617,ux,676,9125
cp,618,ux,659,9123
cp,619,ux,646,8998
cp,620,ux,649,9001
cp,621,ux,671,36161
cp,622,ux,673,36163
cp,623,ux,704,36376
cp,624,ux,719,9341
cp,625,ux,702,9339
cp,626,ux,689,9214
cp,627,ux,692,9217
cp,628,ux,714,36323
cp,629,ux,716,36325
cp,630,ux,5740,63638
cp,631,ux,5884,65978
cp,632,ux,5815,64897
cp,633,ux,5671,62557
cp,634,ux,416,35217
cp,635,ux,395,35215
cp,636,ux,414,7809
cp,637,ux,394,7808
cp,638,ux,383,7701
cp,639,ux,386,7704
cp,640,ux,407,35160
cp,641,ux,406,35159
cp,642,ux,442,35403
cp,643,ux,460,8025
cp,644,ux,441,8024
cp,645,ux,430,7917
cp,646,ux,433,7920
cp,647,ux,454,35349
cp,648,ux,453,35348
cp,649,ux,485,35565
cp,650,ux,503,8241
cp,651,ux,484,8240
cp,652,ux,473,8133
cp,653,ux,476,8136
cp,654,ux,497,35511
cp,655,ux,496,35510
cp,656,ux,528,35727
cp,657,ux,546,8457
cp,658,ux,527,8456
cp,659,ux,516,8349
cp,660,ux,519,8352
cp,661,ux,540,35673
cp,662,ux,539,35672
cp,663,ux,571,8673
cp,664,ux,589,35889
cp,665,ux,570,8672
cp,666,ux,559,8565
cp,667,ux,562,8568

cp,668,ux,583,35835
cp,669,ux,582,35834
cp,670,ux,632,36051
cp,671,ux,614,8889
cp,672,ux,613,8888
cp,673,ux,602,8781
cp,674,ux,605,8784
cp,675,ux,626,35997
cp,676,ux,625,35996
cp,677,ux,657,36213
cp,678,ux,675,9105
cp,679,ux,656,9104
cp,680,ux,645,8997
cp,681,ux,648,9000
cp,682,ux,669,36159
cp,683,ux,668,36158
cp,684,ux,700,36375
cp,685,ux,718,9321
cp,686,ux,699,9320
cp,687,ux,688,9213
cp,688,ux,691,9216
cp,689,ux,712,36321
cp,690,ux,711,36320
cp,691,ux,5737,63618
cp,692,ux,5881,65958
cp,693,ux,390,7772
cp,694,ux,391,7773
cp,695,ux,388,7754
cp,696,ux,437,7988
cp,697,ux,438,7989
cp,698,ux,435,7970
cp,699,ux,480,8204
cp,700,ux,481,8205
cp,701,ux,478,8186
cp,702,ux,523,8420
cp,703,ux,524,8421
cp,704,ux,521,8402
cp,705,ux,566,8636
cp,706,ux,567,8637
cp,707,ux,564,8618
cp,708,ux,609,8852
cp,709,ux,610,8853
cp,710,ux,607,8834
cp,711,ux,652,9068
cp,712,ux,653,9069
cp,713,ux,650,9050
cp,714,ux,695,9284
cp,715,ux,696,9285
cp,716,ux,693,9266
cp,717,ux,392,7774
cp,718,ux,419,35268
cp,719,ux,393,7775
cp,720,ux,421,35270
cp,721,ux,389,7755
cp,722,ux,420,35269
cp,723,ux,439,7990
cp,724,ux,463,35430
cp,725,ux,440,7991
cp,726,ux,465,35432
cp,727,ux,436,7971
cp,728,ux,464,35431
cp,729,ux,482,8206
cp,730,ux,506,35592
cp,731,ux,483,8207
cp,732,ux,508,35594
cp,733,ux,479,8187
cp,734,ux,507,35593
cp,735,ux,525,8422
cp,736,ux,549,35754
cp,737,ux,526,8423
cp,738,ux,551,35756
cp,739,ux,522,8403
cp,740,ux,550,35755
cp,741,ux,568,8638
cp,742,ux,592,35916
cp,743,ux,569,8639
cp,744,ux,594,35918
cp,745,ux,565,8619
cp,746,ux,593,35917
cp,747,ux,611,8854
cp,748,ux,635,36078
cp,749,ux,612,8855
cp,750,ux,637,36080
cp,751,ux,608,8835
cp,752,ux,636,36079
cp,753,ux,654,9070
cp,754,ux,678,36240
cp,755,ux,655,9071
cp,756,ux,680,36242
cp,757,ux,651,9051
cp,758,ux,679,36241
cp,759,ux,697,9286
cp,760,ux,721,36402
cp,761,ux,698,9287
cp,762,ux,723,36404
cp,763,ux,694,9267
cp,764,ux,722,36403
cp,765,ux,5801,64646
cp,766,ux,5657,62306
cp,767,ux,428,55661
cp,768,ux,418,35267
cp,769,ux,423,35272
cp,770,ux,422,35271
cp,771,ux,427,55635
cp,772,ux,462,35429
cp,773,ux,467,35434
cp,774,ux,466,35433
cp,775,ux,471,55698
cp,776,ux,505,35591
cp,777,ux,510,35596
cp,778,ux,509,35595
cp,779,ux,514,55743
cp,780,ux,548,35753
cp,781,ux,553,35758
cp,782,ux,552,35757
cp,783,ux,557,55788
cp,784,ux,591,35915
cp,785,ux,596,35920
cp,786,ux,595,35919
cp,787,ux,600,55833
cp,788,ux,634,36077
cp,789,ux,639,36082
cp,790,ux,638,36081
cp,791,ux,643,55878
cp,792,ux,677,36239
cp,793,ux,682,36244
cp,794,ux,681,36243
cp,795,ux,686,55923
cp,796,ux,720,36401
cp,797,ux,725,36406
cp,798,ux,724,36405
cp,799,ux,729,55968
cp,800,ux,5736,63600
cp,801,ux,5880,65940
cp,802,ux,749,9591
cp,803,ux,773,36645
cp,804,ux,753,9611
cp,805,ux,774,36646
cp,806,ux,752,9610
cp,807,ux,772,36644
cp,808,ux,796,9807
cp,809,ux,817,36807
cp,810,ux,800,9827
cp,811,ux,818,36808
cp,812,ux,799,9826
cp,813,ux,816,36806
cp,814,ux,839,10023
cp,815,ux,860,36969
cp,816,ux,843,10043
cp,817,ux,861,36970
cp,818,ux,842,10042
cp,819,ux,859,36968
cp,820,ux,882,10239
cp,821,ux,903,37131
cp,822,ux,886,10259
cp,823,ux,904,37132
cp,824,ux,885,10258
cp,825,ux,902,37130
cp,826,ux,925,10455
cp,827,ux,946,37293
cp,828,ux,929,10475
cp,829,ux,947,37294
cp,830,ux,928,10474
cp,831,ux,945,37292
cp,832,ux,968,10671
cp,833,ux,989,37455
cp,834,ux,972,10691
cp,835,ux,990,37456
cp,836,ux,971,10690
cp,837,ux,988,37454
cp,838,ux,1011,10887
cp,839,ux,1032,37617
cp,840,ux,1015,10907
cp,841,ux,1033,37618
cp,842,ux,1014,10906
cp,843,ux,1031,37616
cp,844,ux,1054,11103
cp,845,ux,1075,37779
cp,846,ux,1058,11123
cp,847,ux,1076,37780
cp,848,ux,1057,11122
cp,849,ux,1074,37778
cp,850,ux,748,9590
cp,851,ux,751,9609
cp,852,ux,750,9608
cp,853,ux,795,9806
cp,854,ux,798,9825
cp,855,ux,797,9824
cp,856,ux,838,10022
cp,857,ux,841,10041
cp,858,ux,840,10040
cp,859,ux,881,10238
cp,860,ux,884,10257
cp,861,ux,883,10256
cp,862,ux,924,10454
cp,863,ux,927,10473
cp,864,ux,926,10472
cp,865,ux,967,10670
cp,866,ux,970,10689
cp,867,ux,969,10688
cp,868,ux,1010,10886
cp,869,ux,1013,10905
cp,870,ux,1012,10904
cp,871,ux,1053,11102
cp,872,ux,1056,11121
cp,873,ux,1055,11120
cp,874,ux,5800,64645
cp,875,ux,5656,62305
cp,876,ux,760,36536
cp,877,ux,746,36537
cp,878,ux,761,9556
cp,879,ux,744,9554
cp,880,ux,730,9428
cp,881,ux,733,9431
cp,882,ux,756,36484
cp,883,ux,758,36486
cp,884,ux,793,36725
cp,885,ux,807,9772
cp,886,ux,791,9770
cp,887,ux,777,9644
cp,888,ux,780,9647
cp,889,ux,803,36673
cp,890,ux,805,36675
cp,891,ux,836,36887
cp,892,ux,850,9988
cp,893,ux,834,9986
cp,894,ux,820,9860
cp,895,ux,823,9863
cp,896,ux,846,36835
cp,897,ux,848,36837
cp,898,ux,879,37049
cp,899,ux,893,10204
cp,900,ux,877,10202
cp,901,ux,863,10076
cp,902,ux,866,10079
cp,903,ux,889,36997
cp,904,ux,891,36999
cp,905,ux,922,10420
cp,906,ux,936,37211
cp,907,ux,920,10418
cp,908,ux,906,10292
cp,909,ux,909,10295
cp,910,ux,932,37159
cp,911,ux,934,37161
cp,912,ux,979,37373
cp,913,ux,965,10636
cp,914,ux,963,10634
cp,915,ux,949,10508
cp,916,ux,952,10511
cp,917,ux,975,37321
cp,918,ux,977,37323
cp,919,ux,1008,37535
cp,920,ux,1022,10852
cp,921,ux,1006,10850
cp,922,ux,992,10724
cp,923,ux,995,10727
cp,924,ux,1018,37483
cp,925,ux,1020,37485
cp,926,ux,1051,37697
cp,927,ux,1065,11068
cp,928,ux,1049,11066
cp,929,ux,1035,10940
cp,930,ux,1038,10943
cp,931,ux,1061,37645
cp,932,ux,1063,37647
cp,933,ux,5734,63565
cp,934,ux,5878,65905
cp,935,ux,5803,64682
cp,936,ux,5659,62342
cp,937,ux,765,36541
cp,938,ux,747,36539
cp,939,ux,763,9557
cp,940,ux,745,9555
cp,941,ux,732,9430
cp,942,ux,735,9433
cp,943,ux,757,36485
cp,944,ux,759,36487
cp,945,ux,794,36727
cp,946,ux,809,9773
cp,947,ux,792,9771
cp,948,ux,779,9646
cp,949,ux,782,9649
cp,950,ux,804,36674
cp,951,ux,806,36676
cp,952,ux,837,36889
cp,953,ux,852,9989
cp,954,ux,835,9987
cp,955,ux,822,9862
cp,956,ux,825,9865
cp,957,ux,847,36836
cp,958,ux,849,36838
cp,959,ux,880,37051
cp,960,ux,895,10205
cp,961,ux,878,10203
cp,962,ux,865,10078
cp,963,ux,868,10081
cp,964,ux,890,36998
cp,965,ux,892,37000
cp,966,ux,923,10421
cp,967,ux,938,37213
cp,968,ux,921,10419
cp,969,ux,908,10294
cp,970,ux,911,10297
cp,971,ux,933,37160
cp,972,ux,935,37162
cp,973,ux,981,37375
cp,974,ux,966,10637
cp,975,ux,964,10635
cp,976,ux,951,10510
cp,977,ux,954,10513
cp,978,ux,976,37322
cp,979,ux,978,37324
cp,980,ux,1009,37537
cp,981,ux,1024,10853
cp,982,ux,1007,10851
cp,983,ux,994,10726
cp,984,ux,997,10729
cp,985,ux,1019,37484
cp,986,ux,1021,37486
cp,987,ux,1052,37699
cp,988,ux,1067,11069
cp,989,ux,1050,11067
cp,990,ux,1037,10942
cp,991,ux,1040,10945
cp,992,ux,1062,37646
cp,993,ux,1064,37648
cp,994,ux,5735,63566
cp,995,ux,5879,65906
cp,996,ux,5802,64681
cp,997,ux,5658,62341
cp,998,ux,764,36540
cp,999,ux,743,36538

cp,1000,ux,762,9537
cp,1001,ux,742,9536
cp,1002,ux,731,9429
cp,1003,ux,734,9432
cp,1004,ux,755,36483
cp,1005,ux,754,36482
cp,1006,ux,790,36726
cp,1007,ux,808,9753
cp,1008,ux,789,9752
cp,1009,ux,778,9645
cp,1010,ux,781,9648
cp,1011,ux,802,36672
cp,1012,ux,801,36671
cp,1013,ux,833,36888
cp,1014,ux,851,9969
cp,1015,ux,832,9968
cp,1016,ux,821,9861
cp,1017,ux,824,9864
cp,1018,ux,845,36834
cp,1019,ux,844,36833
cp,1020,ux,876,37050
cp,1021,ux,894,10185
cp,1022,ux,875,10184
cp,1023,ux,864,10077
cp,1024,ux,867,10080
cp,1025,ux,888,36996
cp,1026,ux,887,36995
cp,1027,ux,919,10401
cp,1028,ux,937,37212
cp,1029,ux,918,10400
cp,1030,ux,907,10293
cp,1031,ux,910,10296
cp,1032,ux,931,37158
cp,1033,ux,930,37157
cp,1034,ux,980,37374
cp,1035,ux,962,10617
cp,1036,ux,961,10616
cp,1037,ux,950,10509
cp,1038,ux,953,10512
cp,1039,ux,974,37320
cp,1040,ux,973,37319
cp,1041,ux,1005,37536
cp,1042,ux,1023,10833
cp,1043,ux,1004,10832
cp,1044,ux,993,10725
cp,1045,ux,996,10728
cp,1046,ux,1017,37482
cp,1047,ux,1016,37481
cp,1048,ux,1048,37698
cp,1049,ux,1066,11049
cp,1050,ux,1047,11048
cp,1051,ux,1036,10941
cp,1052,ux,1039,10944
cp,1053,ux,1060,37644
cp,1054,ux,1059,37643
cp,1055,ux,5733,63546
cp,1056,ux,5877,65886
cp,1057,ux,738,9500
cp,1058,ux,739,9501
cp,1059,ux,736,9482
cp,1060,ux,785,9716
cp,1061,ux,786,9717
cp,1062,ux,783,9698
cp,1063,ux,828,9932
cp,1064,ux,829,9933
cp,1065,ux,826,9914
cp,1066,ux,871,10148
cp,1067,ux,872,10149
cp,1068,ux,869,10130
cp,1069,ux,914,10364
cp,1070,ux,915,10365
cp,1071,ux,912,10346
cp,1072,ux,957,10580
cp,1073,ux,958,10581
cp,1074,ux,955,10562
cp,1075,ux,1000,10796
cp,1076,ux,1001,10797
cp,1077,ux,998,10778
cp,1078,ux,1043,11012
cp,1079,ux,1044,11013
cp,1080,ux,1041,10994
cp,1081,ux,740,9502
cp,1082,ux,741,9503
cp,1083,ux,737,9483
cp,1084,ux,787,9718
cp,1085,ux,788,9719
cp,1086,ux,784,9699
cp,1087,ux,830,9934
cp,1088,ux,831,9935
cp,1089,ux,827,9915
cp,1090,ux,873,10150
cp,1091,ux,874,10151
cp,1092,ux,870,10131
cp,1093,ux,916,10366
cp,1094,ux,917,10367
cp,1095,ux,913,10347
cp,1096,ux,959,10582
cp,1097,ux,960,10583
cp,1098,ux,956,10563
cp,1099,ux,1002,10798
cp,1100,ux,1003,10799
cp,1101,ux,999,10779
cp,1102,ux,1045,11014
cp,1103,ux,1046,11015
cp,1104,ux,1042,10995
cp,1105,ux,767,36591
cp,1106,ux,769,36593
cp,1107,ux,768,36592
cp,1108,ux,811,36753
cp,1109,ux,813,36755
cp,1110,ux,812,36754
cp,1111,ux,854,36915
cp,1112,ux,856,36917
cp,1113,ux,855,36916
cp,1114,ux,897,37077
cp,1115,ux,899,37079
cp,1116,ux,898,37078
cp,1117,ux,940,37239
cp,1118,ux,942,37241
cp,1119,ux,941,37240
cp,1120,ux,983,37401
cp,1121,ux,985,37403
cp,1122,ux,984,37402
cp,1123,ux,1026,37563
cp,1124,ux,1028,37565
cp,1125,ux,1027,37564
cp,1126,ux,1069,37725
cp,1127,ux,1071,37727
cp,1128,ux,1070,37726
cp,1129,ux,5804,64716
cp,1130,ux,5660,62376
cp,1131,ux,776,56048
cp,1132,ux,766,36590
cp,1133,ux,771,36595
cp,1134,ux,770,36594
cp,1135,ux,775,56022
cp,1136,ux,810,36752
cp,1137,ux,815,36757
cp,1138,ux,814,36756
cp,1139,ux,819,56085
cp,1140,ux,853,36914
cp,1141,ux,858,36919
cp,1142,ux,857,36918
cp,1143,ux,862,56130
cp,1144,ux,896,37076
cp,1145,ux,901,37081
cp,1146,ux,900,37080
cp,1147,ux,905,56175
cp,1148,ux,939,37238
cp,1149,ux,944,37243
cp,1150,ux,943,37242
cp,1151,ux,948,56220
cp,1152,ux,982,37400
cp,1153,ux,987,37405
cp,1154,ux,986,37404
cp,1155,ux,991,56265
cp,1156,ux,1025,37562
cp,1157,ux,1030,37567
cp,1158,ux,1029,37566
cp,1159,ux,1034,56310
cp,1160,ux,1068,37724
cp,1161,ux,1073,37729
cp,1162,ux,1072,37728
cp,1163,ux,1077,56355
cp,1164,ux,5732,63528
cp,1165,ux,5876,65868
cp,1166,ux,1097,11319
cp,1167,ux,1121,37968
cp,1168,ux,1101,11339
cp,1169,ux,1122,37969
cp,1170,ux,1100,11338
cp,1171,ux,1120,37967
cp,1172,ux,1144,11535
cp,1173,ux,1165,38130
cp,1174,ux,1148,11555
cp,1175,ux,1166,38131
cp,1176,ux,1147,11554
cp,1177,ux,1164,38129
cp,1178,ux,1187,11751
cp,1179,ux,1208,38292
cp,1180,ux,1191,11771
cp,1181,ux,1209,38293
cp,1182,ux,1190,11770
cp,1183,ux,1207,38291
cp,1184,ux,1230,11967
cp,1185,ux,1251,38454
cp,1186,ux,1234,11987
cp,1187,ux,1252,38455
cp,1188,ux,1233,11986
cp,1189,ux,1250,38453
cp,1190,ux,1273,12183
cp,1191,ux,1294,38616
cp,1192,ux,1277,12203
cp,1193,ux,1295,38617
cp,1194,ux,1276,12202
cp,1195,ux,1293,38615
cp,1196,ux,1316,12399
cp,1197,ux,1337,38778
cp,1198,ux,1320,12419
cp,1199,ux,1338,38779
cp,1200,ux,1319,12418
cp,1201,ux,1336,38777
cp,1202,ux,1359,12615
cp,1203,ux,1380,38940
cp,1204,ux,1363,12635
cp,1205,ux,1381,38941
cp,1206,ux,1362,12634
cp,1207,ux,1379,38939
cp,1208,ux,1402,12831
cp,1209,ux,1423,39102
cp,1210,ux,1406,12851
cp,1211,ux,1424,39103
cp,1212,ux,1405,12850
cp,1213,ux,1422,39101
cp,1214,ux,1096,11318
cp,1215,ux,1099,11337
cp,1216,ux,1098,11336
cp,1217,ux,1143,11534
cp,1218,ux,1146,11553
cp,1219,ux,1145,11552
cp,1220,ux,1186,11750
cp,1221,ux,1189,11769
cp,1222,ux,1188,11768
cp,1223,ux,1229,11966
cp,1224,ux,1232,11985
cp,1225,ux,1231,11984
cp,1226,ux,1272,12182
cp,1227,ux,1275,12201
cp,1228,ux,1274,12200
cp,1229,ux,1315,12398
cp,1230,ux,1318,12417
cp,1231,ux,1317,12416
cp,1232,ux,1358,12614
cp,1233,ux,1361,12633
cp,1234,ux,1360,12632
cp,1235,ux,1401,12830
cp,1236,ux,1404,12849
cp,1237,ux,1403,12848
cp,1238,ux,5805,64734
cp,1239,ux,5661,62394
cp,1240,ux,1108,37859
cp,1241,ux,1094,37860
cp,1242,ux,1109,11284
cp,1243,ux,1092,11282
cp,1244,ux,1078,11156
cp,1245,ux,1081,11159
cp,1246,ux,1104,37807
cp,1247,ux,1106,37809
cp,1248,ux,1141,38048
cp,1249,ux,1155,11500
cp,1250,ux,1139,11498
cp,1251,ux,1125,11372
cp,1252,ux,1128,11375
cp,1253,ux,1151,37996
cp,1254,ux,1153,37998
cp,1255,ux,1184,38210
cp,1256,ux,1198,11716
cp,1257,ux,1182,11714
cp,1258,ux,1168,11588
cp,1259,ux,1171,11591
cp,1260,ux,1194,38158
cp,1261,ux,1196,38160
cp,1262,ux,1227,38372
cp,1263,ux,1241,11932
cp,1264,ux,1225,11930
cp,1265,ux,1211,11804
cp,1266,ux,1214,11807
cp,1267,ux,1237,38320
cp,1268,ux,1239,38322
cp,1269,ux,1270,12148
cp,1270,ux,1284,38534
cp,1271,ux,1268,12146
cp,1272,ux,1254,12020
cp,1273,ux,1257,12023
cp,1274,ux,1280,38482
cp,1275,ux,1282,38484
cp,1276,ux,1327,38696
cp,1277,ux,1313,12364
cp,1278,ux,1311,12362
cp,1279,ux,1297,12236
cp,1280,ux,1300,12239
cp,1281,ux,1323,38644
cp,1282,ux,1325,38646
cp,1283,ux,1356,38858
cp,1284,ux,1370,12580
cp,1285,ux,1354,12578
cp,1286,ux,1340,12452
cp,1287,ux,1343,12455
cp,1288,ux,1366,38806
cp,1289,ux,1368,38808
cp,1290,ux,1399,39020
cp,1291,ux,1413,12796
cp,1292,ux,1397,12794
cp,1293,ux,1383,12668
cp,1294,ux,1386,12671
cp,1295,ux,1409,38968
cp,1296,ux,1411,38970
cp,1297,ux,5730,63493
cp,1298,ux,5874,65833
cp,1299,ux,5807,64754
cp,1300,ux,5663,62414
cp,1301,ux,1113,37864
cp,1302,ux,1095,37862
cp,1303,ux,1111,11285
cp,1304,ux,1093,11283
cp,1305,ux,1080,11158
cp,1306,ux,1083,11161
cp,1307,ux,1105,37808
cp,1308,ux,1107,37810
cp,1309,ux,1142,38050
cp,1310,ux,1157,11501
cp,1311,ux,1140,11499
cp,1312,ux,1127,11374
cp,1313,ux,1130,11377
cp,1314,ux,1152,37997
cp,1315,ux,1154,37999
cp,1316,ux,1185,38212
cp,1317,ux,1200,11717
cp,1318,ux,1183,11715
cp,1319,ux,1170,11590
cp,1320,ux,1173,11593
cp,1321,ux,1195,38159
cp,1322,ux,1197,38161
cp,1323,ux,1228,38374
cp,1324,ux,1243,11933
cp,1325,ux,1226,11931
cp,1326,ux,1213,11806
cp,1327,ux,1216,11809
cp,1328,ux,1238,38321
cp,1329,ux,1240,38323
cp,1330,ux,1271,12149
cp,1331,ux,1286,38536

cp,1332,ux,1269,12147
cp,1333,ux,1256,12022
cp,1334,ux,1259,12025
cp,1335,ux,1281,38483
cp,1336,ux,1283,38485
cp,1337,ux,1329,38698
cp,1338,ux,1314,12365
cp,1339,ux,1312,12363
cp,1340,ux,1299,12238
cp,1341,ux,1302,12241
cp,1342,ux,1324,38645
cp,1343,ux,1326,38647
cp,1344,ux,1357,38860
cp,1345,ux,1372,12581
cp,1346,ux,1355,12579
cp,1347,ux,1342,12454
cp,1348,ux,1345,12457
cp,1349,ux,1367,38807
cp,1350,ux,1369,38809
cp,1351,ux,1400,39022
cp,1352,ux,1415,12797
cp,1353,ux,1398,12795
cp,1354,ux,1385,12670
cp,1355,ux,1388,12673
cp,1356,ux,1410,38969
cp,1357,ux,1412,38971
cp,1358,ux,5731,63494
cp,1359,ux,5875,65834
cp,1360,ux,5806,64753
cp,1361,ux,5662,62413
cp,1362,ux,1112,37863
cp,1363,ux,1091,37861
cp,1364,ux,1110,11265
cp,1365,ux,1090,11264
cp,1366,ux,1079,11157
cp,1367,ux,1082,11160
cp,1368,ux,1103,37806
cp,1369,ux,1102,37805
cp,1370,ux,1138,38049
cp,1371,ux,1156,11481
cp,1372,ux,1137,11480
cp,1373,ux,1126,11373
cp,1374,ux,1129,11376
cp,1375,ux,1150,37995
cp,1376,ux,1149,37994
cp,1377,ux,1181,38211
cp,1378,ux,1199,11697
cp,1379,ux,1180,11696
cp,1380,ux,1169,11589
cp,1381,ux,1172,11592
cp,1382,ux,1193,38157
cp,1383,ux,1192,38156
cp,1384,ux,1224,38373
cp,1385,ux,1242,11913
cp,1386,ux,1223,11912
cp,1387,ux,1212,11805
cp,1388,ux,1215,11808
cp,1389,ux,1236,38319
cp,1390,ux,1235,38318
cp,1391,ux,1267,12129
cp,1392,ux,1285,38535
cp,1393,ux,1266,12128
cp,1394,ux,1255,12021
cp,1395,ux,1258,12024
cp,1396,ux,1279,38481
cp,1397,ux,1278,38480
cp,1398,ux,1328,38697
cp,1399,ux,1310,12345
cp,1400,ux,1309,12344
cp,1401,ux,1298,12237
cp,1402,ux,1301,12240
cp,1403,ux,1322,38643
cp,1404,ux,1321,38642
cp,1405,ux,1353,38859
cp,1406,ux,1371,12561
cp,1407,ux,1352,12560
cp,1408,ux,1341,12453
cp,1409,ux,1344,12456
cp,1410,ux,1365,38805
cp,1411,ux,1364,38804
cp,1412,ux,1396,39021
cp,1413,ux,1414,12777
cp,1414,ux,1395,12776
cp,1415,ux,1384,12669
cp,1416,ux,1387,12672
cp,1417,ux,1408,38967
cp,1418,ux,1407,38966
cp,1419,ux,5728,63474
cp,1420,ux,5872,65814
cp,1421,ux,1086,11228
cp,1422,ux,1087,11229
cp,1423,ux,1084,11210
cp,1424,ux,1133,11444
cp,1425,ux,1134,11445
cp,1426,ux,1131,11426
cp,1427,ux,1176,11660
cp,1428,ux,1177,11661
cp,1429,ux,1174,11642
cp,1430,ux,1219,11876
cp,1431,ux,1220,11877
cp,1432,ux,1217,11858
cp,1433,ux,1262,12092
cp,1434,ux,1263,12093
cp,1435,ux,1260,12074
cp,1436,ux,1305,12308
cp,1437,ux,1306,12309
cp,1438,ux,1303,12290
cp,1439,ux,1348,12524
cp,1440,ux,1349,12525
cp,1441,ux,1346,12506
cp,1442,ux,1391,12740
cp,1443,ux,1392,12741
cp,1444,ux,1389,12722
cp,1445,ux,1088,11230
cp,1446,ux,1115,37914
cp,1447,ux,1089,11231
cp,1448,ux,1117,37916
cp,1449,ux,1085,11211
cp,1450,ux,1116,37915
cp,1451,ux,1135,11446
cp,1452,ux,1159,38076
cp,1453,ux,1136,11447
cp,1454,ux,1161,38078
cp,1455,ux,1132,11427
cp,1456,ux,1160,38077
cp,1457,ux,1178,11662
cp,1458,ux,1202,38238
cp,1459,ux,1179,11663
cp,1460,ux,1204,38240
cp,1461,ux,1175,11643
cp,1462,ux,1203,38239
cp,1463,ux,1221,11878
cp,1464,ux,1245,38400
cp,1465,ux,1222,11879
cp,1466,ux,1247,38402
cp,1467,ux,1218,11859
cp,1468,ux,1246,38401
cp,1469,ux,1264,12094
cp,1470,ux,1288,38562
cp,1471,ux,1265,12095
cp,1472,ux,1290,38564
cp,1473,ux,1261,12075
cp,1474,ux,1289,38563
cp,1475,ux,1307,12310
cp,1476,ux,1331,38724
cp,1477,ux,1308,12311
cp,1478,ux,1333,38726
cp,1479,ux,1304,12291
cp,1480,ux,1332,38725
cp,1481,ux,1350,12526
cp,1482,ux,1374,38886
cp,1483,ux,1351,12527
cp,1484,ux,1376,38888
cp,1485,ux,1347,12507
cp,1486,ux,1375,38887
cp,1487,ux,1393,12742
cp,1488,ux,1417,39048
cp,1489,ux,1394,12743
cp,1490,ux,1419,39050
cp,1491,ux,1390,12723
cp,1492,ux,1418,39049
cp,1493,ux,5792,64502
cp,1494,ux,5648,62162
cp,1495,ux,1124,56435
cp,1496,ux,1114,37913
cp,1497,ux,1119,37918
cp,1498,ux,1118,37917
cp,1499,ux,1123,56409
cp,1500,ux,1158,38075
cp,1501,ux,1163,38080
cp,1502,ux,1162,38079
cp,1503,ux,1167,56472
cp,1504,ux,1201,38237
cp,1505,ux,1206,38242
cp,1506,ux,1205,38241
cp,1507,ux,1210,56517
cp,1508,ux,1244,38399
cp,1509,ux,1249,38404
cp,1510,ux,1248,38403
cp,1511,ux,1253,56562
cp,1512,ux,1287,38561
cp,1513,ux,1292,38566
cp,1514,ux,1291,38565
cp,1515,ux,1296,56607
cp,1516,ux,1330,38723
cp,1517,ux,1335,38728
cp,1518,ux,1334,38727
cp,1519,ux,1339,56652
cp,1520,ux,1373,38885
cp,1521,ux,1378,38890
cp,1522,ux,1377,38889
cp,1523,ux,1382,56697
cp,1524,ux,1416,39047
cp,1525,ux,1421,39052
cp,1526,ux,1420,39051
cp,1527,ux,1425,56742
cp,1528,ux,5727,63456
cp,1529,ux,5871,65796
cp,1530,ux,1445,13047
cp,1531,ux,1469,39291
cp,1532,ux,1449,13067
cp,1533,ux,1470,39292
cp,1534,ux,1448,13066
cp,1535,ux,1468,39290
cp,1536,ux,1492,13263
cp,1537,ux,1513,39453
cp,1538,ux,1496,13283
cp,1539,ux,1514,39454
cp,1540,ux,1495,13282
cp,1541,ux,1512,39452
cp,1542,ux,1535,13479
cp,1543,ux,1556,39615
cp,1544,ux,1539,13499
cp,1545,ux,1557,39616
cp,1546,ux,1538,13498
cp,1547,ux,1555,39614
cp,1548,ux,1578,13695
cp,1549,ux,1599,39777
cp,1550,ux,1582,13715
cp,1551,ux,1600,39778
cp,1552,ux,1581,13714
cp,1553,ux,1598,39776
cp,1554,ux,1621,13911
cp,1555,ux,1642,39939
cp,1556,ux,1625,13931
cp,1557,ux,1643,39940
cp,1558,ux,1624,13930
cp,1559,ux,1641,39938
cp,1560,ux,1664,14127
cp,1561,ux,1685,40101
cp,1562,ux,1668,14147
cp,1563,ux,1686,40102
cp,1564,ux,1667,14146
cp,1565,ux,1684,40100
cp,1566,ux,1707,14343
cp,1567,ux,1728,40263
cp,1568,ux,1711,14363
cp,1569,ux,1729,40264
cp,1570,ux,1710,14362
cp,1571,ux,1727,40262
cp,1572,ux,1750,14559
cp,1573,ux,1771,40425
cp,1574,ux,1754,14579
cp,1575,ux,1772,40426
cp,1576,ux,1753,14578
cp,1577,ux,1770,40424
cp,1578,ux,1444,13046
cp,1579,ux,1447,13065
cp,1580,ux,1446,13064
cp,1581,ux,1491,13262
cp,1582,ux,1494,13281
cp,1583,ux,1493,13280
cp,1584,ux,1534,13478
cp,1585,ux,1537,13497
cp,1586,ux,1536,13496
cp,1587,ux,1577,13694
cp,1588,ux,1580,13713
cp,1589,ux,1579,13712
cp,1590,ux,1620,13910
cp,1591,ux,1623,13929
cp,1592,ux,1622,13928
cp,1593,ux,1663,14126
cp,1594,ux,1666,14145
cp,1595,ux,1665,14144
cp,1596,ux,1706,14342
cp,1597,ux,1709,14361
cp,1598,ux,1708,14360
cp,1599,ux,1749,14558
cp,1600,ux,1752,14577
cp,1601,ux,1751,14576
cp,1602,ux,5791,64501
cp,1603,ux,5647,62161
cp,1604,ux,1456,39182
cp,1605,ux,1442,39183
cp,1606,ux,1457,13012
cp,1607,ux,1440,13010
cp,1608,ux,1426,12884
cp,1609,ux,1429,12887
cp,1610,ux,1452,39130
cp,1611,ux,1454,39132
cp,1612,ux,1489,39371
cp,1613,ux,1503,13228
cp,1614,ux,1487,13226
cp,1615,ux,1473,13100
cp,1616,ux,1476,13103
cp,1617,ux,1499,39319
cp,1618,ux,1501,39321
cp,1619,ux,1532,39533
cp,1620,ux,1546,13444
cp,1621,ux,1530,13442
cp,1622,ux,1516,13316
cp,1623,ux,1519,13319
cp,1624,ux,1542,39481
cp,1625,ux,1544,39483
cp,1626,ux,1575,39695
cp,1627,ux,1589,13660
cp,1628,ux,1573,13658
cp,1629,ux,1559,13532
cp,1630,ux,1562,13535
cp,1631,ux,1585,39643
cp,1632,ux,1587,39645
cp,1633,ux,1618,13876
cp,1634,ux,1632,39857
cp,1635,ux,1616,13874
cp,1636,ux,1602,13748
cp,1637,ux,1605,13751
cp,1638,ux,1628,39805
cp,1639,ux,1630,39807
cp,1640,ux,1675,40019
cp,1641,ux,1661,14092
cp,1642,ux,1659,14090
cp,1643,ux,1645,13964
cp,1644,ux,1648,13967
cp,1645,ux,1671,39967
cp,1646,ux,1673,39969
cp,1647,ux,1704,40181
cp,1648,ux,1718,14308
cp,1649,ux,1702,14306
cp,1650,ux,1688,14180
cp,1651,ux,1691,14183
cp,1652,ux,1714,40129
cp,1653,ux,1716,40131
cp,1654,ux,1747,40343
cp,1655,ux,1761,14524
cp,1656,ux,1745,14522
cp,1657,ux,1731,14396
cp,1658,ux,1734,14399
cp,1659,ux,1757,40291
cp,1660,ux,1759,40293
cp,1661,ux,5725,63421
cp,1662,ux,5869,65761
cp,1663,ux,5794,64538

cp,1664,ux,5650,62198
cp,1665,ux,1461,39187
cp,1666,ux,1443,39185
cp,1667,ux,1459,13013
cp,1668,ux,1441,13011
cp,1669,ux,1428,12886
cp,1670,ux,1431,12889
cp,1671,ux,1453,39131
cp,1672,ux,1455,39133
cp,1673,ux,1490,39373
cp,1674,ux,1505,13229
cp,1675,ux,1488,13227
cp,1676,ux,1475,13102
cp,1677,ux,1478,13105
cp,1678,ux,1500,39320
cp,1679,ux,1502,39322
cp,1680,ux,1533,39535
cp,1681,ux,1548,13445
cp,1682,ux,1531,13443
cp,1683,ux,1518,13318
cp,1684,ux,1521,13321
cp,1685,ux,1543,39482
cp,1686,ux,1545,39484
cp,1687,ux,1576,39697
cp,1688,ux,1591,13661
cp,1689,ux,1574,13659
cp,1690,ux,1561,13534
cp,1691,ux,1564,13537
cp,1692,ux,1586,39644
cp,1693,ux,1588,39646
cp,1694,ux,1619,13877
cp,1695,ux,1634,39859
cp,1696,ux,1617,13875
cp,1697,ux,1604,13750
cp,1698,ux,1607,13753
cp,1699,ux,1629,39806
cp,1700,ux,1631,39808
cp,1701,ux,1677,40021
cp,1702,ux,1662,14093
cp,1703,ux,1660,14091
cp,1704,ux,1647,13966
cp,1705,ux,1650,13969
cp,1706,ux,1672,39968
cp,1707,ux,1674,39970
cp,1708,ux,1705,40183
cp,1709,ux,1720,14309
cp,1710,ux,1703,14307
cp,1711,ux,1690,14182
cp,1712,ux,1693,14185
cp,1713,ux,1715,40130
cp,1714,ux,1717,40132
cp,1715,ux,1748,40345
cp,1716,ux,1763,14525
cp,1717,ux,1746,14523
cp,1718,ux,1733,14398
cp,1719,ux,1736,14401
cp,1720,ux,1758,40292
cp,1721,ux,1760,40294
cp,1722,ux,5726,63422
cp,1723,ux,5870,65762
cp,1724,ux,5793,64537
cp,1725,ux,5649,62197
cp,1726,ux,1460,39186
cp,1727,ux,1439,39184
cp,1728,ux,1458,12993
cp,1729,ux,1438,12992
cp,1730,ux,1427,12885
cp,1731,ux,1430,12888
cp,1732,ux,1451,39129
cp,1733,ux,1450,39128
cp,1734,ux,1486,39372
cp,1735,ux,1504,13209
cp,1736,ux,1485,13208
cp,1737,ux,1474,13101
cp,1738,ux,1477,13104
cp,1739,ux,1498,39318
cp,1740,ux,1497,39317
cp,1741,ux,1529,39534
cp,1742,ux,1547,13425
cp,1743,ux,1528,13424
cp,1744,ux,1517,13317
cp,1745,ux,1520,13320
cp,1746,ux,1541,39480
cp,1747,ux,1540,39479
cp,1748,ux,1572,39696
cp,1749,ux,1590,13641
cp,1750,ux,1571,13640
cp,1751,ux,1560,13533
cp,1752,ux,1563,13536
cp,1753,ux,1584,39642
cp,1754,ux,1583,39641
cp,1755,ux,1615,13857
cp,1756,ux,1633,39858
cp,1757,ux,1614,13856
cp,1758,ux,1603,13749
cp,1759,ux,1606,13752
cp,1760,ux,1627,39804
cp,1761,ux,1626,39803
cp,1762,ux,1676,40020
cp,1763,ux,1658,14073
cp,1764,ux,1657,14072
cp,1765,ux,1646,13965
cp,1766,ux,1649,13968
cp,1767,ux,1670,39966
cp,1768,ux,1669,39965
cp,1769,ux,1701,40182
cp,1770,ux,1719,14289
cp,1771,ux,1700,14288
cp,1772,ux,1689,14181
cp,1773,ux,1692,14184
cp,1774,ux,1713,40128
cp,1775,ux,1712,40127
cp,1776,ux,1744,40344
cp,1777,ux,1762,14505
cp,1778,ux,1743,14504
cp,1779,ux,1732,14397
cp,1780,ux,1735,14400
cp,1781,ux,1756,40290
cp,1782,ux,1755,40289
cp,1783,ux,5724,63402
cp,1784,ux,5868,65742
cp,1785,ux,1434,12956
cp,1786,ux,1435,12957
cp,1787,ux,1432,12938
cp,1788,ux,1481,13172
cp,1789,ux,1482,13173
cp,1790,ux,1479,13154
cp,1791,ux,1524,13388
cp,1792,ux,1525,13389
cp,1793,ux,1522,13370
cp,1794,ux,1567,13604
cp,1795,ux,1568,13605
cp,1796,ux,1565,13586
cp,1797,ux,1610,13820
cp,1798,ux,1611,13821
cp,1799,ux,1608,13802
cp,1800,ux,1653,14036
cp,1801,ux,1654,14037
cp,1802,ux,1651,14018
cp,1803,ux,1696,14252
cp,1804,ux,1697,14253
cp,1805,ux,1694,14234
cp,1806,ux,1739,14468
cp,1807,ux,1740,14469
cp,1808,ux,1737,14450
cp,1809,ux,1436,12958
cp,1810,ux,1463,39237
cp,1811,ux,1437,12959
cp,1812,ux,1465,39239
cp,1813,ux,1433,12939
cp,1814,ux,1464,39238
cp,1815,ux,1483,13174
cp,1816,ux,1507,39399
cp,1817,ux,1484,13175
cp,1818,ux,1509,39401
cp,1819,ux,1480,13155
cp,1820,ux,1508,39400
cp,1821,ux,1526,13390
cp,1822,ux,1550,39561
cp,1823,ux,1527,13391
cp,1824,ux,1552,39563
cp,1825,ux,1523,13371
cp,1826,ux,1551,39562
cp,1827,ux,1569,13606
cp,1828,ux,1593,39723
cp,1829,ux,1570,13607
cp,1830,ux,1595,39725
cp,1831,ux,1566,13587
cp,1832,ux,1594,39724
cp,1833,ux,1612,13822
cp,1834,ux,1636,39885
cp,1835,ux,1613,13823
cp,1836,ux,1638,39887
cp,1837,ux,1609,13803
cp,1838,ux,1637,39886
cp,1839,ux,1655,14038
cp,1840,ux,1679,40047
cp,1841,ux,1656,14039
cp,1842,ux,1681,40049
cp,1843,ux,1652,14019
cp,1844,ux,1680,40048
cp,1845,ux,1698,14254
cp,1846,ux,1722,40209
cp,1847,ux,1699,14255
cp,1848,ux,1724,40211
cp,1849,ux,1695,14235
cp,1850,ux,1723,40210
cp,1851,ux,1741,14470
cp,1852,ux,1765,40371
cp,1853,ux,1742,14471
cp,1854,ux,1767,40373
cp,1855,ux,1738,14451
cp,1856,ux,1766,40372
cp,1857,ux,5795,64572
cp,1858,ux,5651,62232
cp,1859,ux,1472,56822
cp,1860,ux,1462,39236
cp,1861,ux,1467,39241
cp,1862,ux,1466,39240
cp,1863,ux,1471,56796
cp,1864,ux,1506,39398
cp,1865,ux,1511,39403
cp,1866,ux,1510,39402
cp,1867,ux,1515,56859
cp,1868,ux,1549,39560
cp,1869,ux,1554,39565
cp,1870,ux,1553,39564
cp,1871,ux,1558,56904
cp,1872,ux,1592,39722
cp,1873,ux,1597,39727
cp,1874,ux,1596,39726
cp,1875,ux,1601,56949
cp,1876,ux,1635,39884
cp,1877,ux,1640,39889
cp,1878,ux,1639,39888
cp,1879,ux,1644,56994
cp,1880,ux,1678,40046
cp,1881,ux,1683,40051
cp,1882,ux,1682,40050
cp,1883,ux,1687,57039
cp,1884,ux,1721,40208
cp,1885,ux,1726,40213
cp,1886,ux,1725,40212
cp,1887,ux,1730,57084
cp,1888,ux,1764,40370
cp,1889,ux,1769,40375
cp,1890,ux,1768,40374
cp,1891,ux,1773,57129
cp,1892,ux,5723,63384
cp,1893,ux,5867,65724
cp,1894,ux,1793,14775
cp,1895,ux,1817,40614
cp,1896,ux,1797,14795
cp,1897,ux,1818,40615
cp,1898,ux,1796,14794
cp,1899,ux,1816,40613
cp,1900,ux,1840,14991
cp,1901,ux,1861,40776
cp,1902,ux,1844,15011
cp,1903,ux,1862,40777
cp,1904,ux,1843,15010
cp,1905,ux,1860,40775
cp,1906,ux,1883,15207
cp,1907,ux,1904,40938
cp,1908,ux,1887,15227
cp,1909,ux,1905,40939
cp,1910,ux,1886,15226
cp,1911,ux,1903,40937
cp,1912,ux,1926,15423
cp,1913,ux,1947,41100
cp,1914,ux,1930,15443
cp,1915,ux,1948,41101
cp,1916,ux,1929,15442
cp,1917,ux,1946,41099
cp,1918,ux,1969,15639
cp,1919,ux,1990,41262
cp,1920,ux,1973,15659
cp,1921,ux,1991,41263
cp,1922,ux,1972,15658
cp,1923,ux,1989,41261
cp,1924,ux,2012,15855
cp,1925,ux,2033,41424
cp,1926,ux,2016,15875
cp,1927,ux,2034,41425
cp,1928,ux,2015,15874
cp,1929,ux,2032,41423
cp,1930,ux,2055,16071
cp,1931,ux,2076,41586
cp,1932,ux,2059,16091
cp,1933,ux,2077,41587
cp,1934,ux,2058,16090
cp,1935,ux,2075,41585
cp,1936,ux,2098,16287
cp,1937,ux,2119,41748
cp,1938,ux,2102,16307
cp,1939,ux,2120,41749
cp,1940,ux,2101,16306
cp,1941,ux,2118,41747
cp,1942,ux,1792,14774
cp,1943,ux,1795,14793
cp,1944,ux,1794,14792
cp,1945,ux,1839,14990
cp,1946,ux,1842,15009
cp,1947,ux,1841,15008
cp,1948,ux,1882,15206
cp,1949,ux,1885,15225
cp,1950,ux,1884,15224
cp,1951,ux,1925,15422
cp,1952,ux,1928,15441
cp,1953,ux,1927,15440
cp,1954,ux,1968,15638
cp,1955,ux,1971,15657
cp,1956,ux,1970,15656
cp,1957,ux,2011,15854
cp,1958,ux,2014,15873
cp,1959,ux,2013,15872
cp,1960,ux,2054,16070
cp,1961,ux,2057,16089
cp,1962,ux,2056,16088
cp,1963,ux,2097,16286
cp,1964,ux,2100,16305
cp,1965,ux,2099,16304
cp,1966,ux,5796,64590
cp,1967,ux,5652,62250
cp,1968,ux,1804,40505
cp,1969,ux,1790,40506
cp,1970,ux,1805,14740
cp,1971,ux,1788,14738
cp,1972,ux,1774,14612
cp,1973,ux,1777,14615
cp,1974,ux,1800,40453
cp,1975,ux,1802,40455
cp,1976,ux,1837,40694
cp,1977,ux,1851,14956
cp,1978,ux,1835,14954
cp,1979,ux,1821,14828
cp,1980,ux,1824,14831
cp,1981,ux,1847,40642
cp,1982,ux,1849,40644
cp,1983,ux,1880,40856
cp,1984,ux,1894,15172
cp,1985,ux,1878,15170
cp,1986,ux,1864,15044
cp,1987,ux,1867,15047
cp,1988,ux,1890,40804
cp,1989,ux,1892,40806
cp,1990,ux,1923,41018
cp,1991,ux,1937,15388
cp,1992,ux,1921,15386
cp,1993,ux,1907,15260
cp,1994,ux,1910,15263
cp,1995,ux,1933,40966

cp,1996,ux,1935,40968
cp,1997,ux,1966,15604
cp,1998,ux,1980,41180
cp,1999,ux,1964,15602
cp,2000,ux,1950,15476
cp,2001,ux,1953,15479
cp,2002,ux,1976,41128
cp,2003,ux,1978,41130
cp,2004,ux,2023,41342
cp,2005,ux,2009,15820
cp,2006,ux,2007,15818
cp,2007,ux,1993,15692
cp,2008,ux,1996,15695
cp,2009,ux,2019,41290
cp,2010,ux,2021,41292
cp,2011,ux,2052,41504
cp,2012,ux,2066,16036
cp,2013,ux,2050,16034
cp,2014,ux,2036,15908
cp,2015,ux,2039,15911
cp,2016,ux,2062,41452
cp,2017,ux,2064,41454
cp,2018,ux,2095,41666
cp,2019,ux,2109,16252
cp,2020,ux,2093,16250
cp,2021,ux,2079,16124
cp,2022,ux,2082,16127
cp,2023,ux,2105,41614
cp,2024,ux,2107,41616
cp,2025,ux,5721,63349
cp,2026,ux,5865,65689
cp,2027,ux,5798,64610
cp,2028,ux,5654,62270
cp,2029,ux,1809,40510
cp,2030,ux,1791,40508
cp,2031,ux,1807,14741
cp,2032,ux,1789,14739
cp,2033,ux,1776,14614
cp,2034,ux,1779,14617
cp,2035,ux,1801,40454
cp,2036,ux,1803,40456
cp,2037,ux,1838,40696
cp,2038,ux,1853,14957
cp,2039,ux,1836,14955
cp,2040,ux,1823,14830
cp,2041,ux,1826,14833
cp,2042,ux,1848,40643
cp,2043,ux,1850,40645
cp,2044,ux,1881,40858
cp,2045,ux,1896,15173
cp,2046,ux,1879,15171
cp,2047,ux,1866,15046
cp,2048,ux,1869,15049
cp,2049,ux,1891,40805
cp,2050,ux,1893,40807
cp,2051,ux,1924,41020
cp,2052,ux,1939,15389
cp,2053,ux,1922,15387
cp,2054,ux,1909,15262
cp,2055,ux,1912,15265
cp,2056,ux,1934,40967
cp,2057,ux,1936,40969
cp,2058,ux,1967,15605
cp,2059,ux,1982,41182
cp,2060,ux,1965,15603
cp,2061,ux,1952,15478
cp,2062,ux,1955,15481
cp,2063,ux,1977,41129
cp,2064,ux,1979,41131
cp,2065,ux,2025,41344
cp,2066,ux,2010,15821
cp,2067,ux,2008,15819
cp,2068,ux,1995,15694
cp,2069,ux,1998,15697
cp,2070,ux,2020,41291
cp,2071,ux,2022,41293
cp,2072,ux,2053,41506
cp,2073,ux,2068,16037
cp,2074,ux,2051,16035
cp,2075,ux,2038,15910
cp,2076,ux,2041,15913
cp,2077,ux,2063,41453
cp,2078,ux,2065,41455
cp,2079,ux,2096,41668
cp,2080,ux,2111,16253
cp,2081,ux,2094,16251
cp,2082,ux,2081,16126
cp,2083,ux,2084,16129
cp,2084,ux,2106,41615
cp,2085,ux,2108,41617
cp,2086,ux,5722,63350
cp,2087,ux,5866,65690
cp,2088,ux,5797,64609
cp,2089,ux,5653,62269
cp,2090,ux,1808,40509
cp,2091,ux,1787,40507
cp,2092,ux,1806,14721
cp,2093,ux,1786,14720
cp,2094,ux,1775,14613
cp,2095,ux,1778,14616
cp,2096,ux,1799,40452
cp,2097,ux,1798,40451
cp,2098,ux,1834,40695
cp,2099,ux,1852,14937
cp,2100,ux,1833,14936
cp,2101,ux,1822,14829
cp,2102,ux,1825,14832
cp,2103,ux,1846,40641
cp,2104,ux,1845,40640
cp,2105,ux,1877,40857
cp,2106,ux,1895,15153
cp,2107,ux,1876,15152
cp,2108,ux,1865,15045
cp,2109,ux,1868,15048
cp,2110,ux,1889,40603
cp,2111,ux,1888,40802
cp,2112,ux,1920,41019
cp,2113,ux,1938,15369
cp,2114,ux,1919,15368
cp,2115,ux,1908,15261
cp,2116,ux,1911,15264
cp,2117,ux,1932,40965
cp,2118,ux,1931,40964
cp,2119,ux,1963,15585
cp,2120,ux,1981,41181
cp,2121,ux,1962,15584
cp,2122,ux,1951,15477
cp,2123,ux,1954,15480
cp,2124,ux,1975,41127
cp,2125,ux,1974,41126
cp,2126,ux,2024,41343
cp,2127,ux,2006,15801
cp,2128,ux,2005,15800
cp,2129,ux,1994,15693
cp,2130,ux,1997,15696
cp,2131,ux,2018,41289
cp,2132,ux,2017,41288
cp,2133,ux,2049,41505
cp,2134,ux,2067,16017
cp,2135,ux,2048,16016
cp,2136,ux,2037,15909
cp,2137,ux,2040,15912
cp,2138,ux,2061,41451
cp,2139,ux,2060,41450
cp,2140,ux,2092,41667
cp,2141,ux,2110,16233
cp,2142,ux,2091,16232
cp,2143,ux,2080,16125
cp,2144,ux,2083,16128
cp,2145,ux,2104,41613
cp,2146,ux,2103,41612
cp,2147,ux,5719,63330
cp,2148,ux,5863,65670
cp,2149,ux,1782,14684
cp,2150,ux,1783,14685
cp,2151,ux,1780,14666
cp,2152,ux,1829,14900
cp,2153,ux,1830,14901
cp,2154,ux,1827,14882
cp,2155,ux,1872,15116
cp,2156,ux,1873,15117
cp,2157,ux,1870,15098
cp,2158,ux,1915,15332
cp,2159,ux,1916,15333
cp,2160,ux,1913,15314
cp,2161,ux,1958,15548
cp,2162,ux,1959,15549
cp,2163,ux,1956,15530
cp,2164,ux,2001,15764
cp,2165,ux,2002,15765
cp,2166,ux,1999,15746
cp,2167,ux,2044,15980
cp,2168,ux,2045,15981
cp,2169,ux,2042,15962
cp,2170,ux,2087,16196
cp,2171,ux,2088,16197
cp,2172,ux,2085,16178
cp,2173,ux,1784,14686
cp,2174,ux,1811,40560
cp,2175,ux,1785,14687
cp,2176,ux,1813,40562
cp,2177,ux,1781,14667
cp,2178,ux,1812,40561
cp,2179,ux,1831,14902
cp,2180,ux,1855,40722
cp,2181,ux,1832,14903
cp,2182,ux,1857,40724
cp,2183,ux,1828,14883
cp,2184,ux,1856,40723
cp,2185,ux,1874,15118
cp,2186,ux,1898,40884
cp,2187,ux,1875,15119
cp,2188,ux,1900,40886
cp,2189,ux,1871,15099
cp,2190,ux,1899,40885
cp,2191,ux,1917,15334
cp,2192,ux,1941,41046
cp,2193,ux,1918,15335
cp,2194,ux,1943,41048
cp,2195,ux,1914,15315
cp,2196,ux,1942,41047
cp,2197,ux,1960,15550
cp,2198,ux,1984,41208
cp,2199,ux,1961,15551
cp,2200,ux,1986,41210
cp,2201,ux,1957,15531
cp,2202,ux,1985,41209
cp,2203,ux,2003,15766
cp,2204,ux,2027,41370
cp,2205,ux,2004,15767
cp,2206,ux,2029,41372
cp,2207,ux,2000,15747
cp,2208,ux,2028,41371
cp,2209,ux,2046,15982
cp,2210,ux,2070,41532
cp,2211,ux,2047,15983
cp,2212,ux,2072,41534
cp,2213,ux,2043,15963
cp,2214,ux,2071,41533
cp,2215,ux,2089,16198
cp,2216,ux,2113,41694
cp,2217,ux,2090,16199
cp,2218,ux,2115,41696
cp,2219,ux,2086,16179
cp,2220,ux,2114,41695
cp,2221,ux,5783,64358
cp,2222,ux,5639,62018
cp,2223,ux,1820,57209
cp,2224,ux,1810,40559
cp,2225,ux,1815,40564
cp,2226,ux,1814,40563
cp,2227,ux,1819,57183
cp,2228,ux,1854,40721
cp,2229,ux,1859,40726
cp,2230,ux,1858,40725
cp,2231,ux,1863,57246
cp,2232,ux,1897,40883
cp,2233,ux,1902,40888
cp,2234,ux,1901,40887
cp,2235,ux,1906,57291
cp,2236,ux,1940,41045
cp,2237,ux,1945,41050
cp,2238,ux,1944,41049
cp,2239,ux,1949,57356
cp,2240,ux,1983,41207
cp,2241,ux,1988,41212
cp,2242,ux,1987,41211
cp,2243,ux,1992,57381
cp,2244,ux,2026,41369
cp,2245,ux,2031,41374
cp,2246,ux,2030,41373
cp,2247,ux,2035,57426
cp,2248,ux,2069,41531
cp,2249,ux,2074,41536
cp,2250,ux,2073,41535
cp,2251,ux,2078,57471
cp,2252,ux,2112,41693
cp,2253,ux,2117,41698
cp,2254,ux,2116,41697
cp,2255,ux,2121,57516
cp,2256,ux,5718,63312
cp,2257,ux,5862,65652
cp,2258,ux,2141,16503
cp,2259,ux,2165,41937
cp,2260,ux,2145,16523
cp,2261,ux,2166,41938
cp,2262,ux,2144,16522
cp,2263,ux,2164,41936
cp,2264,ux,2188,16719
cp,2265,ux,2209,42099
cp,2266,ux,2192,16739
cp,2267,ux,2210,42100
cp,2268,ux,2191,16738
cp,2269,ux,2208,42098
cp,2270,ux,2231,16935
cp,2271,ux,2252,42261
cp,2272,ux,2235,16955
cp,2273,ux,2253,42262
cp,2274,ux,2234,16954
cp,2275,ux,2251,42260
cp,2276,ux,2274,17151
cp,2277,ux,2295,42423
cp,2278,ux,2278,17171
cp,2279,ux,2296,42424
cp,2280,ux,2277,17170
cp,2281,ux,2294,42422
cp,2282,ux,2317,17367
cp,2283,ux,2338,42585
cp,2284,ux,2321,17387
cp,2285,ux,2339,42586
cp,2286,ux,2320,17386
cp,2287,ux,2337,42584
cp,2288,ux,2360,17583
cp,2289,ux,2381,42747
cp,2290,ux,2364,17603
cp,2291,ux,2382,42748
cp,2292,ux,2363,17602
cp,2293,ux,2380,42746
cp,2294,ux,2403,17799
cp,2295,ux,2424,42909
cp,2296,ux,2407,17819
cp,2297,ux,2425,42910
cp,2298,ux,2406,17818
cp,2299,ux,2423,42908
cp,2300,ux,2446,18015
cp,2301,ux,2467,43071
cp,2302,ux,2450,18035
cp,2303,ux,2468,43072
cp,2304,ux,2449,18034
cp,2305,ux,2466,43070
cp,2306,ux,2140,16502
cp,2307,ux,2143,16521
cp,2308,ux,2142,16520
cp,2309,ux,2187,16718
cp,2310,ux,2190,16737
cp,2311,ux,2189,16736
cp,2312,ux,2230,16934
cp,2313,ux,2233,16953
cp,2314,ux,2232,16952
cp,2315,ux,2273,17150
cp,2316,ux,2276,17169
cp,2317,ux,2275,17168
cp,2318,ux,2316,17366
cp,2319,ux,2319,17385
cp,2320,ux,2318,17384
cp,2321,ux,2359,17582
cp,2322,ux,2362,17601
cp,2323,ux,2361,17600
cp,2324,ux,2402,17798
cp,2325,ux,2405,17817
cp,2326,ux,2404,17816
cp,2327,ux,2445,18014

cp,2328,ux,2448,18033
cp,2329,ux,2447,18032
cp,2330,ux,5782,64357
cp,2331,ux,5638,62017
cp,2332,ux,2152,41828
cp,2333,ux,2138,41829
cp,2334,ux,2153,16468
cp,2335,ux,2136,16466
cp,2336,ux,2122,16340
cp,2337,ux,2125,16343
cp,2338,ux,2148,41776
cp,2339,ux,2150,41778
cp,2340,ux,2185,42017
cp,2341,ux,2199,16684
cp,2342,ux,2183,16682
cp,2343,ux,2169,16556
cp,2344,ux,2172,16559
cp,2345,ux,2195,41965
cp,2346,ux,2197,41967
cp,2347,ux,2228,42179
cp,2348,ux,2242,16900
cp,2349,ux,2226,16898
cp,2350,ux,2212,16772
cp,2351,ux,2215,16775
cp,2352,ux,2238,42127
cp,2353,ux,2240,42129
cp,2354,ux,2271,42341
cp,2355,ux,2285,17116
cp,2356,ux,2269,17114
cp,2357,ux,2255,16988
cp,2358,ux,2258,16991
cp,2359,ux,2281,42289
cp,2360,ux,2283,42291
cp,2361,ux,2314,17332
cp,2362,ux,2328,42503
cp,2363,ux,2312,17330
cp,2364,ux,2298,17204
cp,2365,ux,2301,17207
cp,2366,ux,2324,42451
cp,2367,ux,2326,42453
cp,2368,ux,2371,42665
cp,2369,ux,2357,17548
cp,2370,ux,2355,17546
cp,2371,ux,2341,17420
cp,2372,ux,2344,17423
cp,2373,ux,2367,42613
cp,2374,ux,2369,42615
cp,2375,ux,2400,42827
cp,2376,ux,2414,17764
cp,2377,ux,2398,17762
cp,2378,ux,2384,17636
cp,2379,ux,2387,17639
cp,2380,ux,2410,42775
cp,2381,ux,2412,42777
cp,2382,ux,2443,42989
cp,2383,ux,2457,17980
cp,2384,ux,2441,17978
cp,2385,ux,2427,17852
cp,2386,ux,2430,17855
cp,2387,ux,2453,42937
cp,2388,ux,2455,42939
cp,2389,ux,5716,63277
cp,2390,ux,5860,65617
cp,2391,ux,5785,64394
cp,2392,ux,5641,62054
cp,2393,ux,2157,41833
cp,2394,ux,2139,41831
cp,2395,ux,2155,16469
cp,2396,ux,2137,16467
cp,2397,ux,2124,16342
cp,2398,ux,2127,16345
cp,2399,ux,2149,41777
cp,2400,ux,2151,41779
cp,2401,ux,2186,42019
cp,2402,ux,2201,16685
cp,2403,ux,2184,16683
cp,2404,ux,2171,16558
cp,2405,ux,2174,16561
cp,2406,ux,2196,41966
cp,2407,ux,2198,41968
cp,2408,ux,2229,42181
cp,2409,ux,2244,16901
cp,2410,ux,2227,16899
cp,2411,ux,2214,16774
cp,2412,ux,2217,16777
cp,2413,ux,2239,42128
cp,2414,ux,2241,42130
cp,2415,ux,2272,42343
cp,2416,ux,2287,17117
cp,2417,ux,2270,17115
cp,2418,ux,2257,16990
cp,2419,ux,2260,16993
cp,2420,ux,2282,42290
cp,2421,ux,2284,42292
cp,2422,ux,2315,17333
cp,2423,ux,2330,42505
cp,2424,ux,2313,17331
cp,2425,ux,2300,17206
cp,2426,ux,2303,17209
cp,2427,ux,2325,42452
cp,2428,ux,2327,42454
cp,2429,ux,2373,42667
cp,2430,ux,2358,17549
cp,2431,ux,2356,17547
cp,2432,ux,2343,17422
cp,2433,ux,2346,17425
cp,2434,ux,2368,42614
cp,2435,ux,2370,42616
cp,2436,ux,2401,42829
cp,2437,ux,2416,17765
cp,2438,ux,2399,17763
cp,2439,ux,2386,17638
cp,2440,ux,2389,17641
cp,2441,ux,2411,42776
cp,2442,ux,2413,42778
cp,2443,ux,2444,42991
cp,2444,ux,2459,17981
cp,2445,ux,2442,17979
cp,2446,ux,2429,17854
cp,2447,ux,2432,17857
cp,2448,ux,2454,42938
cp,2449,ux,2456,42940
cp,2450,ux,5717,63278
cp,2451,ux,5861,65618
cp,2452,ux,5784,64393
cp,2453,ux,5640,62053
cp,2454,ux,2156,41832
cp,2455,ux,2135,41830
cp,2456,ux,2154,16449
cp,2457,ux,2134,16448
cp,2458,ux,2123,16341
cp,2459,ux,2126,16344
cp,2460,ux,2147,41775
cp,2461,ux,2146,41774
cp,2462,ux,2182,42018
cp,2463,ux,2200,16665
cp,2464,ux,2181,16664
cp,2465,ux,2170,16557
cp,2466,ux,2173,16560
cp,2467,ux,2194,41964
cp,2468,ux,2193,41963
cp,2469,ux,2225,42180
cp,2470,ux,2243,16881
cp,2471,ux,2224,16880
cp,2472,ux,2213,16773
cp,2473,ux,2216,16776
cp,2474,ux,2237,42126
cp,2475,ux,2236,42125
cp,2476,ux,2268,42342
cp,2477,ux,2286,17097
cp,2478,ux,2267,17096
cp,2479,ux,2256,16989
cp,2480,ux,2259,16992
cp,2481,ux,2280,42288
cp,2482,ux,2279,42287
cp,2483,ux,2311,17313
cp,2484,ux,2329,42504
cp,2485,ux,2310,17312
cp,2486,ux,2299,17205
cp,2487,ux,2302,17208
cp,2488,ux,2323,42450
cp,2489,ux,2322,42449
cp,2490,ux,2372,42666
cp,2491,ux,2354,17529
cp,2492,ux,2353,17528
cp,2493,ux,2342,17421
cp,2494,ux,2345,17424
cp,2495,ux,2366,42612
cp,2496,ux,2365,42611
cp,2497,ux,2397,42828
cp,2498,ux,2415,17745
cp,2499,ux,2396,17744
cp,2500,ux,2385,17637
cp,2501,ux,2388,17640
cp,2502,ux,2409,42774
cp,2503,ux,2408,42773
cp,2504,ux,2440,42990
cp,2505,ux,2458,17961
cp,2506,ux,2439,17960
cp,2507,ux,2428,17853
cp,2508,ux,2431,17856
cp,2509,ux,2452,42936
cp,2510,ux,2451,42935
cp,2511,ux,5715,63258
cp,2512,ux,5859,65598
cp,2513,ux,2130,16412
cp,2514,ux,2131,16413
cp,2515,ux,2128,16394
cp,2516,ux,2177,16628
cp,2517,ux,2178,16629
cp,2518,ux,2175,16610
cp,2519,ux,2220,16844
cp,2520,ux,2221,16845
cp,2521,ux,2218,16826
cp,2522,ux,2263,17060
cp,2523,ux,2264,17061
cp,2524,ux,2261,17042
cp,2525,ux,2306,17276
cp,2526,ux,2307,17277
cp,2527,ux,2304,17258
cp,2528,ux,2349,17492
cp,2529,ux,2350,17493
cp,2530,ux,2347,17474
cp,2531,ux,2392,17708
cp,2532,ux,2393,17709
cp,2533,ux,2390,17690
cp,2534,ux,2435,17924
cp,2535,ux,2436,17925
cp,2536,ux,2433,17906
cp,2537,ux,2132,16414
cp,2538,ux,2133,16415
cp,2539,ux,2129,16395
cp,2540,ux,2179,16630
cp,2541,ux,2180,16631
cp,2542,ux,2176,16611
cp,2543,ux,2222,16846
cp,2544,ux,2223,16847
cp,2545,ux,2219,16827
cp,2546,ux,2265,17062
cp,2547,ux,2266,17063
cp,2548,ux,2262,17043
cp,2549,ux,2308,17278
cp,2550,ux,2309,17279
cp,2551,ux,2305,17259
cp,2552,ux,2351,17494
cp,2553,ux,2352,17495
cp,2554,ux,2348,17475
cp,2555,ux,2394,17710
cp,2556,ux,2395,17711
cp,2557,ux,2391,17691
cp,2558,ux,2437,17926
cp,2559,ux,2438,17927
cp,2560,ux,2434,17907
cp,2561,ux,2159,41883
cp,2562,ux,2161,41885
cp,2563,ux,2160,41884
cp,2564,ux,2203,42045
cp,2565,ux,2205,42047
cp,2566,ux,2204,42046
cp,2567,ux,2246,42207
cp,2568,ux,2248,42209
cp,2569,ux,2247,42208
cp,2570,ux,2289,42369
cp,2571,ux,2291,42371
cp,2572,ux,2290,42370
cp,2573,ux,2332,42531
cp,2574,ux,2334,42533
cp,2575,ux,2333,42532
cp,2576,ux,2375,42693
cp,2577,ux,2377,42695
cp,2578,ux,2376,42694
cp,2579,ux,2418,42855
cp,2580,ux,2420,42857
cp,2581,ux,2419,42856
cp,2582,ux,2461,43017
cp,2583,ux,2463,43019
cp,2584,ux,2462,43018
cp,2585,ux,5786,64428
cp,2586,ux,5642,62088
cp,2587,ux,2168,57596
cp,2588,ux,2158,41882
cp,2589,ux,2163,41887
cp,2590,ux,2162,41886
cp,2591,ux,2167,57570
cp,2592,ux,2202,42044
cp,2593,ux,2207,42049
cp,2594,ux,2206,42048
cp,2595,ux,2211,57633
cp,2596,ux,2245,42206
cp,2597,ux,2250,42211
cp,2598,ux,2249,42210
cp,2599,ux,2254,57678
cp,2600,ux,2288,42368
cp,2601,ux,2293,42373
cp,2602,ux,2292,42372
cp,2603,ux,2297,57723
cp,2604,ux,2331,42530
cp,2605,ux,2336,42535
cp,2606,ux,2335,42534
cp,2607,ux,2340,57768
cp,2608,ux,2374,42692
cp,2609,ux,2379,42697
cp,2610,ux,2378,42696
cp,2611,ux,2383,57813
cp,2612,ux,2417,42854
cp,2613,ux,2422,42859
cp,2614,ux,2421,42858
cp,2615,ux,2426,57858
cp,2616,ux,2460,43016
cp,2617,ux,2465,43021
cp,2618,ux,2464,43020
cp,2619,ux,2469,57903
cp,2620,ux,5714,63240
cp,2621,ux,5858,65580
cp,2622,ux,2489,18231
cp,2623,ux,2513,43260
cp,2624,ux,2493,18251
cp,2625,ux,2514,43261
cp,2626,ux,2492,18250
cp,2627,ux,2512,43259
cp,2628,ux,2536,18447
cp,2629,ux,2557,43422
cp,2630,ux,2540,18467
cp,2631,ux,2558,43423
cp,2632,ux,2539,18466
cp,2633,ux,2556,43421
cp,2634,ux,2579,18663
cp,2635,ux,2600,43584
cp,2636,ux,2583,18683
cp,2637,ux,2601,43585
cp,2638,ux,2582,18682
cp,2639,ux,2599,43583
cp,2640,ux,2622,18879
cp,2641,ux,2643,43746
cp,2642,ux,2626,18899
cp,2643,ux,2644,43747
cp,2644,ux,2625,18898
cp,2645,ux,2642,43745
cp,2646,ux,2665,19095
cp,2647,ux,2686,43908
cp,2648,ux,2669,19115
cp,2649,ux,2687,43909
cp,2650,ux,2668,19114
cp,2651,ux,2685,43907
cp,2652,ux,2708,19311
cp,2653,ux,2729,44070
cp,2654,ux,2712,19331
cp,2655,ux,2730,44071
cp,2656,ux,2711,19330
cp,2657,ux,2728,44069
cp,2658,ux,2751,19527
cp,2659,ux,2772,44232

cp.2660,ux.2755,19547
cp.2661,ux.2773,44233
cp.2662,ux.2754,19546
cp.2663,ux.2771,44231
cp.2664,ux.2794,19743
cp.2665,ux.2815,44394
cp.2666,ux.2798,19763
cp.2667,ux.2816,44395
cp.2668,ux.2797,19762
cp.2669,ux.2814,44393
cp.2670,ux.2488,18230
cp.2671,ux.2491,18249
cp.2672,ux.2490,18248
cp.2673,ux.2535,18446
cp.2674,ux.2538,18465
cp.2675,ux.2537,18464
cp.2676,ux.2578,18662
cp.2677,ux.2581,18681
cp.2678,ux.2580,18680
cp.2679,ux.2621,18878
cp.2680,ux.2624,18897
cp.2681,ux.2623,18896
cp.2682,ux.2664,19094
cp.2683,ux.2667,19113
cp.2684,ux.2666,19112
cp.2685,ux.2707,19310
cp.2686,ux.2710,19329
cp.2687,ux.2709,19328
cp.2688,ux.2750,19526
cp.2689,ux.2753,19545
cp.2690,ux.2752,19544
cp.2691,ux.2793,19742
cp.2692,ux.2796,19761
cp.2693,ux.2795,19760
cp.2694,ux.5787,64446
cp.2695,ux.5643,62106
cp.2696,ux.2500,43151
cp.2697,ux.2486,43152
cp.2698,ux.2501,18196
cp.2699,ux.2484,18194
cp.2700,ux.2470,18068
cp.2701,ux.2473,18071
cp.2702,ux.2496,43099
cp.2703,ux.2498,43101
cp.2704,ux.2533,43340
cp.2705,ux.2547,18412
cp.2706,ux.2531,18410
cp.2707,ux.2517,18284
cp.2708,ux.2520,18287
cp.2709,ux.2543,43288
cp.2710,ux.2545,43290
cp.2711,ux.2576,43502
cp.2712,ux.2590,18628
cp.2713,ux.2574,18626
cp.2714,ux.2560,18500
cp.2715,ux.2563,18503
cp.2716,ux.2586,43450
cp.2717,ux.2588,43452
cp.2718,ux.2619,43664
cp.2719,ux.2633,18844
cp.2720,ux.2617,18842
cp.2721,ux.2603,18716
cp.2722,ux.2606,18719
cp.2723,ux.2629,43612
cp.2724,ux.2631,43614
cp.2725,ux.2662,19060
cp.2726,ux.2676,43826
cp.2727,ux.2660,19058
cp.2728,ux.2646,18932
cp.2729,ux.2649,18935
cp.2730,ux.2672,43774
cp.2731,ux.2674,43776
cp.2732,ux.2719,43988
cp.2733,ux.2705,19276
cp.2734,ux.2703,19274
cp.2735,ux.2689,19148
cp.2736,ux.2692,19151
cp.2737,ux.2715,43936
cp.2738,ux.2717,43938
cp.2739,ux.2748,44150
cp.2740,ux.2762,19492
cp.2741,ux.2746,19490
cp.2742,ux.2732,19364
cp.2743,ux.2735,19367
cp.2744,ux.2758,44098
cp.2745,ux.2760,44100
cp.2746,ux.2791,44312
cp.2747,ux.2805,19708
cp.2748,ux.2789,19706
cp.2749,ux.2775,19580
cp.2750,ux.2778,19583
cp.2751,ux.2801,44260
cp.2752,ux.2803,44262
cp.2753,ux.5712,63205
cp.2754,ux.5856,65545
cp.2755,ux.5789,64466
cp.2756,ux.5645,62126
cp.2757,ux.2505,43156
cp.2758,ux.2487,43154
cp.2759,ux.2503,18197
cp.2760,ux.2485,18195
cp.2761,ux.2472,18070
cp.2762,ux.2475,18073
cp.2763,ux.2497,43100
cp.2764,ux.2499,43102
cp.2765,ux.2534,43342
cp.2766,ux.2549,18413
cp.2767,ux.2532,18411
cp.2768,ux.2519,18286
cp.2769,ux.2522,18289
cp.2770,ux.2544,43289
cp.2771,ux.2546,43291
cp.2772,ux.2577,43504
cp.2773,ux.2592,18629
cp.2774,ux.2575,18627
cp.2775,ux.2562,18502
cp.2776,ux.2565,18505
cp.2777,ux.2587,43451
cp.2778,ux.2589,43453
cp.2779,ux.2620,43666
cp.2780,ux.2635,18845
cp.2781,ux.2618,18843
cp.2782,ux.2605,18718
cp.2783,ux.2608,18721
cp.2784,ux.2630,43613
cp.2785,ux.2632,43615
cp.2786,ux.2663,19061
cp.2787,ux.2678,43828
cp.2788,ux.2661,19059
cp.2789,ux.2648,18934
cp.2790,ux.2651,18937
cp.2791,ux.2673,43775
cp.2792,ux.2675,43777
cp.2793,ux.2721,43990
cp.2794,ux.2706,19277
cp.2795,ux.2704,19275
cp.2796,ux.2691,19150
cp.2797,ux.2694,19153
cp.2798,ux.2716,43937
cp.2799,ux.2718,43939
cp.2800,ux.2749,44152
cp.2801,ux.2764,19493
cp.2802,ux.2747,19491
cp.2803,ux.2734,19366
cp.2804,ux.2737,19369
cp.2805,ux.2759,44099
cp.2806,ux.2761,44101
cp.2807,ux.2792,44314
cp.2808,ux.2807,19709
cp.2809,ux.2790,19707
cp.2810,ux.2777,19582
cp.2811,ux.2780,19585
cp.2812,ux.2802,44261
cp.2813,ux.2804,44263
cp.2814,ux.5713,63206
cp.2815,ux.5857,65546
cp.2816,ux.5788,64465
cp.2817,ux.5644,62125
cp.2818,ux.2504,43155
cp.2819,ux.2483,43153
cp.2820,ux.2502,18177
cp.2821,ux.2482,18176
cp.2822,ux.2471,18069
cp.2823,ux.2474,18072
cp.2824,ux.2495,43098
cp.2825,ux.2494,43097
cp.2826,ux.2530,43341
cp.2827,ux.2548,18393
cp.2828,ux.2529,18392
cp.2829,ux.2518,18285
cp.2830,ux.2521,18288
cp.2831,ux.2542,43287
cp.2832,ux.2541,43286
cp.2833,ux.2573,43503
cp.2834,ux.2591,18609
cp.2835,ux.2572,18608
cp.2836,ux.2561,18501
cp.2837,ux.2564,18504
cp.2838,ux.2585,43449
cp.2839,ux.2584,43448
cp.2840,ux.2616,43665
cp.2841,ux.2634,18825
cp.2842,ux.2615,18824
cp.2843,ux.2604,18717
cp.2844,ux.2607,18720
cp.2845,ux.2628,43611
cp.2846,ux.2627,43610
cp.2847,ux.2659,19041
cp.2848,ux.2677,43827
cp.2849,ux.2658,19040
cp.2850,ux.2647,18933
cp.2851,ux.2650,18936
cp.2852,ux.2671,43773
cp.2853,ux.2670,43772
cp.2854,ux.2720,43989
cp.2855,ux.2702,19257
cp.2856,ux.2701,19256
cp.2857,ux.2690,19149
cp.2858,ux.2693,19152
cp.2859,ux.2714,43935
cp.2860,ux.2713,43934
cp.2861,ux.2745,44151
cp.2862,ux.2763,19473
cp.2863,ux.2744,19472
cp.2864,ux.2733,19365
cp.2865,ux.2736,19368
cp.2866,ux.2757,44097
cp.2867,ux.2756,44096
cp.2868,ux.2788,44313
cp.2869,ux.2806,19689
cp.2870,ux.2787,19688
cp.2871,ux.2776,19581
cp.2872,ux.2779,19584
cp.2873,ux.2800,44259
cp.2874,ux.2799,44258
cp.2875,ux.5710,63186
cp.2876,ux.5854,65526
cp.2877,ux.2478,18140
cp.2878,ux.2479,18141
cp.2879,ux.2476,18122
cp.2880,ux.2525,18356
cp.2881,ux.2526,18357
cp.2882,ux.2523,18338
cp.2883,ux.2568,18572
cp.2884,ux.2569,18573
cp.2885,ux.2566,18554
cp.2886,ux.2611,18788
cp.2887,ux.2612,18789
cp.2888,ux.2609,18770
cp.2889,ux.2654,19004
cp.2890,ux.2655,19005
cp.2891,ux.2652,18986
cp.2892,ux.2697,19220
cp.2893,ux.2698,19221
cp.2894,ux.2695,19202
cp.2895,ux.2740,19436
cp.2896,ux.2741,19437
cp.2897,ux.2738,19418
cp.2898,ux.2783,19652
cp.2899,ux.2784,19653
cp.2900,ux.2781,19634
cp.2901,ux.2480,18142
cp.2902,ux.2507,43206
cp.2903,ux.2481,18143
cp.2904,ux.2509,43208
cp.2905,ux.2477,18123
cp.2906,ux.2508,43207
cp.2907,ux.2527,18358
cp.2908,ux.2551,43368
cp.2909,ux.2528,18359
cp.2910,ux.2553,43370
cp.2911,ux.2524,18339
cp.2912,ux.2552,43369
cp.2913,ux.2570,18574
cp.2914,ux.2594,43530
cp.2915,ux.2571,18575
cp.2916,ux.2596,43532
cp.2917,ux.2567,18555
cp.2918,ux.2595,43531
cp.2919,ux.2613,18790
cp.2920,ux.2637,43692
cp.2921,ux.2614,18791
cp.2922,ux.2639,43694
cp.2923,ux.2610,18771
cp.2924,ux.2638,43693
cp.2925,ux.2656,19006
cp.2926,ux.2680,43854
cp.2927,ux.2657,19007
cp.2928,ux.2682,43856
cp.2929,ux.2653,18987
cp.2930,ux.2681,43855
cp.2931,ux.2699,19222
cp.2932,ux.2723,44016
cp.2933,ux.2700,19223
cp.2934,ux.2725,44018
cp.2935,ux.2696,19203
cp.2936,ux.2724,44017
cp.2937,ux.2742,19438
cp.2938,ux.2766,44178
cp.2939,ux.2743,19439
cp.2940,ux.2768,44180
cp.2941,ux.2739,19419
cp.2942,ux.2767,44179
cp.2943,ux.2785,19654
cp.2944,ux.2809,44340
cp.2945,ux.2786,19655
cp.2946,ux.2811,44342
cp.2947,ux.2782,19635
cp.2948,ux.2810,44341
cp.2949,ux.5774,64214
cp.2950,ux.5630,61874
cp.2951,ux.2516,57983
cp.2952,ux.2506,43205
cp.2953,ux.2511,43210
cp.2954,ux.2510,43209
cp.2955,ux.2515,57957
cp.2956,ux.2550,43367
cp.2957,ux.2555,43372
cp.2958,ux.2554,43371
cp.2959,ux.2559,58020
cp.2960,ux.2593,43529
cp.2961,ux.2598,43534
cp.2962,ux.2597,43533
cp.2963,ux.2602,58065
cp.2964,ux.2636,43691
cp.2965,ux.2641,43696
cp.2966,ux.2640,43695
cp.2967,ux.2645,58110
cp.2968,ux.2679,43853
cp.2969,ux.2684,43858
cp.2970,ux.2683,43857
cp.2971,ux.2688,58155
cp.2972,ux.2722,44015
cp.2973,ux.2727,44020
cp.2974,ux.2726,44019
cp.2975,ux.2731,58200
cp.2976,ux.2765,44177
cp.2977,ux.2770,44182
cp.2978,ux.2769,44181
cp.2979,ux.2774,58245
cp.2980,ux.2808,44339
cp.2981,ux.2813,44344
cp.2982,ux.2812,44343
cp.2983,ux.2817,58290
cp.2984,ux.5709,63168
cp.2985,ux.5853,65508
cp.2986,ux.2837,19959
cp.2987,ux.2861,44583
cp.2988,ux.2841,19979
cp.2989,ux.2862,44584
cp.2990,ux.2840,19978
cp.2991,ux.2860,44582

cp,2992,ux,2884,20175
cp,2993,ux,2905,44745
cp,2994,ux,2888,20195
cp,2995,ux,2906,44746
cp,2996,ux,2887,20194
cp,2997,ux,2904,44744
cp,2998,ux,2927,20391
cp,2999,ux,2948,44907
cp,3000,ux,2931,20411
cp,3001,ux,2949,44908
cp,3002,ux,2930,20410
cp,3003,ux,2947,44906
cp,3004,ux,2970,20607
cp,3005,ux,2991,45069
cp,3006,ux,2974,20627
cp,3007,ux,2992,45070
cp,3008,ux,2973,20626
cp,3009,ux,2990,45068
cp,3010,ux,3013,20823
cp,3011,ux,3034,45231
cp,3012,ux,3017,20843
cp,3013,ux,3035,45232
cp,3014,ux,3016,20842
cp,3015,ux,3033,45230
cp,3016,ux,3056,21039
cp,3017,ux,3077,45393
cp,3018,ux,3060,21059
cp,3019,ux,3078,45394
cp,3020,ux,3059,21058
cp,3021,ux,3076,45392
cp,3022,ux,3099,21255
cp,3023,ux,3120,45555
cp,3024,ux,3103,21275
cp,3025,ux,3121,45556
cp,3026,ux,3102,21274
cp,3027,ux,3119,45554
cp,3028,ux,3142,21471
cp,3029,ux,3163,45717
cp,3030,ux,3146,21491
cp,3031,ux,3164,45718
cp,3032,ux,3145,21490
cp,3033,ux,3162,45716
cp,3034,ux,2836,19958
cp,3035,ux,2839,19977
cp,3036,ux,2838,19976
cp,3037,ux,2883,20174
cp,3038,ux,2886,20193
cp,3039,ux,2885,20192
cp,3040,ux,2926,20390
cp,3041,ux,2929,20409
cp,3042,ux,2928,20408
cp,3043,ux,2969,20606
cp,3044,ux,2972,20625
cp,3045,ux,2971,20624
cp,3046,ux,3012,20822
cp,3047,ux,3015,20841
cp,3048,ux,3014,20840
cp,3049,ux,3055,21038
cp,3050,ux,3058,21057
cp,3051,ux,3057,21056
cp,3052,ux,3098,21254
cp,3053,ux,3101,21273
cp,3054,ux,3100,21272
cp,3055,ux,3141,21470
cp,3056,ux,3144,21489
cp,3057,ux,3143,21488
cp,3058,ux,5773,64213
cp,3059,ux,5629,61873
cp,3060,ux,2848,44474
cp,3061,ux,2834,44475
cp,3062,ux,2849,19924
cp,3063,ux,2832,19922
cp,3064,ux,2818,19796
cp,3065,ux,2821,19799
cp,3066,ux,2844,44422
cp,3067,ux,2846,44424
cp,3068,ux,2881,44663
cp,3069,ux,2895,20140
cp,3070,ux,2879,20138
cp,3071,ux,2865,20012
cp,3072,ux,2868,20015
cp,3073,ux,2891,44611
cp,3074,ux,2893,44613
cp,3075,ux,2924,44825
cp,3076,ux,2938,20356
cp,3077,ux,2922,20354
cp,3078,ux,2908,20228
cp,3079,ux,2911,20231
cp,3080,ux,2934,44773
cp,3081,ux,2936,44775
cp,3082,ux,2967,44987
cp,3083,ux,2981,20572
cp,3084,ux,2965,20570
cp,3085,ux,2951,20444
cp,3086,ux,2954,20447
cp,3087,ux,2977,44935
cp,3088,ux,2979,44937
cp,3089,ux,3010,20788
cp,3090,ux,3024,45149
cp,3091,ux,3008,20786
cp,3092,ux,2994,20660
cp,3093,ux,2997,20663
cp,3094,ux,3020,45097
cp,3095,ux,3022,45099
cp,3096,ux,3067,45311
cp,3097,ux,3053,21004
cp,3098,ux,3051,21002
cp,3099,ux,3037,20876
cp,3100,ux,3040,20879
cp,3101,ux,3063,45259
cp,3102,ux,3065,45261
cp,3103,ux,3096,45473
cp,3104,ux,3110,21220
cp,3105,ux,3094,21218
cp,3106,ux,3080,21092
cp,3107,ux,3083,21095
cp,3108,ux,3106,45421
cp,3109,ux,3108,45423
cp,3110,ux,3139,45635
cp,3111,ux,3153,21436
cp,3112,ux,3137,21434
cp,3113,ux,3123,21308
cp,3114,ux,3126,21311
cp,3115,ux,3149,45583
cp,3116,ux,3151,45585
cp,3117,ux,5707,63133
cp,3118,ux,5851,65473
cp,3119,ux,5776,64250
cp,3120,ux,5632,61910
cp,3121,ux,2853,44479
cp,3122,ux,2835,44477
cp,3123,ux,2851,19925
cp,3124,ux,2833,19923
cp,3125,ux,2820,19798
cp,3126,ux,2823,19801
cp,3127,ux,2845,44423
cp,3128,ux,2847,44425
cp,3129,ux,2882,44665
cp,3130,ux,2897,20141
cp,3131,ux,2880,20139
cp,3132,ux,2867,20014
cp,3133,ux,2870,20017
cp,3134,ux,2892,44612
cp,3135,ux,2894,44614
cp,3136,ux,2925,44827
cp,3137,ux,2940,20357
cp,3138,ux,2923,20355
cp,3139,ux,2910,20230
cp,3140,ux,2913,20233
cp,3141,ux,2935,44774
cp,3142,ux,2937,44776
cp,3143,ux,2968,44989
cp,3144,ux,2983,20573
cp,3145,ux,2966,20571
cp,3146,ux,2953,20446
cp,3147,ux,2956,20449
cp,3148,ux,2978,44936
cp,3149,ux,2980,44938
cp,3150,ux,3011,20789
cp,3151,ux,3026,45151
cp,3152,ux,3009,20787
cp,3153,ux,2996,20662
cp,3154,ux,2999,20665
cp,3155,ux,3021,45098
cp,3156,ux,3023,45100
cp,3157,ux,3069,45313
cp,3158,ux,3054,21005
cp,3159,ux,3052,21003
cp,3160,ux,3039,20878
cp,3161,ux,3042,20881
cp,3162,ux,3064,45260
cp,3163,ux,3066,45262
cp,3164,ux,3097,45475
cp,3165,ux,3112,21221
cp,3166,ux,3095,21219
cp,3167,ux,3082,21094
cp,3168,ux,3085,21097
cp,3169,ux,3107,45422
cp,3170,ux,3109,45424
cp,3171,ux,3140,45637
cp,3172,ux,3155,21437
cp,3173,ux,3138,21435
cp,3174,ux,3125,21310
cp,3175,ux,3128,21313
cp,3176,ux,3150,45584
cp,3177,ux,3152,45586
cp,3178,ux,5708,63134
cp,3179,ux,5852,65474
cp,3180,ux,5775,64249
cp,3181,ux,5631,61909
cp,3182,ux,2852,44478
cp,3183,ux,2831,44476
cp,3184,ux,2850,19905
cp,3185,ux,2830,19904
cp,3186,ux,2819,19797
cp,3187,ux,2822,19800
cp,3188,ux,2843,44421
cp,3189,ux,2842,44420
cp,3190,ux,2878,44664
cp,3191,ux,2896,20121
cp,3192,ux,2877,20120
cp,3193,ux,2866,20013
cp,3194,ux,2869,20016
cp,3195,ux,2890,44610
cp,3196,ux,2889,44609
cp,3197,ux,2921,44826
cp,3198,ux,2939,20337
cp,3199,ux,2920,20336
cp,3200,ux,2909,20229
cp,3201,ux,2912,20232
cp,3202,ux,2933,44772
cp,3203,ux,2932,44771
cp,3204,ux,2964,44988
cp,3205,ux,2982,20553
cp,3206,ux,2963,20552
cp,3207,ux,2952,20445
cp,3208,ux,2955,20448
cp,3209,ux,2976,44934
cp,3210,ux,2975,44933
cp,3211,ux,3007,20769
cp,3212,ux,3025,45150
cp,3213,ux,3006,20768
cp,3214,ux,2995,20661
cp,3215,ux,2998,20664
cp,3216,ux,3019,45096
cp,3217,ux,3018,45095
cp,3218,ux,3068,45312
cp,3219,ux,3050,20985
cp,3220,ux,3049,20984
cp,3221,ux,3038,20877
cp,3222,ux,3041,20880
cp,3223,ux,3062,45258
cp,3224,ux,3061,45257
cp,3225,ux,3093,45474
cp,3226,ux,3111,21201
cp,3227,ux,3092,21200
cp,3228,ux,3081,21093
cp,3229,ux,3084,21096
cp,3230,ux,3105,45420
cp,3231,ux,3104,45419
cp,3232,ux,3136,45636
cp,3233,ux,3154,21417
cp,3234,ux,3135,21416
cp,3235,ux,3124,21309
cp,3236,ux,3127,21312
cp,3237,ux,3148,45582
cp,3238,ux,3147,45581
cp,3239,ux,5705,63114
cp,3240,ux,5850,65454
cp,3241,ux,2826,19868
cp,3242,ux,2827,19869
cp,3243,ux,2824,19850
cp,3244,ux,2873,20084
cp,3245,ux,2874,20085
cp,3246,ux,2871,20066
cp,3247,ux,2916,20300
cp,3248,ux,2917,20301
cp,3249,ux,2914,20282
cp,3250,ux,2959,20516
cp,3251,ux,2960,20517
cp,3252,ux,2957,20498
cp,3253,ux,3002,20732
cp,3254,ux,3003,20733
cp,3255,ux,3000,20714
cp,3256,ux,3045,20948
cp,3257,ux,3046,20949
cp,3258,ux,3043,20930
cp,3259,ux,3088,21164
cp,3260,ux,3089,21165
cp,3261,ux,3086,21146
cp,3262,ux,3131,21380
cp,3263,ux,3132,21381
cp,3264,ux,3129,21362
cp,3265,ux,2828,19870
cp,3266,ux,2855,44529
cp,3267,ux,2829,19871
cp,3268,ux,2857,44531
cp,3269,ux,2825,19851
cp,3270,ux,2856,44530
cp,3271,ux,2875,20086
cp,3272,ux,2899,44691
cp,3273,ux,2876,20087
cp,3274,ux,2901,44693
cp,3275,ux,2872,20067
cp,3276,ux,2900,44692
cp,3277,ux,2918,20302
cp,3278,ux,2942,44853
cp,3279,ux,2919,20303
cp,3280,ux,2944,44855
cp,3281,ux,2915,20283
cp,3282,ux,2943,44854
cp,3283,ux,2961,20518
cp,3284,ux,2985,45015
cp,3285,ux,2962,20519
cp,3286,ux,2987,45017
cp,3287,ux,2958,20499
cp,3288,ux,2986,45016
cp,3289,ux,3004,20734
cp,3290,ux,3028,45177
cp,3291,ux,3005,20735
cp,3292,ux,3030,45179
cp,3293,ux,3001,20715
cp,3294,ux,3029,45178
cp,3295,ux,3047,20950
cp,3296,ux,3071,45339
cp,3297,ux,3048,20951
cp,3298,ux,3073,45341
cp,3299,ux,3044,20931
cp,3300,ux,3072,45340
cp,3301,ux,3090,21166
cp,3302,ux,3114,45501
cp,3303,ux,3091,21167
cp,3304,ux,3116,45503
cp,3305,ux,3087,21147
cp,3306,ux,3115,45502
cp,3307,ux,3133,21382
cp,3308,ux,3157,45663
cp,3309,ux,3134,21383
cp,3310,ux,3159,45665
cp,3311,ux,3130,21363
cp,3312,ux,3158,45664
cp,3313,ux,5777,64284
cp,3314,ux,5633,61944
cp,3315,ux,2864,58370
cp,3316,ux,2854,44528
cp,3317,ux,2859,44533
cp,3318,ux,2858,44532
cp,3319,ux,2863,58344
cp,3320,ux,2898,44690
cp,3321,ux,2903,44695
cp,3322,ux,2902,44694
cp,3323,ux,2907,58407

cp,3324,ux,2941,44852
cp,3325,ux,2946,44857
cp,3326,ux,2945,44856
cp,3327,ux,2950,58452
cp,3328,ux,2984,45014
cp,3329,ux,2989,45019
cp,3330,ux,2988,45018
cp,3331,ux,2993,58497
cp,3332,ux,3027,45176
cp,3333,ux,3032,45181
cp,3334,ux,3031,45180
cp,3335,ux,3036,58542
cp,3336,ux,3070,45338
cp,3337,ux,3075,45343
cp,3338,ux,3074,45342
cp,3339,ux,3079,58587
cp,3340,ux,3113,45500
cp,3341,ux,3118,45505
cp,3342,ux,3117,45504
cp,3343,ux,3122,58632
cp,3344,ux,3156,45662
cp,3345,ux,3161,45667
cp,3346,ux,3160,45666
cp,3347,ux,3165,58677
cp,3348,ux,5705,63096
cp,3349,ux,5849,65436
cp,3350,ux,3209,45906
cp,3351,ux,3210,45907
cp,3352,ux,3208,45905
cp,3353,ux,3253,46068
cp,3354,ux,3254,46069
cp,3355,ux,3252,46067
cp,3356,ux,3296,46230
cp,3357,ux,3297,46231
cp,3358,ux,3295,46229
cp,3359,ux,3339,46392
cp,3360,ux,3340,46393
cp,3361,ux,3338,46391
cp,3362,ux,3382,46554
cp,3363,ux,3383,46555
cp,3364,ux,3381,46553
cp,3365,ux,3425,46716
cp,3366,ux,3426,46717
cp,3367,ux,3424,46715
cp,3368,ux,3468,46878
cp,3369,ux,3469,46879
cp,3370,ux,3467,46877
cp,3371,ux,3511,47040
cp,3372,ux,3512,47041
cp,3373,ux,3510,47039
cp,3374,ux,3185,21687
cp,3375,ux,3189,21707
cp,3376,ux,3188,21706
cp,3377,ux,3232,21903
cp,3378,ux,3236,21923
cp,3379,ux,3235,21922
cp,3380,ux,3275,22119
cp,3381,ux,3279,22139
cp,3382,ux,3278,22138
cp,3383,ux,3318,22335
cp,3384,ux,3322,22355
cp,3385,ux,3321,22354
cp,3386,ux,3361,22551
cp,3387,ux,3365,22571
cp,3388,ux,3364,22570
cp,3389,ux,3404,22767
cp,3390,ux,3408,22787
cp,3391,ux,3407,22786
cp,3392,ux,3447,22983
cp,3393,ux,3451,23003
cp,3394,ux,3450,23002
cp,3395,ux,3490,23199
cp,3396,ux,3494,23219
cp,3397,ux,3493,23218
cp,3398,ux,3184,21686
cp,3399,ux,3187,21705
cp,3400,ux,3186,21704
cp,3401,ux,3231,21902
cp,3402,ux,3234,21921
cp,3403,ux,3233,21920
cp,3404,ux,3274,22118
cp,3405,ux,3277,22137
cp,3406,ux,3276,22136
cp,3407,ux,3317,22334
cp,3408,ux,3320,22353
cp,3409,ux,3319,22352
cp,3410,ux,3360,22550
cp,3411,ux,3363,22569
cp,3412,ux,3362,22568
cp,3413,ux,3403,22766
cp,3414,ux,3406,22785
cp,3415,ux,3405,22784
cp,3416,ux,3446,22982
cp,3417,ux,3449,23001
cp,3418,ux,3448,23000
cp,3419,ux,3489,23198
cp,3420,ux,3492,23217
cp,3421,ux,3491,23216
cp,3422,ux,5778,64302
cp,3423,ux,5634,61962
cp,3424,ux,3196,45797
cp,3425,ux,3182,45798
cp,3426,ux,3197,21652
cp,3427,ux,3180,21650
cp,3428,ux,3166,21524
cp,3429,ux,3169,21527
cp,3430,ux,3192,45745
cp,3431,ux,3194,45747
cp,3432,ux,3229,45986
cp,3433,ux,3243,21868
cp,3434,ux,3227,21866
cp,3435,ux,3213,21740
cp,3436,ux,3216,21743
cp,3437,ux,3239,45934
cp,3438,ux,3241,45936
cp,3439,ux,3272,46148
cp,3440,ux,3286,22084
cp,3441,ux,3270,22082
cp,3442,ux,3256,21956
cp,3443,ux,3259,21959
cp,3444,ux,3282,46096
cp,3445,ux,3284,46098
cp,3446,ux,3315,46310
cp,3447,ux,3329,22300
cp,3448,ux,3313,22298
cp,3449,ux,3299,22172
cp,3450,ux,3302,22175
cp,3451,ux,3325,46258
cp,3452,ux,3327,46260
cp,3453,ux,3358,22516
cp,3454,ux,3372,46472
cp,3455,ux,3356,22514
cp,3456,ux,3342,22388
cp,3457,ux,3345,22391
cp,3458,ux,3368,46420
cp,3459,ux,3370,46422
cp,3460,ux,3415,46634
cp,3461,ux,3401,22732
cp,3462,ux,3399,22730
cp,3463,ux,3385,22604
cp,3464,ux,3388,22607
cp,3465,ux,3411,46582
cp,3466,ux,3413,46584
cp,3467,ux,3444,46796
cp,3468,ux,3458,22948
cp,3469,ux,3442,22946
cp,3470,ux,3428,22820
cp,3471,ux,3431,22823
cp,3472,ux,3454,46744
cp,3473,ux,3456,46746
cp,3474,ux,3487,46958
cp,3475,ux,3501,23164
cp,3476,ux,3485,23162
cp,3477,ux,3471,23036
cp,3478,ux,3474,23039
cp,3479,ux,3497,46906
cp,3480,ux,3499,46908
cp,3481,ux,5703,63061
cp,3482,ux,5847,65401
cp,3483,ux,5780,64322
cp,3484,ux,5636,61982
cp,3485,ux,3201,45802
cp,3486,ux,3183,45800
cp,3487,ux,3199,21653
cp,3488,ux,3181,21651
cp,3489,ux,3168,21526
cp,3490,ux,3171,21529
cp,3491,ux,3193,45746
cp,3492,ux,3195,45748
cp,3493,ux,3230,45988
cp,3494,ux,3245,21869
cp,3495,ux,3228,21867
cp,3496,ux,3215,21742
cp,3497,ux,3218,21745
cp,3498,ux,3240,45935
cp,3499,ux,3242,45937
cp,3500,ux,3273,46150
cp,3501,ux,3288,22085
cp,3502,ux,3271,22083
cp,3503,ux,3258,21958
cp,3504,ux,3261,21961
cp,3505,ux,3283,46097
cp,3506,ux,3285,46099
cp,3507,ux,3316,46312
cp,3508,ux,3331,22301
cp,3509,ux,3314,22299
cp,3510,ux,3301,22174
cp,3511,ux,3304,22177
cp,3512,ux,3326,46259
cp,3513,ux,3328,46261
cp,3514,ux,3359,22517
cp,3515,ux,3374,46474
cp,3516,ux,3357,22515
cp,3517,ux,3344,22390
cp,3518,ux,3347,22393
cp,3519,ux,3369,46421
cp,3520,ux,3371,46423
cp,3521,ux,3417,46636
cp,3522,ux,3402,22733
cp,3523,ux,3400,22731
cp,3524,ux,3387,22606
cp,3525,ux,3390,22609
cp,3526,ux,3412,46583
cp,3527,ux,3414,46585
cp,3528,ux,3445,46798
cp,3529,ux,3460,22949
cp,3530,ux,3443,22947
cp,3531,ux,3430,22822
cp,3532,ux,3433,22825
cp,3533,ux,3455,46745
cp,3534,ux,3457,46747
cp,3535,ux,3488,46960
cp,3536,ux,3503,23165
cp,3537,ux,3486,23163
cp,3538,ux,3473,23038
cp,3539,ux,3476,23041
cp,3540,ux,3498,46907
cp,3541,ux,3500,46909
cp,3542,ux,5704,63062
cp,3543,ux,5848,65402
cp,3544,ux,5779,64321
cp,3545,ux,5635,61981
cp,3546,ux,3200,45801
cp,3547,ux,3179,45799
cp,3548,ux,3198,21633
cp,3549,ux,3178,21632
cp,3550,ux,3167,21525
cp,3551,ux,3170,21528
cp,3552,ux,3191,45744
cp,3553,ux,3190,45743
cp,3554,ux,3226,45987
cp,3555,ux,3244,21849
cp,3556,ux,3225,21848
cp,3557,ux,3214,21741
cp,3558,ux,3217,21744
cp,3559,ux,3238,45933
cp,3560,ux,3237,45932
cp,3561,ux,3269,46149
cp,3562,ux,3287,22065
cp,3563,ux,3268,22064
cp,3564,ux,3257,21957
cp,3565,ux,3260,21960
cp,3566,ux,3281,46095
cp,3567,ux,3280,46094
cp,3568,ux,3312,46311
cp,3569,ux,3330,22281
cp,3570,ux,3311,22280
cp,3571,ux,3300,22173
cp,3572,ux,3303,22176
cp,3573,ux,3324,46257
cp,3574,ux,3323,46256
cp,3575,ux,3355,22497
cp,3576,ux,3373,46473
cp,3577,ux,3354,22496
cp,3578,ux,3343,22389
cp,3579,ux,3346,22392
cp,3580,ux,3367,46419
cp,3581,ux,3366,46418
cp,3582,ux,3416,46635
cp,3583,ux,3398,22713
cp,3584,ux,3397,22712
cp,3585,ux,3386,22605
cp,3586,ux,3389,22608
cp,3587,ux,3410,46581
cp,3588,ux,3409,46580
cp,3589,ux,3441,46797
cp,3590,ux,3459,22929
cp,3591,ux,3440,22928
cp,3592,ux,3429,22821
cp,3593,ux,3432,22824
cp,3594,ux,3453,46743
cp,3595,ux,3452,46742
cp,3596,ux,3484,46959
cp,3597,ux,3502,23145
cp,3598,ux,3483,23144
cp,3599,ux,3472,23037
cp,3600,ux,3475,23040
cp,3601,ux,3496,46905
cp,3602,ux,3495,46904
cp,3603,ux,5701,63042
cp,3604,ux,5845,65382
cp,3605,ux,3174,21596
cp,3606,ux,3175,21597
cp,3607,ux,3172,21578
cp,3608,ux,3221,21812
cp,3609,ux,3222,21813
cp,3610,ux,3219,21794
cp,3611,ux,3264,22028
cp,3612,ux,3265,22029
cp,3613,ux,3262,22010
cp,3614,ux,3307,22244
cp,3615,ux,3308,22245
cp,3616,ux,3305,22226
cp,3617,ux,3350,22460
cp,3618,ux,3351,22461
cp,3619,ux,3348,22442
cp,3620,ux,3393,22676
cp,3621,ux,3394,22677
cp,3622,ux,3391,22658
cp,3623,ux,3436,22892
cp,3624,ux,3437,22893
cp,3625,ux,3434,22874
cp,3626,ux,3479,23108
cp,3627,ux,3480,23109
cp,3628,ux,3477,23090
cp,3629,ux,3176,21598
cp,3630,ux,3203,45852
cp,3631,ux,3177,21599
cp,3632,ux,3205,45854
cp,3633,ux,3173,21579
cp,3634,ux,3204,45853
cp,3635,ux,3223,21814
cp,3636,ux,3247,46014
cp,3637,ux,3224,21815
cp,3638,ux,3249,46016
cp,3639,ux,3220,21795
cp,3640,ux,3248,46015
cp,3641,ux,3266,22030
cp,3642,ux,3290,46176
cp,3643,ux,3267,22031
cp,3644,ux,3292,46178
cp,3645,ux,3263,22011
cp,3646,ux,3291,46177
cp,3647,ux,3309,22246
cp,3648,ux,3333,46338
cp,3649,ux,3310,22247
cp,3650,ux,3335,46340
cp,3651,ux,3306,22227
cp,3652,ux,3334,46339
cp,3653,ux,3352,22462
cp,3654,ux,3376,46500
cp,3655,ux,3353,22463

cp,3656,ux,3378,46502
cp,3657,ux,3349,22443
cp,3658,ux,3377,46501
cp,3659,ux,3395,22678
cp,3660,ux,3419,46662
cp,3661,ux,3396,22679
cp,3662,ux,3421,46664
cp,3663,ux,3392,22659
cp,3664,ux,3420,46663
cp,3665,ux,3438,22894
cp,3666,ux,3462,46824
cp,3667,ux,3439,22895
cp,3668,ux,3464,46826
cp,3669,ux,3435,22875
cp,3670,ux,3463,46825
cp,3671,ux,3481,23110
cp,3672,ux,3505,46986
cp,3673,ux,3482,23111
cp,3674,ux,3507,46988
cp,3675,ux,3478,23091
cp,3676,ux,3506,46987
cp,3677,ux,5765,64070
cp,3678,ux,5621,61730
cp,3679,ux,3212,58757
cp,3680,ux,3202,45851
cp,3681,ux,3207,45856
cp,3682,ux,3206,45855
cp,3683,ux,3211,58731
cp,3684,ux,3246,46013
cp,3685,ux,3251,46018
cp,3686,ux,3250,46017
cp,3687,ux,3255,58794
cp,3688,ux,3289,46175
cp,3689,ux,3294,46180
cp,3690,ux,3293,46179
cp,3691,ux,3298,58839
cp,3692,ux,3332,46337
cp,3693,ux,3337,46342
cp,3694,ux,3336,46341
cp,3695,ux,3341,58884
cp,3696,ux,3375,46499
cp,3697,ux,3380,46504
cp,3698,ux,3379,46503
cp,3699,ux,3384,58929
cp,3700,ux,3418,46661
cp,3701,ux,3423,46666
cp,3702,ux,3422,46665
cp,3703,ux,3427,58974
cp,3704,ux,3461,46823
cp,3705,ux,3466,46828
cp,3706,ux,3465,46827
cp,3707,ux,3470,59019
cp,3708,ux,3504,46985
cp,3709,ux,3509,46990
cp,3710,ux,3508,46989
cp,3711,ux,3513,59064
cp,3712,ux,5700,63024
cp,3713,ux,5844,65364
cp,3714,ux,3533,23415
cp,3715,ux,3557,47229
cp,3716,ux,3537,23435
cp,3717,ux,3558,47230
cp,3718,ux,3536,23434
cp,3719,ux,3556,47228
cp,3720,ux,3580,23631
cp,3721,ux,3601,47391
cp,3722,ux,3584,23651
cp,3723,ux,3602,47392
cp,3724,ux,3583,23650
cp,3725,ux,3600,47390
cp,3726,ux,3623,23847
cp,3727,ux,3644,47553
cp,3728,ux,3627,23867
cp,3729,ux,3645,47554
cp,3730,ux,3626,23866
cp,3731,ux,3643,47552
cp,3732,ux,3666,24063
cp,3733,ux,3687,47715
cp,3734,ux,3670,24083
cp,3735,ux,3688,47716
cp,3736,ux,3669,24082
cp,3737,ux,3686,47714
cp,3738,ux,3709,24279
cp,3739,ux,3730,47877
cp,3740,ux,3713,24299
cp,3741,ux,3731,47878
cp,3742,ux,3712,24298
cp,3743,ux,3729,47876
cp,3744,ux,3752,24495
cp,3745,ux,3773,48039
cp,3746,ux,3756,24515
cp,3747,ux,3774,48040
cp,3748,ux,3755,24514
cp,3749,ux,3772,48038
cp,3750,ux,3795,24711
cp,3751,ux,3816,48201
cp,3752,ux,3799,24731
cp,3753,ux,3817,48202
cp,3754,ux,3798,24730
cp,3755,ux,3815,48200
cp,3756,ux,3838,24927
cp,3757,ux,3859,48363
cp,3758,ux,3842,24947
cp,3759,ux,3860,48364
cp,3760,ux,3841,24946
cp,3761,ux,3858,48362
cp,3762,ux,3532,23414
cp,3763,ux,3535,23433
cp,3764,ux,3534,23432
cp,3765,ux,3579,23630
cp,3766,ux,3582,23649
cp,3767,ux,3581,23648
cp,3768,ux,3622,23846
cp,3769,ux,3625,23865
cp,3770,ux,3624,23864
cp,3771,ux,3665,24062
cp,3772,ux,3668,24081
cp,3773,ux,3667,24080
cp,3774,ux,3708,24278
cp,3775,ux,3711,24297
cp,3776,ux,3710,24296
cp,3777,ux,3751,24494
cp,3778,ux,3754,24513
cp,3779,ux,3753,24512
cp,3780,ux,3794,24710
cp,3781,ux,3797,24729
cp,3782,ux,3796,24728
cp,3783,ux,3837,24926
cp,3784,ux,3840,24945
cp,3785,ux,3839,24944
cp,3786,ux,5764,64069
cp,3787,ux,5620,61729
cp,3788,ux,3544,47120
cp,3789,ux,3530,47121
cp,3790,ux,3545,23380
cp,3791,ux,3528,23378
cp,3792,ux,3514,23252
cp,3793,ux,3517,23255
cp,3794,ux,3540,47068
cp,3795,ux,3542,47070
cp,3796,ux,3577,47309
cp,3797,ux,3591,23596
cp,3798,ux,3575,23594
cp,3799,ux,3561,23468
cp,3800,ux,3564,23471
cp,3801,ux,3587,47257
cp,3802,ux,3589,47259
cp,3803,ux,3620,47471
cp,3804,ux,3634,23812
cp,3805,ux,3618,23810
cp,3806,ux,3604,23684
cp,3807,ux,3607,23687
cp,3808,ux,3630,47419
cp,3809,ux,3632,47421
cp,3810,ux,3663,47633
cp,3811,ux,3677,24028
cp,3812,ux,3661,24026
cp,3813,ux,3647,23900
cp,3814,ux,3650,23903
cp,3815,ux,3673,47581
cp,3816,ux,3675,47583
cp,3817,ux,3706,24244
cp,3818,ux,3720,47795
cp,3819,ux,3704,24242
cp,3820,ux,3690,24116
cp,3821,ux,3693,24119
cp,3822,ux,3716,47743
cp,3823,ux,3718,47745
cp,3824,ux,3763,47957
cp,3825,ux,3749,24460
cp,3826,ux,3747,24458
cp,3827,ux,3733,24332
cp,3828,ux,3736,24335
cp,3829,ux,3759,47905
cp,3830,ux,3761,47907
cp,3831,ux,3792,48119
cp,3832,ux,3806,24676
cp,3833,ux,3790,24674
cp,3834,ux,3776,24548
cp,3835,ux,3779,24551
cp,3836,ux,3802,48067
cp,3837,ux,3804,48069
cp,3838,ux,3835,48281
cp,3839,ux,3849,24892
cp,3840,ux,3833,24890
cp,3841,ux,3819,24764
cp,3842,ux,3822,24767
cp,3843,ux,3845,48229
cp,3844,ux,3847,48231
cp,3845,ux,5698,62989
cp,3846,ux,5842,65329
cp,3847,ux,5767,64106
cp,3848,ux,5623,61766
cp,3849,ux,3549,47125
cp,3850,ux,3531,47123
cp,3851,ux,3547,23381
cp,3852,ux,3529,23379
cp,3853,ux,3516,23254
cp,3854,ux,3519,23257
cp,3855,ux,3541,47069
cp,3856,ux,3543,47071
cp,3857,ux,3578,47311
cp,3858,ux,3593,23597
cp,3859,ux,3576,23595
cp,3860,ux,3563,23470
cp,3861,ux,3566,23473
cp,3862,ux,3588,47258
cp,3863,ux,3590,47260
cp,3864,ux,3621,47473
cp,3865,ux,3636,23813
cp,3866,ux,3619,23811
cp,3867,ux,3606,23686
cp,3868,ux,3609,23689
cp,3869,ux,3631,47420
cp,3870,ux,3633,47422
cp,3871,ux,3664,47635
cp,3872,ux,3679,24029
cp,3873,ux,3662,24027
cp,3874,ux,3649,23902
cp,3875,ux,3652,23905
cp,3876,ux,3674,47582
cp,3877,ux,3676,47584
cp,3878,ux,3707,24245
cp,3879,ux,3722,47797
cp,3880,ux,3705,24243
cp,3881,ux,3692,24118
cp,3882,ux,3695,24121
cp,3883,ux,3717,47744
cp,3884,ux,3719,47746
cp,3885,ux,3765,47959
cp,3886,ux,3750,24461
cp,3887,ux,3748,24459
cp,3888,ux,3735,24334
cp,3889,ux,3738,24337
cp,3890,ux,3760,47906
cp,3891,ux,3762,47908
cp,3892,ux,3793,48121
cp,3893,ux,3808,24677
cp,3894,ux,3791,24675
cp,3895,ux,3778,24550
cp,3896,ux,3781,24553
cp,3897,ux,3803,48068
cp,3898,ux,3805,48070
cp,3899,ux,3836,48283
cp,3900,ux,3851,24893
cp,3901,ux,3834,24891
cp,3902,ux,3821,24766
cp,3903,ux,3824,24769
cp,3904,ux,3846,48230
cp,3905,ux,3848,48232
cp,3906,ux,5699,62990
cp,3907,ux,5843,65330
cp,3908,ux,5766,64105
cp,3909,ux,5622,61765
cp,3910,ux,3548,47124
cp,3911,ux,3527,47122
cp,3912,ux,3546,23361
cp,3913,ux,3526,23360
cp,3914,ux,3515,23253
cp,3915,ux,3518,23256
cp,3916,ux,3539,47067
cp,3917,ux,3538,47066
cp,3918,ux,3574,47310
cp,3919,ux,3592,23577
cp,3920,ux,3573,23576
cp,3921,ux,3562,23469
cp,3922,ux,3565,23472
cp,3923,ux,3586,47256
cp,3924,ux,3585,47255
cp,3925,ux,3617,47472
cp,3926,ux,3635,23793
cp,3927,ux,3616,23792
cp,3928,ux,3605,23685
cp,3929,ux,3608,23688
cp,3930,ux,3629,47418
cp,3931,ux,3628,47417
cp,3932,ux,3660,47634
cp,3933,ux,3678,24009
cp,3934,ux,3659,24008
cp,3935,ux,3648,23901
cp,3936,ux,3651,23904
cp,3937,ux,3672,47580
cp,3938,ux,3671,47579
cp,3939,ux,3703,24225
cp,3940,ux,3721,47796
cp,3941,ux,3702,24224
cp,3942,ux,3691,24117
cp,3943,ux,3694,24120
cp,3944,ux,3715,47742
cp,3945,ux,3714,47741
cp,3946,ux,3764,47958
cp,3947,ux,3746,24441
cp,3948,ux,3745,24440
cp,3949,ux,3734,24333
cp,3950,ux,3737,24336
cp,3951,ux,3758,47904
cp,3952,ux,3757,47903
cp,3953,ux,3789,48120
cp,3954,ux,3807,24657
cp,3955,ux,3788,24656
cp,3956,ux,3777,24549
cp,3957,ux,3780,24552
cp,3958,ux,3801,48066
cp,3959,ux,3800,48065
cp,3960,ux,3832,48282
cp,3961,ux,3850,24873
cp,3962,ux,3831,24872
cp,3963,ux,3820,24765
cp,3964,ux,3823,24768
cp,3965,ux,3844,48228
cp,3966,ux,3843,48227
cp,3967,ux,5697,62970
cp,3968,ux,5841,65310
cp,3969,ux,3522,23324
cp,3970,ux,3523,23325
cp,3971,ux,3520,23306
cp,3972,ux,3569,23540
cp,3973,ux,3570,23541
cp,3974,ux,3567,23522
cp,3975,ux,3612,23756
cp,3976,ux,3613,23757
cp,3977,ux,3610,23738
cp,3978,ux,3655,23972
cp,3979,ux,3656,23973
cp,3980,ux,3653,23954
cp,3981,ux,3698,24188
cp,3982,ux,3699,24189
cp,3983,ux,3696,24170
cp,3984,ux,3741,24404
cp,3985,ux,3742,24405
cp,3986,ux,3739,24386
cp,3987,ux,3784,24620

cp,3988,ux,3785,24621
cp,3989,ux,3782,24602
cp,3990,ux,3827,24836
cp,3991,ux,3828,24837
cp,3992,ux,3825,24818
cp,3993,ux,3524,23326
cp,3994,ux,3551,47175
cp,3995,ux,3525,23327
cp,3996,ux,3553,47177
cp,3997,ux,3521,23307
cp,3998,ux,3552,47176
cp,3999,ux,3571,23542
cp,4000,ux,3595,47337
cp,4001,ux,3572,23543
cp,4002,ux,3597,47339
cp,4003,ux,3568,23523
cp,4004,ux,3596,47338
cp,4005,ux,3614,23758
cp,4006,ux,3638,47499
cp,4007,ux,3615,23759
cp,4008,ux,3640,47501
cp,4009,ux,3611,23739
cp,4010,ux,3639,47500
cp,4011,ux,3657,23974
cp,4012,ux,3681,47661
cp,4013,ux,3658,23975
cp,4014,ux,3683,47663
cp,4015,ux,3654,23955
cp,4016,ux,3682,47662
cp,4017,ux,3700,24190
cp,4018,ux,3724,47823
cp,4019,ux,3701,24191
cp,4020,ux,3726,47825
cp,4021,ux,3697,24171
cp,4022,ux,3725,47824
cp,4023,ux,3743,24406
cp,4024,ux,3767,47985
cp,4025,ux,3744,24407
cp,4026,ux,3769,47987
cp,4027,ux,3740,24387
cp,4028,ux,3768,47986
cp,4029,ux,3786,24622
cp,4030,ux,3810,48147
cp,4031,ux,3787,24623
cp,4032,ux,3812,48149
cp,4033,ux,3783,24603
cp,4034,ux,3811,48148
cp,4035,ux,3829,24838
cp,4036,ux,3853,48309
cp,4037,ux,3830,24839
cp,4038,ux,3855,48311
cp,4039,ux,3826,24819
cp,4040,ux,3854,48310
cp,4041,ux,5768,64140
cp,4042,ux,5624,61800
cp,4043,ux,3560,59144
cp,4044,ux,3550,47174
cp,4045,ux,3555,47179
cp,4046,ux,3554,47178
cp,4047,ux,3559,59118
cp,4048,ux,3594,47336
cp,4049,ux,3599,47341
cp,4050,ux,3598,47340
cp,4051,ux,3603,59181
cp,4052,ux,3637,47498
cp,4053,ux,3642,47503
cp,4054,ux,3641,47502
cp,4055,ux,3646,59226
cp,4056,ux,3680,47660
cp,4057,ux,3685,47665
cp,4058,ux,3684,47664
cp,4059,ux,3689,59271
cp,4060,ux,3723,47822
cp,4061,ux,3728,47827
cp,4062,ux,3727,47826
cp,4063,ux,3732,59316
cp,4064,ux,3766,47984
cp,4065,ux,3771,47989
cp,4066,ux,3770,47988
cp,4067,ux,3775,59361
cp,4068,ux,3809,48146
cp,4069,ux,3814,48151
cp,4070,ux,3813,48150
cp,4071,ux,3818,59406
cp,4072,ux,3852,48308
cp,4073,ux,3857,48313
cp,4074,ux,3856,48312
cp,4075,ux,3861,59451
cp,4076,ux,5696,62952
cp,4077,ux,5840,65292
cp,4078,ux,3881,25143
cp,4079,ux,3905,48552
cp,4080,ux,3885,25163
cp,4081,ux,3906,48553
cp,4082,ux,3884,25162
cp,4083,ux,3904,48551
cp,4084,ux,3928,25359
cp,4085,ux,3949,48714
cp,4086,ux,3932,25379
cp,4087,ux,3950,48715
cp,4088,ux,3931,25378
cp,4089,ux,3948,48713
cp,4090,ux,3971,25575
cp,4091,ux,3992,48876
cp,4092,ux,3975,25595
cp,4093,ux,3993,48877
cp,4094,ux,3974,25594
cp,4095,ux,3991,48875
cp,4096,ux,4014,25791
cp,4097,ux,4035,49038
cp,4098,ux,4018,25811
cp,4099,ux,4036,49039
cp,4100,ux,4017,25810
cp,4101,ux,4034,49037
cp,4102,ux,4057,26007
cp,4103,ux,4078,49200
cp,4104,ux,4061,26027
cp,4105,ux,4079,49201
cp,4106,ux,4060,26026
cp,4107,ux,4077,49199
cp,4108,ux,4100,26223
cp,4109,ux,4121,49362
cp,4110,ux,4104,26243
cp,4111,ux,4122,49363
cp,4112,ux,4103,26242
cp,4113,ux,4120,49361
cp,4114,ux,4143,26439
cp,4115,ux,4164,49524
cp,4116,ux,4147,26459
cp,4117,ux,4165,49525
cp,4118,ux,4146,26458
cp,4119,ux,4163,49523
cp,4120,ux,4186,26655
cp,4121,ux,4207,49686
cp,4122,ux,4190,26675
cp,4123,ux,4208,49687
cp,4124,ux,4189,26674
cp,4125,ux,4205,49685
cp,4126,ux,3880,25142
cp,4127,ux,3883,25161
cp,4128,ux,3882,25160
cp,4129,ux,3927,25358
cp,4130,ux,3930,25377
cp,4131,ux,3929,25376
cp,4132,ux,3970,25574
cp,4133,ux,3973,25593
cp,4134,ux,3972,25592
cp,4135,ux,4013,25790
cp,4136,ux,4016,25809
cp,4137,ux,4015,25808
cp,4138,ux,4056,26006
cp,4139,ux,4059,26025
cp,4140,ux,4058,26024
cp,4141,ux,4099,26222
cp,4142,ux,4102,26241
cp,4143,ux,4101,26240
cp,4144,ux,4142,26438
cp,4145,ux,4145,26457
cp,4146,ux,4144,26456
cp,4147,ux,4185,26654
cp,4148,ux,4188,26673
cp,4149,ux,4187,26672
cp,4150,ux,5769,64158
cp,4151,ux,5625,61818
cp,4152,ux,3892,48443
cp,4153,ux,3878,48444
cp,4154,ux,3893,25108
cp,4155,ux,3876,25106
cp,4156,ux,3862,24980
cp,4157,ux,3865,24983
cp,4158,ux,3888,48391
cp,4159,ux,3890,48393
cp,4160,ux,3925,48632
cp,4161,ux,3939,25324
cp,4162,ux,3923,25322
cp,4163,ux,3909,25196
cp,4164,ux,3912,25199
cp,4165,ux,3935,48580
cp,4166,ux,3937,48582
cp,4167,ux,3968,48794
cp,4168,ux,3982,25540
cp,4169,ux,3966,25538
cp,4170,ux,3952,25412
cp,4171,ux,3955,25415
cp,4172,ux,3978,48742
cp,4173,ux,3980,48744
cp,4174,ux,4011,48956
cp,4175,ux,4025,25756
cp,4176,ux,4009,25754
cp,4177,ux,3995,25628
cp,4178,ux,3998,25631
cp,4179,ux,4021,48904
cp,4180,ux,4023,48906
cp,4181,ux,4054,25972
cp,4182,ux,4068,49118
cp,4183,ux,4052,25970
cp,4184,ux,4038,25844
cp,4185,ux,4041,25847
cp,4186,ux,4064,49066
cp,4187,ux,4066,49068
cp,4188,ux,4111,49280
cp,4189,ux,4097,26188
cp,4190,ux,4095,26186
cp,4191,ux,4081,26060
cp,4192,ux,4084,26063
cp,4193,ux,4107,49228
cp,4194,ux,4109,49230
cp,4195,ux,4140,49442
cp,4196,ux,4154,26404
cp,4197,ux,4138,26402
cp,4198,ux,4124,26276
cp,4199,ux,4127,26279
cp,4200,ux,4150,49390
cp,4201,ux,4152,49392
cp,4202,ux,4183,49604
cp,4203,ux,4197,26620
cp,4204,ux,4181,26618
cp,4205,ux,4167,26492
cp,4206,ux,4170,26495
cp,4207,ux,4193,49552
cp,4208,ux,4195,49554
cp,4209,ux,5694,62917
cp,4210,ux,5838,65257
cp,4211,ux,5771,64178
cp,4212,ux,5627,61838
cp,4213,ux,3897,48448
cp,4214,ux,3879,48446
cp,4215,ux,3895,25109
cp,4216,ux,3877,25107
cp,4217,ux,3864,24982
cp,4218,ux,3867,24985
cp,4219,ux,3889,48392
cp,4220,ux,3891,48394
cp,4221,ux,3926,48634
cp,4222,ux,3941,25325
cp,4223,ux,3924,25323
cp,4224,ux,3911,25198
cp,4225,ux,3914,25201
cp,4226,ux,3936,48581
cp,4227,ux,3938,48583
cp,4228,ux,3969,48796
cp,4229,ux,3984,25541
cp,4230,ux,3967,25539
cp,4231,ux,3954,25414
cp,4232,ux,3957,25417
cp,4233,ux,3979,48743
cp,4234,ux,3981,48745
cp,4235,ux,4012,48958
cp,4236,ux,4027,25757
cp,4237,ux,4010,25755
cp,4238,ux,3997,25630
cp,4239,ux,4000,25633
cp,4240,ux,4022,48905
cp,4241,ux,4024,48907
cp,4242,ux,4055,25973
cp,4243,ux,4070,49120
cp,4244,ux,4053,25971
cp,4245,ux,4040,25846
cp,4246,ux,4043,25849
cp,4247,ux,4065,49067
cp,4248,ux,4067,49069
cp,4249,ux,4113,49282
cp,4250,ux,4098,26189
cp,4251,ux,4096,26187
cp,4252,ux,4083,26062
cp,4253,ux,4086,26065
cp,4254,ux,4108,49229
cp,4255,ux,4110,49231
cp,4256,ux,4141,49444
cp,4257,ux,4156,26405
cp,4258,ux,4139,26403
cp,4259,ux,4126,26278
cp,4260,ux,4129,26281
cp,4261,ux,4151,49391
cp,4262,ux,4153,49393
cp,4263,ux,4184,49606
cp,4264,ux,4199,26621
cp,4265,ux,4182,26619
cp,4266,ux,4169,26494
cp,4267,ux,4172,26497
cp,4268,ux,4194,49553
cp,4269,ux,4196,49555
cp,4270,ux,5695,62918
cp,4271,ux,5839,65258
cp,4272,ux,5770,64177
cp,4273,ux,5626,61837
cp,4274,ux,3896,48447
cp,4275,ux,3875,48445
cp,4276,ux,3894,25089
cp,4277,ux,3874,25088
cp,4278,ux,3863,24981
cp,4279,ux,3866,24984
cp,4280,ux,3887,48390
cp,4281,ux,3886,48389
cp,4282,ux,3922,48633
cp,4283,ux,3940,25305
cp,4284,ux,3921,25304
cp,4285,ux,3910,25197
cp,4286,ux,3913,25200
cp,4287,ux,3934,48579
cp,4288,ux,3933,48578
cp,4289,ux,3965,48795
cp,4290,ux,3983,25521
cp,4291,ux,3964,25520
cp,4292,ux,3953,25413
cp,4293,ux,3956,25416
cp,4294,ux,3977,48741
cp,4295,ux,3976,48740
cp,4296,ux,4008,48957
cp,4297,ux,4026,25737
cp,4298,ux,4007,25736
cp,4299,ux,3996,25629
cp,4300,ux,3999,25632
cp,4301,ux,4020,48903
cp,4302,ux,4019,48902
cp,4303,ux,4051,25953
cp,4304,ux,4069,49119
cp,4305,ux,4050,25952
cp,4306,ux,4039,25845
cp,4307,ux,4042,25848
cp,4308,ux,4063,49065
cp,4309,ux,4062,49064
cp,4310,ux,4112,49281
cp,4311,ux,4094,26169
cp,4312,ux,4093,26168
cp,4313,ux,4082,26061
cp,4314,ux,4085,26064
cp,4315,ux,4106,49227
cp,4316,ux,4105,49226
cp,4317,ux,4137,49443
cp,4318,ux,4155,26385
cp,4319,ux,4136,26384

cp,4320,ux,4125,26277
cp,4321,ux,4128,26280
cp,4322,ux,4149,49389
cp,4323,ux,4148,49388
cp,4324,ux,4180,49605
cp,4325,ux,4198,26601
cp,4326,ux,4179,26600
cp,4327,ux,4168,26493
cp,4328,ux,4171,26496
cp,4329,ux,4192,49551
cp,4330,ux,4191,49550
cp,4331,ux,5692,62898
cp,4332,ux,5836,65238
cp,4333,ux,3870,25052
cp,4334,ux,3871,25053
cp,4335,ux,3868,25034
cp,4336,ux,3917,25268
cp,4337,ux,3918,25269
cp,4338,ux,3915,25250
cp,4339,ux,3960,25484
cp,4340,ux,3961,25485
cp,4341,ux,3958,25466
cp,4342,ux,4003,25700
cp,4343,ux,4004,25701
cp,4344,ux,4001,25682
cp,4345,ux,4046,25916
cp,4346,ux,4047,25917
cp,4347,ux,4044,25898
cp,4348,ux,4089,26132
cp,4349,ux,4090,26133
cp,4350,ux,4087,26114
cp,4351,ux,4132,26348
cp,4352,ux,4133,26349
cp,4353,ux,4130,26330
cp,4354,ux,4175,26564
cp,4355,ux,4176,26565
cp,4356,ux,4173,26546
cp,4357,ux,3872,25054
cp,4358,ux,3899,48498
cp,4359,ux,3873,25055
cp,4360,ux,3901,48500
cp,4361,ux,3869,25035
cp,4362,ux,3900,48499
cp,4363,ux,3919,25270
cp,4364,ux,3943,48660
cp,4365,ux,3920,25271
cp,4366,ux,3945,48662
cp,4367,ux,3916,25251
cp,4368,ux,3944,48661
cp,4369,ux,3962,25486
cp,4370,ux,3986,48822
cp,4371,ux,3963,25487
cp,4372,ux,3988,48824
cp,4373,ux,3959,25467
cp,4374,ux,3987,48823
cp,4375,ux,4005,25702
cp,4376,ux,4029,48984
cp,4377,ux,4006,25703
cp,4378,ux,4031,48986
cp,4379,ux,4002,25683
cp,4380,ux,4030,48985
cp,4381,ux,4048,25918
cp,4382,ux,4072,49146
cp,4383,ux,4049,25919
cp,4384,ux,4074,49148
cp,4385,ux,4045,25899
cp,4386,ux,4073,49147
cp,4387,ux,4091,26134
cp,4388,ux,4115,49308
cp,4389,ux,4092,26135
cp,4390,ux,4117,49310
cp,4391,ux,4088,26115
cp,4392,ux,4116,49309
cp,4393,ux,4134,26350
cp,4394,ux,4158,49470
cp,4395,ux,4135,26351
cp,4396,ux,4160,49472
cp,4397,ux,4131,26331
cp,4398,ux,4159,49471
cp,4399,ux,4177,26566
cp,4400,ux,4201,49632
cp,4401,ux,4178,26567
cp,4402,ux,4203,49634
cp,4403,ux,4174,26547
cp,4404,ux,4202,49633
cp,4405,ux,5756,63926
cp,4406,ux,5612,61586
cp,4407,ux,3908,59531
cp,4408,ux,3898,48497
cp,4409,ux,3903,48502
cp,4410,ux,3902,48501
cp,4411,ux,3907,59505
cp,4412,ux,3942,48659
cp,4413,ux,3947,48664
cp,4414,ux,3946,48663
cp,4415,ux,3951,59568
cp,4416,ux,3985,48821
cp,4417,ux,3990,48826
cp,4418,ux,3989,48825
cp,4419,ux,3994,59613
cp,4420,ux,4028,48983
cp,4421,ux,4033,48988
cp,4422,ux,4032,48987
cp,4423,ux,4037,59658
cp,4424,ux,4071,49145
cp,4425,ux,4076,49150
cp,4426,ux,4075,49149
cp,4427,ux,4080,59703
cp,4428,ux,4114,49307
cp,4429,ux,4119,49312
cp,4430,ux,4118,49311
cp,4431,ux,4123,59748
cp,4432,ux,4157,49469
cp,4433,ux,4162,49474
cp,4434,ux,4161,49473
cp,4435,ux,4166,59793
cp,4436,ux,4200,49631
cp,4437,ux,4205,49636
cp,4438,ux,4204,49635
cp,4439,ux,4209,59838
cp,4440,ux,5691,62880
cp,4441,ux,5835,65220
cp,4442,ux,4229,26871
cp,4443,ux,4253,49875
cp,4444,ux,4233,26891
cp,4445,ux,4254,49876
cp,4446,ux,4232,26890
cp,4447,ux,4252,49874
cp,4448,ux,4276,27087
cp,4449,ux,4297,50037
cp,4450,ux,4280,27107
cp,4451,ux,4298,50038
cp,4452,ux,4279,27106
cp,4453,ux,4296,50036
cp,4454,ux,4319,27303
cp,4455,ux,4340,50199
cp,4456,ux,4323,27323
cp,4457,ux,4341,50200
cp,4458,ux,4322,27322
cp,4459,ux,4339,50198
cp,4460,ux,4362,27519
cp,4461,ux,4383,50361
cp,4462,ux,4366,27539
cp,4463,ux,4384,50362
cp,4464,ux,4365,27538
cp,4465,ux,4382,50360
cp,4466,ux,4405,27735
cp,4467,ux,4426,50523
cp,4468,ux,4409,27755
cp,4469,ux,4427,50524
cp,4470,ux,4408,27754
cp,4471,ux,4425,50522
cp,4472,ux,4448,27951
cp,4473,ux,4469,50685
cp,4474,ux,4452,27971
cp,4475,ux,4470,50686
cp,4476,ux,4451,27970
cp,4477,ux,4468,50684
cp,4478,ux,4491,28167
cp,4479,ux,4512,50847
cp,4480,ux,4495,28187
cp,4481,ux,4513,50848
cp,4482,ux,4494,28186
cp,4483,ux,4511,50846
cp,4484,ux,4534,28383
cp,4485,ux,4555,51009
cp,4486,ux,4538,28403
cp,4487,ux,4556,51010
cp,4488,ux,4537,28402
cp,4489,ux,4554,51008
cp,4490,ux,4228,26870
cp,4491,ux,4231,26889
cp,4492,ux,4230,26888
cp,4493,ux,4275,27086
cp,4494,ux,4278,27105
cp,4495,ux,4277,27104
cp,4496,ux,4318,27302
cp,4497,ux,4321,27321
cp,4498,ux,4320,27320
cp,4499,ux,4361,27518
cp,4500,ux,4364,27537
cp,4501,ux,4363,27536
cp,4502,ux,4404,27734
cp,4503,ux,4407,27753
cp,4504,ux,4406,27752
cp,4505,ux,4447,27950
cp,4506,ux,4450,27969
cp,4507,ux,4449,27968
cp,4508,ux,4490,28166
cp,4509,ux,4493,28185
cp,4510,ux,4492,28184
cp,4511,ux,4533,28382
cp,4512,ux,4536,28401
cp,4513,ux,4535,28400
cp,4514,ux,5755,63925
cp,4515,ux,5611,61585
cp,4516,ux,4240,49766
cp,4517,ux,4226,49767
cp,4518,ux,4241,26836
cp,4519,ux,4224,26834
cp,4520,ux,4210,26708
cp,4521,ux,4213,26711
cp,4522,ux,4236,49714
cp,4523,ux,4238,49716
cp,4524,ux,4273,49955
cp,4525,ux,4287,27052
cp,4526,ux,4271,27050
cp,4527,ux,4257,26924
cp,4528,ux,4260,26927
cp,4529,ux,4283,49903
cp,4530,ux,4285,49905
cp,4531,ux,4316,50117
cp,4532,ux,4330,27268
cp,4533,ux,4314,27266
cp,4534,ux,4300,27140
cp,4535,ux,4303,27143
cp,4536,ux,4326,50065
cp,4537,ux,4328,50067
cp,4538,ux,4359,50279
cp,4539,ux,4373,27484
cp,4540,ux,4357,27482
cp,4541,ux,4343,27356
cp,4542,ux,4346,27359
cp,4543,ux,4369,50227
cp,4544,ux,4371,50229
cp,4545,ux,4402,27700
cp,4546,ux,4416,50441
cp,4547,ux,4400,27698
cp,4548,ux,4386,27572
cp,4549,ux,4389,27575
cp,4550,ux,4412,50389
cp,4551,ux,4414,50391
cp,4552,ux,4459,50503
cp,4553,ux,4445,27916
cp,4554,ux,4443,27914
cp,4555,ux,4429,27788
cp,4556,ux,4432,27791
cp,4557,ux,4455,50551
cp,4558,ux,4457,50553
cp,4559,ux,4488,50765
cp,4560,ux,4502,28132
cp,4561,ux,4486,28130
cp,4562,ux,4472,28004
cp,4563,ux,4475,28007
cp,4564,ux,4498,50713
cp,4565,ux,4500,50715
cp,4566,ux,4531,50927
cp,4567,ux,4545,28348
cp,4568,ux,4529,28346
cp,4569,ux,4515,28220
cp,4570,ux,4518,28223
cp,4571,ux,4541,50875
cp,4572,ux,4543,50877
cp,4573,ux,5689,62845
cp,4574,ux,5833,65185
cp,4575,ux,5758,63962
cp,4576,ux,5614,61622
cp,4577,ux,4245,49771
cp,4578,ux,4227,49769
cp,4579,ux,4243,26837
cp,4580,ux,4225,26835
cp,4581,ux,4212,26710
cp,4582,ux,4215,26713
cp,4583,ux,4237,49715
cp,4584,ux,4239,49717
cp,4585,ux,4274,49957
cp,4586,ux,4289,27053
cp,4587,ux,4272,27051
cp,4588,ux,4259,26926
cp,4589,ux,4262,26929
cp,4590,ux,4284,49904
cp,4591,ux,4286,49906
cp,4592,ux,4317,50119
cp,4593,ux,4332,27269
cp,4594,ux,4315,27267
cp,4595,ux,4302,27142
cp,4596,ux,4305,27145
cp,4597,ux,4327,50066
cp,4598,ux,4329,50068
cp,4599,ux,4360,50281
cp,4600,ux,4375,27485
cp,4601,ux,4358,27483
cp,4602,ux,4345,27358
cp,4603,ux,4348,27361
cp,4604,ux,4370,50228
cp,4605,ux,4372,50230
cp,4606,ux,4403,27701
cp,4607,ux,4418,50443
cp,4608,ux,4401,27699
cp,4609,ux,4388,27574
cp,4610,ux,4391,27577
cp,4611,ux,4413,50390
cp,4612,ux,4415,50392
cp,4613,ux,4461,50605
cp,4614,ux,4446,27917
cp,4615,ux,4444,27915
cp,4616,ux,4431,27790
cp,4617,ux,4434,27793
cp,4618,ux,4456,50552
cp,4619,ux,4458,50554
cp,4620,ux,4489,50767
cp,4621,ux,4504,28133
cp,4622,ux,4487,28131
cp,4623,ux,4474,28006
cp,4624,ux,4477,28009
cp,4625,ux,4499,50714
cp,4626,ux,4501,50716
cp,4627,ux,4532,50929
cp,4628,ux,4547,28349
cp,4629,ux,4530,28347
cp,4630,ux,4517,28222
cp,4631,ux,4520,28225
cp,4632,ux,4542,50876
cp,4633,ux,4544,50878
cp,4634,ux,5690,62846
cp,4635,ux,5834,65186
cp,4636,ux,5757,63961
cp,4637,ux,5613,61621
cp,4638,ux,4244,49770
cp,4639,ux,4223,49768
cp,4640,ux,4242,26817
cp,4641,ux,4222,26816
cp,4642,ux,4211,26709
cp,4643,ux,4214,26712
cp,4644,ux,4235,49713
cp,4645,ux,4234,49712
cp,4646,ux,4270,49956
cp,4647,ux,4288,27033
cp,4648,ux,4269,27032
cp,4649,ux,4258,26925
cp,4650,ux,4261,26928
cp,4651,ux,4282,49902

cp,4652,ux,4281,49901
cp,4653,ux,4313,50118
cp,4654,ux,4331,27249
cp,4655,ux,4312,27248
cp,4656,ux,4301,27141
cp,4657,ux,4304,27144
cp,4658,ux,4325,50064
cp,4659,ux,4324,50063
cp,4660,ux,4356,50280
cp,4661,ux,4374,27465
cp,4662,ux,4355,27464
cp,4663,ux,4344,27357
cp,4664,ux,4347,27360
cp,4665,ux,4368,50226
cp,4666,ux,4367,50225
cp,4667,ux,4399,27681
cp,4668,ux,4417,50442
cp,4669,ux,4398,27680
cp,4670,ux,4387,27573
cp,4671,ux,4390,27576
cp,4672,ux,4411,50388
cp,4673,ux,4410,50387
cp,4674,ux,4460,50604
cp,4675,ux,4442,27897
cp,4676,ux,4441,27896
cp,4677,ux,4430,27789
cp,4678,ux,4433,27792
cp,4679,ux,4454,50550
cp,4680,ux,4453,50549
cp,4681,ux,4485,50766
cp,4682,ux,4503,28113
cp,4683,ux,4484,28112
cp,4684,ux,4473,28005
cp,4685,ux,4476,28008
cp,4686,ux,4497,50712
cp,4687,ux,4496,50711
cp,4688,ux,4528,50928
cp,4689,ux,4546,28329
cp,4690,ux,4527,28328
cp,4691,ux,4516,28221
cp,4692,ux,4519,28224
cp,4693,ux,4540,50874
cp,4694,ux,4539,50873
cp,4695,ux,5688,62826
cp,4696,ux,5832,65166
cp,4697,ux,4218,26780
cp,4698,ux,4219,26781
cp,4699,ux,4216,26762
cp,4700,ux,4265,26996
cp,4701,ux,4266,26997
cp,4702,ux,4263,26978
cp,4703,ux,4308,27212
cp,4704,ux,4309,27213
cp,4705,ux,4306,27194
cp,4706,ux,4351,27428
cp,4707,ux,4352,27429
cp,4708,ux,4349,27410
cp,4709,ux,4394,27644
cp,4710,ux,4395,27645
cp,4711,ux,4392,27626
cp,4712,ux,4437,27860
cp,4713,ux,4438,27861
cp,4714,ux,4435,27842
cp,4715,ux,4480,28076
cp,4716,ux,4481,28077
cp,4717,ux,4478,28058
cp,4718,ux,4523,28292
cp,4719,ux,4524,28293
cp,4720,ux,4521,28274
cp,4721,ux,4220,26782
cp,4722,ux,4247,49821
cp,4723,ux,4221,26783
cp,4724,ux,4249,49823
cp,4725,ux,4217,26763
cp,4726,ux,4248,49822
cp,4727,ux,4267,26998
cp,4728,ux,4291,49983
cp,4729,ux,4268,26999
cp,4730,ux,4293,49985
cp,4731,ux,4264,26979
cp,4732,ux,4292,49984
cp,4733,ux,4310,27214
cp,4734,ux,4334,50145
cp,4735,ux,4311,27215
cp,4736,ux,4336,50147
cp,4737,ux,4307,27195
cp,4738,ux,4335,50146
cp,4739,ux,4353,27430
cp,4740,ux,4377,50307
cp,4741,ux,4354,27431
cp,4742,ux,4379,50309
cp,4743,ux,4350,27411
cp,4744,ux,4378,50308
cp,4745,ux,4396,27646
cp,4746,ux,4420,50469
cp,4747,ux,4397,27647
cp,4748,ux,4422,50471
cp,4749,ux,4393,27627
cp,4750,ux,4421,50470
cp,4751,ux,4439,27862
cp,4752,ux,4463,50631
cp,4753,ux,4440,27863
cp,4754,ux,4465,50633
cp,4755,ux,4436,27843
cp,4756,ux,4464,50632
cp,4757,ux,4482,28078
cp,4758,ux,4506,50793
cp,4759,ux,4483,28079
cp,4760,ux,4508,50795
cp,4761,ux,4479,28059
cp,4762,ux,4507,50794
cp,4763,ux,4525,28294
cp,4764,ux,4549,50955
cp,4765,ux,4526,28295
cp,4766,ux,4551,50957
cp,4767,ux,4522,28275
cp,4768,ux,4550,50956
cp,4769,ux,5759,63996
cp,4770,ux,5615,61656
cp,4771,ux,4256,59918
cp,4772,ux,4246,49820
cp,4773,ux,4251,49825
cp,4774,ux,4250,49824
cp,4775,ux,4255,59892
cp,4776,ux,4290,49982
cp,4777,ux,4295,49987
cp,4778,ux,4294,49986
cp,4779,ux,4299,59955
cp,4780,ux,4333,50144
cp,4781,ux,4338,50149
cp,4782,ux,4337,50148
cp,4783,ux,4342,60000
cp,4784,ux,4376,50306
cp,4785,ux,4381,50311
cp,4786,ux,4380,50310
cp,4787,ux,4385,60045
cp,4788,ux,4419,50468
cp,4789,ux,4424,50473
cp,4790,ux,4423,50472
cp,4791,ux,4428,60090
cp,4792,ux,4462,50630
cp,4793,ux,4467,50635
cp,4794,ux,4466,50634
cp,4795,ux,4471,60135
cp,4796,ux,4505,50792
cp,4797,ux,4510,50797
cp,4798,ux,4509,50796
cp,4799,ux,4514,60180
cp,4800,ux,4548,50954
cp,4801,ux,4553,50959
cp,4802,ux,4552,50958
cp,4803,ux,4557,60225
cp,4804,ux,5687,62808
cp,4805,ux,5831,65148
cp,4806,ux,4601,51198
cp,4807,ux,4602,51199
cp,4808,ux,4600,51197
cp,4809,ux,4645,51360
cp,4810,ux,4646,51361
cp,4811,ux,4644,51359
cp,4812,ux,4688,51522
cp,4813,ux,4689,51523
cp,4814,ux,4687,51521
cp,4815,ux,4731,51684
cp,4816,ux,4732,51685
cp,4817,ux,4730,51683
cp,4818,ux,4774,51846
cp,4819,ux,4775,51847
cp,4820,ux,4773,51845
cp,4821,ux,4817,52008
cp,4822,ux,4818,52009
cp,4823,ux,4816,52007
cp,4824,ux,4860,52170
cp,4825,ux,4861,52171
cp,4826,ux,4859,52169
cp,4827,ux,4903,52332
cp,4828,ux,4904,52333
cp,4829,ux,4902,52331
cp,4830,ux,4577,28599
cp,4831,ux,4581,28619
cp,4832,ux,4580,28618
cp,4833,ux,4624,28815
cp,4834,ux,4628,28835
cp,4835,ux,4627,28834
cp,4836,ux,4667,29031
cp,4837,ux,4671,29051
cp,4838,ux,4670,29050
cp,4839,ux,4710,29247
cp,4840,ux,4714,29267
cp,4841,ux,4713,29266
cp,4842,ux,4753,29463
cp,4843,ux,4757,29483
cp,4844,ux,4756,29482
cp,4845,ux,4796,29679
cp,4846,ux,4800,29699
cp,4847,ux,4799,29698
cp,4848,ux,4839,29895
cp,4849,ux,4843,29915
cp,4850,ux,4842,29914
cp,4851,ux,4882,30111
cp,4852,ux,4886,30131
cp,4853,ux,4885,30130
cp,4854,ux,4576,28598
cp,4855,ux,4579,28617
cp,4856,ux,4578,28616
cp,4857,ux,4623,28814
cp,4858,ux,4626,28833
cp,4859,ux,4625,28832
cp,4860,ux,4666,29030
cp,4861,ux,4669,29049
cp,4862,ux,4668,29048
cp,4863,ux,4709,29246
cp,4864,ux,4712,29265
cp,4865,ux,4711,29264
cp,4866,ux,4752,29462
cp,4867,ux,4755,29481
cp,4868,ux,4754,29480
cp,4869,ux,4795,29678
cp,4870,ux,4798,29697
cp,4871,ux,4797,29696
cp,4872,ux,4838,29894
cp,4873,ux,4841,29913
cp,4874,ux,4840,29912
cp,4875,ux,4881,30110
cp,4876,ux,4884,30129
cp,4877,ux,4883,30128
cp,4878,ux,5760,64014
cp,4879,ux,5616,61674
cp,4880,ux,4588,51089
cp,4881,ux,4574,51090
cp,4882,ux,4589,28564
cp,4883,ux,4572,28562
cp,4884,ux,4558,28436
cp,4885,ux,4561,28439
cp,4886,ux,4584,51037
cp,4887,ux,4586,51039
cp,4888,ux,4621,51278
cp,4889,ux,4635,28780
cp,4890,ux,4619,28778
cp,4891,ux,4605,28652
cp,4892,ux,4608,28655
cp,4893,ux,4631,51226
cp,4894,ux,4633,51228
cp,4895,ux,4664,51440
cp,4896,ux,4678,28996
cp,4897,ux,4662,28994
cp,4898,ux,4648,28868
cp,4899,ux,4651,28871
cp,4900,ux,4674,51388
cp,4901,ux,4676,51390
cp,4902,ux,4707,51602
cp,4903,ux,4721,29212
cp,4904,ux,4705,29210
cp,4905,ux,4691,29084
cp,4906,ux,4694,29087
cp,4907,ux,4717,51550
cp,4908,ux,4719,51552
cp,4909,ux,4750,29428
cp,4910,ux,4764,51764
cp,4911,ux,4748,29426
cp,4912,ux,4734,29300
cp,4913,ux,4737,29303
cp,4914,ux,4760,51712
cp,4915,ux,4762,51714
cp,4916,ux,4807,51926
cp,4917,ux,4793,29644
cp,4918,ux,4791,29642
cp,4919,ux,4777,29516
cp,4920,ux,4780,29519
cp,4921,ux,4803,51874
cp,4922,ux,4805,51876
cp,4923,ux,4836,52088
cp,4924,ux,4850,29860
cp,4925,ux,4834,29858
cp,4926,ux,4820,29732
cp,4927,ux,4823,29735
cp,4928,ux,4846,52036
cp,4929,ux,4848,52038
cp,4930,ux,4879,52250
cp,4931,ux,4893,30076
cp,4932,ux,4877,30074
cp,4933,ux,4863,29948
cp,4934,ux,4866,29951
cp,4935,ux,4889,52198
cp,4936,ux,4891,52200
cp,4937,ux,5685,62773
cp,4938,ux,5829,65113
cp,4939,ux,5762,64034
cp,4940,ux,5618,61694
cp,4941,ux,4593,51094
cp,4942,ux,4575,51092
cp,4943,ux,4591,28565
cp,4944,ux,4573,28563
cp,4945,ux,4560,28438
cp,4946,ux,4563,28441
cp,4947,ux,4585,51038
cp,4948,ux,4587,51040
cp,4949,ux,4622,51280
cp,4950,ux,4637,28781
cp,4951,ux,4620,28779
cp,4952,ux,4607,28654
cp,4953,ux,4610,28657
cp,4954,ux,4632,51227
cp,4955,ux,4634,51229
cp,4956,ux,4665,51442
cp,4957,ux,4680,28997
cp,4958,ux,4663,28995
cp,4959,ux,4650,28870
cp,4960,ux,4653,28873
cp,4961,ux,4675,51389
cp,4962,ux,4677,51391
cp,4963,ux,4708,51604
cp,4964,ux,4723,29213
cp,4965,ux,4706,29211
cp,4966,ux,4693,29086
cp,4967,ux,4696,29089
cp,4968,ux,4718,51551
cp,4969,ux,4720,51553
cp,4970,ux,4751,29429
cp,4971,ux,4766,51766
cp,4972,ux,4749,29427
cp,4973,ux,4736,29302
cp,4974,ux,4739,29305
cp,4975,ux,4761,51713
cp,4976,ux,4763,51715
cp,4977,ux,4809,51928
cp,4978,ux,4794,29645
cp,4979,ux,4792,29643
cp,4980,ux,4779,29518
cp,4981,ux,4782,29521
cp,4982,ux,4804,51875
cp,4983,ux,4806,51877

cp,4984,ux,4837,52090
cp,4985,ux,4852,29861
cp,4986,ux,4835,29859
cp,4987,ux,4822,29734
cp,4988,ux,4825,29737
cp,4989,ux,4847,52037
cp,4990,ux,4849,52039
cp,4991,ux,4880,52252
cp,4992,ux,4895,30077
cp,4993,ux,4878,30075
cp,4994,ux,4865,29950
cp,4995,ux,4868,29953
cp,4996,ux,4890,52199
cp,4997,ux,4892,52201
cp,4998,ux,5686,62774
cp,4999,ux,5830,65114
cp,5000,ux,5761,64033
cp,5001,ux,5617,61693
cp,5002,ux,4592,51093
cp,5003,ux,4571,51091
cp,5004,ux,4590,28545
cp,5005,ux,4570,28544
cp,5006,ux,4559,28437
cp,5007,ux,4562,28440
cp,5008,ux,4583,51036
cp,5009,ux,4582,51035
cp,5010,ux,4618,51279
cp,5011,ux,4636,28761
cp,5012,ux,4617,28760
cp,5013,ux,4606,28653
cp,5014,ux,4609,28656
cp,5015,ux,4630,51225
cp,5016,ux,4629,51224
cp,5017,ux,4661,51441
cp,5018,ux,4679,28977
cp,5019,ux,4660,28976
cp,5020,ux,4649,28869
cp,5021,ux,4652,28872
cp,5022,ux,4673,51387
cp,5023,ux,4672,51386
cp,5024,ux,4704,51603
cp,5025,ux,4722,29193
cp,5026,ux,4703,29192
cp,5027,ux,4692,29085
cp,5028,ux,4695,29088
cp,5029,ux,4716,51549
cp,5030,ux,4715,51548
cp,5031,ux,4747,29409
cp,5032,ux,4765,51765
cp,5033,ux,4746,29408
cp,5034,ux,4735,29301
cp,5035,ux,4738,29304
cp,5036,ux,4759,51711
cp,5037,ux,4758,51710
cp,5038,ux,4808,51927
cp,5039,ux,4790,29625
cp,5040,ux,4789,29624
cp,5041,ux,4778,29517
cp,5042,ux,4781,29520
cp,5043,ux,4802,51873
cp,5044,ux,4801,51872
cp,5045,ux,4833,52089
cp,5046,ux,4851,29841
cp,5047,ux,4832,29840
cp,5048,ux,4821,29733
cp,5049,ux,4824,29736
cp,5050,ux,4845,52035
cp,5051,ux,4844,52034
cp,5052,ux,4876,52251
cp,5053,ux,4894,30057
cp,5054,ux,4875,30056
cp,5055,ux,4864,29949
cp,5056,ux,4867,29952
cp,5057,ux,4888,52197
cp,5058,ux,4887,52196
cp,5059,ux,5683,62754
cp,5060,ux,5827,65094
cp,5061,ux,4566,28508
cp,5062,ux,4567,28509
cp,5063,ux,4564,28490
cp,5064,ux,4613,28724
cp,5065,ux,4614,28725
cp,5066,ux,4611,28706
cp,5067,ux,4656,28940
cp,5068,ux,4657,28941
cp,5069,ux,4654,28922
cp,5070,ux,4699,29156
cp,5071,ux,4700,29157
cp,5072,ux,4697,29138
cp,5073,ux,4742,29372
cp,5074,ux,4743,29373
cp,5075,ux,4740,29354
cp,5076,ux,4785,29588
cp,5077,ux,4786,29589
cp,5078,ux,4783,29570
cp,5079,ux,4828,29804
cp,5080,ux,4829,29805
cp,5081,ux,4826,29786
cp,5082,ux,4871,30020
cp,5083,ux,4872,30021
cp,5084,ux,4869,30002
cp,5085,ux,4568,28510
cp,5086,ux,4595,51144
cp,5087,ux,4569,28511
cp,5088,ux,4597,51146
cp,5089,ux,4565,28491
cp,5090,ux,4596,51145
cp,5091,ux,4615,28726
cp,5092,ux,4639,51306
cp,5093,ux,4616,28727
cp,5094,ux,4641,51308
cp,5095,ux,4612,28707
cp,5096,ux,4640,51307
cp,5097,ux,4658,28942
cp,5098,ux,4682,51468
cp,5099,ux,4659,28943
cp,5100,ux,4684,51470
cp,5101,ux,4655,28923
cp,5102,ux,4683,51469
cp,5103,ux,4701,29158
cp,5104,ux,4725,51630
cp,5105,ux,4702,29159
cp,5106,ux,4727,51632
cp,5107,ux,4698,29139
cp,5108,ux,4726,51631
cp,5109,ux,4744,29374
cp,5110,ux,4768,51792
cp,5111,ux,4745,29375
cp,5112,ux,4770,51794
cp,5113,ux,4741,29355
cp,5114,ux,4769,51793
cp,5115,ux,4787,29590
cp,5116,ux,4811,51954
cp,5117,ux,4788,29591
cp,5118,ux,4813,51956
cp,5119,ux,4784,29571
cp,5120,ux,4812,51955
cp,5121,ux,4830,29806
cp,5122,ux,4854,52116
cp,5123,ux,4831,29807
cp,5124,ux,4856,52118
cp,5125,ux,4827,29787
cp,5126,ux,4855,52117
cp,5127,ux,4873,30022
cp,5128,ux,4897,52278
cp,5129,ux,4874,30023
cp,5130,ux,4899,52280
cp,5131,ux,4870,30003
cp,5132,ux,4898,52279
cp,5133,ux,5747,63764
cp,5134,ux,5603,61424
cp,5135,ux,4604,60305
cp,5136,ux,4594,51143
cp,5137,ux,4599,51148
cp,5138,ux,4598,51147
cp,5139,ux,4603,60279
cp,5140,ux,4638,51305
cp,5141,ux,4643,51310
cp,5142,ux,4642,51309
cp,5143,ux,4647,60342
cp,5144,ux,4681,51467
cp,5145,ux,4686,51472
cp,5146,ux,4685,51471
cp,5147,ux,4690,60387
cp,5148,ux,4724,51629
cp,5149,ux,4729,51634
cp,5150,ux,4728,51633
cp,5151,ux,4733,60432
cp,5152,ux,4767,51791
cp,5153,ux,4772,51796
cp,5154,ux,4771,51795
cp,5155,ux,4776,60477
cp,5156,ux,4810,51953
cp,5157,ux,4815,51958
cp,5158,ux,4814,51957
cp,5159,ux,4819,60522
cp,5160,ux,4853,52115
cp,5161,ux,4858,52120
cp,5162,ux,4857,52119
cp,5163,ux,4862,60567
cp,5164,ux,4896,52277
cp,5165,ux,4901,52282
cp,5166,ux,4900,52281
cp,5167,ux,4905,60612
cp,5168,ux,5682,62736
cp,5169,ux,5826,65076
cp,5170,ux,4925,30327
cp,5171,ux,4949,52521
cp,5172,ux,4929,30347
cp,5173,ux,4950,52522
cp,5174,ux,4928,30346
cp,5175,ux,4948,52520
cp,5176,ux,4972,30543
cp,5177,ux,4993,52683
cp,5178,ux,4976,30563
cp,5179,ux,4994,52684
cp,5180,ux,4975,30562
cp,5181,ux,4992,52682
cp,5182,ux,5015,30759
cp,5183,ux,5036,52845
cp,5184,ux,5019,30779
cp,5185,ux,5037,52846
cp,5186,ux,5018,30778
cp,5187,ux,5035,52844
cp,5188,ux,5058,30975
cp,5189,ux,5079,53007
cp,5190,ux,5062,30995
cp,5191,ux,5080,53008
cp,5192,ux,5061,30994
cp,5193,ux,5078,53006
cp,5194,ux,5101,31191
cp,5195,ux,5122,53169
cp,5196,ux,5105,31211
cp,5197,ux,5123,53170
cp,5198,ux,5104,31210
cp,5199,ux,5121,53168
cp,5200,ux,5144,31407
cp,5201,ux,5165,53331
cp,5202,ux,5148,31427
cp,5203,ux,5166,53332
cp,5204,ux,5147,31426
cp,5205,ux,5164,53330
cp,5206,ux,5187,31623
cp,5207,ux,5208,53493
cp,5208,ux,5191,31643
cp,5209,ux,5209,53494
cp,5210,ux,5190,31642
cp,5211,ux,5207,53492
cp,5212,ux,5230,31839
cp,5213,ux,5251,53655
cp,5214,ux,5234,31859
cp,5215,ux,5252,53656
cp,5216,ux,5233,31858
cp,5217,ux,5250,53654
cp,5218,ux,4924,30326
cp,5219,ux,4927,30345
cp,5220,ux,4926,30344
cp,5221,ux,4971,30542
cp,5222,ux,4974,30561
cp,5223,ux,4973,30560
cp,5224,ux,5014,30758
cp,5225,ux,5017,30777
cp,5226,ux,5016,30776
cp,5227,ux,5057,30974
cp,5228,ux,5060,30993
cp,5229,ux,5059,30992
cp,5230,ux,5100,31190
cp,5231,ux,5103,31209
cp,5232,ux,5102,31208
cp,5233,ux,5143,31406
cp,5234,ux,5146,31425
cp,5235,ux,5145,31424
cp,5236,ux,5186,31622
cp,5237,ux,5189,31641
cp,5238,ux,5188,31640
cp,5239,ux,5229,31838
cp,5240,ux,5232,31857
cp,5241,ux,5231,31856
cp,5242,ux,5746,63763
cp,5243,ux,5602,61423
cp,5244,ux,4936,52412
cp,5245,ux,4922,52413
cp,5246,ux,4937,30292
cp,5247,ux,4920,30290
cp,5248,ux,4906,30164
cp,5249,ux,4909,30167
cp,5250,ux,4932,52360
cp,5251,ux,4934,52362
cp,5252,ux,4969,52601
cp,5253,ux,4983,30508
cp,5254,ux,4967,30506
cp,5255,ux,4953,30380
cp,5256,ux,4956,30383
cp,5257,ux,4979,52549
cp,5258,ux,4981,52551
cp,5259,ux,5012,52763
cp,5260,ux,5026,30724
cp,5261,ux,5010,30722
cp,5262,ux,4996,30596
cp,5263,ux,4999,30599
cp,5264,ux,5022,52711
cp,5265,ux,5024,52713
cp,5266,ux,5055,52925
cp,5267,ux,5069,30940
cp,5268,ux,5053,30938
cp,5269,ux,5039,30812
cp,5270,ux,5042,30815
cp,5271,ux,5065,52873
cp,5272,ux,5067,52875
cp,5273,ux,5098,31156
cp,5274,ux,5112,53087
cp,5275,ux,5096,31154
cp,5276,ux,5082,31028
cp,5277,ux,5085,31031
cp,5278,ux,5108,53035
cp,5279,ux,5110,53037
cp,5280,ux,5155,53249
cp,5281,ux,5141,31372
cp,5282,ux,5139,31370
cp,5283,ux,5125,31244
cp,5284,ux,5128,31247
cp,5285,ux,5151,53197
cp,5286,ux,5153,53199
cp,5287,ux,5184,53411
cp,5288,ux,5198,31588
cp,5289,ux,5182,31586
cp,5290,ux,5168,31460
cp,5291,ux,5171,31463
cp,5292,ux,5194,53359
cp,5293,ux,5196,53361
cp,5294,ux,5227,53573
cp,5295,ux,5241,31804
cp,5296,ux,5225,31802
cp,5297,ux,5211,31676
cp,5298,ux,5214,31679
cp,5299,ux,5237,53521
cp,5300,ux,5239,53523
cp,5301,ux,5680,62701
cp,5302,ux,5824,65041
cp,5303,ux,5749,63800
cp,5304,ux,5605,61460
cp,5305,ux,4941,52417
cp,5306,ux,4923,52415
cp,5307,ux,4939,30293
cp,5308,ux,4921,30291
cp,5309,ux,4908,30166
cp,5310,ux,4911,30169
cp,5311,ux,4933,52361
cp,5312,ux,4935,52363
cp,5313,ux,4970,52603
cp,5314,ux,4985,30509
cp,5315,ux,4968,30507

cp,5316,ux,4955,30382
cp,5317,ux,4958,30385
cp,5318,ux,4980,52550
cp,5319,ux,4982,52552
cp,5320,ux,5013,52765
cp,5321,ux,5028,30725
cp,5322,ux,5011,30723
cp,5323,ux,4998,30598
cp,5324,ux,5001,30601
cp,5325,ux,5023,52712
cp,5326,ux,5025,52714
cp,5327,ux,5056,52927
cp,5328,ux,5071,30941
cp,5329,ux,5054,30939
cp,5330,ux,5041,30814
cp,5331,ux,5044,30817
cp,5332,ux,5066,52874
cp,5333,ux,5068,52876
cp,5334,ux,5099,31157
cp,5335,ux,5114,53089
cp,5336,ux,5097,31155
cp,5337,ux,5084,31030
cp,5338,ux,5087,31033
cp,5339,ux,5109,53036
cp,5340,ux,5111,53038
cp,5341,ux,5157,53251
cp,5342,ux,5142,31373
cp,5343,ux,5140,31371
cp,5344,ux,5127,31246
cp,5345,ux,5130,31249
cp,5346,ux,5152,53198
cp,5347,ux,5154,53200
cp,5348,ux,5185,53413
cp,5349,ux,5200,31589
cp,5350,ux,5183,31587
cp,5351,ux,5170,31462
cp,5352,ux,5173,31465
cp,5353,ux,5195,53360
cp,5354,ux,5197,53362
cp,5355,ux,5228,53575
cp,5356,ux,5243,31805
cp,5357,ux,5226,31803
cp,5358,ux,5213,31678
cp,5359,ux,5216,31681
cp,5360,ux,5238,53522
cp,5361,ux,5240,53524
cp,5362,ux,5681,62702
cp,5363,ux,5825,65042
cp,5364,ux,5748,63799
cp,5365,ux,5604,61459
cp,5366,ux,4940,52416
cp,5367,ux,4919,52414
cp,5368,ux,4938,30273
cp,5369,ux,4918,30272
cp,5370,ux,4907,30165
cp,5371,ux,4910,30168
cp,5372,ux,4931,52359
cp,5373,ux,4930,52358
cp,5374,ux,4966,52602
cp,5375,ux,4984,30489
cp,5376,ux,4965,30488
cp,5377,ux,4954,30381
cp,5378,ux,4957,30384
cp,5379,ux,4978,52548
cp,5380,ux,4977,52547
cp,5381,ux,5009,52764
cp,5382,ux,5027,30705
cp,5383,ux,5008,30704
cp,5384,ux,4997,30597
cp,5385,ux,5000,30600
cp,5386,ux,5021,52710
cp,5387,ux,5020,52709
cp,5388,ux,5052,52926
cp,5389,ux,5070,30921
cp,5390,ux,5051,30920
cp,5391,ux,5040,30813
cp,5392,ux,5043,30816
cp,5393,ux,5064,52872
cp,5394,ux,5063,52871
cp,5395,ux,5095,31137
cp,5396,ux,5113,53088
cp,5397,ux,5094,31136
cp,5398,ux,5083,31029
cp,5399,ux,5086,31032
cp,5400,ux,5107,53034
cp,5401,ux,5106,53033
cp,5402,ux,5156,53250
cp,5403,ux,5138,31353
cp,5404,ux,5137,31352
cp,5405,ux,5126,31245
cp,5406,ux,5129,31248
cp,5407,ux,5150,53196
cp,5408,ux,5149,53195
cp,5409,ux,5181,53412
cp,5410,ux,5199,31569
cp,5411,ux,5180,31568
cp,5412,ux,5169,31461
cp,5413,ux,5172,31464
cp,5414,ux,5193,53358
cp,5415,ux,5192,53357
cp,5416,ux,5224,53574
cp,5417,ux,5242,31785
cp,5418,ux,5223,31784
cp,5419,ux,5212,31677
cp,5420,ux,5215,31680
cp,5421,ux,5236,53520
cp,5422,ux,5235,53519
cp,5423,ux,5679,62682
cp,5424,ux,5823,65022
cp,5425,ux,4914,30236
cp,5426,ux,4915,30237
cp,5427,ux,4912,30218
cp,5428,ux,4961,30452
cp,5429,ux,4962,30453
cp,5430,ux,4959,30434
cp,5431,ux,5004,30668
cp,5432,ux,5005,30669
cp,5433,ux,5002,30650
cp,5434,ux,5047,30884
cp,5435,ux,5048,30885
cp,5436,ux,5045,30866
cp,5437,ux,5090,31100
cp,5438,ux,5091,31101
cp,5439,ux,5088,31082
cp,5440,ux,5133,31316
cp,5441,ux,5134,31317
cp,5442,ux,5131,31298
cp,5443,ux,5176,31532
cp,5444,ux,5177,31533
cp,5445,ux,5174,31514
cp,5446,ux,5219,31748
cp,5447,ux,5220,31749
cp,5448,ux,5217,31730
cp,5449,ux,4916,30238
cp,5450,ux,4943,52467
cp,5451,ux,4917,30239
cp,5452,ux,4945,52469
cp,5453,ux,4913,30219
cp,5454,ux,4944,52468
cp,5455,ux,4963,30454
cp,5456,ux,4987,52629
cp,5457,ux,4964,30455
cp,5458,ux,4989,52631
cp,5459,ux,4960,30435
cp,5460,ux,4988,52630
cp,5461,ux,5006,30670
cp,5462,ux,5030,52791
cp,5463,ux,5007,30671
cp,5464,ux,5032,52793
cp,5465,ux,5003,30651
cp,5466,ux,5031,52792
cp,5467,ux,5049,30886
cp,5468,ux,5073,52953
cp,5469,ux,5050,30887
cp,5470,ux,5075,52955
cp,5471,ux,5046,30867
cp,5472,ux,5074,52954
cp,5473,ux,5092,31102
cp,5474,ux,5116,53115
cp,5475,ux,5093,31103
cp,5476,ux,5118,53117
cp,5477,ux,5089,31083
cp,5478,ux,5117,53116
cp,5479,ux,5135,31318
cp,5480,ux,5159,53277
cp,5481,ux,5136,31319
cp,5482,ux,5161,53279
cp,5483,ux,5132,31299
cp,5484,ux,5160,53278
cp,5485,ux,5178,31534
cp,5486,ux,5202,53439
cp,5487,ux,5179,31535
cp,5488,ux,5204,53441
cp,5489,ux,5175,31515
cp,5490,ux,5203,53440
cp,5491,ux,5221,31750
cp,5492,ux,5245,53601
cp,5493,ux,5222,31751
cp,5494,ux,5247,53603
cp,5495,ux,5218,31731
cp,5496,ux,5246,53602
cp,5497,ux,5750,63834
cp,5498,ux,5606,61494
cp,5499,ux,4952,60692
cp,5500,ux,4942,52466
cp,5501,ux,4947,52471
cp,5502,ux,4946,52470
cp,5503,ux,4951,60666
cp,5504,ux,4986,52628
cp,5505,ux,4991,52633
cp,5506,ux,4990,52632
cp,5507,ux,4995,60729
cp,5508,ux,5029,52790
cp,5509,ux,5034,52795
cp,5510,ux,5033,52794
cp,5511,ux,5038,60774
cp,5512,ux,5072,52952
cp,5513,ux,5077,52957
cp,5514,ux,5076,52956
cp,5515,ux,5081,60819
cp,5516,ux,5115,53114
cp,5517,ux,5120,53119
cp,5518,ux,5119,53118
cp,5519,ux,5124,60864
cp,5520,ux,5158,53276
cp,5521,ux,5163,53281
cp,5522,ux,5162,53280
cp,5523,ux,5167,60909
cp,5524,ux,5201,53438
cp,5525,ux,5206,53443
cp,5526,ux,5205,53442
cp,5527,ux,5210,60954
cp,5528,ux,5244,53600
cp,5529,ux,5249,53605
cp,5530,ux,5248,53604
cp,5531,ux,5253,60999
cp,5532,ux,5678,62664
cp,5533,ux,5822,65004
cp,5534,ux,5273,32055
cp,5535,ux,5297,53844
cp,5536,ux,5277,32075
cp,5537,ux,5298,53845
cp,5538,ux,5276,32074
cp,5539,ux,5296,53843
cp,5540,ux,5320,32271
cp,5541,ux,5341,54006
cp,5542,ux,5324,32291
cp,5543,ux,5342,54007
cp,5544,ux,5323,32290
cp,5545,ux,5340,54005
cp,5546,ux,5363,32487
cp,5547,ux,5384,54168
cp,5548,ux,5367,32507
cp,5549,ux,5385,54169
cp,5550,ux,5366,32506
cp,5551,ux,5383,54167
cp,5552,ux,5406,32703
cp,5553,ux,5427,54330
cp,5554,ux,5410,32723
cp,5555,ux,5428,54331
cp,5556,ux,5409,32722
cp,5557,ux,5426,54329
cp,5558,ux,5449,32919
cp,5559,ux,5470,54492
cp,5560,ux,5453,32939
cp,5561,ux,5471,54493
cp,5562,ux,5452,32938
cp,5563,ux,5469,54491
cp,5564,ux,5492,33135
cp,5565,ux,5513,54654
cp,5566,ux,5496,33155
cp,5567,ux,5514,54655
cp,5568,ux,5495,33154
cp,5569,ux,5512,54653
cp,5570,ux,5535,33351
cp,5571,ux,5556,54816
cp,5572,ux,5539,33371
cp,5573,ux,5557,54817
cp,5574,ux,5538,33370
cp,5575,ux,5555,54815
cp,5576,ux,5578,33567
cp,5577,ux,5599,54978
cp,5578,ux,5582,33587
cp,5579,ux,5600,54979
cp,5580,ux,5581,33586
cp,5581,ux,5598,54977
cp,5582,ux,5272,32054
cp,5583,ux,5275,32073
cp,5584,ux,5274,32072
cp,5585,ux,5319,32270
cp,5586,ux,5322,32289
cp,5587,ux,5321,32288
cp,5588,ux,5362,32486
cp,5589,ux,5365,32505
cp,5590,ux,5364,32504
cp,5591,ux,5405,32702
cp,5592,ux,5408,32721
cp,5593,ux,5407,32720
cp,5594,ux,5448,32918
cp,5595,ux,5451,32937
cp,5596,ux,5450,32936
cp,5597,ux,5491,33134
cp,5598,ux,5494,33153
cp,5599,ux,5493,33152
cp,5600,ux,5534,33350
cp,5601,ux,5537,33369
cp,5602,ux,5536,33368
cp,5603,ux,5577,33566
cp,5604,ux,5580,33585
cp,5605,ux,5579,33584
cp,5606,ux,5751,63852
cp,5607,ux,5607,61512
cp,5608,ux,5284,53735
cp,5609,ux,5270,53736
cp,5610,ux,5285,32020
cp,5611,ux,5268,32018
cp,5612,ux,5254,31892
cp,5613,ux,5257,31895
cp,5614,ux,5280,53683
cp,5615,ux,5282,53685
cp,5616,ux,5317,53924
cp,5617,ux,5331,32236
cp,5618,ux,5315,32234
cp,5619,ux,5301,32108
cp,5620,ux,5304,32111
cp,5621,ux,5327,53872
cp,5622,ux,5329,53874
cp,5623,ux,5360,54086
cp,5624,ux,5374,32452
cp,5625,ux,5358,32450
cp,5626,ux,5344,32324
cp,5627,ux,5347,32327
cp,5628,ux,5370,54034
cp,5629,ux,5372,54036
cp,5630,ux,5403,54248
cp,5631,ux,5417,32668
cp,5632,ux,5401,32666
cp,5633,ux,5387,32540
cp,5634,ux,5390,32543
cp,5635,ux,5413,54196
cp,5636,ux,5415,54198
cp,5637,ux,5446,32884
cp,5638,ux,5460,54410
cp,5639,ux,5444,32882
cp,5640,ux,5430,32756
cp,5641,ux,5433,32759
cp,5642,ux,5456,54358
cp,5643,ux,5458,54360
cp,5644,ux,5503,54572
cp,5645,ux,5489,33100
cp,5646,ux,5487,33098
cp,5647,ux,5473,32972

```
cp,5648,ux,5476,32975
cp,5649,ux,5499,54520
cp,5650,ux,5501,54522
cp,5651,ux,5532,54734
cp,5652,ux,5546,33316
cp,5653,ux,5530,33314
cp,5654,ux,5516,33188
cp,5655,ux,5519,33191
cp,5656,ux,5542,54682
cp,5657,ux,5544,54684
cp,5658,ux,5575,54896
cp,5659,ux,5589,33532
cp,5660,ux,5573,33530
cp,5661,ux,5559,33404
cp,5662,ux,5562,33407
cp,5663,ux,5585,54844
cp,5664,ux,5587,54846
cp,5665,ux,5676,62629
cp,5666,ux,5820,64969
cp,5667,ux,5753,63872
cp,5668,ux,5609,61532
cp,5669,ux,5289,53740
cp,5670,ux,5271,53738
cp,5671,ux,5287,32021
cp,5672,ux,5269,32019
cp,5673,ux,5256,31894
cp,5674,ux,5259,31897
cp,5675,ux,5281,53684
cp,5676,ux,5283,53686
cp,5677,ux,5318,53926
cp,5678,ux,5333,32237
cp,5679,ux,5316,32235
cp,5680,ux,5303,32110
cp,5681,ux,5306,32113
cp,5682,ux,5328,53873
cp,5683,ux,5330,53875
cp,5684,ux,5361,54088
cp,5685,ux,5376,32453
cp,5686,ux,5359,32451
cp,5687,ux,5346,32326
cp,5688,ux,5349,32329
cp,5689,ux,5371,54035
cp,5690,ux,5373,54037
cp,5691,ux,5404,54250
cp,5692,ux,5419,32669
cp,5693,ux,5402,32667
cp,5694,ux,5389,32542
cp,5695,ux,5392,32545
cp,5696,ux,5414,54197
cp,5697,ux,5416,54199
cp,5698,ux,5447,32885
cp,5699,ux,5462,54412
cp,5700,ux,5445,32883
cp,5701,ux,5432,32758
cp,5702,ux,5435,32761
cp,5703,ux,5457,54359
cp,5704,ux,5459,54361
cp,5705,ux,5505,54574
cp,5706,ux,5490,33101
cp,5707,ux,5488,33099
cp,5708,ux,5475,32974
cp,5709,ux,5478,32977
cp,5710,ux,5500,54521
cp,5711,ux,5502,54523
cp,5712,ux,5533,54736
cp,5713,ux,5548,33317
cp,5714,ux,5531,33315
cp,5715,ux,5518,33190
cp,5716,ux,5521,33193
cp,5717,ux,5543,54683
cp,5718,ux,5545,54685
cp,5719,ux,5576,54898
cp,5720,ux,5591,33533
cp,5721,ux,5574,33531
cp,5722,ux,5561,33406
cp,5723,ux,5564,33409
cp,5724,ux,5586,54845
cp,5725,ux,5588,54847
cp,5726,ux,5677,62630
cp,5727,ux,5821,64970
cp,5728,ux,5752,63871
cp,5729,ux,5608,61531
cp,5730,ux,5288,53739
cp,5731,ux,5267,53737
cp,5732,ux,5286,32001
cp,5733,ux,5266,32000
cp,5734,ux,5255,31893
cp,5735,ux,5258,31896
cp,5736,ux,5279,53682
cp,5737,ux,5278,53681
cp,5738,ux,5314,53925
cp,5739,ux,5332,32217
cp,5740,ux,5313,32216
cp,5741,ux,5302,32109
cp,5742,ux,5305,32112
cp,5743,ux,5326,53871
cp,5744,ux,5325,53870
cp,5745,ux,5357,54087
cp,5746,ux,5375,32433
cp,5747,ux,5356,32432
cp,5748,ux,5345,32325
cp,5749,ux,5348,32328
cp,5750,ux,5369,54033
cp,5751,ux,5368,54032
cp,5752,ux,5400,54249
cp,5753,ux,5418,32649
cp,5754,ux,5399,32648
cp,5755,ux,5388,32541
cp,5756,ux,5391,32544
cp,5757,ux,5412,54195
cp,5758,ux,5411,54194
cp,5759,ux,5443,32865
cp,5760,ux,5461,54411
cp,5761,ux,5442,32864
cp,5762,ux,5431,32757
cp,5763,ux,5434,32760
cp,5764,ux,5455,54357
cp,5765,ux,5454,54356
cp,5766,ux,5504,54573
cp,5767,ux,5486,33081
cp,5768,ux,5485,33080
cp,5769,ux,5474,32973
cp,5770,ux,5477,32976
cp,5771,ux,5498,54519
cp,5772,ux,5497,54518
cp,5773,ux,5529,54735
cp,5774,ux,5547,33297
cp,5775,ux,5528,33296
cp,5776,ux,5517,33189
cp,5777,ux,5520,33192
cp,5778,ux,5541,54681
cp,5779,ux,5540,54680
cp,5780,ux,5572,54897
cp,5781,ux,5590,33513
cp,5782,ux,5571,33512
cp,5783,ux,5560,33405
cp,5784,ux,5563,33408
cp,5785,ux,5584,54843
cp,5786,ux,5583,54842
cp,5787,ux,5674,62593
cp,5788,ux,5818,64933
cp,5789,ux,5262,31964
cp,5790,ux,5263,31965
cp,5791,ux,5260,31946
cp,5792,ux,5309,32180
cp,5793,ux,5310,32181
cp,5794,ux,5307,32162
cp,5795,ux,5352,32396
cp,5796,ux,5353,32397
cp,5797,ux,5350,32378
cp,5798,ux,5395,32612
cp,5799,ux,5396,32613
cp,5800,ux,5393,32594
cp,5801,ux,5438,32828
cp,5802,ux,5439,32829
cp,5803,ux,5436,32810
cp,5804,ux,5481,33044
cp,5805,ux,5482,33045
cp,5806,ux,5479,33026
cp,5807,ux,5524,33260
cp,5808,ux,5525,33261
cp,5809,ux,5522,33242
cp,5810,ux,5567,33476
cp,5811,ux,5568,33477
cp,5812,ux,5565,33458
cp,5813,ux,5264,31966
cp,5814,ux,5291,53790
cp,5815,ux,5265,31967
cp,5816,ux,5293,53792
cp,5817,ux,5261,31947
cp,5818,ux,5292,53791
cp,5819,ux,5311,32182
cp,5820,ux,5335,53952
cp,5821,ux,5312,32183
cp,5822,ux,5337,53954
cp,5823,ux,5308,32163
cp,5824,ux,5336,53953
cp,5825,ux,5354,32398
cp,5826,ux,5378,54114
cp,5827,ux,5355,32399
cp,5828,ux,5380,54116
cp,5829,ux,5351,32379
cp,5830,ux,5379,54115
cp,5831,ux,5397,32614
cp,5832,ux,5421,54276
cp,5833,ux,5398,32615
cp,5834,ux,5423,54278
cp,5835,ux,5394,32595
cp,5836,ux,5422,54277
cp,5837,ux,5440,32830
cp,5838,ux,5464,54438
cp,5839,ux,5441,32831
cp,5840,ux,5466,54440
cp,5841,ux,5437,32811
cp,5842,ux,5465,54439
cp,5843,ux,5483,33046
cp,5844,ux,5507,54600
cp,5845,ux,5484,33047
cp,5846,ux,5509,54602
cp,5847,ux,5480,33027
cp,5848,ux,5508,54601
cp,5849,ux,5526,33262
cp,5850,ux,5550,54762
cp,5851,ux,5527,33263
cp,5852,ux,5552,54764
cp,5853,ux,5523,33243
cp,5854,ux,5551,54763
cp,5855,ux,5569,33478
cp,5856,ux,5593,54924
cp,5857,ux,5570,33479
cp,5858,ux,5595,54926
cp,5859,ux,5566,33459
cp,5860,ux,5594,54925
cp,5861,ux,5754,63906
cp,5862,ux,5610,61566
cp,5863,ux,5300,61079
cp,5864,ux,5290,53789
cp,5865,ux,5295,53794
cp,5866,ux,5294,53793
cp,5867,ux,5299,61053
cp,5868,ux,5334,53951
cp,5869,ux,5339,53956
cp,5870,ux,5338,53955
cp,5871,ux,5343,61116
cp,5872,ux,5377,54113
cp,5873,ux,5382,54118
cp,5874,ux,5381,54117
cp,5875,ux,5386,61161
cp,5876,ux,5420,54275
cp,5877,ux,5425,54280
cp,5878,ux,5424,54279
cp,5879,ux,5429,61206
cp,5880,ux,5463,54437
cp,5881,ux,5468,54442
cp,5882,ux,5467,54441
cp,5883,ux,5472,61251
cp,5884,ux,5506,54599
cp,5885,ux,5511,54604
cp,5886,ux,5510,54603
cp,5887,ux,5515,61296
cp,5888,ux,5549,54761
cp,5889,ux,5554,54766
cp,5890,ux,5553,54765
cp,5891,ux,5558,61341
cp,5892,ux,5592,54923
cp,5893,ux,5597,54928
cp,5894,ux,5596,54927
cp,5895,ux,5601,61386
cp,5896,ux,5675,62594
cp,5897,ux,5819,64934
cp,5898,ux,5971,67417
cp,5899,ux,5890,66103
cp,5900,ux,5891,66102
cp,5901,ux,5892,66129
cp,5902,ux,5895,66149
cp,5903,ux,5894,66148
cp,5904,ux,5896,66183
cp,5905,ux,5897,66201
cp,5906,ux,5899,66221
cp,5907,ux,5898,66220
cp,5908,ux,5900,66255
cp,5909,ux,5901,66273
cp,5910,ux,5904,66293
cp,5911,ux,5903,66292
cp,5912,ux,5905,66327
cp,5913,ux,5906,66345
cp,5914,ux,5908,66365
cp,5915,ux,5907,66364
cp,5916,ux,5909,66399
cp,5917,ux,5910,66417
cp,5918,ux,5913,66437
cp,5919,ux,5912,66436
cp,5920,ux,5914,66471
cp,5921,ux,5915,66489
cp,5922,ux,5917,66509
cp,5923,ux,5916,66508
cp,5924,ux,5918,66543
cp,5925,ux,5919,66561
cp,5926,ux,5922,66581
cp,5927,ux,5921,66580
cp,5928,ux,5923,66615
cp,5929,ux,5924,66633
cp,5930,ux,5926,66653
cp,5931,ux,5925,66652
cp,5932,ux,5927,66687
cp,5933,ux,5928,66704
/com
/com  generate uy and uz couples
from ux's
*do,i,1,5933
cplgen,i,uy,uz
*enddo
f,1,fx,340.674
f,2,fx,340.674
f,3,fx,340.674
f,7,fx,349.352
f,9,fx,388.24
f,10,fx,368.635
f,13,fx,396.918
f,15,fx,396.918
f,16,fx,396.918
f,19,fx,388.24
f,21,fx,349.352
f,22,fx,368.635
f,53,fx,263.861
f,54,fx,263.861
f,55,fx,263.861
f,59,fx,272.539
f,61,fx,311.427
f,62,fx,291.822
f,65,fx,320.105
f,67,fx,320.105
f,68,fx,320.105
f,71,fx,311.427
f,73,fx,272.539
f,74,fx,291.822
f,100,fx,187.048
f,101,fx,187.048
f,102,fx,187.048
f,106,fx,195.404
f,108,fx,234.293
f,109,fx,215.009
f,112,fx,242.97
f,114,fx,242.97
f,115,fx,242.97
f,118,fx,234.293
f,120,fx,195.404
f,121,fx,215.009
f,147,fx,109.914
f,148,fx,109.914
f,149,fx,109.914
f,153,fx,118.591
```

f,155,fx,157.48
f,156,fx,138.196
f,159,fx,166.158
f,161,fx,166.158
f,162,fx,166.158
f,165,fx,157.48
f,167,fx,118.591
f,168,fx,138.196
f,194,fx,33.1009
f,195,fx,33.1009
f,196,fx,33.1009
f,200,fx,41.7785
f,202,fx,80.667
f,203,fx,61.0621
f,206,fx,89.3446
f,208,fx,89.3446
f,209,fx,89.3446
f,212,fx,80.667
f,214,fx,41.7785
f,215,fx,61.0621
f,241,fx,-43.712
f,242,fx,-43.712
f,243,fx,-43.712
f,247,fx,-35.034
f,249,fx,3.85411
f,250,fx,-15.751
f,253,fx,12.2103
f,255,fx,12.2103
f,256,fx,12.2103
f,259,fx,3.85411
f,261,fx,-35.034
f,262,fx,-15.751
f,288,fx,-120.85
f,289,fx,-120.85
f,290,fx,-120.85
f,294,fx,-112.17
f,296,fx,-73.28
f,297,fx,-92.564
f,300,fx,-64.603
f,302,fx,-64.603
f,303,fx,-64.603
f,306,fx,-73.28
f,308,fx,-112.17
f,309,fx,-92.564
f,335,fx,-197.66
f,336,fx,-197.66
f,337,fx,-197.66
f,341,fx,-188.98
f,343,fx,-150.09
f,344,fx,-169.38
f,347,fx,-141.42
f,349,fx,-141.42
f,350,fx,-141.42
f,353,fx,-150.09
f,355,fx,-188.98
f,356,fx,-169.38
f,382,fx,340.674
f,383,fx,340.674
f,384,fx,340.674
f,388,fx,349.352
f,390,fx,388.24
f,391,fx,368.635
f,394,fx,396.918
f,396,fx,396.918
f,397,fx,396.918
f,400,fx,388.24
f,402,fx,349.352
f,403,fx,368.635
f,429,fx,263.861
f,430,fx,263.861
f,431,fx,263.861
f,435,fx,272.539
f,437,fx,311.427
f,438,fx,291.822
f,441,fx,320.105
f,443,fx,320.105
f,444,fx,320.105
f,447,fx,311.427
f,449,fx,272.539
f,450,fx,291.822
f,472,fx,187.048
f,473,fx,187.048
f,474,fx,187.048
f,478,fx,195.404
f,480,fx,234.293
f,481,fx,215.009
f,484,fx,242.97
f,486,fx,242.97
f,487,fx,242.97
f,490,fx,234.293
f,492,fx,195.404
f,493,fx,215.009
f,515,fx,109.914
f,516,fx,109.914
f,517,fx,109.914
f,521,fx,118.591
f,523,fx,157.48
f,524,fx,138.196
f,527,fx,166.158
f,529,fx,166.158
f,530,fx,166.158
f,533,fx,157.48
f,535,fx,118.591
f,536,fx,138.196
f,558,fx,33.1009
f,559,fx,33.1009
f,560,fx,33.1009
f,564,fx,41.7785
f,566,fx,80.667
f,567,fx,61.0621
f,570,fx,89.3446
f,572,fx,89.3446
f,573,fx,89.3446
f,576,fx,80.667
f,578,fx,41.7785
f,579,fx,61.0621
f,601,fx,-43.712
f,602,fx,-43.712
f,603,fx,-43.712
f,607,fx,-35.034
f,609,fx,3.85411
f,610,fx,-15.751
f,613,fx,12.2103
f,615,fx,12.2103
f,616,fx,12.2103
f,619,fx,3.85411
f,621,fx,-35.034
f,622,fx,-15.751
f,644,fx,-120.85
f,645,fx,-120.85
f,646,fx,-120.85
f,650,fx,-112.17
f,652,fx,-73.28
f,653,fx,-92.564
f,656,fx,-64.603
f,658,fx,-64.603
f,659,fx,-64.603
f,662,fx,-73.28
f,664,fx,-112.17
f,665,fx,-92.564
f,687,fx,-197.66
f,688,fx,-197.66
f,689,fx,-197.66
f,693,fx,-188.98
f,695,fx,-150.09
f,696,fx,-169.38
f,699,fx,-141.42
f,701,fx,-141.42
f,702,fx,-141.42
f,705,fx,-150.09
f,707,fx,-188.98
f,708,fx,-169.38
f,730,fx,340.674
f,731,fx,340.674
f,732,fx,340.674
f,736,fx,349.352
f,738,fx,388.24
f,739,fx,368.635
f,742,fx,396.918
f,744,fx,396.918
f,745,fx,396.918
f,748,fx,388.24
f,750,fx,349.352
f,751,fx,368.635
f,777,fx,263.861
f,778,fx,263.861
f,779,fx,263.861
f,783,fx,272.539
f,785,fx,311.427
f,786,fx,291.822
f,789,fx,320.105
f,791,fx,320.105
f,792,fx,320.105
f,795,fx,311.427
f,797,fx,272.539
f,798,fx,291.822
f,820,fx,187.048
f,821,fx,187.048
f,822,fx,187.048
f,826,fx,195.404
f,828,fx,234.293
f,829,fx,215.009
f,832,fx,242.97
f,834,fx,242.97
f,835,fx,242.97
f,838,fx,234.293
f,840,fx,195.404
f,841,fx,215.009
f,863,fx,109.914
f,864,fx,109.914
f,865,fx,109.914
f,869,fx,118.591
f,871,fx,157.48
f,872,fx,138.196
f,875,fx,166.158
f,877,fx,166.158
f,878,fx,166.158
f,881,fx,157.48
f,883,fx,118.591
f,884,fx,138.196
f,906,fx,33.1009
f,907,fx,33.1009
f,908,fx,33.1009
f,912,fx,41.7785
f,914,fx,80.667
f,915,fx,61.0621
f,918,fx,89.3446
f,920,fx,89.3446
f,921,fx,89.3446
f,924,fx,80.667
f,926,fx,41.7785
f,927,fx,61.0621
f,949,fx,-43.712
f,950,fx,-43.712
f,951,fx,-43.712
f,955,fx,-35.034
f,957,fx,3.85411
f,958,fx,-15.751
f,961,fx,12.2103
f,963,fx,12.2103
f,964,fx,12.2103
f,967,fx,3.85411
f,969,fx,-35.034
f,970,fx,-15.751
f,992,fx,-120.85
f,993,fx,-120.85
f,994,fx,-120.85
f,998,fx,-112.17
f,1000,fx,-73.28
f,1001,fx,-92.564
f,1004,fx,-64.603
f,1006,fx,-64.603
f,1007,fx,-64.603
f,1010,fx,-73.28
f,1012,fx,-112.17
f,1013,fx,-92.564
f,1035,fx,-197.66
f,1036,fx,-197.66
f,1037,fx,-197.66
f,1041,fx,-188.98
f,1043,fx,-150.09
f,1044,fx,-169.38
f,1047,fx,-141.42
f,1049,fx,-141.42
f,1050,fx,-141.42
f,1053,fx,-150.09
f,1055,fx,-188.98
f,1056,fx,-169.38
f,1078,fx,340.674
f,1079,fx,340.674
f,1080,fx,340.674
f,1084,fx,349.352
f,1086,fx,388.24
f,1087,fx,368.635
f,1090,fx,396.918
f,1092,fx,396.918
f,1093,fx,396.918
f,1096,fx,388.24
f,1098,fx,349.352
f,1099,fx,368.635
f,1125,fx,263.861
f,1126,fx,263.861
f,1127,fx,263.861
f,1131,fx,272.539
f,1133,fx,311.427
f,1134,fx,291.822
f,1137,fx,320.105
f,1139,fx,320.105
f,1140,fx,320.105
f,1143,fx,311.427
f,1145,fx,272.539
f,1146,fx,291.822
f,1168,fx,187.048
f,1169,fx,187.048
f,1170,fx,187.048
f,1174,fx,195.404
f,1176,fx,234.293
f,1177,fx,215.009
f,1180,fx,242.97
f,1182,fx,242.97
f,1183,fx,242.97
f,1186,fx,234.293
f,1188,fx,195.404
f,1189,fx,215.009
f,1211,fx,109.914
f,1212,fx,109.914
f,1213,fx,109.914
f,1217,fx,118.591
f,1219,fx,157.48
f,1220,fx,138.196
f,1223,fx,166.158
f,1225,fx,166.158
f,1226,fx,166.158
f,1229,fx,157.48
f,1231,fx,118.591
f,1232,fx,138.196
f,1254,fx,33.1009
f,1255,fx,33.1009
f,1256,fx,33.1009
f,1260,fx,41.7785
f,1262,fx,80.667
f,1263,fx,61.0621
f,1266,fx,89.3446
f,1268,fx,89.3446
f,1269,fx,89.3446
f,1272,fx,80.667
f,1274,fx,41.7785
f,1275,fx,61.0621
f,1297,fx,-43.712
f,1298,fx,-43.712
f,1299,fx,-43.712
f,1303,fx,-35.034
f,1305,fx,3.85411
f,1306,fx,-15.751
f,1309,fx,12.2103
f,1311,fx,12.2103
f,1312,fx,12.2103
f,1315,fx,3.85411
f,1317,fx,-35.034
f,1318,fx,-15.751
f,1340,fx,-120.85
f,1341,fx,-120.85
f,1342,fx,-120.85
f,1346,fx,-112.17
f,1348,fx,-73.28
f,1349,fx,-92.564
f,1352,fx,-64.603
f,1354,fx,-64.603
f,1355,fx,-64.603
f,1358,fx,-73.28
f,1360,fx,-112.17
f,1361,fx,-92.564

f,1383,fx,-197.66
f,1384,fx,-197.66
f,1385,fx,-197.66
f,1389,fx,-188.98
f,1391,fx,-150.09
f,1392,fx,-169.38
f,1395,fx,-141.42
f,1397,fx,-141.42
f,1398,fx,-141.42
f,1401,fx,-150.09
f,1403,fx,-188.98
f,1404,fx,-169.38
f,1426,fx,340.674
f,1427,fx,340.674
f,1428,fx,340.674
f,1432,fx,349.352
f,1434,fx,388.24
f,1435,fx,368.635
f,1438,fx,396.918
f,1440,fx,396.918
f,1441,fx,396.918
f,1444,fx,388.24
f,1446,fx,349.352
f,1447,fx,368.635
f,1473,fx,263.861
f,1474,fx,263.861
f,1475,fx,263.861
f,1479,fx,272.539
f,1481,fx,311.427
f,1482,fx,291.822
f,1485,fx,320.105
f,1487,fx,320.105
f,1488,fx,320.105
f,1491,fx,311.427
f,1493,fx,272.539
f,1494,fx,291.822
f,1516,fx,187.048
f,1517,fx,187.048
f,1518,fx,187.048
f,1522,fx,195.404
f,1524,fx,234.293
f,1525,fx,215.009
f,1528,fx,242.97
f,1530,fx,242.97
f,1531,fx,242.97
f,1534,fx,234.293
f,1536,fx,195.404
f,1537,fx,215.009
f,1559,fx,109.914
f,1560,fx,109.914
f,1561,fx,109.914
f,1565,fx,118.591
f,1567,fx,157.48
f,1568,fx,138.196
f,1571,fx,166.158
f,1573,fx,166.158
f,1574,fx,166.158
f,1577,fx,157.48
f,1579,fx,118.591
f,1580,fx,138.196
f,1602,fx,33.1009
f,1603,fx,33.1009
f,1604,fx,33.1009
f,1608,fx,41.7785
f,1610,fx,80.667
f,1611,fx,61.0621
f,1614,fx,89.3446
f,1616,fx,89.3446
f,1617,fx,89.3446
f,1620,fx,80.667
f,1622,fx,41.7785
f,1623,fx,61.0621
f,1645,fx,-43.712
f,1646,fx,-43.712
f,1647,fx,-43.712
f,1651,fx,-35.034
f,1653,fx,3.85411
f,1654,fx,-15.751
f,1657,fx,12.2103
f,1659,fx,12.2103
f,1660,fx,12.2103
f,1663,fx,3.85411
f,1665,fx,-35.034
f,1666,fx,-15.751
f,1688,fx,-120.85
f,1689,fx,-120.85
f,1690,fx,-120.85
f,1694,fx,-112.17
f,1696,fx,-73.28
f,1697,fx,-92.564
f,1700,fx,-64.603
f,1702,fx,-64.603
f,1703,fx,-64.603
f,1706,fx,-73.28
f,1708,fx,-112.17
f,1709,fx,-92.564
f,1731,fx,-197.66
f,1732,fx,-197.66
f,1733,fx,-197.66
f,1737,fx,-188.98
f,1739,fx,-150.09
f,1740,fx,-169.38
f,1743,fx,-141.42
f,1745,fx,-141.42
f,1746,fx,-141.42
f,1749,fx,-150.09
f,1751,fx,-188.98
f,1752,fx,-169.38
f,1774,fx,340.674
f,1775,fx,340.674
f,1776,fx,340.674
f,1780,fx,349.352
f,1782,fx,388.24
f,1783,fx,368.635
f,1786,fx,396.918
f,1788,fx,396.918
f,1789,fx,396.918
f,1792,fx,388.24
f,1794,fx,349.352
f,1795,fx,368.635
f,1821,fx,263.861
f,1822,fx,263.861
f,1823,fx,263.861
f,1827,fx,272.539
f,1829,fx,311.427
f,1830,fx,291.822
f,1833,fx,320.105
f,1835,fx,320.105
f,1836,fx,320.105
f,1839,fx,311.427
f,1841,fx,272.539
f,1842,fx,291.822
f,1864,fx,187.048
f,1865,fx,187.048
f,1866,fx,187.048
f,1870,fx,195.404
f,1872,fx,234.293
f,1873,fx,215.009
f,1876,fx,242.97
f,1878,fx,242.97
f,1879,fx,242.97
f,1882,fx,234.293
f,1884,fx,195.404
f,1885,fx,215.009
f,1907,fx,109.914
f,1908,fx,109.914
f,1909,fx,109.914
f,1913,fx,118.591
f,1915,fx,157.48
f,1916,fx,138.196
f,1919,fx,166.158
f,1921,fx,166.158
f,1922,fx,166.158
f,1925,fx,157.48
f,1927,fx,118.591
f,1928,fx,138.196
f,1950,fx,33.1009
f,1951,fx,33.1009
f,1952,fx,33.1009
f,1956,fx,41.7785
f,1958,fx,80.667
f,1959,fx,61.0621
f,1962,fx,89.3446
f,1964,fx,89.3446
f,1965,fx,89.3446
f,1968,fx,80.667
f,1970,fx,41.7785
f,1971,fx,61.0621
f,1993,fx,-43.712
f,1994,fx,-43.712
f,1995,fx,-43.712
f,1999,fx,-35.034
f,2001,fx,3.85411
f,2002,fx,-15.751
f,2005,fx,12.2103
f,2007,fx,12.2103
f,2008,fx,12.2103
f,2011,fx,3.85411
f,2013,fx,-35.034
f,2014,fx,-15.751
f,2036,fx,-120.85
f,2037,fx,-120.85
f,2038,fx,-120.85
f,2042,fx,-112.17
f,2044,fx,-73.28
f,2045,fx,-92.564
f,2048,fx,-64.603
f,2050,fx,-64.603
f,2051,fx,-64.603
f,2054,fx,-73.28
f,2056,fx,-112.17
f,2057,fx,-92.564
f,2079,fx,-197.66
f,2080,fx,-197.66
f,2081,fx,-197.66
f,2085,fx,-188.98
f,2087,fx,-150.09
f,2088,fx,-169.38
f,2091,fx,-141.42
f,2093,fx,-141.42
f,2094,fx,-141.42
f,2097,fx,-150.09
f,2099,fx,-188.98
f,2100,fx,-169.38
f,2122,fx,340.674
f,2123,fx,340.674
f,2124,fx,340.674
f,2128,fx,349.352
f,2130,fx,388.24
f,2131,fx,368.635
f,2134,fx,396.918
f,2136,fx,396.918
f,2137,fx,396.918
f,2140,fx,388.24
f,2142,fx,349.352
f,2143,fx,368.635
f,2169,fx,263.861
f,2170,fx,263.861
f,2171,fx,263.861
f,2175,fx,272.539
f,2177,fx,311.427
f,2178,fx,291.822
f,2181,fx,320.105
f,2183,fx,320.105
f,2184,fx,320.105
f,2187,fx,311.427
f,2189,fx,272.539
f,2190,fx,291.822
f,2212,fx,187.048
f,2213,fx,187.048
f,2214,fx,187.048
f,2218,fx,195.404
f,2220,fx,234.293
f,2221,fx,215.009
f,2224,fx,242.97
f,2226,fx,242.97
f,2227,fx,242.97
f,2230,fx,234.293
f,2232,fx,195.404
f,2233,fx,215.009
f,2255,fx,109.914
f,2256,fx,109.914
f,2257,fx,109.914
f,2261,fx,118.591
f,2263,fx,157.48
f,2264,fx,138.196
f,2267,fx,166.158
f,2269,fx,166.158
f,2270,fx,166.158
f,2273,fx,157.48
f,2275,fx,118.591
f,2276,fx,138.196
f,2298,fx,33.1009
f,2299,fx,33.1009
f,2300,fx,33.1009
f,2304,fx,41.7785
f,2306,fx,80.667
f,2307,fx,61.0621
f,2310,fx,89.3446
f,2312,fx,89.3446
f,2313,fx,89.3446
f,2316,fx,80.667
f,2318,fx,41.7785
f,2319,fx,61.0621
f,2341,fx,-43.712
f,2342,fx,-43.712
f,2343,fx,-43.712
f,2347,fx,-35.034
f,2349,fx,3.85411
f,2350,fx,-15.751
f,2353,fx,12.2103
f,2355,fx,12.2103
f,2356,fx,12.2103
f,2359,fx,3.85411
f,2361,fx,-35.034
f,2362,fx,-15.751
f,2384,fx,-120.85
f,2385,fx,-120.85
f,2386,fx,-120.85
f,2390,fx,-112.17
f,2392,fx,-73.28
f,2393,fx,-92.564
f,2396,fx,-64.603
f,2398,fx,-64.603
f,2399,fx,-64.603
f,2402,fx,-73.28
f,2404,fx,-112.17
f,2405,fx,-92.564
f,2427,fx,-197.66
f,2428,fx,-197.66
f,2429,fx,-197.66
f,2433,fx,-188.98
f,2435,fx,-150.09
f,2436,fx,-169.38
f,2439,fx,-141.42
f,2441,fx,-141.42
f,2442,fx,-141.42
f,2445,fx,-150.09
f,2447,fx,-188.98
f,2448,fx,-169.38
f,2470,fx,340.674
f,2471,fx,340.674
f,2472,fx,340.674
f,2476,fx,349.352
f,2478,fx,388.24
f,2479,fx,368.635
f,2482,fx,396.918
f,2484,fx,396.918
f,2485,fx,396.918
f,2488,fx,388.24
f,2490,fx,349.352
f,2491,fx,368.635
f,2517,fx,263.861
f,2518,fx,263.861
f,2519,fx,263.861
f,2523,fx,272.539
f,2525,fx,311.427
f,2526,fx,291.822
f,2529,fx,320.105
f,2531,fx,320.105
f,2532,fx,320.105
f,2535,fx,311.427
f,2537,fx,272.539
f,2538,fx,291.822
f,2560,fx,187.048
f,2561,fx,187.048
f,2562,fx,187.048
f,2566,fx,195.404
f,2568,fx,234.293
f,2569,fx,215.009
f,2572,fx,242.97
f,2574,fx,242.97

f.2575,fx.242.97
f.2578,fx.234.293
f.2580,fx.195.404
f.2581,fx.215.009
f.2603,fx.109.914
f.2604,fx.109.914
f.2605,fx.109.914
f.2609,fx.118.591
f.2611,fx.157.48
f.2612,fx.138.196
f.2615,fx.166.158
f.2617,fx.166.158
f.2618,fx.166.158
f.2621,fx.157.48
f.2623,fx.118.591
f.2624,fx.138.196
f.2646,fx.33.1009
f.2647,fx.33.1009
f.2648,fx.33.1009
f.2652,fx.41.7785
f.2654,fx.80.667
f.2655,fx.61.0621
f.2658,fx.89.3446
f.2660,fx.89.3446
f.2661,fx.89.3446
f.2664,fx.80.667
f.2666,fx.41.7785
f.2667,fx.61.0621
f.2689,fx.-43.712
f.2690,fx.-43.712
f.2691,fx.-43.712
f.2695,fx.-35.034
f.2697,fx.3.85411
f.2698,fx.-15.751
f.2701,fx.12.2103
f.2703,fx.12.2103
f.2704,fx.12.2103
f.2707,fx.3.85411
f.2709,fx.-35.034
f.2710,fx.-15.751
f.2732,fx.-120.85
f.2733,fx.-120.85
f.2734,fx.-120.85
f.2738,fx.-112.17
f.2740,fx.-73.28
f.2741,fx.-92.564
f.2744,fx.-64.603
f.2746,fx.-64.603
f.2747,fx.-64.603
f.2750,fx.-73.28
f.2752,fx.-112.17
f.2753,fx.-92.564
f.2775,fx.-197.66
f.2776,fx.-197.66
f.2777,fx.-197.66
f.2781,fx.-188.98
f.2783,fx.-150.09
f.2784,fx.-169.38
f.2787,fx.-141.42
f.2789,fx.-141.42
f.2790,fx.-141.42
f.2793,fx.-150.09
f.2795,fx.-188.98
f.2796,fx.-169.38
f.2818,fx.340.674
f.2819,fx.340.674
f.2820,fx.340.674
f.2824,fx.349.352
f.2826,fx.388.24
f.2827,fx.368.635
f.2830,fx.396.918
f.2832,fx.396.918
f.2833,fx.396.918
f.2836,fx.388.24
f.2838,fx.349.352
f.2839,fx.368.635
f.2865,fx.263.861
f.2866,fx.263.861
f.2867,fx.263.861
f.2871,fx.272.539
f.2873,fx.311.427
f.2874,fx.291.822
f.2877,fx.320.105
f.2879,fx.320.105
f.2880,fx.320.105
f.2883,fx.311.427
f.2885,fx.272.539
f.2886,fx.291.822
f.2908,fx.187.048
f.2909,fx.187.048
f.2910,fx.187.048
f.2914,fx.195.404
f.2916,fx.234.293
f.2917,fx.215.009
f.2920,fx.242.97
f.2922,fx.242.97
f.2923,fx.242.97
f.2926,fx.234.293
f.2928,fx.195.404
f.2929,fx.215.009
f.2951,fx.109.914
f.2952,fx.109.914
f.2953,fx.109.914
f.2957,fx.118.591
f.2959,fx.157.48
f.2960,fx.138.196
f.2963,fx.166.158
f.2965,fx.166.158
f.2966,fx.166.158
f.2969,fx.157.48
f.2971,fx.118.591
f.2972,fx.138.196
f.2994,fx.33.1009
f.2995,fx.33.1009
f.2996,fx.33.1009
f.3000,fx.41.7785
f.3002,fx.80.667
f.3003,fx.61.0621
f.3006,fx.89.3446
f.3008,fx.89.3446
f.3009,fx.89.3446
f.3012,fx.80.667
f.3014,fx.41.7785
f.3015,fx.61.0621
f.3037,fx.-43.712
f.3038,fx.-43.712
f.3039,fx.-43.712
f.3043,fx.-35.034
f.3045,fx.3.85411
f.3046,fx.-15.751
f.3049,fx.12.2103
f.3051,fx.12.2103
f.3052,fx.12.2103
f.3055,fx.3.85411
f.3057,fx.-35.034
f.3058,fx.-15.751
f.3080,fx.-120.85
f.3081,fx.-120.85
f.3082,fx.-120.85
f.3086,fx.-112.17
f.3088,fx.-73.28
f.3089,fx.-92.564
f.3092,fx.-64.603
f.3094,fx.-64.603
f.3095,fx.-64.603
f.3098,fx.-73.28
f.3100,fx.-112.17
f.3101,fx.-92.564
f.3123,fx.-197.66
f.3124,fx.-197.66
f.3125,fx.-197.66
f.3129,fx.-188.98
f.3131,fx.-150.09
f.3132,fx.-169.38
f.3135,fx.-141.42
f.3137,fx.-141.42
f.3138,fx.-141.42
f.3141,fx.-150.09
f.3143,fx.-188.98
f.3144,fx.-169.38
f.3166,fx.340.674
f.3167,fx.340.674
f.3168,fx.340.674
f.3172,fx.349.352
f.3174,fx.388.24
f.3175,fx.368.635
f.3178,fx.396.918
f.3180,fx.396.918
f.3181,fx.396.918
f.3184,fx.388.24
f.3186,fx.349.352
f.3187,fx.368.635
f.3213,fx.263.861
f.3214,fx.263.861
f.3215,fx.263.861
f.3219,fx.272.539
f.3221,fx.311.427
f.3222,fx.291.822
f.3225,fx.320.105
f.3227,fx.320.105
f.3228,fx.320.105
f.3231,fx.311.427
f.3233,fx.272.539
f.3234,fx.291.822
f.3256,fx.187.048
f.3257,fx.187.048
f.3258,fx.187.048
f.3262,fx.195.404
f.3264,fx.234.293
f.3265,fx.215.009
f.3268,fx.242.97
f.3270,fx.242.97
f.3271,fx.242.97
f.3274,fx.234.293
f.3276,fx.195.404
f.3277,fx.215.009
f.3299,fx.109.914
f.3300,fx.109.914
f.3301,fx.109.914
f.3305,fx.118.591
f.3307,fx.157.48
f.3308,fx.138.196
f.3311,fx.166.158
f.3313,fx.166.158
f.3314,fx.166.158
f.3317,fx.157.48
f.3319,fx.118.591
f.3320,fx.138.196
f.3342,fx.33.1009
f.3343,fx.33.1009
f.3344,fx.33.1009
f.3348,fx.41.7785
f.3350,fx.80.667
f.3351,fx.61.0621
f.3354,fx.89.3446
f.3356,fx.89.3446
f.3357,fx.89.3446
f.3360,fx.80.667
f.3362,fx.41.7785
f.3363,fx.61.0621
f.3385,fx.-43.712
f.3386,fx.-43.712
f.3387,fx.-43.712
f.3391,fx.-35.034
f.3393,fx.3.85411
f.3394,fx.-15.751
f.3397,fx.12.2103
f.3399,fx.12.2103
f.3400,fx.12.2103
f.3403,fx.3.85411
f.3405,fx.-35.034
f.3406,fx.-15.751
f.3428,fx.-120.85
f.3429,fx.-120.85
f.3430,fx.-120.85
f.3434,fx.-112.17
f.3436,fx.-73.28
f.3437,fx.-92.564
f.3440,fx.-64.603
f.3442,fx.-64.603
f.3443,fx.-64.603
f.3446,fx.-73.28
f.3448,fx.-112.17
f.3449,fx.-92.564
f.3471,fx.-197.66
f.3472,fx.-197.66
f.3473,fx.-197.66
f.3477,fx.-188.98
f.3479,fx.-150.09
f.3480,fx.-169.38
f.3483,fx.-141.42
f.3485,fx.-141.42
f.3486,fx.-141.42
f.3489,fx.-150.09
f.3491,fx.-188.98
f.3492,fx.-169.38
f.3514,fx.340.674
f.3515,fx.340.674
f.3516,fx.340.674
f.3520,fx.349.352
f.3522,fx.388.24
f.3523,fx.368.635
f.3526,fx.396.918
f.3528,fx.396.918
f.3529,fx.396.918
f.3532,fx.388.24
f.3534,fx.349.352
f.3535,fx.368.635
f.3561,fx.263.861
f.3562,fx.263.861
f.3563,fx.263.861
f.3567,fx.272.539
f.3569,fx.311.427
f.3570,fx.291.822
f.3573,fx.320.105
f.3575,fx.320.105
f.3576,fx.320.105
f.3579,fx.311.427
f.3581,fx.272.539
f.3582,fx.291.822
f.3604,fx.187.048
f.3605,fx.187.048
f.3606,fx.187.048
f.3610,fx.195.404
f.3612,fx.234.293
f.3613,fx.215.009
f.3616,fx.242.97
f.3618,fx.242.97
f.3619,fx.242.97
f.3622,fx.234.293
f.3624,fx.195.404
f.3625,fx.215.009
f.3647,fx.109.914
f.3648,fx.109.914
f.3649,fx.109.914
f.3653,fx.118.591
f.3655,fx.157.48
f.3656,fx.138.196
f.3659,fx.166.158
f.3661,fx.166.158
f.3662,fx.166.158
f.3665,fx.157.48
f.3667,fx.118.591
f.3668,fx.138.196
f.3690,fx.33.1009
f.3691,fx.33.1009
f.3692,fx.33.1009
f.3696,fx.41.7785
f.3698,fx.80.667
f.3699,fx.61.0621
f.3702,fx.89.3446
f.3704,fx.89.3446
f.3705,fx.89.3446
f.3708,fx.80.667
f.3710,fx.41.7785
f.3711,fx.61.0621
f.3733,fx.-43.712
f.3734,fx.-43.712
f.3735,fx.-43.712
f.3739,fx.-35.034
f.3741,fx.3.85411
f.3742,fx.-15.751
f.3745,fx.12.2103
f.3747,fx.12.2103
f.3748,fx.12.2103
f.3751,fx.3.85411
f.3753,fx.-35.034
f.3754,fx.-15.751
f.3776,fx.-120.85
f.3777,fx.-120.85
f.3778,fx.-120.85
f.3782,fx.-112.17

f,3784,fx,-73.28
f,3785,fx,-92.564
f,3788,fx,-64.603
f,3790,fx,-64.603
f,3791,fx,-64.603
f,3794,fx,-73.28
f,3796,fx,-112.17
f,3797,fx,-92.564
f,3819,fx,-197.66
f,3820,fx,-197.66
f,3821,fx,-197.66
f,3825,fx,-188.98
f,3827,fx,-150.09
f,3828,fx,-169.38
f,3831,fx,-141.42
f,3833,fx,-141.42
f,3834,fx,-141.42
f,3837,fx,-150.09
f,3839,fx,-188.98
f,3840,fx,-169.38
f,3862,fx,340.674
f,3863,fx,340.674
f,3864,fx,340.674
f,3868,fx,349.352
f,3870,fx,388.24
f,3871,fx,368.635
f,3874,fx,396.918
f,3876,fx,396.918
f,3877,fx,396.918
f,3880,fx,388.24
f,3882,fx,349.352
f,3883,fx,368.635
f,3909,fx,263.861
f,3910,fx,263.861
f,3911,fx,263.861
f,3915,fx,272.539
f,3917,fx,311.427
f,3918,fx,291.822
f,3921,fx,320.105
f,3923,fx,320.105
f,3924,fx,320.105
f,3927,fx,311.427
f,3929,fx,272.539
f,3930,fx,291.822
f,3952,fx,187.048
f,3953,fx,187.048
f,3954,fx,187.048
f,3958,fx,195.404
f,3960,fx,234.293
f,3961,fx,215.009
f,3964,fx,242.97
f,3966,fx,242.97
f,3967,fx,242.97
f,3970,fx,234.293
f,3972,fx,195.404
f,3973,fx,215.009
f,3995,fx,109.914
f,3996,fx,109.914
f,3997,fx,109.914
f,4001,fx,118.591
f,4003,fx,157.48
f,4004,fx,138.196
f,4007,fx,166.158
f,4009,fx,166.158
f,4010,fx,166.158
f,4013,fx,157.48
f,4015,fx,118.591
f,4016,fx,138.196
f,4038,fx,33.1009
f,4039,fx,33.1009
f,4040,fx,33.1009
f,4044,fx,41.7785
f,4046,fx,80.667
f,4047,fx,61.0621
f,4050,fx,89.3446
f,4052,fx,89.3446
f,4053,fx,89.3446
f,4056,fx,80.667
f,4058,fx,41.7785
f,4059,fx,61.0621
f,4081,fx,-43.712
f,4082,fx,-43.712
f,4083,fx,-43.712
f,4087,fx,-35.034
f,4089,fx,3.85411
f,4090,fx,-15.751
f,4093,fx,12.2103
f,4095,fx,12.2103
f,4096,fx,12.2103
f,4099,fx,3.85411
f,4101,fx,-35.034
f,4102,fx,-15.751
f,4124,fx,-120.85
f,4125,fx,-120.85
f,4126,fx,-120.85
f,4130,fx,-112.17
f,4132,fx,-73.28
f,4133,fx,-92.564
f,4136,fx,-64.603
f,4138,fx,-64.603
f,4139,fx,-64.603
f,4142,fx,-73.28
f,4144,fx,-112.17
f,4145,fx,-92.564
f,4167,fx,-197.66
f,4168,fx,-197.66
f,4169,fx,-197.66
f,4173,fx,-188.98
f,4175,fx,-150.09
f,4176,fx,-169.38
f,4179,fx,-141.42
f,4181,fx,-141.42
f,4182,fx,-141.42
f,4185,fx,-150.09
f,4187,fx,-188.98
f,4188,fx,-169.38
f,4210,fx,340.674
f,4211,fx,340.674
f,4212,fx,340.674
f,4216,fx,349.352
f,4218,fx,388.24
f,4219,fx,368.635
f,4222,fx,396.918
f,4224,fx,396.918
f,4225,fx,396.918
f,4228,fx,388.24
f,4230,fx,349.352
f,4231,fx,368.635
f,4257,fx,263.861
f,4258,fx,263.861
f,4259,fx,263.861
f,4263,fx,272.539
f,4265,fx,311.427
f,4266,fx,291.822
f,4269,fx,320.105
f,4271,fx,320.105
f,4272,fx,320.105
f,4275,fx,311.427
f,4277,fx,272.539
f,4278,fx,291.822
f,4300,fx,187.048
f,4301,fx,187.048
f,4302,fx,187.048
f,4306,fx,195.404
f,4308,fx,234.293
f,4309,fx,215.009
f,4312,fx,242.97
f,4314,fx,242.97
f,4315,fx,242.97
f,4318,fx,234.293
f,4320,fx,195.404
f,4321,fx,215.009
f,4343,fx,109.914
f,4344,fx,109.914
f,4345,fx,109.914
f,4349,fx,118.591
f,4351,fx,157.48
f,4352,fx,138.196
f,4355,fx,166.158
f,4357,fx,166.158
f,4358,fx,166.158
f,4361,fx,157.48
f,4363,fx,118.591
f,4364,fx,138.196
f,4386,fx,33.1009
f,4387,fx,33.1009
f,4388,fx,33.1009
f,4392,fx,41.7785
f,4394,fx,80.667
f,4395,fx,61.0621
f,4398,fx,89.3446
f,4400,fx,89.3446
f,4401,fx,89.3446
f,4404,fx,80.667
f,4406,fx,41.7785
f,4407,fx,61.0621
f,4429,fx,-43.712
f,4430,fx,-43.712
f,4431,fx,-43.712
f,4435,fx,-35.034
f,4437,fx,3.85411
f,4438,fx,-15.751
f,4441,fx,12.2103
f,4443,fx,12.2103
f,4444,fx,12.2103
f,4447,fx,3.85411
f,4449,fx,-35.034
f,4450,fx,-15.751
f,4472,fx,-120.85
f,4473,fx,-120.85
f,4474,fx,-120.85
f,4478,fx,-112.17
f,4480,fx,-73.28
f,4481,fx,-92.564
f,4484,fx,-64.603
f,4486,fx,-64.603
f,4487,fx,-64.603
f,4490,fx,-73.28
f,4492,fx,-112.17
f,4493,fx,-92.564
f,4515,fx,-197.66
f,4516,fx,-197.66
f,4517,fx,-197.66
f,4521,fx,-188.98
f,4523,fx,-150.09
f,4524,fx,-169.38
f,4527,fx,-141.42
f,4529,fx,-141.42
f,4530,fx,-141.42
f,4533,fx,-150.09
f,4535,fx,-188.98
f,4536,fx,-169.38
f,4558,fx,340.674
f,4559,fx,340.674
f,4560,fx,340.674
f,4564,fx,349.352
f,4566,fx,388.24
f,4567,fx,368.635
f,4570,fx,396.918
f,4572,fx,396.918
f,4573,fx,396.918
f,4576,fx,388.24
f,4578,fx,349.352
f,4579,fx,368.635
f,4605,fx,263.861
f,4606,fx,263.861
f,4607,fx,263.861
f,4611,fx,272.539
f,4613,fx,311.427
f,4614,fx,291.822
f,4617,fx,320.105
f,4619,fx,320.105
f,4620,fx,320.105
f,4623,fx,311.427
f,4625,fx,272.539
f,4626,fx,291.822
f,4648,fx,187.048
f,4649,fx,187.048
f,4650,fx,187.048
f,4654,fx,195.404
f,4656,fx,234.293
f,4657,fx,215.009
f,4660,fx,242.97
f,4662,fx,242.97
f,4663,fx,242.97
f,4666,fx,234.293
f,4668,fx,195.404
f,4669,fx,215.009
f,4691,fx,109.914
f,4692,fx,109.914
f,4693,fx,109.914
f,4697,fx,118.591
f,4699,fx,157.48
f,4700,fx,138.196
f,4703,fx,166.158
f,4705,fx,166.158
f,4706,fx,166.158
f,4709,fx,157.48
f,4711,fx,118.591
f,4712,fx,138.196
f,4734,fx,33.1009
f,4735,fx,33.1009
f,4736,fx,33.1009
f,4740,fx,41.7785
f,4742,fx,80.667
f,4743,fx,61.0621
f,4746,fx,89.3446
f,4748,fx,89.3446
f,4749,fx,89.3446
f,4752,fx,80.667
f,4754,fx,41.7785
f,4755,fx,61.0621
f,4777,fx,-43.712
f,4778,fx,-43.712
f,4779,fx,-43.712
f,4783,fx,-35.034
f,4785,fx,3.85411
f,4786,fx,-15.751
f,4789,fx,12.2103
f,4791,fx,12.2103
f,4792,fx,12.2103
f,4795,fx,3.85411
f,4797,fx,-35.034
f,4798,fx,-15.751
f,4820,fx,-120.85
f,4821,fx,-120.85
f,4822,fx,-120.85
f,4826,fx,-112.17
f,4828,fx,-73.28
f,4829,fx,-92.564
f,4832,fx,-64.603
f,4834,fx,-64.603
f,4835,fx,-64.603
f,4838,fx,-73.28
f,4840,fx,-112.17
f,4841,fx,-92.564
f,4863,fx,-197.66
f,4864,fx,-197.66
f,4865,fx,-197.66
f,4869,fx,-188.98
f,4871,fx,-150.09
f,4872,fx,-169.38
f,4875,fx,-141.42
f,4877,fx,-141.42
f,4878,fx,-141.42
f,4881,fx,-150.09
f,4883,fx,-188.98
f,4884,fx,-169.38
f,4906,fx,340.674
f,4907,fx,340.674
f,4908,fx,340.674
f,4912,fx,349.352
f,4914,fx,388.24
f,4915,fx,368.635
f,4918,fx,396.918
f,4920,fx,396.918
f,4921,fx,396.918
f,4924,fx,388.24
f,4926,fx,349.352
f,4927,fx,368.635
f,4953,fx,263.861
f,4954,fx,263.861
f,4955,fx,263.861
f,4959,fx,272.539
f,4961,fx,311.427
f,4962,fx,291.822
f,4965,fx,320.105
f,4967,fx,320.105
f,4968,fx,320.105
f,4971,fx,311.427
f,4973,fx,272.539
f,4974,fx,291.822

f,4996,fx,187.048
f,4997,fx,187.048
f,4998,fx,187.048
f,5002,fx,195.404
f,5004,fx,234.293
f,5005,fx,215.009
f,5008,fx,242.97
f,5010,fx,242.97
f,5011,fx,242.97
f,5014,fx,234.293
f,5016,fx,195.404
f,5017,fx,215.009
f,5039,fx,109.914
f,5040,fx,109.914
f,5041,fx,109.914
f,5045,fx,118.591
f,5047,fx,157.48
f,5048,fx,138.196
f,5051,fx,166.158
f,5053,fx,166.158
f,5054,fx,166.158
f,5057,fx,157.48
f,5059,fx,118.591
f,5060,fx,138.196
f,5082,fx,33.1009
f,5083,fx,33.1009
f,5084,fx,33.1009
f,5088,fx,41.7785
f,5090,fx,80.667
f,5091,fx,61.0621
f,5094,fx,89.3446
f,5096,fx,89.3446
f,5097,fx,89.3446
f,5100,fx,80.667
f,5102,fx,41.7785
f,5103,fx,61.0621
f,5125,fx,-43.712
f,5126,fx,-43.712
f,5127,fx,-43.712
f,5131,fx,-35.034
f,5133,fx,3.85411
f,5134,fx,-15.751
f,5137,fx,12.2103
f,5139,fx,12.2103
f,5140,fx,12.2103
f,5143,fx,3.85411
f,5145,fx,-35.034
f,5146,fx,-15.751
f,5168,fx,-120.85
f,5169,fx,-120.85
f,5170,fx,-120.85
f,5174,fx,-112.17
f,5176,fx,-73.28
f,5177,fx,-92.564
f,5180,fx,-64.603
f,5182,fx,-64.603
f,5183,fx,-64.603
f,5186,fx,-73.28
f,5188,fx,-112.17
f,5189,fx,-92.564
f,5211,fx,-197.66
f,5212,fx,-197.66
f,5213,fx,-197.66
f,5217,fx,-188.98
f,5219,fx,-150.09
f,5220,fx,-169.38
f,5223,fx,-141.42
f,5225,fx,-141.42
f,5226,fx,-141.42
f,5229,fx,-150.09
f,5231,fx,-188.98
f,5232,fx,-169.38
f,5254,fx,340.674
f,5255,fx,340.674
f,5256,fx,340.674
f,5260,fx,349.352
f,5262,fx,388.24
f,5263,fx,368.635
f,5266,fx,396.918
f,5268,fx,396.918
f,5269,fx,396.918
f,5272,fx,388.24
f,5274,fx,349.352
f,5275,fx,368.635
f,5301,fx,263.861
f,5302,fx,263.861
f,5303,fx,263.861
f,5307,fx,272.539
f,5309,fx,311.427
f,5310,fx,291.822
f,5313,fx,320.105
f,5315,fx,320.105
f,5316,fx,320.105
f,5319,fx,311.427
f,5321,fx,272.539
f,5322,fx,291.822
f,5344,fx,187.048
f,5345,fx,187.048
f,5346,fx,187.048
f,5350,fx,195.404
f,5352,fx,234.293
f,5353,fx,215.009
f,5356,fx,242.97
f,5358,fx,242.97
f,5359,fx,242.97
f,5362,fx,234.293
f,5364,fx,195.404
f,5365,fx,215.009
f,5387,fx,109.914
f,5388,fx,109.914
f,5389,fx,109.914
f,5393,fx,118.591
f,5395,fx,157.48
f,5396,fx,138.196
f,5399,fx,166.158
f,5401,fx,166.158
f,5402,fx,166.158
f,5405,fx,157.48
f,5407,fx,118.591
f,5408,fx,138.196
f,5430,fx,33.1009
f,5431,fx,33.1009
f,5432,fx,33.1009
f,5436,fx,41.7785
f,5438,fx,80.667
f,5439,fx,61.0621
f,5442,fx,89.3446
f,5444,fx,89.3446
f,5445,fx,89.3446
f,5448,fx,80.667
f,5450,fx,41.7785
f,5451,fx,61.0621
f,5473,fx,-43.712
f,5474,fx,-43.712
f,5475,fx,-43.712
f,5479,fx,-35.034
f,5481,fx,3.85411
f,5482,fx,-15.751
f,5485,fx,12.2103
f,5487,fx,12.2103
f,5488,fx,12.2103
f,5491,fx,3.85411
f,5493,fx,-35.034
f,5494,fx,-15.751
f,5516,fx,-120.85
f,5517,fx,-120.85
f,5518,fx,-120.85
f,5522,fx,-112.17
f,5524,fx,-73.28
f,5525,fx,-92.564
f,5528,fx,-64.603
f,5530,fx,-64.603
f,5531,fx,-64.603
f,5534,fx,-73.28
f,5536,fx,-112.17
f,5537,fx,-92.564
f,5559,fx,-197.66
f,5560,fx,-197.66
f,5561,fx,-197.66
f,5565,fx,-188.98
f,5567,fx,-150.09
f,5568,fx,-169.38
f,5571,fx,-141.42
f,5573,fx,-141.42
f,5574,fx,-141.42
f,5577,fx,-150.09
f,5579,fx,-188.98
f,5580,fx,-169.38
f,5978,fx,685.907
f,5986,fx,685.907
f,6010,fx,685.907
f,6028,fx,703.262
f,6048,fx,781.039
f,6064,fx,741.829
f,6082,fx,798.394
f,6102,fx,798.394
f,6118,fx,798.394
f,6136,fx,781.039
f,6156,fx,703.262
f,6172,fx,741.829
f,6194,fx,532.281
f,6202,fx,532.281
f,6226,fx,532.281
f,6244,fx,549.636
f,6264,fx,627.413
f,6280,fx,588.203
f,6298,fx,644.768
f,6318,fx,644.768
f,6334,fx,644.768
f,6352,fx,627.413
f,6372,fx,549.636
f,6388,fx,588.203
f,6410,fx,378.655
f,6418,fx,378.655
f,6442,fx,378.655
f,6460,fx,395.368
f,6480,fx,473.145
f,6496,fx,434.577
f,6514,fx,490.5
f,6534,fx,490.5
f,6550,fx,490.5
f,6568,fx,473.145
f,6588,fx,395.368
f,6604,fx,434.577
f,6626,fx,224.386
f,6634,fx,224.386
f,6658,fx,224.386
f,6676,fx,241.742
f,6696,fx,319.519
f,6712,fx,280.952
f,6730,fx,336.874
f,6750,fx,336.874
f,6766,fx,336.874
f,6784,fx,319.519
f,6804,fx,241.742
f,6820,fx,280.952
f,6842,fx,70.7606
f,6850,fx,70.7606
f,6874,fx,70.7606
f,6892,fx,88.1159
f,6912,fx,165.893
f,6928,fx,126.683
f,6946,fx,183.248
f,6966,fx,183.248
f,6982,fx,183.248
f,7000,fx,165.893
f,7020,fx,88.1159
f,7036,fx,126.683
f,7058,fx,-82.865
f,7066,fx,-82.865
f,7090,fx,-82.865
f,7108,fx,-65.51
f,7128,fx,12.2671
f,7144,fx,-26.943
f,7162,fx,28.9795
f,7182,fx,28.9795
f,7198,fx,28.9795
f,7216,fx,12.2671
f,7236,fx,-65.51
f,7252,fx,-26.943
f,7274,fx,-237.13
f,7282,fx,-237.13
f,7306,fx,-237.13
f,7324,fx,-219.78
f,7344,fx,-142
f,7360,fx,-180.57
f,7378,fx,-124.65
f,7398,fx,-124.65
f,7414,fx,-124.65
f,7432,fx,-142
f,7452,fx,-219.78
f,7468,fx,-180.57
f,7490,fx,-390.76
f,7498,fx,-390.76
f,7522,fx,-390.76
f,7540,fx,-373.4
f,7560,fx,-295.63
f,7576,fx,-334.19
f,7594,fx,-278.27
f,7614,fx,-278.27
f,7630,fx,-278.27
f,7648,fx,-295.63
f,7668,fx,-373.4
f,7684,fx,-334.19
f,7706,fx,685.907
f,7714,fx,685.907
f,7738,fx,685.907
f,7756,fx,703.262
f,7776,fx,781.039
f,7792,fx,741.829
f,7810,fx,798.394
f,7830,fx,798.394
f,7846,fx,798.394
f,7864,fx,781.039
f,7884,fx,703.262
f,7900,fx,741.829
f,7922,fx,532.281
f,7930,fx,532.281
f,7954,fx,532.281
f,7972,fx,549.636
f,7992,fx,627.413
f,8008,fx,588.203
f,8026,fx,644.768
f,8046,fx,644.768
f,8062,fx,644.768
f,8080,fx,627.413
f,8100,fx,549.636
f,8116,fx,588.203
f,8138,fx,378.655
f,8146,fx,378.655
f,8170,fx,378.655
f,8188,fx,395.368
f,8208,fx,473.145
f,8224,fx,434.577
f,8242,fx,490.5
f,8262,fx,490.5
f,8278,fx,490.5
f,8296,fx,473.145
f,8316,fx,395.368
f,8332,fx,434.577
f,8354,fx,224.386
f,8362,fx,224.386
f,8386,fx,224.386
f,8404,fx,241.742
f,8424,fx,319.519
f,8440,fx,280.952
f,8458,fx,336.874
f,8478,fx,336.874
f,8494,fx,336.874
f,8512,fx,319.519
f,8532,fx,241.742
f,8548,fx,280.952
f,8570,fx,70.7606
f,8578,fx,70.7606
f,8602,fx,70.7606
f,8620,fx,88.1159
f,8640,fx,165.893
f,8656,fx,126.683
f,8674,fx,183.248
f,8694,fx,183.248
f,8710,fx,183.248
f,8728,fx,165.893
f,8748,fx,88.1159
f,8764,fx,126.683
f,8786,fx,-82.865
f,8794,fx,-82.865
f,8818,fx,-82.865
f,8836,fx,-65.51
f,8856,fx,12.2671
f,8872,fx,-26.943
f,8890,fx,28.9795
f,8910,fx,28.9795

f,8926,fx,28.9795
f,8944,fx,12.2671
f,8964,fx,-65.51
f,8980,fx,-26.943
f,9002,fx,-237.13
f,9010,fx,-237.13
f,9034,fx,-237.13
f,9052,fx,-219.78
f,9072,fx,-142
f,9088,fx,-180.57
f,9106,fx,-124.65
f,9126,fx,-124.65
f,9142,fx,-124.65
f,9160,fx,-142
f,9180,fx,-219.78
f,9196,fx,-180.57
f,9218,fx,-390.76
f,9226,fx,-390.76
f,9250,fx,-390.76
f,9268,fx,-373.4
f,9288,fx,-295.63
f,9304,fx,-334.19
f,9322,fx,-278.27
f,9342,fx,-278.27
f,9358,fx,-278.27
f,9376,fx,-295.63
f,9396,fx,-373.4
f,9412,fx,-334.19
f,9434,fx,685.907
f,9442,fx,685.907
f,9466,fx,685.907
f,9484,fx,703.262
f,9504,fx,781.039
f,9520,fx,741.829
f,9538,fx,798.394
f,9558,fx,798.394
f,9574,fx,798.394
f,9592,fx,781.039
f,9612,fx,703.262
f,9628,fx,741.829
f,9650,fx,532.281
f,9658,fx,532.281
f,9682,fx,532.281
f,9700,fx,549.636
f,9720,fx,627.413
f,9736,fx,588.203
f,9754,fx,644.768
f,9774,fx,644.768
f,9790,fx,644.768
f,9808,fx,627.413
f,9828,fx,549.636
f,9844,fx,588.203
f,9866,fx,378.655
f,9874,fx,378.655
f,9898,fx,378.655
f,9916,fx,395.368
f,9936,fx,473.145
f,9952,fx,434.577
f,9970,fx,490.5
f,9990,fx,490.5
f,10006,fx,490.5
f,10024,fx,473.145
f,10044,fx,395.368
f,10060,fx,434.577
f,10082,fx,224.386
f,10090,fx,224.386
f,10114,fx,224.386
f,10132,fx,241.742
f,10152,fx,319.519
f,10168,fx,280.952
f,10186,fx,336.874
f,10206,fx,336.874
f,10222,fx,336.874
f,10240,fx,319.519
f,10260,fx,241.742
f,10276,fx,280.952
f,10298,fx,70.7606
f,10306,fx,70.7606
f,10330,fx,70.7606
f,10348,fx,88.1159
f,10368,fx,165.893
f,10384,fx,126.683
f,10402,fx,183.248
f,10422,fx,183.248
f,10438,fx,183.248
f,10456,fx,165.893
f,10476,fx,88.1159
f,10492,fx,126.683
f,10514,fx,-82.865
f,10522,fx,-82.865
f,10546,fx,-82.865
f,10564,fx,-65.51
f,10584,fx,12.2671
f,10600,fx,-26.943
f,10618,fx,28.9795
f,10638,fx,28.9795
f,10654,fx,28.9795
f,10672,fx,12.2671
f,10692,fx,-65.51
f,10708,fx,-26.943
f,10730,fx,-237.13
f,10738,fx,-237.13
f,10762,fx,-237.13
f,10780,fx,-219.78
f,10800,fx,-142
f,10816,fx,-180.57
f,10834,fx,-124.65
f,10854,fx,-124.65
f,10870,fx,-124.65
f,10888,fx,-142
f,10908,fx,-219.78
f,10924,fx,-180.57
f,10946,fx,-390.76
f,10954,fx,-390.76
f,10978,fx,-390.76
f,10996,fx,-373.4
f,11016,fx,-295.63
f,11032,fx,-334.19
f,11050,fx,-278.27
f,11070,fx,-278.27
f,11086,fx,-278.27
f,11104,fx,-295.63
f,11124,fx,-373.4
f,11140,fx,-334.19
f,11162,fx,685.907
f,11170,fx,685.907
f,11194,fx,685.907
f,11212,fx,703.262
f,11232,fx,781.039
f,11248,fx,741.829
f,11266,fx,798.394
f,11286,fx,798.394
f,11302,fx,798.394
f,11320,fx,781.039
f,11340,fx,703.262
f,11356,fx,741.829
f,11378,fx,532.281
f,11386,fx,532.281
f,11410,fx,532.281
f,11428,fx,549.636
f,11448,fx,627.413
f,11464,fx,588.203
f,11482,fx,644.768
f,11502,fx,644.768
f,11518,fx,644.768
f,11536,fx,627.413
f,11556,fx,549.636
f,11572,fx,588.203
f,11594,fx,378.655
f,11602,fx,378.655
f,11626,fx,378.655
f,11644,fx,395.368
f,11664,fx,473.145
f,11680,fx,434.577
f,11698,fx,490.5
f,11718,fx,490.5
f,11734,fx,490.5
f,11752,fx,473.145
f,11772,fx,395.368
f,11788,fx,434.577
f,11810,fx,224.386
f,11818,fx,224.386
f,11842,fx,224.386
f,11860,fx,241.742
f,11880,fx,319.519
f,11896,fx,280.952
f,11914,fx,336.874
f,11934,fx,336.874
f,11950,fx,336.874
f,11968,fx,319.519
f,11988,fx,241.742
f,12004,fx,280.952
f,12026,fx,70.7606
f,12034,fx,70.7606
f,12058,fx,70.7606
f,12076,fx,88.1159
f,12096,fx,165.893
f,12112,fx,126.683
f,12130,fx,183.248
f,12150,fx,183.248
f,12166,fx,183.248
f,12184,fx,165.893
f,12204,fx,88.1159
f,12220,fx,126.683
f,12242,fx,-82.865
f,12250,fx,-82.865
f,12274,fx,-82.865
f,12292,fx,-65.51
f,12312,fx,12.2671
f,12328,fx,-26.943
f,12346,fx,28.9795
f,12366,fx,28.9795
f,12382,fx,28.9795
f,12400,fx,12.2671
f,12420,fx,-65.51
f,12436,fx,-26.943
f,12458,fx,-237.13
f,12466,fx,-237.13
f,12490,fx,-237.13
f,12508,fx,-219.78
f,12528,fx,-142
f,12544,fx,-180.57
f,12562,fx,-124.65
f,12582,fx,-124.65
f,12598,fx,-124.65
f,12616,fx,-142
f,12636,fx,-219.78
f,12652,fx,-180.57
f,12674,fx,-390.76
f,12682,fx,-390.76
f,12706,fx,-390.76
f,12724,fx,-373.4
f,12744,fx,-295.63
f,12760,fx,-334.19
f,12778,fx,-278.27
f,12798,fx,-278.27
f,12814,fx,-278.27
f,12832,fx,-295.63
f,12852,fx,-373.4
f,12868,fx,-334.19
f,12890,fx,685.907
f,12898,fx,685.907
f,12922,fx,685.907
f,12940,fx,703.262
f,12960,fx,781.039
f,12976,fx,741.829
f,12994,fx,798.394
f,13014,fx,798.394
f,13030,fx,798.394
f,13048,fx,781.039
f,13068,fx,703.262
f,13084,fx,741.829
f,13106,fx,532.281
f,13114,fx,532.281
f,13138,fx,532.281
f,13156,fx,549.636
f,13176,fx,627.413
f,13192,fx,588.203
f,13210,fx,644.768
f,13230,fx,644.768
f,13246,fx,644.768
f,13264,fx,627.413
f,13284,fx,549.636
f,13300,fx,588.203
f,13322,fx,378.655
f,13330,fx,378.655
f,13354,fx,378.655
f,13372,fx,395.368
f,13392,fx,473.145
f,13408,fx,434.577
f,13426,fx,490.5
f,13446,fx,490.5
f,13462,fx,490.5
f,13480,fx,473.145
f,13500,fx,395.368
f,13516,fx,434.577
f,13538,fx,224.386
f,13546,fx,224.386
f,13570,fx,224.386
f,13588,fx,241.742
f,13608,fx,319.519
f,13624,fx,280.952
f,13642,fx,336.874
f,13662,fx,336.874
f,13678,fx,336.874
f,13696,fx,319.519
f,13716,fx,241.742
f,13732,fx,280.952
f,13754,fx,70.7606
f,13762,fx,70.7606
f,13786,fx,70.7606
f,13804,fx,88.1159
f,13824,fx,165.893
f,13840,fx,126.683
f,13858,fx,183.248
f,13878,fx,183.248
f,13894,fx,183.248
f,13912,fx,165.893
f,13932,fx,88.1159
f,13948,fx,126.683
f,13970,fx,-82.865
f,13978,fx,-82.865
f,14002,fx,-82.865
f,14020,fx,-65.51
f,14040,fx,12.2671
f,14056,fx,-26.943
f,14074,fx,28.9795
f,14094,fx,28.9795
f,14110,fx,28.9795
f,14128,fx,12.2671
f,14148,fx,-65.51
f,14164,fx,-26.943
f,14186,fx,-237.13
f,14194,fx,-237.13
f,14218,fx,-237.13
f,14236,fx,-219.78
f,14256,fx,-142
f,14272,fx,-180.57
f,14290,fx,-124.65
f,14310,fx,-124.65
f,14326,fx,-124.65
f,14344,fx,-142
f,14364,fx,-219.78
f,14380,fx,-180.57
f,14402,fx,-390.76
f,14410,fx,-390.76
f,14434,fx,-390.76
f,14452,fx,-373.4
f,14472,fx,-295.63
f,14488,fx,-334.19
f,14506,fx,-278.27
f,14526,fx,-278.27
f,14542,fx,-278.27
f,14560,fx,-295.63
f,14580,fx,-373.4
f,14596,fx,-334.19
f,14618,fx,685.907
f,14626,fx,685.907
f,14650,fx,685.907
f,14668,fx,703.262
f,14688,fx,781.039
f,14704,fx,741.829
f,14722,fx,798.394
f,14742,fx,798.394
f,14758,fx,798.394
f,14776,fx,781.039
f,14796,fx,703.262
f,14812,fx,741.829
f,14834,fx,532.281
f,14842,fx,532.281
f,14866,fx,532.281
f,14884,fx,549.636

f,14904,fx,627.413
f,14920,fx,588.203
f,14938,fx,644.768
f,14958,fx,644.768
f,14974,fx,644.768
f,14992,fx,627.413
f,15012,fx,549.636
f,15028,fx,588.203
f,15050,fx,378.655
f,15058,fx,378.655
f,15082,fx,378.655
f,15100,fx,395.368
f,15120,fx,473.145
f,15136,fx,434.577
f,15154,fx,490.5
f,15174,fx,490.5
f,15190,fx,490.5
f,15208,fx,473.145
f,15228,fx,395.368
f,15244,fx,434.577
f,15266,fx,224.386
f,15274,fx,224.386
f,15298,fx,224.386
f,15316,fx,241.742
f,15336,fx,319.519
f,15352,fx,280.952
f,15370,fx,336.874
f,15390,fx,336.874
f,15406,fx,336.874
f,15424,fx,319.519
f,15444,fx,241.742
f,15460,fx,280.952
f,15482,fx,70.7606
f,15490,fx,70.7606
f,15514,fx,70.7606
f,15532,fx,88.1159
f,15552,fx,165.893
f,15568,fx,126.683
f,15586,fx,183.248
f,15606,fx,183.248
f,15622,fx,183.248
f,15640,fx,165.893
f,15660,fx,88.1159
f,15676,fx,126.683
f,15698,fx,-82.865
f,15706,fx,-82.865
f,15730,fx,-82.865
f,15748,fx,-65.51
f,15768,fx,12.2671
f,15784,fx,-26.943
f,15802,fx,28.9795
f,15822,fx,28.9795
f,15838,fx,28.9795
f,15856,fx,12.2671
f,15876,fx,-65.51
f,15892,fx,-26.943
f,15914,fx,-237.13
f,15922,fx,-237.13
f,15946,fx,-237.13
f,15964,fx,-219.78
f,15984,fx,-142
f,16000,fx,-180.57
f,16018,fx,-124.65
f,16038,fx,-124.65
f,16054,fx,-124.65
f,16072,fx,-142
f,16092,fx,-219.78
f,16108,fx,-180.57
f,16130,fx,-390.76
f,16138,fx,-390.76
f,16162,fx,-390.76
f,16180,fx,-373.4
f,16200,fx,-295.63
f,16216,fx,-334.19
f,16234,fx,-278.27
f,16254,fx,-278.27
f,16270,fx,-278.27
f,16288,fx,-295.63
f,16308,fx,-373.4
f,16324,fx,-334.19
f,16346,fx,685.907
f,16354,fx,685.907
f,16378,fx,685.907
f,16396,fx,703.262
f,16416,fx,781.039
f,16432,fx,741.829
f,16450,fx,798.394
f,16470,fx,798.394
f,16486,fx,798.394
f,16504,fx,781.039
f,16524,fx,703.262
f,16540,fx,741.829
f,16562,fx,532.281
f,16570,fx,532.281
f,16594,fx,532.281
f,16612,fx,549.636
f,16632,fx,627.413
f,16648,fx,588.203
f,16666,fx,644.768
f,16686,fx,644.768
f,16702,fx,644.768
f,16720,fx,627.413
f,16740,fx,549.636
f,16756,fx,588.203
f,16778,fx,378.655
f,16786,fx,378.655
f,16810,fx,378.655
f,16828,fx,395.368
f,16848,fx,473.145
f,16864,fx,434.577
f,16882,fx,490.5
f,16902,fx,490.5
f,16918,fx,490.5
f,16936,fx,473.145
f,16956,fx,395.368
f,16972,fx,434.577
f,16994,fx,224.386
f,17002,fx,224.386
f,17026,fx,224.386
f,17044,fx,241.742
f,17064,fx,319.519
f,17080,fx,280.952
f,17098,fx,336.874
f,17118,fx,336.874
f,17134,fx,336.874
f,17152,fx,319.519
f,17172,fx,241.742
f,17188,fx,280.952
f,17210,fx,70.7606
f,17218,fx,70.7606
f,17242,fx,70.7606
f,17260,fx,88.1159
f,17280,fx,165.893
f,17296,fx,126.683
f,17314,fx,183.248
f,17334,fx,183.248
f,17350,fx,183.248
f,17368,fx,165.893
f,17388,fx,88.1159
f,17404,fx,126.683
f,17426,fx,-82.865
f,17434,fx,-82.865
f,17458,fx,-82.865
f,17476,fx,-65.51
f,17496,fx,12.2671
f,17512,fx,-26.943
f,17530,fx,28.9795
f,17550,fx,28.9795
f,17566,fx,28.9795
f,17584,fx,12.2671
f,17604,fx,-65.51
f,17620,fx,-26.943
f,17642,fx,-237.13
f,17650,fx,-237.13
f,17674,fx,-237.13
f,17692,fx,-219.78
f,17712,fx,-142
f,17728,fx,-180.57
f,17746,fx,-124.65
f,17766,fx,-124.65
f,17782,fx,-124.65
f,17800,fx,-142
f,17820,fx,-219.78
f,17836,fx,-180.57
f,17858,fx,-390.76
f,17866,fx,-390.76
f,17890,fx,-390.76
f,17908,fx,-373.4
f,17928,fx,-295.63
f,17944,fx,-334.19
f,17962,fx,-278.27
f,17982,fx,-278.27
f,17998,fx,-278.27
f,18016,fx,-295.63
f,18036,fx,-373.4
f,18052,fx,-334.19
f,18074,fx,685.907
f,18082,fx,685.907
f,18106,fx,685.907
f,18124,fx,703.262
f,18144,fx,781.039
f,18160,fx,741.829
f,18178,fx,798.394
f,18198,fx,798.394
f,18214,fx,798.394
f,18232,fx,781.039
f,18252,fx,703.262
f,18268,fx,741.829
f,18290,fx,532.281
f,18298,fx,532.281
f,18322,fx,532.281
f,18340,fx,549.636
f,18360,fx,627.413
f,18376,fx,588.203
f,18394,fx,644.768
f,18414,fx,644.768
f,18430,fx,644.768
f,18448,fx,627.413
f,18468,fx,549.636
f,18484,fx,588.203
f,18506,fx,378.655
f,18514,fx,378.655
f,18538,fx,378.655
f,18556,fx,395.368
f,18576,fx,473.145
f,18592,fx,434.577
f,18610,fx,490.5
f,18630,fx,490.5
f,18646,fx,490.5
f,18664,fx,473.145
f,18684,fx,395.368
f,18700,fx,434.577
f,18722,fx,224.386
f,18730,fx,224.386
f,18754,fx,224.386
f,18772,fx,241.742
f,18792,fx,319.519
f,18808,fx,280.952
f,18826,fx,336.874
f,18846,fx,336.874
f,18862,fx,336.874
f,18880,fx,319.519
f,18900,fx,241.742
f,18916,fx,280.952
f,18938,fx,70.7606
f,18946,fx,70.7606
f,18970,fx,70.7606
f,18988,fx,88.1159
f,19008,fx,165.893
f,19024,fx,126.683
f,19042,fx,183.248
f,19062,fx,183.248
f,19078,fx,183.248
f,19096,fx,165.893
f,19116,fx,88.1159
f,19132,fx,126.683
f,19154,fx,-82.865
f,19162,fx,-82.865
f,19186,fx,-82.865
f,19204,fx,-65.51
f,19224,fx,12.2671
f,19240,fx,-26.943
f,19258,fx,28.9795
f,19278,fx,28.9795
f,19294,fx,28.9795
f,19312,fx,12.2671
f,19332,fx,-65.51
f,19348,fx,-26.943
f,19370,fx,-237.13
f,19378,fx,-237.13
f,19402,fx,-237.13
f,19420,fx,-219.78
f,19440,fx,-142
f,19456,fx,-180.57
f,19474,fx,-124.65
f,19494,fx,-124.65
f,19510,fx,-124.65
f,19528,fx,-142
f,19548,fx,-219.78
f,19564,fx,-180.57
f,19586,fx,-390.76
f,19594,fx,-390.76
f,19618,fx,-390.76
f,19636,fx,-373.4
f,19656,fx,-295.63
f,19672,fx,-334.19
f,19690,fx,-278.27
f,19710,fx,-278.27
f,19726,fx,-278.27
f,19744,fx,-295.63
f,19764,fx,-373.4
f,19780,fx,-334.19
f,19802,fx,685.907
f,19810,fx,685.907
f,19834,fx,685.907
f,19852,fx,703.262
f,19872,fx,781.039
f,19888,fx,741.829
f,19906,fx,798.394
f,19926,fx,798.394
f,19942,fx,798.394
f,19960,fx,781.039
f,19980,fx,703.262
f,19996,fx,741.829
f,20018,fx,532.281
f,20026,fx,532.281
f,20050,fx,532.281
f,20068,fx,549.636
f,20088,fx,627.413
f,20104,fx,588.203
f,20122,fx,644.768
f,20142,fx,644.768
f,20158,fx,644.768
f,20176,fx,627.413
f,20196,fx,549.636
f,20212,fx,588.203
f,20234,fx,378.655
f,20242,fx,378.655
f,20266,fx,378.655
f,20284,fx,395.368
f,20304,fx,473.145
f,20320,fx,434.577
f,20338,fx,490.5
f,20358,fx,490.5
f,20374,fx,490.5
f,20392,fx,473.145
f,20412,fx,395.368
f,20428,fx,434.577
f,20450,fx,224.386
f,20458,fx,224.386
f,20482,fx,224.386
f,20500,fx,241.742
f,20520,fx,319.519
f,20536,fx,280.952
f,20554,fx,336.874
f,20574,fx,336.874
f,20590,fx,336.874
f,20608,fx,319.519
f,20628,fx,241.742
f,20644,fx,280.952
f,20666,fx,70.7606
f,20674,fx,70.7606
f,20698,fx,70.7606
f,20716,fx,88.1159
f,20736,fx,165.893
f,20752,fx,126.683
f,20770,fx,183.248
f,20790,fx,183.248
f,20806,fx,183.248
f,20824,fx,165.893
f,20844,fx,88.1159
f,20860,fx,126.683

f,20882,fx,-82.865
f,20890,fx,-82.865
f,20914,fx,-82.865
f,20932,fx,-65.51
f,20952,fx,12.2671
f,20968,fx,-26.943
f,20986,fx,28.9795
f,21006,fx,28.9795
f,21022,fx,28.9795
f,21040,fx,12.2671
f,21060,fx,-65.51
f,21076,fx,-26.943
f,21098,fx,-237.13
f,21106,fx,-237.13
f,21130,fx,-237.13
f,21148,fx,-219.78
f,21168,fx,-142
f,21184,fx,-180.57
f,21202,fx,-124.65
f,21222,fx,-124.65
f,21238,fx,-124.65
f,21256,fx,-142
f,21276,fx,-219.78
f,21292,fx,-180.57
f,21314,fx,-390.76
f,21322,fx,-390.76
f,21346,fx,-390.76
f,21364,fx,-373.4
f,21384,fx,-295.63
f,21400,fx,-334.19
f,21418,fx,-278.27
f,21438,fx,-278.27
f,21454,fx,-278.27
f,21472,fx,-295.63
f,21492,fx,-373.4
f,21508,fx,-334.19
f,21530,fx,685.907
f,21538,fx,685.907
f,21562,fx,685.907
f,21580,fx,703.262
f,21600,fx,781.039
f,21616,fx,741.829
f,21634,fx,798.394
f,21654,fx,798.394
f,21670,fx,798.394
f,21688,fx,781.039
f,21708,fx,703.262
f,21724,fx,741.829
f,21746,fx,532.281
f,21754,fx,532.281
f,21778,fx,532.281
f,21796,fx,549.636
f,21816,fx,627.413
f,21832,fx,588.203
f,21850,fx,644.768
f,21870,fx,644.768
f,21886,fx,644.768
f,21904,fx,627.413
f,21924,fx,549.636
f,21940,fx,588.203
f,21962,fx,378.655
f,21970,fx,378.655
f,21994,fx,378.655
f,22012,fx,395.368
f,22032,fx,473.145
f,22048,fx,434.577
f,22066,fx,490.5
f,22086,fx,490.5
f,22102,fx,490.5
f,22120,fx,473.145
f,22140,fx,395.368
f,22156,fx,434.577
f,22178,fx,224.386
f,22186,fx,224.386
f,22210,fx,224.386
f,22228,fx,241.742
f,22248,fx,319.519
f,22264,fx,280.952
f,22282,fx,336.874
f,22302,fx,336.874
f,22318,fx,336.874
f,22336,fx,319.519
f,22356,fx,241.742
f,22372,fx,280.952
f,22394,fx,70.7606
f,22402,fx,70.7606
f,22426,fx,70.7606
f,22444,fx,88.1159
f,22464,fx,165.893
f,22480,fx,126.683
f,22498,fx,183.248
f,22518,fx,183.248
f,22534,fx,183.248
f,22552,fx,165.893
f,22572,fx,88.1159
f,22588,fx,126.683
f,22610,fx,-82.865
f,22618,fx,-82.865
f,22642,fx,-82.865
f,22660,fx,-65.51
f,22680,fx,12.2671
f,22696,fx,-26.943
f,22714,fx,28.9795
f,22734,fx,28.9795
f,22750,fx,28.9795
f,22768,fx,12.2671
f,22788,fx,-65.51
f,22804,fx,-26.943
f,22826,fx,-237.13
f,22834,fx,-237.13
f,22858,fx,-237.13
f,22876,fx,-219.78
f,22896,fx,-142
f,22912,fx,-180.57
f,22930,fx,-124.65
f,22950,fx,-124.65
f,22966,fx,-124.65
f,22984,fx,-142
f,23004,fx,-219.78
f,23020,fx,-180.57
f,23042,fx,-390.76
f,23050,fx,-390.76
f,23074,fx,-390.76
f,23092,fx,-373.4
f,23112,fx,-295.63
f,23128,fx,-334.19
f,23146,fx,-278.27
f,23166,fx,-278.27
f,23182,fx,-278.27
f,23200,fx,-295.63
f,23220,fx,-373.4
f,23236,fx,-334.19
f,23258,fx,685.907
f,23266,fx,685.907
f,23290,fx,685.907
f,23308,fx,703.262
f,23328,fx,781.039
f,23344,fx,741.829
f,23362,fx,798.394
f,23382,fx,798.394
f,23398,fx,798.394
f,23416,fx,781.039
f,23436,fx,703.262
f,23452,fx,741.829
f,23474,fx,532.281
f,23482,fx,532.281
f,23506,fx,532.281
f,23524,fx,549.636
f,23544,fx,627.413
f,23560,fx,588.203
f,23578,fx,644.768
f,23598,fx,644.768
f,23614,fx,644.768
f,23632,fx,627.413
f,23652,fx,549.636
f,23668,fx,588.203
f,23690,fx,378.655
f,23698,fx,378.655
f,23722,fx,378.655
f,23740,fx,395.368
f,23760,fx,473.145
f,23776,fx,434.577
f,23794,fx,490.5
f,23814,fx,490.5
f,23830,fx,490.5
f,23848,fx,473.145
f,23868,fx,395.368
f,23884,fx,434.577
f,23906,fx,224.386
f,23914,fx,224.386
f,23938,fx,224.386
f,23956,fx,241.742
f,23976,fx,319.519
f,23992,fx,280.952
f,24010,fx,336.874
f,24030,fx,336.874
f,24046,fx,336.874
f,24064,fx,319.519
f,24084,fx,241.742
f,24100,fx,280.952
f,24122,fx,70.7606
f,24130,fx,70.7606
f,24154,fx,70.7606
f,24172,fx,88.1159
f,24192,fx,165.893
f,24208,fx,126.683
f,24226,fx,183.248
f,24246,fx,183.248
f,24262,fx,183.248
f,24280,fx,165.893
f,24300,fx,88.1159
f,24316,fx,126.683
f,24338,fx,-82.865
f,24346,fx,-82.865
f,24370,fx,-82.865
f,24388,fx,-65.51
f,24408,fx,12.2671
f,24424,fx,-26.943
f,24442,fx,28.9795
f,24462,fx,28.9795
f,24478,fx,28.9795
f,24496,fx,12.2671
f,24516,fx,-65.51
f,24532,fx,-26.943
f,24554,fx,-237.13
f,24562,fx,-237.13
f,24586,fx,-237.13
f,24604,fx,-219.78
f,24624,fx,-142
f,24640,fx,-180.57
f,24658,fx,-124.65
f,24678,fx,-124.65
f,24694,fx,-124.65
f,24712,fx,-142
f,24732,fx,-219.78
f,24748,fx,-180.57
f,24770,fx,-390.76
f,24778,fx,-390.76
f,24802,fx,-390.76
f,24820,fx,-373.4
f,24840,fx,-295.63
f,24856,fx,-334.19
f,24874,fx,-278.27
f,24894,fx,-278.27
f,24910,fx,-278.27
f,24928,fx,-295.63
f,24948,fx,-373.4
f,24964,fx,-334.19
f,24986,fx,685.907
f,24994,fx,685.907
f,25018,fx,685.907
f,25036,fx,703.262
f,25056,fx,781.039
f,25072,fx,741.829
f,25090,fx,798.394
f,25110,fx,798.394
f,25126,fx,798.394
f,25144,fx,781.039
f,25164,fx,703.262
f,25180,fx,741.829
f,25202,fx,532.281
f,25210,fx,532.281
f,25234,fx,532.281
f,25252,fx,549.636
f,25272,fx,627.413
f,25288,fx,588.203
f,25306,fx,644.768
f,25326,fx,644.768
f,25342,fx,644.768
f,25360,fx,627.413
f,25380,fx,549.636
f,25396,fx,588.203
f,25418,fx,378.655
f,25426,fx,378.655
f,25450,fx,378.655
f,25468,fx,395.368
f,25488,fx,473.145
f,25504,fx,434.577
f,25522,fx,490.5
f,25542,fx,490.5
f,25558,fx,490.5
f,25576,fx,473.145
f,25596,fx,395.368
f,25612,fx,434.577
f,25634,fx,224.386
f,25642,fx,224.386
f,25666,fx,224.386
f,25684,fx,241.742
f,25704,fx,319.519
f,25720,fx,280.952
f,25738,fx,336.874
f,25758,fx,336.874
f,25774,fx,336.874
f,25792,fx,319.519
f,25812,fx,241.742
f,25828,fx,280.952
f,25850,fx,70.7606
f,25858,fx,70.7606
f,25882,fx,70.7606
f,25900,fx,88.1159
f,25920,fx,165.893
f,25936,fx,126.683
f,25954,fx,183.248
f,25974,fx,183.248
f,25990,fx,183.248
f,26008,fx,165.893
f,26028,fx,88.1159
f,26044,fx,126.683
f,26066,fx,-82.865
f,26074,fx,-82.865
f,26098,fx,-82.865
f,26116,fx,-65.51
f,26136,fx,12.2671
f,26152,fx,-26.943
f,26170,fx,28.9795
f,26190,fx,28.9795
f,26206,fx,28.9795
f,26224,fx,12.2671
f,26244,fx,-65.51
f,26260,fx,-26.943
f,26282,fx,-237.13
f,26290,fx,-237.13
f,26314,fx,-237.13
f,26332,fx,-219.78
f,26352,fx,-142
f,26368,fx,-180.57
f,26386,fx,-124.65
f,26406,fx,-124.65
f,26422,fx,-124.65
f,26440,fx,-142
f,26460,fx,-219.78
f,26476,fx,-180.57
f,26498,fx,-390.76
f,26506,fx,-390.76
f,26530,fx,-390.76
f,26548,fx,-373.4
f,26568,fx,-295.63
f,26584,fx,-334.19
f,26602,fx,-278.27
f,26622,fx,-278.27
f,26638,fx,-278.27
f,26656,fx,-295.63
f,26676,fx,-373.4
f,26692,fx,-334.19
f,26714,fx,685.907
f,26722,fx,685.907
f,26746,fx,685.907
f,26764,fx,703.262
f,26784,fx,781.039
f,26800,fx,741.829
f,26818,fx,798.394
f,26838,fx,798.394

f,26854,fx,798.394
f,26872,fx,781.039
f,26892,fx,703.262
f,26908,fx,741.829
f,26930,fx,532.281
f,26938,fx,532.281
f,26962,fx,532.281
f,26980,fx,549.636
f,27000,fx,627.413
f,27016,fx,588.203
f,27034,fx,644.768
f,27054,fx,644.768
f,27070,fx,644.768
f,27088,fx,627.413
f,27108,fx,549.636
f,27124,fx,588.203
f,27146,fx,378.655
f,27154,fx,378.655
f,27178,fx,378.655
f,27196,fx,395.368
f,27216,fx,473.145
f,27232,fx,434.577
f,27250,fx,490.5
f,27270,fx,490.5
f,27286,fx,490.5
f,27304,fx,473.145
f,27324,fx,395.368
f,27340,fx,434.577
f,27362,fx,224.386
f,27370,fx,224.386
f,27394,fx,224.386
f,27412,fx,241.742
f,27432,fx,319.519
f,27448,fx,280.952
f,27466,fx,336.874
f,27486,fx,336.874
f,27502,fx,336.874
f,27520,fx,319.519
f,27540,fx,241.742
f,27556,fx,280.952
f,27578,fx,70.7606
f,27586,fx,70.7606
f,27610,fx,70.7606
f,27628,fx,88.1159
f,27648,fx,165.893
f,27664,fx,126.683
f,27682,fx,183.248
f,27702,fx,183.248
f,27718,fx,183.248
f,27736,fx,165.893
f,27756,fx,88.1159
f,27772,fx,126.683
f,27794,fx,-82.865
f,27802,fx,-82.865
f,27826,fx,-82.865
f,27844,fx,-65.51
f,27864,fx,12.2671
f,27880,fx,-26.943
f,27898,fx,28.9795
f,27918,fx,28.9795
f,27934,fx,28.9795
f,27952,fx,12.2671
f,27972,fx,-65.51
f,27988,fx,-26.943
f,28010,fx,-237.13
f,28018,fx,-237.13
f,28042,fx,-237.13
f,28060,fx,-219.78
f,28080,fx,-142
f,28096,fx,-180.57
f,28114,fx,-124.65
f,28134,fx,-124.65
f,28150,fx,-124.65
f,28168,fx,-142
f,28188,fx,-219.78
f,28204,fx,-180.57
f,28226,fx,-390.76
f,28234,fx,-390.76
f,28258,fx,-390.76
f,28276,fx,-373.4
f,28296,fx,-295.63
f,28312,fx,-334.19
f,28330,fx,-278.27
f,28350,fx,-278.27
f,28366,fx,-278.27
f,28384,fx,-295.63
f,28404,fx,-373.4
f,28420,fx,-334.19
f,28442,fx,685.907
f,28450,fx,685.907
f,28474,fx,685.907
f,28492,fx,703.262
f,28512,fx,781.039
f,28528,fx,741.829
f,28546,fx,798.394
f,28566,fx,798.394
f,28582,fx,798.394
f,28600,fx,781.039
f,28620,fx,703.262
f,28636,fx,741.829
f,28658,fx,532.281
f,28666,fx,532.281
f,28690,fx,532.281
f,28708,fx,549.636
f,28728,fx,627.413
f,28744,fx,588.203
f,28762,fx,644.768
f,28782,fx,644.768
f,28798,fx,644.768
f,28816,fx,627.413
f,28836,fx,549.636
f,28852,fx,588.203
f,28874,fx,378.655
f,28882,fx,378.655
f,28906,fx,378.655
f,28924,fx,395.368
f,28944,fx,473.145
f,28960,fx,434.577
f,28978,fx,490.5
f,28998,fx,490.5
f,29014,fx,490.5
f,29032,fx,473.145
f,29052,fx,395.368
f,29068,fx,434.577
f,29090,fx,224.386
f,29098,fx,224.386
f,29122,fx,224.386
f,29140,fx,241.742
f,29160,fx,319.519
f,29176,fx,280.952
f,29194,fx,336.874
f,29214,fx,336.874
f,29230,fx,336.874
f,29248,fx,319.519
f,29268,fx,241.742
f,29284,fx,280.952
f,29306,fx,70.7606
f,29314,fx,70.7606
f,29338,fx,70.7606
f,29356,fx,88.1159
f,29376,fx,165.893
f,29392,fx,126.683
f,29410,fx,183.248
f,29430,fx,183.248
f,29446,fx,183.248
f,29464,fx,165.893
f,29484,fx,88.1159
f,29500,fx,126.683
f,29522,fx,-82.865
f,29530,fx,-82.865
f,29554,fx,-82.865
f,29572,fx,-65.51
f,29592,fx,12.2671
f,29608,fx,-26.943
f,29626,fx,28.9795
f,29646,fx,28.9795
f,29662,fx,28.9795
f,29680,fx,12.2671
f,29700,fx,-65.51
f,29716,fx,-26.943
f,29738,fx,-237.13
f,29746,fx,-237.13
f,29770,fx,-237.13
f,29788,fx,-219.78
f,29808,fx,-142
f,29824,fx,-180.57
f,29842,fx,-124.65
f,29862,fx,-124.65
f,29878,fx,-124.65
f,29896,fx,-142
f,29916,fx,-219.78
f,29932,fx,-180.57
f,29954,fx,-390.76
f,29962,fx,-390.76
f,29986,fx,-390.76
f,30004,fx,-373.4
f,30024,fx,-295.63
f,30040,fx,-334.19
f,30058,fx,-278.27
f,30078,fx,-278.27
f,30094,fx,-278.27
f,30112,fx,-295.63
f,30132,fx,-373.4
f,30148,fx,-334.19
f,30170,fx,685.907
f,30178,fx,685.907
f,30202,fx,685.907
f,30220,fx,703.262
f,30240,fx,781.039
f,30256,fx,741.829
f,30274,fx,798.394
f,30294,fx,798.394
f,30310,fx,798.394
f,30328,fx,781.039
f,30348,fx,703.262
f,30364,fx,741.829
f,30386,fx,532.281
f,30394,fx,532.281
f,30418,fx,532.281
f,30436,fx,549.636
f,30456,fx,627.413
f,30472,fx,588.203
f,30490,fx,644.768
f,30510,fx,644.768
f,30526,fx,644.768
f,30544,fx,627.413
f,30564,fx,549.636
f,30580,fx,588.203
f,30602,fx,378.655
f,30610,fx,378.655
f,30634,fx,378.655
f,30652,fx,395.368
f,30672,fx,473.145
f,30688,fx,434.577
f,30706,fx,490.5
f,30726,fx,490.5
f,30742,fx,490.5
f,30760,fx,473.145
f,30780,fx,395.368
f,30796,fx,434.577
f,30818,fx,224.386
f,30826,fx,224.386
f,30850,fx,224.386
f,30868,fx,241.742
f,30888,fx,319.519
f,30904,fx,280.952
f,30922,fx,336.874
f,30942,fx,336.874
f,30958,fx,336.874
f,30976,fx,319.519
f,30996,fx,241.742
f,31012,fx,280.952
f,31034,fx,70.7606
f,31042,fx,70.7606
f,31066,fx,70.7606
f,31084,fx,88.1159
f,31104,fx,165.893
f,31120,fx,126.683
f,31138,fx,183.248
f,31158,fx,183.248
f,31174,fx,183.248
f,31192,fx,165.893
f,31212,fx,88.1159
f,31228,fx,126.683
f,31250,fx,-82.865
f,31258,fx,-82.865
f,31282,fx,-82.865
f,31300,fx,-65.51
f,31320,fx,12.2671
f,31336,fx,-26.943
f,31354,fx,28.9795
f,31374,fx,28.9795
f,31390,fx,28.9795
f,31408,fx,12.2671
f,31428,fx,-65.51
f,31444,fx,-26.943
f,31466,fx,-237.13
f,31474,fx,-237.13
f,31498,fx,-237.13
f,31516,fx,-219.78
f,31536,fx,-142
f,31552,fx,-180.57
f,31570,fx,-124.65
f,31590,fx,-124.65
f,31606,fx,-124.65
f,31624,fx,-142
f,31644,fx,-219.78
f,31660,fx,-180.57
f,31682,fx,-390.76
f,31690,fx,-390.76
f,31714,fx,-390.76
f,31732,fx,-373.4
f,31752,fx,-295.63
f,31768,fx,-334.19
f,31786,fx,-278.27
f,31806,fx,-278.27
f,31822,fx,-278.27
f,31840,fx,-295.63
f,31860,fx,-373.4
f,31876,fx,-334.19
f,31898,fx,685.907
f,31906,fx,685.907
f,31930,fx,685.907
f,31948,fx,703.262
f,31968,fx,781.039
f,31984,fx,741.829
f,32002,fx,798.394
f,32022,fx,798.394
f,32038,fx,798.394
f,32056,fx,781.039
f,32076,fx,703.262
f,32092,fx,741.829
f,32114,fx,532.281
f,32122,fx,532.281
f,32146,fx,532.281
f,32164,fx,549.636
f,32184,fx,627.413
f,32200,fx,588.203
f,32218,fx,644.768
f,32238,fx,644.768
f,32254,fx,644.768
f,32272,fx,627.413
f,32292,fx,549.636
f,32308,fx,588.203
f,32330,fx,378.655
f,32338,fx,378.655
f,32362,fx,378.655
f,32380,fx,395.368
f,32400,fx,473.145
f,32416,fx,434.577
f,32434,fx,490.5
f,32454,fx,490.5
f,32470,fx,490.5
f,32488,fx,473.145
f,32508,fx,395.368
f,32524,fx,434.577
f,32546,fx,224.386
f,32554,fx,224.386
f,32578,fx,224.386
f,32596,fx,241.742
f,32616,fx,319.519
f,32632,fx,280.952
f,32650,fx,336.874
f,32670,fx,336.874
f,32686,fx,336.874
f,32704,fx,319.519
f,32724,fx,241.742
f,32740,fx,280.952
f,32762,fx,70.7606
f,32770,fx,70.7606
f,32794,fx,70.7606
f,32812,fx,88.1159

f,32832,fx,165.893
f,32848,fx,126.683
f,32866,fx,183.248
f,32886,fx,183.248
f,32902,fx,183.248
f,32920,fx,165.893
f,32940,fx,88.1159
f,32956,fx,126.683
f,32978,fx,-82.865
f,32986,fx,-82.865
f,33010,fx,-82.865
f,33028,fx,-65.51
f,33048,fx,12.2671
f,33064,fx,-26.943
f,33082,fx,28.9795
f,33102,fx,28.9795
f,33118,fx,28.9795
f,33136,fx,12.2671
f,33156,fx,-65.51
f,33172,fx,-26.943
f,33194,fx,-237.13
f,33202,fx,-237.13
f,33226,fx,-237.13
f,33244,fx,-219.78
f,33264,fx,-142
f,33280,fx,-180.57
f,33298,fx,-124.65
f,33318,fx,-124.65
f,33334,fx,-124.65
f,33352,fx,-142
f,33372,fx,-219.78
f,33388,fx,-180.57
f,33410,fx,-390.76
f,33418,fx,-390.76
f,33442,fx,-390.76
f,33460,fx,-373.4
f,33480,fx,-295.63
f,33496,fx,-334.19
f,33514,fx,-278.27
f,33534,fx,-278.27
f,33550,fx,-278.27
f,33568,fx,-295.63
f,33588,fx,-373.4
f,33604,fx,-334.19
f,5979,fx,682.931
f,5987,fx,682.931
f,6011,fx,682.931
f,6029,fx,700.286
f,6049,fx,778.063
f,6065,fx,738.854
f,6083,fx,795.419
f,6103,fx,795.419
f,6119,fx,795.419
f,6137,fx,778.063
f,6157,fx,700.286
f,6173,fx,738.854
f,6195,fx,529.305
f,6203,fx,529.305
f,6227,fx,529.305
f,6245,fx,546.661
f,6265,fx,624.438
f,6281,fx,585.228
f,6299,fx,641.793
f,6319,fx,641.793
f,6335,fx,641.793
f,6353,fx,624.438
f,6373,fx,546.661
f,6389,fx,585.228
f,6411,fx,375.679
f,6419,fx,375.679
f,6443,fx,375.679
f,6461,fx,392.392
f,6481,fx,470.169
f,6497,fx,431.602
f,6515,fx,487.524
f,6535,fx,487.524
f,6551,fx,487.524
f,6569,fx,470.169
f,6589,fx,392.392
f,6605,fx,431.602
f,6627,fx,221.411
f,6635,fx,221.411
f,6659,fx,221.411
f,6677,fx,238.766
f,6697,fx,316.543
f,6713,fx,277.976
f,6731,fx,333.898
f,6751,fx,333.898
f,6767,fx,333.898
f,6785,fx,316.543
f,6805,fx,238.766
f,6821,fx,277.976
f,6843,fx,67.785
f,6851,fx,67.785
f,6875,fx,67.785
f,6893,fx,85.1402
f,6913,fx,162.917
f,6929,fx,123.707
f,6947,fx,180.273
f,6967,fx,180.273
f,6983,fx,180.273
f,7001,fx,162.917
f,7021,fx,85.1402
f,7037,fx,123.707
f,7059,fx,-85.841
f,7067,fx,-85.841
f,7091,fx,-85.841
f,7109,fx,-68.486
f,7129,fx,9.2915
f,7145,fx,-29.918
f,7163,fx,26.0039
f,7183,fx,26.0039
f,7199,fx,26.0039
f,7217,fx,9.2915
f,7237,fx,-68.486
f,7253,fx,-29.918
f,7275,fx,-240.11
f,7283,fx,-240.11
f,7307,fx,-240.11
f,7325,fx,-222.75
f,7345,fx,-144.98
f,7361,fx,-183.54
f,7379,fx,-127.62
f,7399,fx,-127.62
f,7415,fx,-127.62
f,7433,fx,-144.98
f,7453,fx,-222.75
f,7469,fx,-183.54
f,7491,fx,-393.74
f,7499,fx,-393.74
f,7523,fx,-393.74
f,7541,fx,-376.38
f,7561,fx,-298.6
f,7577,fx,-337.17
f,7595,fx,-281.25
f,7615,fx,-281.25
f,7631,fx,-281.25
f,7649,fx,-298.6
f,7669,fx,-376.38
f,7685,fx,-337.17
f,7707,fx,682.931
f,7715,fx,682.931
f,7739,fx,682.931
f,7757,fx,700.286
f,7777,fx,778.063
f,7793,fx,738.854
f,7811,fx,795.419
f,7831,fx,795.419
f,7847,fx,795.419
f,7865,fx,778.063
f,7885,fx,700.286
f,7901,fx,738.854
f,7923,fx,529.305
f,7931,fx,529.305
f,7955,fx,529.305
f,7973,fx,546.661
f,7993,fx,624.438
f,8009,fx,585.228
f,8027,fx,641.793
f,8047,fx,641.793
f,8063,fx,641.793
f,8081,fx,624.438
f,8101,fx,546.661
f,8117,fx,585.228
f,8139,fx,375.679
f,8147,fx,375.679
f,8171,fx,375.679
f,8189,fx,392.392
f,8209,fx,470.169
f,8225,fx,431.602
f,8243,fx,487.524
f,8263,fx,487.524
f,8279,fx,487.524
f,8297,fx,470.169
f,8317,fx,392.392
f,8333,fx,431.602
f,8355,fx,221.411
f,8363,fx,221.411
f,8387,fx,221.411
f,8405,fx,238.766
f,8425,fx,316.543
f,8441,fx,277.976
f,8459,fx,333.898
f,8479,fx,333.898
f,8495,fx,333.898
f,8513,fx,316.543
f,8533,fx,238.766
f,8549,fx,277.976
f,8571,fx,67.785
f,8579,fx,67.785
f,8603,fx,67.785
f,8621,fx,85.1402
f,8641,fx,162.917
f,8657,fx,123.707
f,8675,fx,180.273
f,8695,fx,180.273
f,8711,fx,180.273
f,8729,fx,162.917
f,8749,fx,85.1402
f,8765,fx,123.707
f,8787,fx,-85.841
f,8795,fx,-85.841
f,8819,fx,-85.841
f,8837,fx,-68.486
f,8857,fx,9.2915
f,8873,fx,-29.918
f,8891,fx,26.0039
f,8911,fx,26.0039
f,8927,fx,26.0039
f,8945,fx,9.2915
f,8965,fx,-68.486
f,8981,fx,-29.918
f,9003,fx,-240.11
f,9011,fx,-240.11
f,9035,fx,-240.11
f,9053,fx,-222.75
f,9073,fx,-144.98
f,9089,fx,-183.54
f,9107,fx,-127.62
f,9127,fx,-127.62
f,9143,fx,-127.62
f,9161,fx,-144.98
f,9181,fx,-222.75
f,9197,fx,-183.54
f,9219,fx,-393.74
f,9227,fx,-393.74
f,9251,fx,-393.74
f,9269,fx,-376.38
f,9289,fx,-298.6
f,9305,fx,-337.17
f,9323,fx,-281.25
f,9343,fx,-281.25
f,9359,fx,-281.25
f,9377,fx,-298.6
f,9397,fx,-376.38
f,9413,fx,-337.17
f,9435,fx,682.931
f,9443,fx,682.931
f,9467,fx,682.931
f,9485,fx,700.286
f,9505,fx,778.063
f,9521,fx,738.854
f,9539,fx,795.419
f,9559,fx,795.419
f,9575,fx,795.419
f,9593,fx,778.063
f,9613,fx,700.286
f,9629,fx,738.854
f,9651,fx,529.305
f,9659,fx,529.305
f,9683,fx,529.305
f,9701,fx,546.661
f,9721,fx,624.438
f,9737,fx,585.228
f,9755,fx,641.793
f,9775,fx,641.793
f,9791,fx,641.793
f,9809,fx,624.438
f,9829,fx,546.661
f,9845,fx,585.228
f,9867,fx,375.679
f,9875,fx,375.679
f,9899,fx,375.679
f,9917,fx,392.392
f,9937,fx,470.169
f,9953,fx,431.602
f,9971,fx,487.524
f,9991,fx,487.524
f,10007,fx,487.524
f,10025,fx,470.169
f,10045,fx,392.392
f,10061,fx,431.602
f,10083,fx,221.411
f,10091,fx,221.411
f,10115,fx,221.411
f,10133,fx,238.766
f,10153,fx,316.543
f,10169,fx,277.976
f,10187,fx,333.898
f,10207,fx,333.898
f,10223,fx,333.898
f,10241,fx,316.543
f,10261,fx,238.766
f,10277,fx,277.976
f,10299,fx,67.785
f,10307,fx,67.785
f,10331,fx,67.785
f,10349,fx,85.1402
f,10369,fx,162.917
f,10385,fx,123.707
f,10403,fx,180.273
f,10423,fx,180.273
f,10439,fx,180.273
f,10457,fx,162.917
f,10477,fx,85.1402
f,10493,fx,123.707
f,10515,fx,-85.841
f,10523,fx,-85.841
f,10547,fx,-85.841
f,10565,fx,-68.486
f,10585,fx,9.2915
f,10601,fx,-29.918
f,10619,fx,26.0039
f,10639,fx,26.0039
f,10655,fx,26.0039
f,10673,fx,9.2915
f,10693,fx,-68.486
f,10709,fx,-29.918
f,10731,fx,-240.11
f,10739,fx,-240.11
f,10763,fx,-240.11
f,10781,fx,-222.75
f,10801,fx,-144.98
f,10817,fx,-183.54
f,10835,fx,-127.62
f,10855,fx,-127.62
f,10871,fx,-127.62
f,10889,fx,-144.98
f,10909,fx,-222.75
f,10925,fx,-183.54
f,10947,fx,-393.74
f,10955,fx,-393.74
f,10979,fx,-393.74
f,10997,fx,-376.38
f,11017,fx,-298.6
f,11033,fx,-337.17
f,11051,fx,-281.25
f,11071,fx,-281.25
f,11087,fx,-281.25
f,11105,fx,-298.6
f,11125,fx,-376.38
f,11141,fx,-337.17

f,11163,fx,682.931
f,11171,fx,682.931
f,11195,fx,682.931
f,11213,fx,700.286
f,11233,fx,778.063
f,11249,fx,738.854
f,11267,fx,795.419
f,11287,fx,795.419
f,11303,fx,795.419
f,11321,fx,778.063
f,11341,fx,700.286
f,11357,fx,738.854
f,11379,fx,529.305
f,11387,fx,529.305
f,11411,fx,529.305
f,11429,fx,546.661
f,11449,fx,624.438
f,11465,fx,585.228
f,11483,fx,641.793
f,11503,fx,641.793
f,11519,fx,641.793
f,11537,fx,624.438
f,11557,fx,546.661
f,11573,fx,585.228
f,11595,fx,375.679
f,11603,fx,375.679
f,11627,fx,375.679
f,11645,fx,392.392
f,11665,fx,470.169
f,11681,fx,431.602
f,11699,fx,487.524
f,11719,fx,487.524
f,11735,fx,487.524
f,11753,fx,470.169
f,11773,fx,392.392
f,11789,fx,431.602
f,11811,fx,221.411
f,11819,fx,221.411
f,11843,fx,221.411
f,11861,fx,238.766
f,11881,fx,316.543
f,11897,fx,277.976
f,11915,fx,333.898
f,11935,fx,333.898
f,11951,fx,333.898
f,11969,fx,316.543
f,11989,fx,238.766
f,12005,fx,277.976
f,12027,fx,67.785
f,12035,fx,67.785
f,12059,fx,67.785
f,12077,fx,85.1402
f,12097,fx,162.917
f,12113,fx,123.707
f,12131,fx,180.273
f,12151,fx,180.273
f,12167,fx,180.273
f,12185,fx,162.917
f,12205,fx,85.1402
f,12221,fx,123.707
f,12243,fx,-85.841
f,12251,fx,-85.841
f,12275,fx,-85.841
f,12293,fx,-68.486
f,12313,fx,9.2915
f,12329,fx,-29.918
f,12347,fx,26.0039
f,12367,fx,26.0039
f,12383,fx,26.0039
f,12401,fx,9.2915
f,12421,fx,-68.486
f,12437,fx,-29.918
f,12459,fx,-240.11
f,12467,fx,-240.11
f,12491,fx,-240.11
f,12509,fx,-222.75
f,12529,fx,-144.98
f,12545,fx,-183.54
f,12563,fx,-127.62
f,12583,fx,-127.62
f,12599,fx,-127.62
f,12617,fx,-144.98
f,12637,fx,-222.75
f,12653,fx,-183.54
f,12675,fx,-393.74
f,12683,fx,-393.74
f,12707,fx,-393.74
f,12725,fx,-376.38
f,12745,fx,-298.6
f,12761,fx,-337.17
f,12779,fx,-281.25
f,12799,fx,-281.25
f,12815,fx,-281.25
f,12833,fx,-298.6
f,12853,fx,-376.38
f,12869,fx,-337.17
f,12891,fx,682.931
f,12899,fx,682.931
f,12923,fx,682.931
f,12941,fx,700.286
f,12961,fx,778.063
f,12977,fx,738.854
f,12995,fx,795.419
f,13015,fx,795.419
f,13031,fx,795.419
f,13049,fx,778.063
f,13069,fx,700.286
f,13085,fx,738.854
f,13107,fx,529.305
f,13115,fx,529.305
f,13139,fx,529.305
f,13157,fx,546.661
f,13177,fx,624.438
f,13193,fx,585.228
f,13211,fx,641.793
f,13231,fx,641.793
f,13247,fx,641.793
f,13265,fx,624.438
f,13285,fx,546.661
f,13301,fx,585.228
f,13323,fx,375.679
f,13331,fx,375.679
f,13355,fx,375.679
f,13373,fx,392.392
f,13393,fx,470.169
f,13409,fx,431.602
f,13427,fx,487.524
f,13447,fx,487.524
f,13463,fx,487.524
f,13481,fx,470.169
f,13501,fx,392.392
f,13517,fx,431.602
f,13539,fx,221.411
f,13547,fx,221.411
f,13571,fx,221.411
f,13589,fx,238.766
f,13609,fx,316.543
f,13625,fx,277.976
f,13643,fx,333.898
f,13663,fx,333.898
f,13679,fx,333.898
f,13697,fx,316.543
f,13717,fx,238.766
f,13733,fx,277.976
f,13755,fx,67.785
f,13763,fx,67.785
f,13787,fx,67.785
f,13805,fx,85.1402
f,13825,fx,162.917
f,13841,fx,123.707
f,13859,fx,180.273
f,13879,fx,180.273
f,13895,fx,180.273
f,13913,fx,162.917
f,13933,fx,85.1402
f,13949,fx,123.707
f,13971,fx,-85.841
f,13979,fx,-85.841
f,14003,fx,-85.841
f,14021,fx,-68.486
f,14041,fx,9.2915
f,14057,fx,-29.918
f,14075,fx,26.0039
f,14095,fx,26.0039
f,14111,fx,26.0039
f,14129,fx,9.2915
f,14149,fx,-68.486
f,14165,fx,-29.918
f,14187,fx,-240.11
f,14195,fx,-240.11
f,14219,fx,-240.11
f,14237,fx,-222.75
f,14257,fx,-144.98
f,14273,fx,-183.54
f,14291,fx,-127.62
f,14311,fx,-127.62
f,14327,fx,-127.62
f,14345,fx,-144.98
f,14365,fx,-222.75
f,14381,fx,-183.54
f,14403,fx,-393.74
f,14411,fx,-393.74
f,14435,fx,-393.74
f,14453,fx,-376.38
f,14473,fx,-298.6
f,14489,fx,-337.17
f,14507,fx,-281.25
f,14527,fx,-281.25
f,14543,fx,-281.25
f,14561,fx,-298.6
f,14581,fx,-376.38
f,14597,fx,-337.17
f,14619,fx,682.931
f,14627,fx,682.931
f,14651,fx,682.931
f,14669,fx,700.286
f,14689,fx,778.063
f,14705,fx,738.854
f,14723,fx,795.419
f,14743,fx,795.419
f,14759,fx,795.419
f,14777,fx,778.063
f,14797,fx,700.286
f,14813,fx,738.854
f,14835,fx,529.305
f,14843,fx,529.305
f,14867,fx,529.305
f,14885,fx,546.661
f,14905,fx,624.438
f,14921,fx,585.228
f,14939,fx,641.793
f,14959,fx,641.793
f,14975,fx,641.793
f,14993,fx,624.438
f,15013,fx,546.661
f,15029,fx,585.228
f,15051,fx,375.679
f,15059,fx,375.679
f,15083,fx,375.679
f,15101,fx,392.392
f,15121,fx,470.169
f,15137,fx,431.602
f,15155,fx,487.524
f,15175,fx,487.524
f,15191,fx,487.524
f,15209,fx,470.169
f,15229,fx,392.392
f,15245,fx,431.602
f,15267,fx,221.411
f,15275,fx,221.411
f,15299,fx,221.411
f,15317,fx,238.766
f,15337,fx,316.543
f,15353,fx,277.976
f,15371,fx,333.898
f,15391,fx,333.898
f,15407,fx,333.898
f,15425,fx,316.543
f,15445,fx,238.766
f,15461,fx,277.976
f,15483,fx,67.785
f,15491,fx,67.785
f,15515,fx,67.785
f,15533,fx,85.1402
f,15553,fx,162.917
f,15569,fx,123.707
f,15587,fx,180.273
f,15607,fx,180.273
f,15623,fx,180.273
f,15641,fx,162.917
f,15661,fx,85.1402
f,15677,fx,123.707
f,15699,fx,-85.841
f,15707,fx,-85.841
f,15731,fx,-85.841
f,15749,fx,-68.486
f,15769,fx,9.2915
f,15785,fx,-29.918
f,15803,fx,26.0039
f,15823,fx,26.0039
f,15839,fx,26.0039
f,15857,fx,9.2915
f,15877,fx,-68.486
f,15893,fx,-29.918
f,15915,fx,-240.11
f,15923,fx,-240.11
f,15947,fx,-240.11
f,15965,fx,-222.75
f,15985,fx,-144.98
f,16001,fx,-183.54
f,16019,fx,-127.62
f,16039,fx,-127.62
f,16055,fx,-127.62
f,16073,fx,-144.98
f,16093,fx,-222.75
f,16109,fx,-183.54
f,16131,fx,-393.74
f,16139,fx,-393.74
f,16163,fx,-393.74
f,16181,fx,-376.38
f,16201,fx,-298.6
f,16217,fx,-337.17
f,16235,fx,-281.25
f,16255,fx,-281.25
f,16271,fx,-281.25
f,16289,fx,-298.6
f,16309,fx,-376.38
f,16325,fx,-337.17
f,16347,fx,682.931
f,16355,fx,682.931
f,16379,fx,682.931
f,16397,fx,700.286
f,16417,fx,778.063
f,16433,fx,738.854
f,16451,fx,795.419
f,16471,fx,795.419
f,16487,fx,795.419
f,16505,fx,778.063
f,16525,fx,700.286
f,16541,fx,738.854
f,16563,fx,529.305
f,16571,fx,529.305
f,16595,fx,529.305
f,16613,fx,546.661
f,16633,fx,624.438
f,16649,fx,585.228
f,16667,fx,641.793
f,16687,fx,641.793
f,16703,fx,641.793
f,16721,fx,624.438
f,16741,fx,546.661
f,16757,fx,585.228
f,16779,fx,375.679
f,16787,fx,375.679
f,16811,fx,375.679
f,16829,fx,392.392
f,16849,fx,470.169
f,16865,fx,431.602
f,16883,fx,487.524
f,16903,fx,487.524
f,16919,fx,487.524
f,16937,fx,470.169
f,16957,fx,392.392
f,16973,fx,431.602
f,16995,fx,221.411
f,17003,fx,221.411
f,17027,fx,221.411
f,17045,fx,238.766
f,17065,fx,316.543
f,17081,fx,277.976
f,17099,fx,333.898
f,17119,fx,333.898

f,17135,fx,333.898
f,17153,fx,316.543
f,17173,fx,238.766
f,17189,fx,277.976
f,17211,fx,67.785
f,17219,fx,67.785
f,17243,fx,67.785
f,17261,fx,85.1402
f,17281,fx,162.917
f,17297,fx,123.707
f,17315,fx,180.273
f,17335,fx,180.273
f,17351,fx,180.273
f,17369,fx,162.917
f,17389,fx,85.1402
f,17405,fx,123.707
f,17427,fx,-85.841
f,17435,fx,-85.841
f,17459,fx,-85.841
f,17477,fx,-68.486
f,17497,fx,9.2915
f,17513,fx,-29.918
f,17531,fx,26.0039
f,17551,fx,26.0039
f,17567,fx,26.0039
f,17585,fx,9.2915
f,17605,fx,-68.486
f,17621,fx,-29.918
f,17643,fx,-240.11
f,17651,fx,-240.11
f,17675,fx,-240.11
f,17693,fx,-222.75
f,17713,fx,-144.98
f,17729,fx,-183.54
f,17747,fx,-127.62
f,17767,fx,-127.62
f,17783,fx,-127.62
f,17801,fx,-144.98
f,17821,fx,-222.75
f,17837,fx,-183.54
f,17859,fx,-393.74
f,17867,fx,-393.74
f,17891,fx,-393.74
f,17909,fx,-376.38
f,17929,fx,-298.6
f,17945,fx,-337.17
f,17963,fx,-281.25
f,17983,fx,-281.25
f,17999,fx,-281.25
f,18017,fx,-298.6
f,18037,fx,-376.38
f,18053,fx,-337.17
f,18075,fx,682.931
f,18083,fx,682.931
f,18107,fx,682.931
f,18125,fx,700.286
f,18145,fx,778.063
f,18161,fx,738.854
f,18179,fx,795.419
f,18199,fx,795.419
f,18215,fx,795.419
f,18233,fx,778.063
f,18253,fx,700.286
f,18269,fx,738.854
f,18291,fx,529.305
f,18299,fx,529.305
f,18323,fx,529.305
f,18341,fx,546.661
f,18361,fx,624.438
f,18377,fx,585.228
f,18395,fx,641.793
f,18415,fx,641.793
f,18431,fx,641.793
f,18449,fx,624.438
f,18469,fx,546.661
f,18485,fx,585.228
f,18507,fx,375.679
f,18515,fx,375.679
f,18539,fx,375.679
f,18557,fx,392.392
f,18577,fx,470.169
f,18593,fx,431.602
f,18611,fx,487.524
f,18631,fx,487.524
f,18647,fx,487.524
f,18665,fx,470.169
f,18685,fx,392.392
f,18701,fx,431.602
f,18723,fx,221.411
f,18731,fx,221.411
f,18755,fx,221.411
f,18773,fx,238.766
f,18793,fx,316.543
f,18809,fx,277.976
f,18827,fx,333.898
f,18847,fx,333.898
f,18863,fx,333.898
f,18881,fx,316.543
f,18901,fx,238.766
f,18917,fx,277.976
f,18939,fx,67.785
f,18947,fx,67.785
f,18971,fx,67.785
f,18989,fx,85.1402
f,19009,fx,162.917
f,19025,fx,123.707
f,19043,fx,180.273
f,19063,fx,180.273
f,19079,fx,180.273
f,19097,fx,162.917
f,19117,fx,85.1402
f,19133,fx,123.707
f,19155,fx,-85.841
f,19163,fx,-85.841
f,19187,fx,-85.841
f,19205,fx,-68.486
f,19225,fx,9.2915
f,19241,fx,-29.918
f,19259,fx,26.0039
f,19279,fx,26.0039
f,19295,fx,26.0039
f,19313,fx,9.2915
f,19333,fx,-68.486
f,19349,fx,-29.918
f,19371,fx,-240.11
f,19379,fx,-240.11
f,19403,fx,-240.11
f,19421,fx,-222.75
f,19441,fx,-144.98
f,19457,fx,-183.54
f,19475,fx,-127.62
f,19495,fx,-127.62
f,19511,fx,-127.62
f,19529,fx,-144.98
f,19549,fx,-222.75
f,19565,fx,-183.54
f,19587,fx,-393.74
f,19595,fx,-393.74
f,19619,fx,-393.74
f,19637,fx,-376.38
f,19657,fx,-298.6
f,19673,fx,-337.17
f,19691,fx,-281.25
f,19711,fx,-281.25
f,19727,fx,-281.25
f,19745,fx,-298.6
f,19765,fx,-376.38
f,19781,fx,-337.17
f,19803,fx,682.931
f,19811,fx,682.931
f,19835,fx,682.931
f,19853,fx,700.286
f,19873,fx,778.063
f,19889,fx,738.854
f,19907,fx,795.419
f,19927,fx,795.419
f,19943,fx,795.419
f,19961,fx,778.063
f,19981,fx,700.286
f,19997,fx,738.854
f,20019,fx,529.305
f,20027,fx,529.305
f,20051,fx,529.305
f,20069,fx,546.661
f,20089,fx,624.438
f,20105,fx,585.228
f,20123,fx,641.793
f,20143,fx,641.793
f,20159,fx,641.793
f,20177,fx,624.438
f,20197,fx,546.661
f,20213,fx,585.228
f,20235,fx,375.679
f,20243,fx,375.679
f,20267,fx,375.679
f,20285,fx,392.392
f,20305,fx,470.169
f,20321,fx,431.602
f,20339,fx,487.524
f,20359,fx,487.524
f,20375,fx,487.524
f,20393,fx,470.169
f,20413,fx,392.392
f,20429,fx,431.602
f,20451,fx,221.411
f,20459,fx,221.411
f,20483,fx,221.411
f,20501,fx,238.766
f,20521,fx,316.543
f,20537,fx,277.976
f,20555,fx,333.898
f,20575,fx,333.898
f,20591,fx,333.898
f,20609,fx,316.543
f,20629,fx,238.766
f,20645,fx,277.976
f,20667,fx,67.785
f,20675,fx,67.785
f,20699,fx,67.785
f,20717,fx,85.1402
f,20737,fx,162.917
f,20753,fx,123.707
f,20771,fx,180.273
f,20791,fx,180.273
f,20807,fx,180.273
f,20825,fx,162.917
f,20845,fx,85.1402
f,20861,fx,123.707
f,20883,fx,-85.841
f,20891,fx,-85.841
f,20915,fx,-85.841
f,20933,fx,-68.486
f,20953,fx,9.2915
f,20969,fx,-29.918
f,20987,fx,26.0039
f,21007,fx,26.0039
f,21023,fx,26.0039
f,21041,fx,9.2915
f,21061,fx,-68.486
f,21077,fx,-29.918
f,21099,fx,-240.11
f,21107,fx,-240.11
f,21131,fx,-240.11
f,21149,fx,-222.75
f,21169,fx,-144.98
f,21185,fx,-183.54
f,21203,fx,-127.62
f,21223,fx,-127.62
f,21239,fx,-127.62
f,21257,fx,-144.98
f,21277,fx,-222.75
f,21293,fx,-183.54
f,21315,fx,-393.74
f,21323,fx,-393.74
f,21347,fx,-393.74
f,21365,fx,-376.38
f,21385,fx,-298.6
f,21401,fx,-337.17
f,21419,fx,-281.25
f,21439,fx,-281.25
f,21455,fx,-281.25
f,21473,fx,-298.6
f,21493,fx,-376.38
f,21509,fx,-337.17
f,21531,fx,682.931
f,21539,fx,682.931
f,21563,fx,682.931
f,21581,fx,700.286
f,21601,fx,778.063
f,21617,fx,738.854
f,21635,fx,795.419
f,21655,fx,795.419
f,21671,fx,795.419
f,21689,fx,778.063
f,21709,fx,700.286
f,21725,fx,738.854
f,21747,fx,529.305
f,21755,fx,529.305
f,21779,fx,529.305
f,21797,fx,546.661
f,21817,fx,624.438
f,21833,fx,585.228
f,21851,fx,641.793
f,21871,fx,641.793
f,21887,fx,641.793
f,21905,fx,624.438
f,21925,fx,546.661
f,21941,fx,585.228
f,21963,fx,375.679
f,21971,fx,375.679
f,21995,fx,375.679
f,22013,fx,392.392
f,22033,fx,470.169
f,22049,fx,431.602
f,22067,fx,487.524
f,22087,fx,487.524
f,22103,fx,487.524
f,22121,fx,470.169
f,22141,fx,392.392
f,22157,fx,431.602
f,22179,fx,221.411
f,22187,fx,221.411
f,22211,fx,221.411
f,22229,fx,238.766
f,22249,fx,316.543
f,22265,fx,277.976
f,22283,fx,333.898
f,22303,fx,333.898
f,22319,fx,333.898
f,22337,fx,316.543
f,22357,fx,238.766
f,22373,fx,277.976
f,22395,fx,67.785
f,22403,fx,67.785
f,22427,fx,67.785
f,22445,fx,85.1402
f,22465,fx,162.917
f,22481,fx,123.707
f,22499,fx,180.273
f,22519,fx,180.273
f,22535,fx,180.273
f,22553,fx,162.917
f,22573,fx,85.1402
f,22589,fx,123.707
f,22611,fx,-85.841
f,22619,fx,-85.841
f,22643,fx,-85.841
f,22661,fx,-68.486
f,22681,fx,9.2915
f,22697,fx,-29.918
f,22715,fx,26.0039
f,22735,fx,26.0039
f,22751,fx,26.0039
f,22769,fx,9.2915
f,22789,fx,-68.486
f,22805,fx,-29.918
f,22827,fx,-240.11
f,22835,fx,-240.11
f,22859,fx,-240.11
f,22877,fx,-222.75
f,22897,fx,-144.98
f,22913,fx,-183.54
f,22931,fx,-127.62
f,22951,fx,-127.62
f,22967,fx,-127.62
f,22985,fx,-144.98
f,23005,fx,-222.75
f,23021,fx,-183.54
f,23043,fx,-393.74
f,23051,fx,-393.74
f,23075,fx,-393.74
f,23093,fx,-376.38

f,23113,fx,-298.6
f,23129,fx,-337.17
f,23147,fx,-281.25
f,23167,fx,-281.25
f,23183,fx,-281.25
f,23201,fx,-298.6
f,23221,fx,-376.38
f,23237,fx,-337.17
f,23259,fx,682.931
f,23267,fx,682.931
f,23291,fx,682.931
f,23309,fx,700.286
f,23329,fx,778.063
f,23345,fx,738.854
f,23363,fx,795.419
f,23383,fx,795.419
f,23399,fx,795.419
f,23417,fx,778.063
f,23437,fx,700.286
f,23453,fx,738.854
f,23475,fx,529.305
f,23483,fx,529.305
f,23507,fx,529.305
f,23525,fx,546.661
f,23545,fx,624.438
f,23561,fx,585.228
f,23579,fx,641.793
f,23599,fx,641.793
f,23615,fx,641.793
f,23633,fx,624.438
f,23653,fx,546.661
f,23669,fx,585.228
f,23691,fx,375.679
f,23699,fx,375.679
f,23723,fx,375.679
f,23741,fx,392.392
f,23761,fx,470.169
f,23777,fx,431.602
f,23795,fx,487.524
f,23815,fx,487.524
f,23831,fx,487.524
f,23849,fx,470.169
f,23869,fx,392.392
f,23885,fx,431.602
f,23907,fx,221.411
f,23915,fx,221.411
f,23939,fx,221.411
f,23957,fx,238.766
f,23977,fx,316.543
f,23993,fx,277.976
f,24011,fx,333.898
f,24031,fx,333.898
f,24047,fx,333.898
f,24065,fx,316.543
f,24085,fx,238.766
f,24101,fx,277.976
f,24123,fx,67.785
f,24131,fx,67.785
f,24155,fx,67.785
f,24173,fx,85.1402
f,24193,fx,162.917
f,24209,fx,123.707
f,24227,fx,180.273
f,24247,fx,180.273
f,24263,fx,180.273
f,24281,fx,162.917
f,24301,fx,85.1402
f,24317,fx,123.707
f,24339,fx,-85.841
f,24347,fx,-85.841
f,24371,fx,-85.841
f,24389,fx,-68.486
f,24409,fx,9.2915
f,24425,fx,-29.918
f,24443,fx,26.0039
f,24463,fx,26.0039
f,24479,fx,26.0039
f,24497,fx,9.2915
f,24517,fx,-68.486
f,24533,fx,-29.918
f,24555,fx,-240.11
f,24563,fx,-240.11
f,24587,fx,-240.11
f,24605,fx,-222.75
f,24625,fx,-144.98
f,24641,fx,-183.54
f,24659,fx,-127.62
f,24679,fx,-127.62
f,24695,fx,-127.62
f,24713,fx,-144.98
f,24733,fx,-222.75
f,24749,fx,-183.54
f,24771,fx,-393.74
f,24779,fx,-393.74
f,24803,fx,-393.74
f,24821,fx,-376.38
f,24841,fx,-298.6
f,24857,fx,-337.17
f,24875,fx,-281.25
f,24895,fx,-281.25
f,24911,fx,-281.25
f,24929,fx,-298.6
f,24949,fx,-376.38
f,24965,fx,-337.17
f,24987,fx,682.931
f,24995,fx,682.931
f,25019,fx,682.931
f,25037,fx,700.286
f,25057,fx,778.063
f,25073,fx,738.854
f,25091,fx,795.419
f,25111,fx,795.419
f,25127,fx,795.419
f,25145,fx,778.063
f,25165,fx,700.286
f,25181,fx,738.854
f,25203,fx,529.305
f,25211,fx,529.305
f,25235,fx,529.305
f,25253,fx,546.661
f,25273,fx,624.438
f,25289,fx,585.228
f,25307,fx,641.793
f,25327,fx,641.793
f,25343,fx,641.793
f,25361,fx,624.438
f,25381,fx,546.661
f,25397,fx,585.228
f,25419,fx,375.679
f,25427,fx,375.679
f,25451,fx,375.679
f,25469,fx,392.392
f,25489,fx,470.169
f,25505,fx,431.602
f,25523,fx,487.524
f,25543,fx,487.524
f,25559,fx,487.524
f,25577,fx,470.169
f,25597,fx,392.392
f,25613,fx,431.602
f,25635,fx,221.411
f,25643,fx,221.411
f,25667,fx,221.411
f,25685,fx,238.766
f,25705,fx,316.543
f,25721,fx,277.976
f,25739,fx,333.898
f,25759,fx,333.898
f,25775,fx,333.898
f,25793,fx,316.543
f,25813,fx,238.766
f,25829,fx,277.976
f,25851,fx,67.785
f,25859,fx,67.785
f,25883,fx,67.785
f,25901,fx,85.1402
f,25921,fx,162.917
f,25937,fx,123.707
f,25955,fx,180.273
f,25975,fx,180.273
f,25991,fx,180.273
f,26009,fx,162.917
f,26029,fx,85.1402
f,26045,fx,123.707
f,26067,fx,-85.841
f,26075,fx,-85.841
f,26099,fx,-85.841
f,26117,fx,-68.486
f,26137,fx,9.2915
f,26153,fx,-29.918
f,26171,fx,26.0039
f,26191,fx,26.0039
f,26207,fx,26.0039
f,26225,fx,9.2915
f,26245,fx,-68.486
f,26261,fx,-29.918
f,26283,fx,-240.11
f,26291,fx,-240.11
f,26315,fx,-240.11
f,26333,fx,-222.75
f,26353,fx,-144.98
f,26369,fx,-183.54
f,26387,fx,-127.62
f,26407,fx,-127.62
f,26423,fx,-127.62
f,26441,fx,-144.98
f,26461,fx,-222.75
f,26477,fx,-183.54
f,26499,fx,-393.74
f,26507,fx,-393.74
f,26531,fx,-393.74
f,26549,fx,-376.38
f,26569,fx,-298.6
f,26585,fx,-337.17
f,26603,fx,-281.25
f,26623,fx,-281.25
f,26639,fx,-281.25
f,26657,fx,-298.6
f,26677,fx,-376.38
f,26693,fx,-337.17
f,26715,fx,682.931
f,26723,fx,682.931
f,26747,fx,682.931
f,26765,fx,700.286
f,26785,fx,778.063
f,26801,fx,738.854
f,26819,fx,795.419
f,26839,fx,795.419
f,26855,fx,795.419
f,26873,fx,778.063
f,26893,fx,700.286
f,26909,fx,738.854
f,26931,fx,529.305
f,26939,fx,529.305
f,26963,fx,529.305
f,26981,fx,546.661
f,27001,fx,624.438
f,27017,fx,585.228
f,27035,fx,641.793
f,27055,fx,641.793
f,27071,fx,641.793
f,27089,fx,624.438
f,27109,fx,546.661
f,27125,fx,585.228
f,27147,fx,375.679
f,27155,fx,375.679
f,27179,fx,375.679
f,27197,fx,392.392
f,27217,fx,470.169
f,27233,fx,431.602
f,27251,fx,487.524
f,27271,fx,487.524
f,27287,fx,487.524
f,27305,fx,470.169
f,27325,fx,392.392
f,27341,fx,431.602
f,27363,fx,221.411
f,27371,fx,221.411
f,27395,fx,221.411
f,27413,fx,238.766
f,27433,fx,316.543
f,27449,fx,277.976
f,27467,fx,333.898
f,27487,fx,333.898
f,27503,fx,333.898
f,27521,fx,316.543
f,27541,fx,238.766
f,27557,fx,277.976
f,27579,fx,67.785
f,27587,fx,67.785
f,27611,fx,67.785
f,27629,fx,85.1402
f,27649,fx,162.917
f,27665,fx,123.707
f,27683,fx,180.273
f,27703,fx,180.273
f,27719,fx,180.273
f,27737,fx,162.917
f,27757,fx,85.1402
f,27773,fx,123.707
f,27795,fx,-85.841
f,27803,fx,-85.841
f,27827,fx,-85.841
f,27845,fx,-68.486
f,27865,fx,9.2915
f,27881,fx,-29.918
f,27899,fx,26.0039
f,27919,fx,26.0039
f,27935,fx,26.0039
f,27953,fx,9.2915
f,27973,fx,-68.486
f,27989,fx,-29.918
f,28011,fx,-240.11
f,28019,fx,-240.11
f,28043,fx,-240.11
f,28061,fx,-222.75
f,28081,fx,-144.98
f,28097,fx,-183.54
f,28115,fx,-127.62
f,28135,fx,-127.62
f,28151,fx,-127.62
f,28169,fx,-144.98
f,28189,fx,-222.75
f,28205,fx,-183.54
f,28227,fx,-393.74
f,28235,fx,-393.74
f,28259,fx,-393.74
f,28277,fx,-376.38
f,28297,fx,-298.6
f,28313,fx,-337.17
f,28331,fx,-281.25
f,28351,fx,-281.25
f,28367,fx,-281.25
f,28385,fx,-298.6
f,28405,fx,-376.38
f,28421,fx,-337.17
f,28443,fx,682.931
f,28451,fx,682.931
f,28475,fx,682.931
f,28493,fx,700.286
f,28513,fx,778.063
f,28529,fx,738.854
f,28547,fx,795.419
f,28567,fx,795.419
f,28583,fx,795.419
f,28601,fx,778.063
f,28621,fx,700.286
f,28637,fx,738.854
f,28659,fx,529.305
f,28667,fx,529.305
f,28691,fx,529.305
f,28709,fx,546.661
f,28729,fx,624.438
f,28745,fx,585.228
f,28763,fx,641.793
f,28783,fx,641.793
f,28799,fx,641.793
f,28817,fx,624.438
f,28837,fx,546.661
f,28853,fx,585.228
f,28875,fx,375.679
f,28883,fx,375.679
f,28907,fx,375.679
f,28925,fx,392.392
f,28945,fx,470.169
f,28961,fx,431.602
f,28979,fx,487.524
f,28999,fx,487.524
f,29015,fx,487.524
f,29033,fx,470.169
f,29053,fx,392.392
f,29069,fx,431.602

f,29091,fx,221.411
f,29099,fx,221.411
f,29123,fx,221.411
f,29141,fx,238.766
f,29161,fx,316.543
f,29177,fx,277.976
f,29195,fx,333.898
f,29215,fx,333.898
f,29231,fx,333.898
f,29249,fx,316.543
f,29269,fx,238.766
f,29285,fx,277.976
f,29307,fx,67.785
f,29315,fx,67.785
f,29339,fx,67.785
f,29357,fx,85.1402
f,29377,fx,162.917
f,29393,fx,123.707
f,29411,fx,180.273
f,29431,fx,180.273
f,29447,fx,180.273
f,29465,fx,162.917
f,29485,fx,85.1402
f,29501,fx,123.707
f,29523,fx,-85.841
f,29531,fx,-85.841
f,29555,fx,-85.841
f,29573,fx,-68.486
f,29593,fx,9.2915
f,29609,fx,-29.918
f,29627,fx,26.0039
f,29647,fx,26.0039
f,29663,fx,26.0039
f,29681,fx,9.2915
f,29701,fx,-68.486
f,29717,fx,-29.918
f,29739,fx,-240.11
f,29747,fx,-240.11
f,29771,fx,-240.11
f,29789,fx,-222.75
f,29809,fx,-144.98
f,29825,fx,-183.54
f,29843,fx,-127.62
f,29863,fx,-127.62
f,29879,fx,-127.62
f,29897,fx,-144.98
f,29917,fx,-222.75
f,29933,fx,-183.54
f,29955,fx,-393.74
f,29963,fx,-393.74
f,29987,fx,-393.74
f,30005,fx,-376.38
f,30025,fx,-298.6
f,30041,fx,-337.17
f,30059,fx,-281.25
f,30079,fx,-281.25
f,30095,fx,-281.25
f,30113,fx,-298.6
f,30133,fx,-376.38
f,30149,fx,-337.17
f,30171,fx,682.931
f,30179,fx,682.931
f,30203,fx,682.931
f,30221,fx,700.286
f,30241,fx,778.063
f,30257,fx,738.854
f,30275,fx,795.419
f,30295,fx,795.419
f,30311,fx,795.419
f,30329,fx,778.063
f,30349,fx,700.286
f,30365,fx,738.854
f,30387,fx,529.305
f,30395,fx,529.305
f,30419,fx,529.305
f,30437,fx,546.661
f,30457,fx,624.438
f,30473,fx,585.228
f,30491,fx,641.793
f,30511,fx,641.793
f,30527,fx,641.793
f,30545,fx,624.438
f,30565,fx,546.661
f,30581,fx,585.228
f,30603,fx,375.679
f,30611,fx,375.679
f,30635,fx,375.679
f,30653,fx,392.392
f,30673,fx,470.169
f,30689,fx,431.602
f,30707,fx,487.524
f,30727,fx,487.524
f,30743,fx,487.524
f,30761,fx,470.169
f,30781,fx,392.392
f,30797,fx,431.602
f,30819,fx,221.411
f,30827,fx,221.411
f,30851,fx,221.411
f,30869,fx,238.766
f,30889,fx,316.543
f,30905,fx,277.976
f,30923,fx,333.898
f,30943,fx,333.898
f,30959,fx,333.898
f,30977,fx,316.543
f,30997,fx,238.766
f,31013,fx,277.976
f,31035,fx,67.785
f,31043,fx,67.785
f,31067,fx,67.785
f,31085,fx,85.1402
f,31105,fx,162.917
f,31121,fx,123.707
f,31139,fx,180.273
f,31159,fx,180.273
f,31175,fx,180.273
f,31193,fx,162.917
f,31213,fx,85.1402
f,31229,fx,123.707
f,31251,fx,-85.841
f,31259,fx,-85.841
f,31283,fx,-85.841
f,31301,fx,-68.486
f,31321,fx,9.2915
f,31337,fx,-29.918
f,31355,fx,26.0039
f,31375,fx,26.0039
f,31391,fx,26.0039
f,31409,fx,9.2915
f,31429,fx,-68.486
f,31445,fx,-29.918
f,31467,fx,-240.11
f,31475,fx,-240.11
f,31499,fx,-240.11
f,31517,fx,-222.75
f,31537,fx,-144.98
f,31553,fx,-183.54
f,31571,fx,-127.62
f,31591,fx,-127.62
f,31607,fx,-127.62
f,31625,fx,-144.98
f,31645,fx,-222.75
f,31661,fx,-183.54
f,31683,fx,-393.74
f,31691,fx,-393.74
f,31715,fx,-393.74
f,31733,fx,-376.38
f,31753,fx,-298.6
f,31769,fx,-337.17
f,31787,fx,-281.25
f,31807,fx,-281.25
f,31823,fx,-281.25
f,31841,fx,-298.6
f,31861,fx,-376.38
f,31877,fx,-337.17
f,31899,fx,682.931
f,31907,fx,682.931
f,31931,fx,682.931
f,31949,fx,700.286
f,31969,fx,778.063
f,31985,fx,738.854
f,32003,fx,795.419
f,32023,fx,795.419
f,32039,fx,795.419
f,32057,fx,778.063
f,32077,fx,700.286
f,32093,fx,738.854
f,32115,fx,529.305
f,32123,fx,529.305
f,32147,fx,529.305
f,32165,fx,546.661
f,32185,fx,624.438
f,32201,fx,585.228
f,32219,fx,641.793
f,32239,fx,641.793
f,32255,fx,641.793
f,32273,fx,624.438
f,32293,fx,546.661
f,32309,fx,585.228
f,32331,fx,375.679
f,32339,fx,375.679
f,32363,fx,375.679
f,32381,fx,392.392
f,32401,fx,470.169
f,32417,fx,431.602
f,32435,fx,487.524
f,32455,fx,487.524
f,32471,fx,487.524
f,32489,fx,470.169
f,32509,fx,392.392
f,32525,fx,431.602
f,32547,fx,221.411
f,32555,fx,221.411
f,32579,fx,221.411
f,32597,fx,238.766
f,32617,fx,316.543
f,32633,fx,277.976
f,32651,fx,333.898
f,32671,fx,333.898
f,32687,fx,333.898
f,32705,fx,316.543
f,32725,fx,238.766
f,32741,fx,277.976
f,32763,fx,67.785
f,32771,fx,67.785
f,32795,fx,67.785
f,32813,fx,85.1402
f,32833,fx,162.917
f,32849,fx,123.707
f,32867,fx,180.273
f,32887,fx,180.273
f,32903,fx,180.273
f,32921,fx,162.917
f,32941,fx,85.1402
f,32957,fx,123.707
f,32979,fx,-85.841
f,32987,fx,-85.841
f,33011,fx,-85.841
f,33029,fx,-68.486
f,33049,fx,9.2915
f,33065,fx,-29.918
f,33083,fx,26.0039
f,33103,fx,26.0039
f,33119,fx,26.0039
f,33137,fx,9.2915
f,33157,fx,-68.486
f,33173,fx,-29.918
f,33195,fx,-240.11
f,33203,fx,-240.11
f,33227,fx,-240.11
f,33245,fx,-222.75
f,33265,fx,-144.98
f,33281,fx,-183.54
f,33299,fx,-127.62
f,33319,fx,-127.62
f,33335,fx,-127.62
f,33353,fx,-144.98
f,33373,fx,-222.75
f,33389,fx,-183.54
f,33411,fx,-393.74
f,33419,fx,-393.74
f,33443,fx,-393.74
f,33461,fx,-376.38
f,33481,fx,-298.6
f,33497,fx,-337.17
f,33515,fx,-281.25
f,33535,fx,-281.25
f,33551,fx,-281.25
f,33569,fx,-298.6
f,33589,fx,-376.38
f,33605,fx,-337.17
f,5980,fx,677.339
f,5988,fx,677.339
f,6012,fx,677.339
f,6030,fx,694.694
f,6050,fx,772.471
f,6066,fx,733.261
f,6084,fx,789.826
f,6104,fx,789.826
f,6120,fx,789.826
f,6138,fx,772.471
f,6158,fx,694.694
f,6174,fx,733.261
f,6196,fx,523.713
f,6204,fx,523.713
f,6228,fx,523.713
f,6246,fx,541.068
f,6266,fx,618.845
f,6282,fx,579.635
f,6300,fx,636.201
f,6320,fx,636.201
f,6336,fx,636.201
f,6354,fx,618.845
f,6374,fx,541.068
f,6390,fx,579.635
f,6412,fx,370.087
f,6420,fx,370.087
f,6444,fx,370.087
f,6462,fx,386.8
f,6482,fx,464.577
f,6498,fx,426.01
f,6516,fx,481.932
f,6536,fx,481.932
f,6552,fx,481.932
f,6570,fx,464.577
f,6590,fx,386.8
f,6606,fx,426.01
f,6628,fx,215.819
f,6636,fx,215.819
f,6660,fx,215.819
f,6678,fx,233.174
f,6698,fx,310.951
f,6714,fx,272.384
f,6732,fx,328.306
f,6752,fx,328.306
f,6768,fx,328.306
f,6786,fx,310.951
f,6806,fx,233.174
f,6822,fx,272.384
f,6844,fx,62.1927
f,6852,fx,62.1927
f,6876,fx,62.1927
f,6894,fx,79.5479
f,6914,fx,157.325
f,6930,fx,118.115
f,6948,fx,174.68
f,6968,fx,174.68
f,6984,fx,174.68
f,7002,fx,157.325
f,7022,fx,79.5479
f,7038,fx,118.115
f,7060,fx,-91.433
f,7068,fx,-91.433
f,7092,fx,-91.433
f,7110,fx,-74.078
f,7130,fx,3.69919
f,7146,fx,-35.511
f,7164,fx,20.4116
f,7184,fx,20.4116
f,7200,fx,20.4116
f,7218,fx,3.69919
f,7238,fx,-74.078
f,7254,fx,-35.511
f,7276,fx,-245.7
f,7284,fx,-245.7
f,7308,fx,-245.7
f,7326,fx,-228.35
f,7346,fx,-150.57
f,7362,fx,-189.14
f,7380,fx,-133.21
f,7400,fx,-133.21

f,7416,fx,-133.21
f,7434,fx,-150.57
f,7454,fx,-228.35
f,7470,fx,-189.14
f,7492,fx,-399.33
f,7500,fx,-399.33
f,7524,fx,-399.33
f,7542,fx,-381.97
f,7562,fx,-304.2
f,7578,fx,-342.76
f,7596,fx,-286.84
f,7616,fx,-286.84
f,7632,fx,-286.84
f,7650,fx,-304.2
f,7670,fx,-381.97
f,7686,fx,-342.76
f,7708,fx,677.339
f,7716,fx,677.339
f,7740,fx,677.339
f,7758,fx,694.694
f,7778,fx,772.471
f,7794,fx,733.261
f,7812,fx,789.826
f,7832,fx,789.826
f,7848,fx,789.826
f,7866,fx,772.471
f,7886,fx,694.694
f,7902,fx,733.261
f,7924,fx,523.713
f,7932,fx,523.713
f,7956,fx,523.713
f,7974,fx,541.068
f,7994,fx,618.845
f,8010,fx,579.635
f,8028,fx,636.201
f,8048,fx,636.201
f,8064,fx,636.201
f,8082,fx,618.845
f,8102,fx,541.068
f,8118,fx,579.635
f,8140,fx,370.087
f,8148,fx,370.087
f,8172,fx,370.087
f,8190,fx,386.8
f,8210,fx,464.577
f,8226,fx,426.01
f,8244,fx,481.932
f,8264,fx,481.932
f,8280,fx,481.932
f,8298,fx,464.577
f,8318,fx,386.8
f,8334,fx,426.01
f,8356,fx,215.819
f,8364,fx,215.819
f,8388,fx,215.819
f,8406,fx,233.174
f,8426,fx,310.951
f,8442,fx,272.384
f,8460,fx,328.306
f,8480,fx,328.306
f,8496,fx,328.306
f,8514,fx,310.951
f,8534,fx,233.174
f,8550,fx,272.384
f,8572,fx,62.1927
f,8580,fx,62.1927
f,8604,fx,62.1927
f,8622,fx,79.5479
f,8642,fx,157.325
f,8658,fx,118.115
f,8676,fx,174.68
f,8696,fx,174.68
f,8712,fx,174.68
f,8730,fx,157.325
f,8750,fx,79.5479
f,8766,fx,118.115
f,8788,fx,-91.433
f,8796,fx,-91.433
f,8820,fx,-91.433
f,8838,fx,-74.078
f,8858,fx,3.69919
f,8874,fx,-35.511
f,8892,fx,20.4116
f,8912,fx,20.4116
f,8928,fx,20.4116
f,8946,fx,3.69919
f,8966,fx,-74.078
f,8982,fx,-35.511
f,9004,fx,-245.7
f,9012,fx,-245.7
f,9036,fx,-245.7
f,9054,fx,-228.35
f,9074,fx,-150.57
f,9090,fx,-189.14
f,9108,fx,-133.21
f,9128,fx,-133.21
f,9144,fx,-133.21
f,9162,fx,-150.57
f,9182,fx,-228.35
f,9198,fx,-189.14
f,9220,fx,-399.33
f,9228,fx,-399.33
f,9252,fx,-399.33
f,9270,fx,-381.97
f,9290,fx,-304.2
f,9306,fx,-342.76
f,9324,fx,-286.84
f,9344,fx,-286.84
f,9360,fx,-286.84
f,9378,fx,-304.2
f,9398,fx,-381.97
f,9414,fx,-342.76
f,9436,fx,677.339
f,9444,fx,677.339
f,9468,fx,677.339
f,9486,fx,694.694
f,9506,fx,772.471
f,9522,fx,733.261
f,9540,fx,789.826
f,9560,fx,789.826
f,9576,fx,789.826
f,9594,fx,772.471
f,9614,fx,694.694
f,9630,fx,733.261
f,9652,fx,523.713
f,9660,fx,523.713
f,9684,fx,523.713
f,9702,fx,541.068
f,9722,fx,618.845
f,9738,fx,579.635
f,9756,fx,636.201
f,9776,fx,636.201
f,9792,fx,636.201
f,9810,fx,618.845
f,9830,fx,541.068
f,9846,fx,579.635
f,9868,fx,370.087
f,9876,fx,370.087
f,9900,fx,370.087
f,9918,fx,386.8
f,9938,fx,464.577
f,9954,fx,426.01
f,9972,fx,481.932
f,9992,fx,481.932
f,10008,fx,481.932
f,10026,fx,464.577
f,10046,fx,386.8
f,10062,fx,426.01
f,10084,fx,215.819
f,10092,fx,215.819
f,10116,fx,215.819
f,10134,fx,233.174
f,10154,fx,310.951
f,10170,fx,272.384
f,10188,fx,328.306
f,10208,fx,328.306
f,10224,fx,328.306
f,10242,fx,310.951
f,10262,fx,233.174
f,10278,fx,272.384
f,10300,fx,62.1927
f,10308,fx,62.1927
f,10332,fx,62.1927
f,10350,fx,79.5479
f,10370,fx,157.325
f,10386,fx,118.115
f,10404,fx,174.68
f,10424,fx,174.68
f,10440,fx,174.68
f,10458,fx,157.325
f,10478,fx,79.5479
f,10494,fx,118.115
f,10516,fx,-91.433
f,10524,fx,-91.433
f,10548,fx,-91.433
f,10566,fx,-74.078
f,10586,fx,3.69919
f,10602,fx,-35.511
f,10620,fx,20.4116
f,10640,fx,20.4116
f,10656,fx,20.4116
f,10674,fx,3.69919
f,10694,fx,-74.078
f,10710,fx,-35.511
f,10732,fx,-245.7
f,10740,fx,-245.7
f,10764,fx,-245.7
f,10782,fx,-228.35
f,10802,fx,-150.57
f,10818,fx,-189.14
f,10836,fx,-133.21
f,10856,fx,-133.21
f,10872,fx,-133.21
f,10890,fx,-150.57
f,10910,fx,-228.35
f,10926,fx,-189.14
f,10948,fx,-399.33
f,10956,fx,-399.33
f,10980,fx,-399.33
f,10998,fx,-381.97
f,11018,fx,-304.2
f,11034,fx,-342.76
f,11052,fx,-286.84
f,11072,fx,-286.84
f,11088,fx,-286.84
f,11106,fx,-304.2
f,11126,fx,-381.97
f,11142,fx,-342.76
f,11164,fx,677.339
f,11172,fx,677.339
f,11196,fx,677.339
f,11214,fx,694.694
f,11234,fx,772.471
f,11250,fx,733.261
f,11268,fx,789.826
f,11288,fx,789.826
f,11304,fx,789.826
f,11322,fx,772.471
f,11342,fx,694.694
f,11358,fx,733.261
f,11380,fx,523.713
f,11388,fx,523.713
f,11412,fx,523.713
f,11430,fx,541.068
f,11450,fx,618.845
f,11466,fx,579.635
f,11484,fx,636.201
f,11504,fx,636.201
f,11520,fx,636.201
f,11538,fx,618.845
f,11558,fx,541.068
f,11574,fx,579.635
f,11596,fx,370.087
f,11604,fx,370.087
f,11628,fx,370.087
f,11646,fx,386.8
f,11666,fx,464.577
f,11682,fx,426.01
f,11700,fx,481.932
f,11720,fx,481.932
f,11736,fx,481.932
f,11754,fx,464.577
f,11774,fx,386.8
f,11790,fx,426.01
f,11812,fx,215.819
f,11820,fx,215.819
f,11844,fx,215.819
f,11862,fx,233.174
f,11882,fx,310.951
f,11898,fx,272.384
f,11916,fx,328.306
f,11936,fx,328.306
f,11952,fx,328.306
f,11970,fx,310.951
f,11990,fx,233.174
f,12006,fx,272.384
f,12028,fx,62.1927
f,12036,fx,62.1927
f,12060,fx,62.1927
f,12078,fx,79.5479
f,12098,fx,157.325
f,12114,fx,118.115
f,12132,fx,174.68
f,12152,fx,174.68
f,12168,fx,174.68
f,12186,fx,157.325
f,12206,fx,79.5479
f,12222,fx,118.115
f,12244,fx,-91.433
f,12252,fx,-91.433
f,12276,fx,-91.433
f,12294,fx,-74.078
f,12314,fx,3.69919
f,12330,fx,-35.511
f,12348,fx,20.4116
f,12368,fx,20.4116
f,12384,fx,20.4116
f,12402,fx,3.69919
f,12422,fx,-74.078
f,12438,fx,-35.511
f,12460,fx,-245.7
f,12468,fx,-245.7
f,12492,fx,-245.7
f,12510,fx,-228.35
f,12530,fx,-150.57
f,12546,fx,-189.14
f,12564,fx,-133.21
f,12584,fx,-133.21
f,12600,fx,-133.21
f,12618,fx,-150.57
f,12638,fx,-228.35
f,12654,fx,-189.14
f,12676,fx,-399.33
f,12684,fx,-399.33
f,12708,fx,-399.33
f,12726,fx,-381.97
f,12746,fx,-304.2
f,12762,fx,-342.76
f,12780,fx,-286.84
f,12800,fx,-286.84
f,12816,fx,-286.84
f,12834,fx,-304.2
f,12854,fx,-381.97
f,12870,fx,-342.76
f,12892,fx,677.339
f,12900,fx,677.339
f,12924,fx,677.339
f,12942,fx,694.694
f,12962,fx,772.471
f,12978,fx,733.261
f,12996,fx,789.826
f,13016,fx,789.826
f,13032,fx,789.826
f,13050,fx,772.471
f,13070,fx,694.694
f,13086,fx,733.261
f,13108,fx,523.713
f,13116,fx,523.713
f,13140,fx,523.713
f,13158,fx,541.068
f,13178,fx,618.845
f,13194,fx,579.635
f,13212,fx,636.201
f,13232,fx,636.201
f,13248,fx,636.201
f,13266,fx,618.845
f,13286,fx,541.068
f,13302,fx,579.635
f,13324,fx,370.087
f,13332,fx,370.087
f,13356,fx,370.087
f,13374,fx,386.8

f,13394,fx,464.577
f,13410,fx,426.01
f,13428,fx,481.932
f,13448,fx,481.932
f,13464,fx,481.932
f,13482,fx,464.577
f,13502,fx,386.8
f,13518,fx,426.01
f,13540,fx,215.819
f,13548,fx,215.819
f,13572,fx,215.819
f,13590,fx,233.174
f,13610,fx,310.951
f,13626,fx,272.384
f,13644,fx,328.306
f,13664,fx,328.306
f,13680,fx,328.306
f,13698,fx,310.951
f,13718,fx,233.174
f,13734,fx,272.384
f,13756,fx,62.1927
f,13764,fx,62.1927
f,13788,fx,62.1927
f,13806,fx,79.5479
f,13826,fx,157.325
f,13842,fx,118.115
f,13860,fx,174.68
f,13880,fx,174.68
f,13896,fx,174.68
f,13914,fx,157.325
f,13934,fx,79.5479
f,13950,fx,118.115
f,13972,fx,-91.433
f,13980,fx,-91.433
f,14004,fx,-91.433
f,14022,fx,-74.078
f,14042,fx,3.69919
f,14058,fx,-35.511
f,14076,fx,20.4116
f,14096,fx,20.4116
f,14112,fx,20.4116
f,14130,fx,3.69919
f,14150,fx,-74.078
f,14166,fx,-35.511
f,14188,fx,-245.7
f,14196,fx,-245.7
f,14220,fx,-245.7
f,14238,fx,-228.35
f,14258,fx,-150.57
f,14274,fx,-189.14
f,14292,fx,-133.21
f,14312,fx,-133.21
f,14328,fx,-133.21
f,14346,fx,-150.57
f,14366,fx,-228.35
f,14382,fx,-189.14
f,14404,fx,-399.33
f,14412,fx,-399.33
f,14436,fx,-399.33
f,14454,fx,-381.97
f,14474,fx,-304.2
f,14490,fx,-342.76
f,14508,fx,-286.84
f,14528,fx,-286.84
f,14544,fx,-286.84
f,14562,fx,-304.2
f,14582,fx,-381.97
f,14598,fx,-342.76
f,14620,fx,677.339
f,14628,fx,677.339
f,14652,fx,677.339
f,14670,fx,694.694
f,14690,fx,772.471
f,14706,fx,733.261
f,14724,fx,789.826
f,14744,fx,789.826
f,14760,fx,789.826
f,14778,fx,772.471
f,14798,fx,694.694
f,14814,fx,733.261
f,14836,fx,523.713
f,14844,fx,523.713
f,14868,fx,523.713
f,14886,fx,541.068
f,14906,fx,618.845
f,14922,fx,579.635
f,14940,fx,636.201
f,14960,fx,636.201
f,14976,fx,636.201
f,14994,fx,618.845
f,15014,fx,541.068
f,15030,fx,579.635
f,15052,fx,370.087
f,15060,fx,370.087
f,15084,fx,370.087
f,15102,fx,386.8
f,15122,fx,464.577
f,15138,fx,426.01
f,15156,fx,481.932
f,15176,fx,481.932
f,15192,fx,481.932
f,15210,fx,464.577
f,15230,fx,386.8
f,15246,fx,426.01
f,15268,fx,215.819
f,15276,fx,215.819
f,15300,fx,215.819
f,15318,fx,233.174
f,15338,fx,310.951
f,15354,fx,272.384
f,15372,fx,328.306
f,15392,fx,328.306
f,15408,fx,328.306
f,15426,fx,310.951
f,15446,fx,233.174
f,15462,fx,272.384
f,15484,fx,62.1927
f,15492,fx,62.1927
f,15516,fx,62.1927
f,15534,fx,79.5479
f,15554,fx,157.325
f,15570,fx,118.115
f,15588,fx,174.68
f,15608,fx,174.68
f,15624,fx,174.68
f,15642,fx,157.325
f,15662,fx,79.5479
f,15678,fx,118.115
f,15700,fx,-91.433
f,15708,fx,-91.433
f,15732,fx,-91.433
f,15750,fx,-74.078
f,15770,fx,3.69919
f,15786,fx,-35.511
f,15804,fx,20.4116
f,15824,fx,20.4116
f,15840,fx,20.4116
f,15858,fx,3.69919
f,15878,fx,-74.078
f,15894,fx,-35.511
f,15916,fx,-245.7
f,15924,fx,-245.7
f,15948,fx,-245.7
f,15966,fx,-228.35
f,15986,fx,-150.57
f,16002,fx,-189.14
f,16020,fx,-133.21
f,16040,fx,-133.21
f,16056,fx,-133.21
f,16074,fx,-150.57
f,16094,fx,-228.35
f,16110,fx,-189.14
f,16132,fx,-399.33
f,16140,fx,-399.33
f,16164,fx,-399.33
f,16182,fx,-381.97
f,16202,fx,-304.2
f,16218,fx,-342.76
f,16236,fx,-286.84
f,16256,fx,-286.84
f,16272,fx,-286.84
f,16290,fx,-304.2
f,16310,fx,-381.97
f,16326,fx,-342.76
f,16348,fx,677.339
f,16356,fx,677.339
f,16380,fx,677.339
f,16398,fx,694.694
f,16418,fx,772.471
f,16434,fx,733.261
f,16452,fx,789.826
f,16472,fx,789.826
f,16488,fx,789.826
f,16506,fx,772.471
f,16526,fx,694.694
f,16542,fx,733.261
f,16564,fx,523.713
f,16572,fx,523.713
f,16596,fx,523.713
f,16614,fx,541.068
f,16634,fx,618.845
f,16650,fx,579.635
f,16668,fx,636.201
f,16688,fx,636.201
f,16704,fx,636.201
f,16722,fx,618.845
f,16742,fx,541.068
f,16758,fx,579.635
f,16780,fx,370.087
f,16788,fx,370.087
f,16812,fx,370.087
f,16830,fx,386.8
f,16850,fx,464.577
f,16866,fx,426.01
f,16884,fx,481.932
f,16904,fx,481.932
f,16920,fx,481.932
f,16938,fx,464.577
f,16958,fx,386.8
f,16974,fx,426.01
f,16996,fx,215.819
f,17004,fx,215.819
f,17028,fx,215.819
f,17046,fx,233.174
f,17066,fx,310.951
f,17082,fx,272.384
f,17100,fx,328.306
f,17120,fx,328.306
f,17136,fx,328.306
f,17154,fx,310.951
f,17174,fx,233.174
f,17190,fx,272.384
f,17212,fx,62.1927
f,17220,fx,62.1927
f,17244,fx,62.1927
f,17262,fx,79.5479
f,17282,fx,157.325
f,17298,fx,118.115
f,17316,fx,174.68
f,17336,fx,174.68
f,17352,fx,174.68
f,17370,fx,157.325
f,17390,fx,79.5479
f,17406,fx,118.115
f,17428,fx,-91.433
f,17436,fx,-91.433
f,17460,fx,-91.433
f,17478,fx,-74.078
f,17498,fx,3.69919
f,17514,fx,-35.511
f,17532,fx,20.4116
f,17552,fx,20.4116
f,17568,fx,20.4116
f,17586,fx,3.69919
f,17606,fx,-74.078
f,17622,fx,-35.511
f,17644,fx,-245.7
f,17652,fx,-245.7
f,17676,fx,-245.7
f,17694,fx,-228.35
f,17714,fx,-150.57
f,17730,fx,-189.14
f,17748,fx,-133.21
f,17768,fx,-133.21
f,17784,fx,-133.21
f,17802,fx,-150.57
f,17822,fx,-228.35
f,17838,fx,-189.14
f,17860,fx,-399.33
f,17868,fx,-399.33
f,17892,fx,-399.33
f,17910,fx,-381.97
f,17930,fx,-304.2
f,17946,fx,-342.76
f,17964,fx,-286.84
f,17984,fx,-286.84
f,18000,fx,-286.84
f,18018,fx,-304.2
f,18038,fx,-381.97
f,18054,fx,-342.76
f,18076,fx,677.339
f,18084,fx,677.339
f,18108,fx,677.339
f,18126,fx,694.694
f,18146,fx,772.471
f,18162,fx,733.261
f,18180,fx,789.826
f,18200,fx,789.826
f,18216,fx,789.826
f,18234,fx,772.471
f,18254,fx,694.694
f,18270,fx,733.261
f,18292,fx,523.713
f,18300,fx,523.713
f,18324,fx,523.713
f,18342,fx,541.068
f,18362,fx,618.845
f,18378,fx,579.635
f,18396,fx,636.201
f,18416,fx,636.201
f,18432,fx,636.201
f,18450,fx,618.845
f,18470,fx,541.068
f,18486,fx,579.635
f,18508,fx,370.087
f,18516,fx,370.087
f,18540,fx,370.087
f,18558,fx,386.8
f,18578,fx,464.577
f,18594,fx,426.01
f,18612,fx,481.932
f,18632,fx,481.932
f,18648,fx,481.932
f,18666,fx,464.577
f,18686,fx,386.8
f,18702,fx,426.01
f,18724,fx,215.819
f,18732,fx,215.819
f,18756,fx,215.819
f,18774,fx,233.174
f,18794,fx,310.951
f,18810,fx,272.384
f,18828,fx,328.306
f,18848,fx,328.306
f,18864,fx,328.306
f,18882,fx,310.951
f,18902,fx,233.174
f,18918,fx,272.384
f,18940,fx,62.1927
f,18948,fx,62.1927
f,18972,fx,62.1927
f,18990,fx,79.5479
f,19010,fx,157.325
f,19026,fx,118.115
f,19044,fx,174.68
f,19064,fx,174.68
f,19080,fx,174.68
f,19098,fx,157.325
f,19118,fx,79.5479
f,19134,fx,118.115
f,19156,fx,-91.433
f,19164,fx,-91.433
f,19188,fx,-91.433
f,19206,fx,-74.078
f,19226,fx,3.69919
f,19242,fx,-35.511
f,19260,fx,20.4116
f,19280,fx,20.4116
f,19296,fx,20.4116
f,19314,fx,3.69919
f,19334,fx,-74.078
f,19350,fx,-35.511

f,19372,fx,-245.7
f,19380,fx,-245.7
f,19404,fx,-245.7
f,19422,fx,-228.35
f,19442,fx,-150.57
f,19458,fx,-189.14
f,19476,fx,-133.21
f,19496,fx,-133.21
f,19512,fx,-133.21
f,19530,fx,-150.57
f,19550,fx,-228.35
f,19566,fx,-189.14
f,19588,fx,-399.33
f,19596,fx,-399.33
f,19620,fx,-399.33
f,19638,fx,-381.97
f,19658,fx,-304.2
f,19674,fx,-342.76
f,19692,fx,-286.84
f,19712,fx,-286.84
f,19728,fx,-286.84
f,19746,fx,-304.2
f,19766,fx,-381.97
f,19782,fx,-342.76
f,19804,fx,677.339
f,19812,fx,677.339
f,19836,fx,677.339
f,19854,fx,694.694
f,19874,fx,772.471
f,19890,fx,733.261
f,19908,fx,789.826
f,19928,fx,789.826
f,19944,fx,789.826
f,19962,fx,772.471
f,19982,fx,694.694
f,19998,fx,733.261
f,20020,fx,523.713
f,20028,fx,523.713
f,20052,fx,523.713
f,20070,fx,541.068
f,20090,fx,618.845
f,20106,fx,579.635
f,20124,fx,636.201
f,20144,fx,636.201
f,20160,fx,636.201
f,20178,fx,618.845
f,20198,fx,541.068
f,20214,fx,579.635
f,20236,fx,370.087
f,20244,fx,370.087
f,20268,fx,370.087
f,20286,fx,386.8
f,20306,fx,464.577
f,20322,fx,426.01
f,20340,fx,481.932
f,20360,fx,481.932
f,20376,fx,481.932
f,20394,fx,464.577
f,20414,fx,386.8
f,20430,fx,426.01
f,20452,fx,215.819
f,20460,fx,215.819
f,20484,fx,215.819
f,20502,fx,233.174
f,20522,fx,310.951
f,20538,fx,272.384
f,20556,fx,328.306
f,20576,fx,328.306
f,20592,fx,328.306
f,20610,fx,310.951
f,20630,fx,233.174
f,20646,fx,272.384
f,20668,fx,62.1927
f,20676,fx,62.1927
f,20700,fx,62.1927
f,20718,fx,79.5479
f,20738,fx,157.325
f,20754,fx,118.115
f,20772,fx,174.68
f,20792,fx,174.68
f,20808,fx,174.68
f,20826,fx,157.325
f,20846,fx,79.5479
f,20862,fx,118.115
f,20884,fx,-91.433
f,20892,fx,-91.433
f,20916,fx,-91.433
f,20934,fx,-74.078
f,20954,fx,3.69919
f,20970,fx,-35.511
f,20988,fx,20.4116
f,21008,fx,20.4116
f,21024,fx,20.4116
f,21042,fx,3.69919
f,21062,fx,-74.078
f,21078,fx,-35.511
f,21100,fx,-245.7
f,21108,fx,-245.7
f,21132,fx,-245.7
f,21150,fx,-228.35
f,21170,fx,-150.57
f,21186,fx,-189.14
f,21204,fx,-133.21
f,21224,fx,-133.21
f,21240,fx,-133.21
f,21258,fx,-150.57
f,21278,fx,-228.35
f,21294,fx,-189.14
f,21316,fx,-399.33
f,21324,fx,-399.33
f,21348,fx,-399.33
f,21366,fx,-381.97
f,21386,fx,-304.2
f,21402,fx,-342.76
f,21420,fx,-286.84
f,21440,fx,-286.84
f,21456,fx,-286.84
f,21474,fx,-304.2
f,21494,fx,-381.97
f,21510,fx,-342.76
f,21532,fx,677.339
f,21540,fx,677.339
f,21564,fx,677.339
f,21582,fx,694.694
f,21602,fx,772.471
f,21618,fx,733.261
f,21636,fx,789.826
f,21656,fx,789.826
f,21672,fx,789.826
f,21690,fx,772.471
f,21710,fx,694.694
f,21726,fx,733.261
f,21748,fx,523.713
f,21756,fx,523.713
f,21780,fx,523.713
f,21798,fx,541.068
f,21818,fx,618.845
f,21834,fx,579.635
f,21852,fx,636.201
f,21872,fx,636.201
f,21888,fx,636.201
f,21906,fx,618.845
f,21926,fx,541.068
f,21942,fx,579.635
f,21964,fx,370.087
f,21972,fx,370.087
f,21996,fx,370.087
f,22014,fx,386.8
f,22034,fx,464.577
f,22050,fx,426.01
f,22068,fx,481.932
f,22088,fx,481.932
f,22104,fx,481.932
f,22122,fx,464.577
f,22142,fx,386.8
f,22158,fx,426.01
f,22180,fx,215.819
f,22188,fx,215.819
f,22212,fx,215.819
f,22230,fx,233.174
f,22250,fx,310.951
f,22266,fx,272.384
f,22284,fx,328.306
f,22304,fx,328.306
f,22320,fx,328.306
f,22338,fx,310.951
f,22358,fx,233.174
f,22374,fx,272.384
f,22396,fx,62.1927
f,22404,fx,62.1927
f,22428,fx,62.1927
f,22446,fx,79.5479
f,22466,fx,157.325
f,22482,fx,118.115
f,22500,fx,174.68
f,22520,fx,174.68
f,22536,fx,174.68
f,22554,fx,157.325
f,22574,fx,79.5479
f,22590,fx,118.115
f,22612,fx,-91.433
f,22620,fx,-91.433
f,22644,fx,-91.433
f,22662,fx,-74.078
f,22682,fx,3.69919
f,22698,fx,-35.511
f,22716,fx,20.4116
f,22736,fx,20.4116
f,22752,fx,20.4116
f,22770,fx,3.69919
f,22790,fx,-74.078
f,22806,fx,-35.511
f,22828,fx,-245.7
f,22836,fx,-245.7
f,22860,fx,-245.7
f,22878,fx,-228.35
f,22898,fx,-150.57
f,22914,fx,-189.14
f,22932,fx,-133.21
f,22952,fx,-133.21
f,22968,fx,-133.21
f,22986,fx,-150.57
f,23006,fx,-228.35
f,23022,fx,-189.14
f,23044,fx,-399.33
f,23052,fx,-399.33
f,23076,fx,-399.33
f,23094,fx,-381.97
f,23114,fx,-304.2
f,23130,fx,-342.76
f,23148,fx,-286.84
f,23168,fx,-286.84
f,23184,fx,-286.84
f,23202,fx,-304.2
f,23222,fx,-381.97
f,23238,fx,-342.76
f,23260,fx,677.339
f,23268,fx,677.339
f,23292,fx,677.339
f,23310,fx,694.694
f,23330,fx,772.471
f,23346,fx,733.261
f,23364,fx,789.826
f,23384,fx,789.826
f,23400,fx,789.826
f,23418,fx,772.471
f,23438,fx,694.694
f,23454,fx,733.261
f,23476,fx,523.713
f,23484,fx,523.713
f,23508,fx,523.713
f,23526,fx,541.068
f,23546,fx,618.845
f,23562,fx,579.635
f,23580,fx,636.201
f,23600,fx,636.201
f,23616,fx,636.201
f,23634,fx,618.845
f,23654,fx,541.068
f,23670,fx,579.635
f,23692,fx,370.087
f,23700,fx,370.087
f,23724,fx,370.087
f,23742,fx,386.8
f,23762,fx,464.577
f,23778,fx,426.01
f,23796,fx,481.932
f,23816,fx,481.932
f,23832,fx,481.932
f,23850,fx,464.577
f,23870,fx,386.8
f,23886,fx,426.01
f,23908,fx,215.819
f,23916,fx,215.819
f,23940,fx,215.819
f,23958,fx,233.174
f,23978,fx,310.951
f,23994,fx,272.384
f,24012,fx,328.306
f,24032,fx,328.306
f,24048,fx,328.306
f,24066,fx,310.951
f,24086,fx,233.174
f,24102,fx,272.384
f,24124,fx,62.1927
f,24132,fx,62.1927
f,24156,fx,62.1927
f,24174,fx,79.5479
f,24194,fx,157.325
f,24210,fx,118.115
f,24228,fx,174.68
f,24248,fx,174.68
f,24264,fx,174.68
f,24282,fx,157.325
f,24302,fx,79.5479
f,24318,fx,118.115
f,24340,fx,-91.433
f,24348,fx,-91.433
f,24372,fx,-91.433
f,24390,fx,-74.078
f,24410,fx,3.69919
f,24426,fx,-35.511
f,24444,fx,20.4116
f,24464,fx,20.4116
f,24480,fx,20.4116
f,24498,fx,3.69919
f,24518,fx,-74.078
f,24534,fx,-35.511
f,24556,fx,-245.7
f,24564,fx,-245.7
f,24588,fx,-245.7
f,24606,fx,-228.35
f,24626,fx,-150.57
f,24642,fx,-189.14
f,24660,fx,-133.21
f,24680,fx,-133.21
f,24696,fx,-133.21
f,24714,fx,-150.57
f,24734,fx,-228.35
f,24750,fx,-189.14
f,24772,fx,-399.33
f,24780,fx,-399.33
f,24804,fx,-399.33
f,24822,fx,-381.97
f,24842,fx,-304.2
f,24858,fx,-342.76
f,24876,fx,-286.84
f,24896,fx,-286.84
f,24912,fx,-286.84
f,24930,fx,-304.2
f,24950,fx,-381.97
f,24966,fx,-342.76
f,24988,fx,677.339
f,24996,fx,677.339
f,25020,fx,677.339
f,25038,fx,694.694
f,25058,fx,772.471
f,25074,fx,733.261
f,25092,fx,789.826
f,25112,fx,789.826
f,25128,fx,789.826
f,25146,fx,772.471
f,25166,fx,694.694
f,25182,fx,733.261
f,25204,fx,523.713
f,25212,fx,523.713
f,25236,fx,523.713
f,25254,fx,541.068
f,25274,fx,618.845
f,25290,fx,579.635
f,25308,fx,636.201
f,25328,fx,636.201

f,25344,fx,636.201
f,25362,fx,618.845
f,25382,fx,541.068
f,25398,fx,579.635
f,25420,fx,370.087
f,25428,fx,370.087
f,25452,fx,370.087
f,25470,fx,386.8
f,25490,fx,464.577
f,25506,fx,426.01
f,25524,fx,481.932
f,25544,fx,481.932
f,25560,fx,481.932
f,25578,fx,464.577
f,25598,fx,386.8
f,25614,fx,426.01
f,25636,fx,215.819
f,25644,fx,215.819
f,25668,fx,215.819
f,25686,fx,233.174
f,25706,fx,310.951
f,25722,fx,272.384
f,25740,fx,328.306
f,25760,fx,328.306
f,25776,fx,328.306
f,25794,fx,310.951
f,25814,fx,233.174
f,25830,fx,272.384
f,25852,fx,62.1927
f,25860,fx,62.1927
f,25884,fx,62.1927
f,25902,fx,79.5479
f,25922,fx,157.325
f,25938,fx,118.115
f,25956,fx,174.68
f,25976,fx,174.68
f,25992,fx,174.68
f,26010,fx,157.325
f,26030,fx,79.5479
f,26046,fx,118.115
f,26068,fx,-91.433
f,26076,fx,-91.433
f,26100,fx,-91.433
f,26118,fx,-74.078
f,26138,fx,3.69919
f,26154,fx,-35.511
f,26172,fx,20.4116
f,26192,fx,20.4116
f,26208,fx,20.4116
f,26226,fx,3.69919
f,26246,fx,-74.078
f,26262,fx,-35.511
f,26284,fx,-245.7
f,26292,fx,-245.7
f,26316,fx,-245.7
f,26334,fx,-228.35
f,26354,fx,-150.57
f,26370,fx,-189.14
f,26388,fx,-133.21
f,26408,fx,-133.21
f,26424,fx,-133.21
f,26442,fx,-150.57
f,26462,fx,-228.35
f,26478,fx,-189.14
f,26500,fx,-399.33
f,26508,fx,-399.33
f,26532,fx,-399.33
f,26550,fx,-381.97
f,26570,fx,-304.2
f,26586,fx,-342.76
f,26604,fx,-286.84
f,26624,fx,-286.84
f,26640,fx,-286.84
f,26658,fx,-304.2
f,26678,fx,-381.97
f,26694,fx,-342.76
f,26716,fx,677.339
f,26724,fx,677.339
f,26748,fx,677.339
f,26766,fx,694.694
f,26786,fx,772.471
f,26802,fx,733.261
f,26820,fx,789.826
f,26840,fx,789.826
f,26856,fx,789.826
f,26874,fx,772.471
f,26894,fx,694.694
f,26910,fx,733.261
f,26932,fx,523.713
f,26940,fx,523.713
f,26964,fx,523.713
f,26982,fx,541.068
f,27002,fx,618.845
f,27018,fx,579.635
f,27036,fx,636.201
f,27056,fx,636.201
f,27072,fx,636.201
f,27090,fx,618.845
f,27110,fx,541.068
f,27126,fx,579.635
f,27148,fx,370.087
f,27156,fx,370.087
f,27180,fx,370.087
f,27198,fx,386.8
f,27218,fx,464.577
f,27234,fx,426.01
f,27252,fx,481.932
f,27272,fx,481.932
f,27288,fx,481.932
f,27306,fx,464.577
f,27326,fx,386.8
f,27342,fx,426.01
f,27364,fx,215.819
f,27372,fx,215.819
f,27396,fx,215.819
f,27414,fx,233.174
f,27434,fx,310.951
f,27450,fx,272.384
f,27468,fx,328.306
f,27488,fx,328.306
f,27504,fx,328.306
f,27522,fx,310.951
f,27542,fx,233.174
f,27558,fx,272.384
f,27580,fx,62.1927
f,27588,fx,62.1927
f,27612,fx,62.1927
f,27630,fx,79.5479
f,27650,fx,157.325
f,27666,fx,118.115
f,27684,fx,174.68
f,27704,fx,174.68
f,27720,fx,174.68
f,27738,fx,157.325
f,27758,fx,79.5479
f,27774,fx,118.115
f,27796,fx,-91.433
f,27804,fx,-91.433
f,27828,fx,-91.433
f,27846,fx,-74.078
f,27866,fx,3.69919
f,27882,fx,-35.511
f,27900,fx,20.4116
f,27920,fx,20.4116
f,27936,fx,20.4116
f,27954,fx,3.69919
f,27974,fx,-74.078
f,27990,fx,-35.511
f,28012,fx,-245.7
f,28020,fx,-245.7
f,28044,fx,-245.7
f,28062,fx,-228.35
f,28082,fx,-150.57
f,28098,fx,-189.14
f,28116,fx,-133.21
f,28136,fx,-133.21
f,28152,fx,-133.21
f,28170,fx,-150.57
f,28190,fx,-228.35
f,28206,fx,-189.14
f,28228,fx,-399.33
f,28236,fx,-399.33
f,28260,fx,-399.33
f,28278,fx,-381.97
f,28298,fx,-304.2
f,28314,fx,-342.76
f,28332,fx,-286.84
f,28352,fx,-286.84
f,28368,fx,-286.84
f,28386,fx,-304.2
f,28406,fx,-381.97
f,28422,fx,-342.76
f,28444,fx,677.339
f,28452,fx,677.339
f,28476,fx,677.339
f,28494,fx,694.694
f,28514,fx,772.471
f,28530,fx,733.261
f,28548,fx,789.826
f,28568,fx,789.826
f,28584,fx,789.826
f,28602,fx,772.471
f,28622,fx,694.694
f,28638,fx,733.261
f,28660,fx,523.713
f,28668,fx,523.713
f,28692,fx,523.713
f,28710,fx,541.068
f,28730,fx,618.845
f,28746,fx,579.635
f,28764,fx,636.201
f,28784,fx,636.201
f,28800,fx,636.201
f,28818,fx,618.845
f,28838,fx,541.068
f,28854,fx,579.635
f,28876,fx,370.087
f,28884,fx,370.087
f,28908,fx,370.087
f,28926,fx,386.8
f,28946,fx,464.577
f,28962,fx,426.01
f,28980,fx,481.932
f,29000,fx,481.932
f,29016,fx,481.932
f,29034,fx,464.577
f,29054,fx,386.8
f,29070,fx,426.01
f,29092,fx,215.819
f,29100,fx,215.819
f,29124,fx,215.819
f,29142,fx,233.174
f,29162,fx,310.951
f,29178,fx,272.384
f,29196,fx,328.306
f,29216,fx,328.306
f,29232,fx,328.306
f,29250,fx,310.951
f,29270,fx,233.174
f,29286,fx,272.384
f,29308,fx,62.1927
f,29316,fx,62.1927
f,29340,fx,62.1927
f,29358,fx,79.5479
f,29378,fx,157.325
f,29394,fx,118.115
f,29412,fx,174.68
f,29432,fx,174.68
f,29448,fx,174.68
f,29466,fx,157.325
f,29486,fx,79.5479
f,29502,fx,118.115
f,29524,fx,-91.433
f,29532,fx,-91.433
f,29556,fx,-91.433
f,29574,fx,-74.078
f,29594,fx,3.69919
f,29610,fx,-35.511
f,29628,fx,20.4116
f,29648,fx,20.4116
f,29664,fx,20.4116
f,29682,fx,3.69919
f,29702,fx,-74.078
f,29718,fx,-35.511
f,29740,fx,-245.7
f,29748,fx,-245.7
f,29772,fx,-245.7
f,29790,fx,-228.35
f,29810,fx,-150.57
f,29826,fx,-189.14
f,29844,fx,-133.21
f,29864,fx,-133.21
f,29880,fx,-133.21
f,29898,fx,-150.57
f,29918,fx,-228.35
f,29934,fx,-189.14
f,29956,fx,-399.33
f,29964,fx,-399.33
f,29988,fx,-399.33
f,30006,fx,-381.97
f,30026,fx,-304.2
f,30042,fx,-342.76
f,30060,fx,-286.84
f,30080,fx,-286.84
f,30096,fx,-286.84
f,30114,fx,-304.2
f,30134,fx,-381.97
f,30150,fx,-342.76
f,30172,fx,677.339
f,30180,fx,677.339
f,30204,fx,677.339
f,30222,fx,694.694
f,30242,fx,772.471
f,30258,fx,733.261
f,30276,fx,789.826
f,30296,fx,789.826
f,30312,fx,789.826
f,30330,fx,772.471
f,30350,fx,694.694
f,30366,fx,733.261
f,30388,fx,523.713
f,30396,fx,523.713
f,30420,fx,523.713
f,30438,fx,541.068
f,30458,fx,618.845
f,30474,fx,579.635
f,30492,fx,636.201
f,30512,fx,636.201
f,30528,fx,636.201
f,30546,fx,618.845
f,30566,fx,541.068
f,30582,fx,579.635
f,30604,fx,370.087
f,30612,fx,370.087
f,30636,fx,370.087
f,30654,fx,386.8
f,30674,fx,464.577
f,30690,fx,426.01
f,30708,fx,481.932
f,30728,fx,481.932
f,30744,fx,481.932
f,30762,fx,464.577
f,30782,fx,386.8
f,30798,fx,426.01
f,30820,fx,215.819
f,30828,fx,215.819
f,30852,fx,215.819
f,30870,fx,233.174
f,30890,fx,310.951
f,30906,fx,272.384
f,30924,fx,328.306
f,30944,fx,328.306
f,30960,fx,328.306
f,30978,fx,310.951
f,30998,fx,233.174
f,31014,fx,272.384
f,31036,fx,62.1927
f,31044,fx,62.1927
f,31068,fx,62.1927
f,31086,fx,79.5479
f,31106,fx,157.325
f,31122,fx,118.115
f,31140,fx,174.68
f,31160,fx,174.68
f,31176,fx,174.68
f,31194,fx,157.325
f,31214,fx,79.5479
f,31230,fx,118.115
f,31252,fx,-91.433
f,31260,fx,-91.433
f,31284,fx,-91.433
f,31302,fx,-74.078

f.31322,fx,3.69919
f.31338,fx,-35.511
f.31356,fx,20.4116
f.31376,fx,20.4116
f.31392,fx,20.4116
f.31410,fx,3.69919
f.31430,fx,-74.078
f.31446,fx,-35.511
f.31468,fx,-245.7
f.31476,fx,-245.7
f.31500,fx,-245.7
f.31518,fx,-228.35
f.31538,fx,-150.57
f.31554,fx,-189.14
f.31572,fx,-133.21
f.31592,fx,-133.21
f.31608,fx,-133.21
f.31626,fx,-150.57
f.31646,fx,-228.35
f.31662,fx,-189.14
f.31684,fx,-399.33
f.31692,fx,-399.33
f.31716,fx,-399.33
f.31734,fx,-381.97
f.31754,fx,-304.2
f.31770,fx,-342.76
f.31788,fx,-286.84
f.31808,fx,-286.84
f.31824,fx,-286.84
f.31842,fx,-304.2
f.31862,fx,-381.97
f.31878,fx,-342.76
f.31900,fx,677.339
f.31908,fx,677.339
f.31932,fx,677.339
f.31950,fx,694.694
f.31970,fx,772.471
f.31986,fx,733.261
f.32004,fx,789.826
f.32024,fx,789.826
f.32040,fx,789.826
f.32058,fx,772.471
f.32078,fx,694.694
f.32094,fx,733.261
f.32116,fx,523.713
f.32124,fx,523.713
f.32148,fx,523.713
f.32166,fx,541.068
f.32186,fx,618.845
f.32202,fx,579.635
f.32220,fx,636.201
f.32240,fx,636.201
f.32256,fx,636.201
f.32274,fx,618.845
f.32294,fx,541.068
f.32310,fx,579.635
f.32332,fx,370.087
f.32340,fx,370.087
f.32364,fx,370.087
f.32382,fx,386.8
f.32402,fx,464.577
f.32418,fx,426.01
f.32436,fx,481.932
f.32456,fx,481.932
f.32472,fx,481.932
f.32490,fx,464.577
f.32510,fx,386.8
f.32526,fx,426.01
f.32548,fx,215.819
f.32556,fx,215.819
f.32580,fx,215.819
f.32598,fx,233.174
f.32618,fx,310.951
f.32634,fx,272.384
f.32652,fx,328.306
f.32672,fx,328.306
f.32688,fx,328.306
f.32706,fx,310.951
f.32726,fx,233.174
f.32742,fx,272.384
f.32764,fx,62.1927
f.32772,fx,62.1927
f.32796,fx,62.1927
f.32814,fx,79.5479
f.32834,fx,157.325
f.32850,fx,118.115
f.32868,fx,174.68
f.32888,fx,174.68
f.32904,fx,174.68
f.32922,fx,157.325
f.32942,fx,79.5479
f.32958,fx,118.115
f.32960,fx,-91.433
f.32988,fx,-91.433
f.33012,fx,-91.433
f.33030,fx,-74.078
f.33050,fx,3.69919
f.33066,fx,-35.511
f.33084,fx,20.4116
f.33104,fx,20.4116
f.33120,fx,20.4116
f.33138,fx,3.69919
f.33158,fx,-74.078
f.33174,fx,-35.511
f.33196,fx,-245.7
f.33204,fx,-245.7
f.33228,fx,-245.7
f.33246,fx,-228.35
f.33266,fx,-150.57
f.33282,fx,-189.14
f.33300,fx,-133.21
f.33320,fx,-133.21
f.33336,fx,-133.21
f.33354,fx,-150.57
f.33374,fx,-228.35
f.33390,fx,-189.14
f.33412,fx,-399.33
f.33420,fx,-399.33
f.33444,fx,-399.33
f.33462,fx,-381.97
f.33482,fx,-304.2
f.33498,fx,-342.76
f.33516,fx,-286.84
f.33536,fx,-286.84
f.33552,fx,-286.84
f.33570,fx,-304.2
f.33590,fx,-381.97
f.33606,fx,-342.76
f.5981,fx,678.372
f.5989,fx,678.372
f.6013,fx,678.372
f.6031,fx,695.727
f.6051,fx,773.505
f.6067,fx,734.295
f.6085,fx,790.86
f.6105,fx,790.86
f.6121,fx,790.86
f.6139,fx,773.505
f.6159,fx,695.727
f.6175,fx,734.295
f.6197,fx,524.746
f.6205,fx,524.746
f.6229,fx,524.746
f.6247,fx,542.102
f.6267,fx,619.879
f.6283,fx,580.669
f.6301,fx,637.234
f.6321,fx,637.234
f.6337,fx,637.234
f.6355,fx,619.879
f.6375,fx,542.102
f.6391,fx,580.669
f.6413,fx,371.121
f.6421,fx,371.121
f.6445,fx,371.121
f.6463,fx,387.833
f.6483,fx,465.61
f.6499,fx,427.043
f.6517,fx,482.965
f.6537,fx,482.965
f.6553,fx,482.965
f.6571,fx,465.61
f.6591,fx,387.833
f.6607,fx,427.043
f.6629,fx,216.852
f.6637,fx,216.852
f.6661,fx,216.852
f.6679,fx,234.207
f.6699,fx,311.984
f.6715,fx,273.417
f.6733,fx,329.34
f.6753,fx,329.34
f.6769,fx,329.34
f.6787,fx,311.984
f.6807,fx,234.207
f.6823,fx,273.417
f.6845,fx,63.2261
f.6853,fx,63.2261
f.6877,fx,63.2261
f.6895,fx,80.5813
f.6915,fx,158.358
f.6931,fx,119.149
f.6949,fx,175.714
f.6969,fx,175.714
f.6985,fx,175.714
f.7003,fx,158.358
f.7023,fx,80.5813
f.7039,fx,119.149
f.7061,fx,-90.4
f.7069,fx,-90.4
f.7093,fx,-90.4
f.7111,fx,-73.044
f.7131,fx,4.73261
f.7147,fx,-34.477
f.7165,fx,21.445
f.7185,fx,21.445
f.7201,fx,21.445
f.7219,fx,4.73261
f.7239,fx,-73.044
f.7255,fx,-34.477
f.7277,fx,-244.67
f.7285,fx,-244.67
f.7309,fx,-244.67
f.7327,fx,-227.31
f.7347,fx,-149.54
f.7363,fx,-188.1
f.7381,fx,-132.18
f.7401,fx,-132.18
f.7417,fx,-132.18
f.7435,fx,-149.54
f.7455,fx,-227.31
f.7471,fx,-188.1
f.7493,fx,-398.29
f.7501,fx,-398.29
f.7525,fx,-398.29
f.7543,fx,-380.94
f.7563,fx,-303.16
f.7579,fx,-341.73
f.7597,fx,-285.81
f.7617,fx,-285.81
f.7633,fx,-285.81
f.7651,fx,-303.16
f.7671,fx,-380.94
f.7687,fx,-341.73
f.7709,fx,678.372
f.7717,fx,678.372
f.7741,fx,678.372
f.7759,fx,695.727
f.7779,fx,773.505
f.7795,fx,734.295
f.7813,fx,790.86
f.7833,fx,790.86
f.7849,fx,790.86
f.7867,fx,773.505
f.7887,fx,695.727
f.7903,fx,734.295
f.7925,fx,524.746
f.7933,fx,524.746
f.7957,fx,524.746
f.7975,fx,542.102
f.7995,fx,619.879
f.8011,fx,580.669
f.8029,fx,637.234
f.8049,fx,637.234
f.8065,fx,637.234
f.8083,fx,619.879
f.8103,fx,542.102
f.8119,fx,580.669
f.8141,fx,371.121
f.8149,fx,371.121
f.8173,fx,371.121
f.8191,fx,387.833
f.8211,fx,465.61
f.8227,fx,427.043
f.8245,fx,482.965
f.8265,fx,482.965
f.8281,fx,482.965
f.8299,fx,465.61
f.8319,fx,387.833
f.8335,fx,427.043
f.8357,fx,216.852
f.8365,fx,216.852
f.8389,fx,216.852
f.8407,fx,234.207
f.8427,fx,311.984
f.8443,fx,273.417
f.8461,fx,329.34
f.8481,fx,329.34
f.8497,fx,329.34
f.8515,fx,311.984
f.8535,fx,234.207
f.8551,fx,273.417
f.8573,fx,63.2261
f.8581,fx,63.2261
f.8605,fx,63.2261
f.8623,fx,80.5813
f.8643,fx,158.358
f.8659,fx,119.149
f.8677,fx,175.714
f.8697,fx,175.714
f.8713,fx,175.714
f.8731,fx,158.358
f.8751,fx,80.5813
f.8767,fx,119.149
f.8789,fx,-90.4
f.8797,fx,-90.4
f.8821,fx,-90.4
f.8839,fx,-73.044
f.8859,fx,4.73261
f.8875,fx,-34.477
f.8893,fx,21.445
f.8913,fx,21.445
f.8929,fx,21.445
f.8947,fx,4.73261
f.8967,fx,-73.044
f.8983,fx,-34.477
f.9005,fx,-244.67
f.9013,fx,-244.67
f.9037,fx,-244.67
f.9055,fx,-227.31
f.9075,fx,-149.54
f.9091,fx,-188.1
f.9109,fx,-132.18
f.9129,fx,-132.18
f.9145,fx,-132.18
f.9163,fx,-149.54
f.9183,fx,-227.31
f.9199,fx,-188.1
f.9221,fx,-398.29
f.9229,fx,-398.29
f.9253,fx,-398.29
f.9271,fx,-380.94
f.9291,fx,-303.16
f.9307,fx,-341.73
f.9325,fx,-285.81
f.9345,fx,-285.81
f.9361,fx,-285.81
f.9379,fx,-303.16
f.9399,fx,-380.94
f.9415,fx,-341.73
f.9437,fx,678.372
f.9445,fx,678.372
f.9469,fx,678.372
f.9487,fx,695.727
f.9507,fx,773.505
f.9523,fx,734.295
f.9541,fx,790.86
f.9561,fx,790.86
f.9577,fx,790.86
f.9595,fx,773.505
f.9615,fx,695.727
f.9631,fx,734.295

f,9653,fx,524.746
f,9661,fx,524.746
f,9685,fx,524.746
f,9703,fx,542.102
f,9723,fx,619.879
f,9739,fx,580.669
f,9757,fx,637.234
f,9777,fx,637.234
f,9793,fx,637.234
f,9811,fx,619.879
f,9831,fx,542.102
f,9847,fx,580.669
f,9869,fx,371.121
f,9877,fx,371.121
f,9901,fx,371.121
f,9919,fx,387.833
f,9939,fx,465.61
f,9955,fx,427.043
f,9973,fx,482.965
f,9993,fx,482.965
f,10009,fx,482.965
f,10027,fx,465.61
f,10047,fx,387.833
f,10063,fx,427.043
f,10085,fx,216.852
f,10093,fx,216.852
f,10117,fx,216.852
f,10135,fx,234.207
f,10155,fx,311.984
f,10171,fx,273.417
f,10189,fx,329.34
f,10209,fx,329.34
f,10225,fx,329.34
f,10243,fx,311.984
f,10263,fx,234.207
f,10279,fx,273.417
f,10301,fx,63.2261
f,10309,fx,63.2261
f,10333,fx,63.2261
f,10351,fx,80.5813
f,10371,fx,158.358
f,10387,fx,119.149
f,10405,fx,175.714
f,10425,fx,175.714
f,10441,fx,175.714
f,10459,fx,158.358
f,10479,fx,80.5813
f,10495,fx,119.149
f,10517,fx,-90.4
f,10525,fx,-90.4
f,10549,fx,-90.4
f,10567,fx,-73.044
f,10587,fx,4.73261
f,10603,fx,-34.477
f,10621,fx,21.445
f,10641,fx,21.445
f,10657,fx,21.445
f,10675,fx,4.73261
f,10695,fx,-73.044
f,10711,fx,-34.477
f,10733,fx,-244.67
f,10741,fx,-244.67
f,10765,fx,-244.67
f,10783,fx,-227.31
f,10803,fx,-149.54
f,10819,fx,-188.1
f,10837,fx,-132.18
f,10857,fx,-132.18
f,10873,fx,-132.18
f,10891,fx,-149.54
f,10911,fx,-227.31
f,10927,fx,-188.1
f,10949,fx,-398.29
f,10957,fx,-398.29
f,10981,fx,-398.29
f,10999,fx,-380.94
f,11019,fx,-303.16
f,11035,fx,-341.73
f,11053,fx,-285.81
f,11073,fx,-285.81
f,11089,fx,-285.81
f,11107,fx,-303.16
f,11127,fx,-380.94
f,11143,fx,-341.73
f,11165,fx,678.372
f,11173,fx,678.372
f,11197,fx,678.372
f,11215,fx,695.727
f,11235,fx,773.505
f,11251,fx,734.295
f,11269,fx,790.86
f,11289,fx,790.86
f,11305,fx,790.86
f,11323,fx,773.505
f,11343,fx,695.727
f,11359,fx,734.295
f,11381,fx,524.746
f,11389,fx,524.746
f,11413,fx,524.746
f,11431,fx,542.102
f,11451,fx,619.879
f,11467,fx,580.669
f,11485,fx,637.234
f,11505,fx,637.234
f,11521,fx,637.234
f,11539,fx,619.879
f,11559,fx,542.102
f,11575,fx,580.669
f,11597,fx,371.121
f,11605,fx,371.121
f,11629,fx,371.121
f,11647,fx,387.833
f,11667,fx,465.61
f,11683,fx,427.043
f,11701,fx,482.965
f,11721,fx,482.965
f,11737,fx,482.965
f,11755,fx,465.61
f,11775,fx,387.833
f,11791,fx,427.043
f,11813,fx,216.852
f,11821,fx,216.852
f,11845,fx,216.852
f,11863,fx,234.207
f,11883,fx,311.984
f,11899,fx,273.417
f,11917,fx,329.34
f,11937,fx,329.34
f,11953,fx,329.34
f,11971,fx,311.984
f,11991,fx,234.207
f,12007,fx,273.417
f,12029,fx,63.2261
f,12037,fx,63.2261
f,12061,fx,63.2261
f,12079,fx,80.5813
f,12099,fx,158.358
f,12115,fx,119.149
f,12133,fx,175.714
f,12153,fx,175.714
f,12169,fx,175.714
f,12187,fx,158.358
f,12207,fx,80.5813
f,12223,fx,119.149
f,12245,fx,-90.4
f,12253,fx,-90.4
f,12277,fx,-90.4
f,12295,fx,-73.044
f,12315,fx,4.73261
f,12331,fx,-34.477
f,12349,fx,21.445
f,12369,fx,21.445
f,12385,fx,21.445
f,12403,fx,4.73261
f,12423,fx,-73.044
f,12439,fx,-34.477
f,12461,fx,-244.67
f,12469,fx,-244.67
f,12493,fx,-244.67
f,12511,fx,-227.31
f,12531,fx,-149.54
f,12547,fx,-188.1
f,12565,fx,-132.18
f,12585,fx,-132.18
f,12601,fx,-132.18
f,12619,fx,-149.54
f,12639,fx,-227.31
f,12655,fx,-188.1
f,12677,fx,-398.29
f,12685,fx,-398.29
f,12709,fx,-398.29
f,12727,fx,-380.94
f,12747,fx,-303.16
f,12763,fx,-341.73
f,12781,fx,-285.81
f,12801,fx,-285.81
f,12817,fx,-285.81
f,12835,fx,-303.16
f,12855,fx,-380.94
f,12871,fx,-341.73
f,12893,fx,678.372
f,12901,fx,678.372
f,12925,fx,678.372
f,12943,fx,695.727
f,12963,fx,773.505
f,12979,fx,734.295
f,12997,fx,790.86
f,13017,fx,790.86
f,13033,fx,790.86
f,13051,fx,773.505
f,13071,fx,695.727
f,13087,fx,734.295
f,13109,fx,524.746
f,13117,fx,524.746
f,13141,fx,524.746
f,13159,fx,542.102
f,13179,fx,619.879
f,13195,fx,580.669
f,13213,fx,637.234
f,13233,fx,637.234
f,13249,fx,637.234
f,13267,fx,619.879
f,13287,fx,542.102
f,13303,fx,580.669
f,13325,fx,371.121
f,13333,fx,371.121
f,13357,fx,371.121
f,13375,fx,387.833
f,13395,fx,465.61
f,13411,fx,427.043
f,13429,fx,482.965
f,13449,fx,482.965
f,13465,fx,482.965
f,13483,fx,465.61
f,13503,fx,387.833
f,13519,fx,427.043
f,13541,fx,216.852
f,13549,fx,216.852
f,13573,fx,216.852
f,13591,fx,234.207
f,13611,fx,311.984
f,13627,fx,273.417
f,13645,fx,329.34
f,13665,fx,329.34
f,13681,fx,329.34
f,13699,fx,311.984
f,13719,fx,234.207
f,13735,fx,273.417
f,13757,fx,63.2261
f,13765,fx,63.2261
f,13789,fx,63.2261
f,13807,fx,80.5813
f,13827,fx,158.358
f,13843,fx,119.149
f,13861,fx,175.714
f,13881,fx,175.714
f,13897,fx,175.714
f,13915,fx,158.358
f,13935,fx,80.5813
f,13951,fx,119.149
f,13973,fx,-90.4
f,13981,fx,-90.4
f,14005,fx,-90.4
f,14023,fx,-73.044
f,14043,fx,4.73261
f,14059,fx,-34.477
f,14077,fx,21.445
f,14097,fx,21.445
f,14113,fx,21.445
f,14131,fx,4.73261
f,14151,fx,-73.044
f,14167,fx,-34.477
f,14189,fx,-244.67
f,14197,fx,-244.67
f,14221,fx,-244.67
f,14239,fx,-227.31
f,14259,fx,-149.54
f,14275,fx,-188.1
f,14293,fx,-132.18
f,14313,fx,-132.18
f,14329,fx,-132.18
f,14347,fx,-149.54
f,14367,fx,-227.31
f,14383,fx,-188.1
f,14405,fx,-398.29
f,14413,fx,-398.29
f,14437,fx,-398.29
f,14455,fx,-380.94
f,14475,fx,-303.16
f,14491,fx,-341.73
f,14509,fx,-285.81
f,14529,fx,-285.81
f,14545,fx,-285.81
f,14563,fx,-303.16
f,14583,fx,-380.94
f,14599,fx,-341.73
f,14621,fx,678.372
f,14629,fx,678.372
f,14653,fx,678.372
f,14671,fx,695.727
f,14691,fx,773.505
f,14707,fx,734.295
f,14725,fx,790.86
f,14745,fx,790.86
f,14761,fx,790.86
f,14779,fx,773.505
f,14799,fx,695.727
f,14815,fx,734.295
f,14837,fx,524.746
f,14845,fx,524.746
f,14869,fx,524.746
f,14887,fx,542.102
f,14907,fx,619.879
f,14923,fx,580.669
f,14941,fx,637.234
f,14961,fx,637.234
f,14977,fx,637.234
f,14995,fx,619.879
f,15015,fx,542.102
f,15031,fx,580.669
f,15053,fx,371.121
f,15061,fx,371.121
f,15085,fx,371.121
f,15103,fx,387.833
f,15123,fx,465.61
f,15139,fx,427.043
f,15157,fx,482.965
f,15177,fx,482.965
f,15193,fx,482.965
f,15211,fx,465.61
f,15231,fx,387.833
f,15247,fx,427.043
f,15269,fx,216.852
f,15277,fx,216.852
f,15301,fx,216.852
f,15319,fx,234.207
f,15339,fx,311.984
f,15355,fx,273.417
f,15373,fx,329.34
f,15393,fx,329.34
f,15409,fx,329.34
f,15427,fx,311.984
f,15447,fx,234.207
f,15463,fx,273.417
f,15485,fx,63.2261
f,15493,fx,63.2261
f,15517,fx,63.2261
f,15535,fx,80.5813
f,15555,fx,158.358
f,15571,fx,119.149
f,15589,fx,175.714
f,15609,fx,175.714

f,15625,fx,175.714
f,15643,fx,158.358
f,15663,fx,80.5813
f,15679,fx,119.149
f,15701,fx,-90.4
f,15709,fx,-90.4
f,15733,fx,-90.4
f,15751,fx,-73.044
f,15771,fx,4.73261
f,15787,fx,-34.477
f,15805,fx,21.445
f,15825,fx,21.445
f,15841,fx,21.445
f,15859,fx,4.73261
f,15879,fx,-73.044
f,15895,fx,-34.477
f,15917,fx,-244.67
f,15925,fx,-244.67
f,15949,fx,-244.67
f,15967,fx,-227.31
f,15987,fx,-149.54
f,16003,fx,-188.1
f,16021,fx,-132.18
f,16041,fx,-132.18
f,16057,fx,-132.18
f,16075,fx,-149.54
f,16095,fx,-227.31
f,16111,fx,-188.1
f,16133,fx,-398.29
f,16141,fx,-398.29
f,16165,fx,-398.29
f,16183,fx,-380.94
f,16203,fx,-303.16
f,16219,fx,-341.73
f,16237,fx,-285.81
f,16257,fx,-285.81
f,16273,fx,-285.81
f,16291,fx,-303.16
f,16311,fx,-380.94
f,16327,fx,-341.73
f,16349,fx,678.372
f,16357,fx,678.372
f,16381,fx,678.372
f,16399,fx,695.727
f,16419,fx,773.505
f,16435,fx,734.295
f,16453,fx,790.86
f,16473,fx,790.86
f,16489,fx,790.86
f,16507,fx,773.505
f,16527,fx,695.727
f,16543,fx,734.295
f,16565,fx,524.746
f,16573,fx,524.746
f,16597,fx,524.746
f,16615,fx,542.102
f,16635,fx,619.879
f,16651,fx,580.669
f,16669,fx,637.234
f,16689,fx,637.234
f,16705,fx,637.234
f,16723,fx,619.879
f,16743,fx,542.102
f,16759,fx,580.669
f,16781,fx,371.121
f,16789,fx,371.121
f,16813,fx,371.121
f,16831,fx,387.833
f,16851,fx,465.61
f,16867,fx,427.043
f,16885,fx,482.965
f,16905,fx,482.965
f,16921,fx,482.965
f,16939,fx,465.61
f,16959,fx,387.833
f,16975,fx,427.043
f,16997,fx,216.852
f,17005,fx,216.852
f,17029,fx,216.852
f,17047,fx,234.207
f,17067,fx,311.984
f,17083,fx,273.417
f,17101,fx,329.34
f,17121,fx,329.34
f,17137,fx,329.34
f,17155,fx,311.984
f,17175,fx,234.207
f,17191,fx,273.417
f,17213,fx,63.2261
f,17221,fx,63.2261
f,17245,fx,63.2261
f,17263,fx,80.5813
f,17283,fx,158.358
f,17299,fx,119.149
f,17317,fx,175.714
f,17337,fx,175.714
f,17353,fx,175.714
f,17371,fx,158.358
f,17391,fx,80.5813
f,17407,fx,119.149
f,17429,fx,-90.4
f,17437,fx,-90.4
f,17461,fx,-90.4
f,17479,fx,-73.044
f,17499,fx,4.73261
f,17515,fx,-34.477
f,17533,fx,21.445
f,17553,fx,21.445
f,17569,fx,21.445
f,17587,fx,4.73261
f,17607,fx,-73.044
f,17623,fx,-34.477
f,17645,fx,-244.67
f,17653,fx,-244.67
f,17677,fx,-244.67
f,17695,fx,-227.31
f,17715,fx,-149.54
f,17731,fx,-188.1
f,17749,fx,-132.18
f,17769,fx,-132.18
f,17785,fx,-132.18
f,17803,fx,-149.54
f,17823,fx,-227.31
f,17839,fx,-188.1
f,17861,fx,-398.29
f,17869,fx,-398.29
f,17893,fx,-398.29
f,17911,fx,-380.94
f,17931,fx,-303.16
f,17947,fx,-341.73
f,17965,fx,-285.81
f,17985,fx,-285.81
f,18001,fx,-285.81
f,18019,fx,-303.16
f,18039,fx,-380.94
f,18055,fx,-341.73
f,18077,fx,678.372
f,18085,fx,678.372
f,18109,fx,678.372
f,18127,fx,695.727
f,18147,fx,773.505
f,18163,fx,734.295
f,18181,fx,790.86
f,18201,fx,790.86
f,18217,fx,790.86
f,18235,fx,773.505
f,18255,fx,695.727
f,18271,fx,734.295
f,18293,fx,524.746
f,18301,fx,524.746
f,18325,fx,524.746
f,18343,fx,542.102
f,18363,fx,619.879
f,18379,fx,580.669
f,18397,fx,637.234
f,18417,fx,637.234
f,18433,fx,637.234
f,18451,fx,619.879
f,18471,fx,542.102
f,18487,fx,580.669
f,18509,fx,371.121
f,18517,fx,371.121
f,18541,fx,371.121
f,18559,fx,387.833
f,18579,fx,465.61
f,18595,fx,427.043
f,18613,fx,482.965
f,18633,fx,482.965
f,18649,fx,482.965
f,18667,fx,465.61
f,18687,fx,387.833
f,18703,fx,427.043
f,18725,fx,216.852
f,18733,fx,216.852
f,18757,fx,216.852
f,18775,fx,234.207
f,18795,fx,311.984
f,18811,fx,273.417
f,18829,fx,329.34
f,18849,fx,329.34
f,18865,fx,329.34
f,18883,fx,311.984
f,18903,fx,234.207
f,18919,fx,273.417
f,18941,fx,63.2261
f,18949,fx,63.2261
f,18973,fx,63.2261
f,18991,fx,80.5813
f,19011,fx,158.358
f,19027,fx,119.149
f,19045,fx,175.714
f,19065,fx,175.714
f,19081,fx,175.714
f,19099,fx,158.358
f,19119,fx,80.5813
f,19135,fx,119.149
f,19157,fx,-90.4
f,19165,fx,-90.4
f,19189,fx,-90.4
f,19207,fx,-73.044
f,19227,fx,4.73261
f,19243,fx,-34.477
f,19261,fx,21.445
f,19281,fx,21.445
f,19297,fx,21.445
f,19315,fx,4.73261
f,19335,fx,-73.044
f,19351,fx,-34.477
f,19373,fx,-244.67
f,19381,fx,-244.67
f,19405,fx,-244.67
f,19423,fx,-227.31
f,19443,fx,-149.54
f,19459,fx,-188.1
f,19477,fx,-132.18
f,19497,fx,-132.18
f,19513,fx,-132.18
f,19531,fx,-149.54
f,19551,fx,-227.31
f,19567,fx,-188.1
f,19589,fx,-398.29
f,19597,fx,-398.29
f,19621,fx,-398.29
f,19639,fx,-380.94
f,19659,fx,-303.16
f,19675,fx,-341.73
f,19693,fx,-285.81
f,19713,fx,-285.81
f,19729,fx,-285.81
f,19747,fx,-303.16
f,19767,fx,-380.94
f,19783,fx,-341.73
f,19805,fx,678.372
f,19813,fx,678.372
f,19837,fx,678.372
f,19855,fx,695.727
f,19875,fx,773.505
f,19891,fx,734.295
f,19909,fx,790.86
f,19929,fx,790.86
f,19945,fx,790.86
f,19963,fx,773.505
f,19983,fx,695.727
f,19999,fx,734.295
f,20021,fx,524.746
f,20029,fx,524.746
f,20053,fx,524.746
f,20071,fx,542.102
f,20091,fx,619.879
f,20107,fx,580.669
f,20125,fx,637.234
f,20145,fx,637.234
f,20161,fx,637.234
f,20179,fx,619.879
f,20199,fx,542.102
f,20215,fx,580.669
f,20237,fx,371.121
f,20245,fx,371.121
f,20269,fx,371.121
f,20287,fx,387.833
f,20307,fx,465.61
f,20323,fx,427.043
f,20341,fx,482.965
f,20361,fx,482.965
f,20377,fx,482.965
f,20395,fx,465.61
f,20415,fx,387.833
f,20431,fx,427.043
f,20453,fx,216.852
f,20461,fx,216.852
f,20485,fx,216.852
f,20503,fx,234.207
f,20523,fx,311.984
f,20539,fx,273.417
f,20557,fx,329.34
f,20577,fx,329.34
f,20593,fx,329.34
f,20611,fx,311.984
f,20631,fx,234.207
f,20647,fx,273.417
f,20669,fx,63.2261
f,20677,fx,63.2261
f,20701,fx,63.2261
f,20719,fx,80.5813
f,20739,fx,158.358
f,20755,fx,119.149
f,20773,fx,175.714
f,20793,fx,175.714
f,20809,fx,175.714
f,20827,fx,158.358
f,20847,fx,80.5813
f,20863,fx,119.149
f,20885,fx,-90.4
f,20893,fx,-90.4
f,20917,fx,-90.4
f,20935,fx,-73.044
f,20955,fx,4.73261
f,20971,fx,-34.477
f,20989,fx,21.445
f,21009,fx,21.445
f,21025,fx,21.445
f,21043,fx,4.73261
f,21063,fx,-73.044
f,21079,fx,-34.477
f,21101,fx,-244.67
f,21109,fx,-244.67
f,21133,fx,-244.67
f,21151,fx,-227.31
f,21171,fx,-149.54
f,21187,fx,-188.1
f,21205,fx,-132.18
f,21225,fx,-132.18
f,21241,fx,-132.18
f,21259,fx,-149.54
f,21279,fx,-227.31
f,21295,fx,-188.1
f,21317,fx,-398.29
f,21325,fx,-398.29
f,21349,fx,-398.29
f,21367,fx,-380.94
f,21387,fx,-303.16
f,21403,fx,-341.73
f,21421,fx,-285.81
f,21441,fx,-285.81
f,21457,fx,-285.81
f,21475,fx,-303.16
f,21495,fx,-380.94
f,21511,fx,-341.73
f,21533,fx,678.372
f,21541,fx,678.372
f,21565,fx,678.372
f,21583,fx,695.727

f,21603,fx,773.505
f,21619,fx,734.295
f,21637,fx,790.86
f,21657,fx,790.86
f,21673,fx,790.86
f,21691,fx,773.505
f,21711,fx,695.727
f,21727,fx,734.295
f,21749,fx,524.746
f,21757,fx,524.746
f,21781,fx,524.746
f,21799,fx,542.102
f,21819,fx,619.879
f,21835,fx,580.669
f,21853,fx,637.234
f,21873,fx,637.234
f,21889,fx,637.234
f,21907,fx,619.879
f,21927,fx,542.102
f,21943,fx,580.669
f,21965,fx,371.121
f,21973,fx,371.121
f,21997,fx,371.121
f,22015,fx,387.833
f,22035,fx,465.61
f,22051,fx,427.043
f,22069,fx,482.965
f,22089,fx,482.965
f,22105,fx,482.965
f,22123,fx,465.61
f,22143,fx,387.833
f,22159,fx,427.043
f,22181,fx,216.852
f,22189,fx,216.852
f,22213,fx,216.852
f,22231,fx,234.207
f,22251,fx,311.984
f,22267,fx,273.417
f,22285,fx,329.34
f,22305,fx,329.34
f,22321,fx,329.34
f,22339,fx,311.984
f,22359,fx,234.207
f,22375,fx,273.417
f,22397,fx,63.2261
f,22405,fx,63.2261
f,22429,fx,63.2261
f,22447,fx,80.5813
f,22467,fx,158.358
f,22483,fx,119.149
f,22501,fx,175.714
f,22521,fx,175.714
f,22537,fx,175.714
f,22555,fx,158.358
f,22575,fx,80.5813
f,22591,fx,119.149
f,22613,fx,-90.4
f,22621,fx,-90.4
f,22645,fx,-90.4
f,22663,fx,-73.044
f,22683,fx,4.73261
f,22699,fx,-34.477
f,22717,fx,21.445
f,22737,fx,21.445
f,22753,fx,21.445
f,22771,fx,4.73261
f,22791,fx,-73.044
f,22807,fx,-34.477
f,22829,fx,-244.67
f,22837,fx,-244.67
f,22861,fx,-244.67
f,22879,fx,-227.31
f,22899,fx,-149.54
f,22915,fx,-188.1
f,22933,fx,-132.18
f,22953,fx,-132.18
f,22969,fx,-132.18
f,22987,fx,-149.54
f,23007,fx,-227.31
f,23023,fx,-188.1
f,23045,fx,-398.29
f,23053,fx,-398.29
f,23077,fx,-398.29
f,23095,fx,-380.94
f,23115,fx,-303.16
f,23131,fx,-341.73
f,23149,fx,-285.81
f,23169,fx,-285.81
f,23185,fx,-285.81
f,23203,fx,-303.16
f,23223,fx,-380.94
f,23239,fx,-341.73
f,23261,fx,678.372
f,23269,fx,678.372
f,23293,fx,678.372
f,23311,fx,695.727
f,23331,fx,773.505
f,23347,fx,734.295
f,23365,fx,790.86
f,23385,fx,790.86
f,23401,fx,790.86
f,23419,fx,773.505
f,23439,fx,695.727
f,23455,fx,734.295
f,23477,fx,524.746
f,23485,fx,524.746
f,23509,fx,524.746
f,23527,fx,542.102
f,23547,fx,619.879
f,23563,fx,580.669
f,23581,fx,637.234
f,23601,fx,637.234
f,23617,fx,637.234
f,23635,fx,619.879
f,23655,fx,542.102
f,23671,fx,580.669
f,23693,fx,371.121
f,23701,fx,371.121
f,23725,fx,371.121
f,23743,fx,387.833
f,23763,fx,465.61
f,23779,fx,427.043
f,23797,fx,482.965
f,23817,fx,482.965
f,23833,fx,482.965
f,23851,fx,465.61
f,23871,fx,387.833
f,23887,fx,427.043
f,23909,fx,216.852
f,23917,fx,216.852
f,23941,fx,216.852
f,23959,fx,234.207
f,23979,fx,311.984
f,23995,fx,273.417
f,24013,fx,329.34
f,24033,fx,329.34
f,24049,fx,329.34
f,24067,fx,311.984
f,24087,fx,234.207
f,24103,fx,273.417
f,24125,fx,63.2261
f,24133,fx,63.2261
f,24157,fx,63.2261
f,24175,fx,80.5813
f,24195,fx,158.358
f,24211,fx,119.149
f,24229,fx,175.714
f,24249,fx,175.714
f,24265,fx,175.714
f,24283,fx,158.358
f,24303,fx,80.5813
f,24319,fx,119.149
f,24341,fx,-90.4
f,24349,fx,-90.4
f,24373,fx,-90.4
f,24391,fx,-73.044
f,24411,fx,4.73261
f,24427,fx,-34.477
f,24445,fx,21.445
f,24465,fx,21.445
f,24481,fx,21.445
f,24499,fx,4.73261
f,24519,fx,-73.044
f,24535,fx,-34.477
f,24557,fx,-244.67
f,24565,fx,-244.67
f,24589,fx,-244.67
f,24607,fx,-227.31
f,24627,fx,-149.54
f,24643,fx,-188.1
f,24661,fx,-132.18
f,24681,fx,-132.18
f,24697,fx,-132.18
f,24715,fx,-149.54
f,24735,fx,-227.31
f,24751,fx,-188.1
f,24773,fx,-398.29
f,24781,fx,-398.29
f,24805,fx,-398.29
f,24823,fx,-380.94
f,24843,fx,-303.16
f,24859,fx,-341.73
f,24877,fx,-285.81
f,24897,fx,-285.81
f,24913,fx,-285.81
f,24931,fx,-303.16
f,24951,fx,-380.94
f,24967,fx,-341.73
f,24989,fx,678.372
f,24997,fx,678.372
f,25021,fx,678.372
f,25039,fx,695.727
f,25059,fx,773.505
f,25075,fx,734.295
f,25093,fx,790.86
f,25113,fx,790.86
f,25129,fx,790.86
f,25147,fx,773.505
f,25167,fx,695.727
f,25183,fx,734.295
f,25205,fx,524.746
f,25213,fx,524.746
f,25237,fx,524.746
f,25255,fx,542.102
f,25275,fx,619.879
f,25291,fx,580.669
f,25309,fx,637.234
f,25329,fx,637.234
f,25345,fx,637.234
f,25363,fx,619.879
f,25383,fx,542.102
f,25399,fx,580.669
f,25421,fx,371.121
f,25429,fx,371.121
f,25453,fx,371.121
f,25471,fx,387.833
f,25491,fx,465.61
f,25507,fx,427.043
f,25525,fx,482.965
f,25545,fx,482.965
f,25561,fx,482.965
f,25579,fx,465.61
f,25599,fx,387.833
f,25615,fx,427.043
f,25637,fx,216.852
f,25645,fx,216.852
f,25669,fx,216.852
f,25687,fx,234.207
f,25707,fx,311.984
f,25723,fx,273.417
f,25741,fx,329.34
f,25761,fx,329.34
f,25777,fx,329.34
f,25795,fx,311.984
f,25815,fx,234.207
f,25831,fx,273.417
f,25853,fx,63.2261
f,25861,fx,63.2261
f,25885,fx,63.2261
f,25903,fx,80.5813
f,25923,fx,158.358
f,25939,fx,119.149
f,25957,fx,175.714
f,25977,fx,175.714
f,25993,fx,175.714
f,26011,fx,158.358
f,26031,fx,80.5813
f,26047,fx,119.149
f,26069,fx,-90.4
f,26077,fx,-90.4
f,26101,fx,-90.4
f,26119,fx,-73.044
f,26139,fx,4.73261
f,26155,fx,-34.477
f,26173,fx,21.445
f,26193,fx,21.445
f,26209,fx,21.445
f,26227,fx,4.73261
f,26247,fx,-73.044
f,26263,fx,-34.477
f,26285,fx,-244.67
f,26293,fx,-244.67
f,26317,fx,-244.67
f,26335,fx,-227.31
f,26355,fx,-149.54
f,26371,fx,-188.1
f,26389,fx,-132.18
f,26409,fx,-132.18
f,26425,fx,-132.18
f,26443,fx,-149.54
f,26463,fx,-227.31
f,26479,fx,-188.1
f,26501,fx,-398.29
f,26509,fx,-398.29
f,26533,fx,-398.29
f,26551,fx,-380.94
f,26571,fx,-303.16
f,26587,fx,-341.73
f,26605,fx,-285.81
f,26625,fx,-285.81
f,26641,fx,-285.81
f,26659,fx,-303.16
f,26679,fx,-380.94
f,26695,fx,-341.73
f,26717,fx,678.372
f,26725,fx,678.372
f,26749,fx,678.372
f,26767,fx,695.727
f,26787,fx,773.505
f,26803,fx,734.295
f,26821,fx,790.86
f,26841,fx,790.86
f,26857,fx,790.86
f,26875,fx,773.505
f,26895,fx,695.727
f,26911,fx,734.295
f,26933,fx,524.746
f,26941,fx,524.746
f,26965,fx,524.746
f,26983,fx,542.102
f,27003,fx,619.879
f,27019,fx,580.669
f,27037,fx,637.234
f,27057,fx,637.234
f,27073,fx,637.234
f,27091,fx,619.879
f,27111,fx,542.102
f,27127,fx,580.669
f,27149,fx,371.121
f,27157,fx,371.121
f,27181,fx,371.121
f,27199,fx,387.833
f,27219,fx,465.61
f,27235,fx,427.043
f,27253,fx,482.965
f,27273,fx,482.965
f,27289,fx,482.965
f,27307,fx,465.61
f,27327,fx,387.833
f,27343,fx,427.043
f,27365,fx,216.852
f,27373,fx,216.852
f,27397,fx,216.852
f,27415,fx,234.207
f,27435,fx,311.984
f,27451,fx,273.417
f,27469,fx,329.34
f,27489,fx,329.34
f,27505,fx,329.34
f,27523,fx,311.984
f,27543,fx,234.207
f,27559,fx,273.417

f.27581,fx,63.2261
f.27589,fx,63.2261
f.27613,fx,63.2261
f.27631,fx,80.5813
f.27651,fx,158.358
f.27667,fx,119.149
f.27685,fx,175.714
f.27705,fx,175.714
f.27721,fx,175.714
f.27739,fx,158.358
f.27759,fx,80.5813
f.27775,fx,119.149
f.27797,fx,-90.4
f.27805,fx,-90.4
f.27829,fx,-90.4
f.27847,fx,-73.044
f.27867,fx,4.73261
f.27883,fx,-34.477
f.27901,fx,21.445
f.27921,fx,21.445
f.27937,fx,21.445
f.27955,fx,4.73261
f.27975,fx,-73.044
f.27991,fx,-34.477
f.28013,fx,-244.67
f.28021,fx,-244.67
f.28045,fx,-244.67
f.28063,fx,-227.31
f.28083,fx,-149.54
f.28099,fx,-188.1
f.28117,fx,-132.18
f.28137,fx,-132.18
f.28153,fx,-132.18
f.28171,fx,-149.54
f.28191,fx,-227.31
f.28207,fx,-188.1
f.28229,fx,-398.29
f.28237,fx,-398.29
f.28261,fx,-398.29
f.28279,fx,-380.94
f.28299,fx,-303.16
f.28315,fx,-341.73
f.28333,fx,-285.81
f.28353,fx,-285.81
f.28369,fx,-285.81
f.28387,fx,-303.16
f.28407,fx,-380.94
f.28423,fx,-341.73
f.28445,fx,678.372
f.28453,fx,678.372
f.28477,fx,678.372
f.28495,fx,695.727
f.28515,fx,773.505
f.28531,fx,734.295
f.28549,fx,790.86
f.28569,fx,790.86
f.28585,fx,790.86
f.28603,fx,773.505
f.28623,fx,695.727
f.28639,fx,734.295
f.28661,fx,524.746
f.28669,fx,524.746
f.28693,fx,524.746
f.28711,fx,542.102
f.28731,fx,619.879
f.28747,fx,580.669
f.28765,fx,637.234
f.28785,fx,637.234
f.28801,fx,637.234
f.28819,fx,619.879
f.28839,fx,542.102
f.28855,fx,580.669
f.28877,fx,371.121
f.28885,fx,371.121
f.28909,fx,371.121
f.28927,fx,387.833
f.28947,fx,465.61
f.28963,fx,427.043
f.28981,fx,482.965
f.29001,fx,482.965
f.29017,fx,482.965
f.29035,fx,465.61
f.29055,fx,387.833
f.29071,fx,427.043
f.29093,fx,216.852
f.29101,fx,216.852
f.29125,fx,216.852
f.29143,fx,234.207
f.29163,fx,311.984
f.29179,fx,273.417
f.29197,fx,329.34
f.29217,fx,329.34
f.29233,fx,329.34
f.29251,fx,311.984
f.29271,fx,234.207
f.29287,fx,273.417
f.29309,fx,63.2261
f.29317,fx,63.2261
f.29341,fx,63.2261
f.29359,fx,80.5813
f.29379,fx,158.358
f.29395,fx,119.149
f.29413,fx,175.714
f.29433,fx,175.714
f.29449,fx,175.714
f.29467,fx,158.358
f.29487,fx,80.5813
f.29503,fx,119.149
f.29525,fx,-90.4
f.29533,fx,-90.4
f.29557,fx,-90.4
f.29575,fx,-73.044
f.29595,fx,4.73261
f.29611,fx,-34.477
f.29629,fx,21.445
f.29649,fx,21.445
f.29665,fx,21.445
f.29683,fx,4.73261
f.29703,fx,-73.044
f.29719,fx,-34.477
f.29741,fx,-244.67
f.29749,fx,-244.67
f.29773,fx,-244.67
f.29791,fx,-227.31
f.29811,fx,-149.54
f.29827,fx,-188.1
f.29845,fx,-132.18
f.29865,fx,-132.18
f.29881,fx,-132.18
f.29899,fx,-149.54
f.29919,fx,-227.31
f.29935,fx,-188.1
f.29957,fx,-398.29
f.29965,fx,-398.29
f.29989,fx,-398.29
f.30007,fx,-380.94
f.30027,fx,-303.16
f.30043,fx,-341.73
f.30061,fx,-285.81
f.30081,fx,-285.81
f.30097,fx,-285.81
f.30115,fx,-303.16
f.30135,fx,-380.94
f.30151,fx,-341.73
f.30173,fx,678.372
f.30181,fx,678.372
f.30205,fx,678.372
f.30223,fx,695.727
f.30243,fx,773.505
f.30259,fx,734.295
f.30277,fx,790.86
f.30297,fx,790.86
f.30313,fx,790.86
f.30331,fx,773.505
f.30351,fx,695.727
f.30367,fx,734.295
f.30389,fx,524.746
f.30397,fx,524.746
f.30421,fx,524.746
f.30439,fx,542.102
f.30459,fx,619.879
f.30475,fx,580.669
f.30493,fx,637.234
f.30513,fx,637.234
f.30529,fx,637.234
f.30547,fx,619.879
f.30567,fx,542.102
f.30583,fx,580.669
f.30605,fx,371.121
f.30613,fx,371.121
f.30637,fx,371.121
f.30655,fx,387.833
f.30675,fx,465.61
f.30691,fx,427.043
f.30709,fx,482.965
f.30729,fx,482.965
f.30745,fx,482.965
f.30763,fx,465.61
f.30783,fx,387.833
f.30799,fx,427.043
f.30821,fx,216.852
f.30829,fx,216.852
f.30853,fx,216.852
f.30871,fx,234.207
f.30891,fx,311.984
f.30907,fx,273.417
f.30925,fx,329.34
f.30945,fx,329.34
f.30961,fx,329.34
f.30979,fx,311.984
f.30999,fx,234.207
f.31015,fx,273.417
f.31037,fx,63.2261
f.31045,fx,63.2261
f.31069,fx,63.2261
f.31087,fx,80.5813
f.31107,fx,158.358
f.31123,fx,119.149
f.31141,fx,175.714
f.31161,fx,175.714
f.31177,fx,175.714
f.31195,fx,158.358
f.31215,fx,80.5813
f.31231,fx,119.149
f.31253,fx,-90.4
f.31261,fx,-90.4
f.31285,fx,-90.4
f.31303,fx,-73.044
f.31323,fx,4.73261
f.31339,fx,-34.477
f.31357,fx,21.445
f.31377,fx,21.445
f.31393,fx,21.445
f.31411,fx,4.73261
f.31431,fx,-73.044
f.31447,fx,-34.477
f.31469,fx,-244.67
f.31477,fx,-244.67
f.31501,fx,-244.67
f.31519,fx,-227.31
f.31539,fx,-149.54
f.31555,fx,-188.1
f.31573,fx,-132.18
f.31593,fx,-132.18
f.31609,fx,-132.18
f.31627,fx,-149.54
f.31647,fx,-227.31
f.31663,fx,-188.1
f.31685,fx,-398.29
f.31693,fx,-398.29
f.31717,fx,-398.29
f.31735,fx,-380.94
f.31755,fx,-303.16
f.31771,fx,-341.73
f.31789,fx,-285.81
f.31809,fx,-285.81
f.31825,fx,-285.81
f.31843,fx,-303.16
f.31863,fx,-380.94
f.31879,fx,-341.73
f.31901,fx,678.372
f.31909,fx,678.372
f.31933,fx,678.372
f.31951,fx,695.727
f.31971,fx,773.505
f.31987,fx,734.295
f.32005,fx,790.86
f.32025,fx,790.86
f.32041,fx,790.86
f.32059,fx,773.505
f.32079,fx,695.727
f.32095,fx,734.295
f.32117,fx,524.746
f.32125,fx,524.746
f.32149,fx,524.746
f.32167,fx,542.102
f.32187,fx,619.879
f.32203,fx,580.669
f.32221,fx,637.234
f.32241,fx,637.234
f.32257,fx,637.234
f.32275,fx,619.879
f.32295,fx,542.102
f.32311,fx,580.669
f.32333,fx,371.121
f.32341,fx,371.121
f.32365,fx,371.121
f.32383,fx,387.833
f.32403,fx,465.61
f.32419,fx,427.043
f.32437,fx,482.965
f.32457,fx,482.965
f.32473,fx,482.965
f.32491,fx,465.61
f.32511,fx,387.833
f.32527,fx,427.043
f.32549,fx,216.852
f.32557,fx,216.852
f.32581,fx,216.852
f.32599,fx,234.207
f.32619,fx,311.984
f.32635,fx,273.417
f.32653,fx,329.34
f.32673,fx,329.34
f.32689,fx,329.34
f.32707,fx,311.984
f.32727,fx,234.207
f.32743,fx,273.417
f.32765,fx,63.2261
f.32773,fx,63.2261
f.32797,fx,63.2261
f.32815,fx,80.5813
f.32835,fx,158.358
f.32851,fx,119.149
f.32869,fx,175.714
f.32889,fx,175.714
f.32905,fx,175.714
f.32923,fx,158.358
f.32943,fx,80.5813
f.32959,fx,119.149
f.32981,fx,-90.4
f.32989,fx,-90.4
f.33013,fx,-90.4
f.33031,fx,-73.044
f.33051,fx,4.73261
f.33067,fx,-34.477
f.33085,fx,21.445
f.33105,fx,21.445
f.33121,fx,21.445
f.33139,fx,4.73261
f.33159,fx,-73.044
f.33175,fx,-34.477
f.33197,fx,-244.67
f.33205,fx,-244.67
f.33229,fx,-244.67
f.33247,fx,-227.31
f.33267,fx,-149.54
f.33283,fx,-188.1
f.33301,fx,-132.18
f.33321,fx,-132.18
f.33337,fx,-132.18
f.33355,fx,-149.54
f.33375,fx,-227.31
f.33391,fx,-188.1
f.33413,fx,-398.29
f.33421,fx,-398.29
f.33445,fx,-398.29
f.33463,fx,-380.94
f.33483,fx,-303.16
f.33499,fx,-341.73
f.33517,fx,-285.81
f.33537,fx,-285.81

f,33553,fx,-285.81
f,33571,fx,-303.16
f,33591,fx,-380.94
f,33607,fx,-341.73
f,5982,fx,684.323
f,5990,fx,684.323
f,6014,fx,684.323
f,6032,fx,701.679
f,6052,fx,779.456
f,6068,fx,740.246
f,6086,fx,796.811
f,6106,fx,796.811
f,6122,fx,796.811
f,6140,fx,779.456
f,6160,fx,701.679
f,6176,fx,740.246
f,6198,fx,530.698
f,6206,fx,530.698
f,6230,fx,530.698
f,6248,fx,548.053
f,6268,fx,625.83
f,6284,fx,586.62
f,6302,fx,643.185
f,6322,fx,643.185
f,6338,fx,643.185
f,6356,fx,625.83
f,6376,fx,548.053
f,6392,fx,586.62
f,6414,fx,377.072
f,6422,fx,377.072
f,6446,fx,377.072
f,6464,fx,393.784
f,6484,fx,471.561
f,6500,fx,432.994
f,6518,fx,488.917
f,6538,fx,488.917
f,6554,fx,488.917
f,6572,fx,471.561
f,6592,fx,393.784
f,6608,fx,432.994
f,6630,fx,222.803
f,6638,fx,222.803
f,6662,fx,222.803
f,6680,fx,240.158
f,6700,fx,317.935
f,6716,fx,279.368
f,6734,fx,335.291
f,6754,fx,335.291
f,6770,fx,335.291
f,6788,fx,317.935
f,6808,fx,240.158
f,6824,fx,279.368
f,6846,fx,69.1773
f,6854,fx,69.1773
f,6878,fx,69.1773
f,6896,fx,86.5326
f,6916,fx,164.31
f,6932,fx,125.1
f,6950,fx,181.665
f,6970,fx,181.665
f,6986,fx,181.665
f,7004,fx,164.31
f,7024,fx,86.5326
f,7040,fx,125.1
f,7062,fx,-84.448
f,7070,fx,-84.448
f,7094,fx,-84.448
f,7112,fx,-67.093
f,7132,fx,10.6838
f,7148,fx,-28.526
f,7166,fx,27.3963
f,7186,fx,27.3963
f,7202,fx,27.3963
f,7220,fx,10.6838
f,7240,fx,-67.093
f,7256,fx,-28.526
f,7278,fx,-238.72
f,7286,fx,-238.72
f,7310,fx,-238.72
f,7328,fx,-221.36
f,7348,fx,-143.58
f,7364,fx,-182.15
f,7382,fx,-126.23
f,7402,fx,-126.23
f,7418,fx,-126.23
f,7436,fx,-143.58
f,7456,fx,-221.36
f,7472,fx,-182.15
f,7494,fx,-392.34
f,7502,fx,-392.34
f,7526,fx,-392.34
f,7544,fx,-374.99
f,7564,fx,-297.21
f,7580,fx,-335.78
f,7598,fx,-279.86
f,7618,fx,-279.86
f,7634,fx,-279.86
f,7652,fx,-297.21
f,7672,fx,-374.99
f,7688,fx,-335.78
f,7710,fx,684.323
f,7718,fx,684.323
f,7742,fx,684.323
f,7760,fx,701.679
f,7780,fx,779.456
f,7796,fx,740.246
f,7814,fx,796.811
f,7834,fx,796.811
f,7850,fx,796.811
f,7868,fx,779.456
f,7888,fx,701.679
f,7904,fx,740.246
f,7926,fx,530.698
f,7934,fx,530.698
f,7958,fx,530.698
f,7976,fx,548.053
f,7996,fx,625.83
f,8012,fx,586.62
f,8030,fx,643.185
f,8050,fx,643.185
f,8066,fx,643.185
f,8084,fx,625.83
f,8104,fx,548.053
f,8120,fx,586.62
f,8142,fx,377.072
f,8150,fx,377.072
f,8174,fx,377.072
f,8192,fx,393.784
f,8212,fx,471.561
f,8228,fx,432.994
f,8246,fx,488.917
f,8266,fx,488.917
f,8282,fx,488.917
f,8300,fx,471.561
f,8320,fx,393.784
f,8336,fx,432.994
f,8358,fx,222.803
f,8366,fx,222.803
f,8390,fx,222.803
f,8408,fx,240.158
f,8428,fx,317.935
f,8444,fx,279.368
f,8462,fx,335.291
f,8482,fx,335.291
f,8498,fx,335.291
f,8516,fx,317.935
f,8536,fx,240.158
f,8552,fx,279.368
f,8574,fx,69.1773
f,8582,fx,69.1773
f,8606,fx,69.1773
f,8624,fx,86.5326
f,8644,fx,164.31
f,8660,fx,125.1
f,8678,fx,181.665
f,8698,fx,181.665
f,8714,fx,181.665
f,8732,fx,164.31
f,8752,fx,86.5326
f,8768,fx,125.1
f,8790,fx,-84.448
f,8798,fx,-84.448
f,8822,fx,-84.448
f,8840,fx,-67.093
f,8860,fx,10.6838
f,8876,fx,-28.526
f,8894,fx,27.3963
f,8914,fx,27.3963
f,8930,fx,27.3963
f,8948,fx,10.6838
f,8968,fx,-67.093
f,8984,fx,-28.526
f,9006,fx,-238.72
f,9014,fx,-238.72
f,9038,fx,-238.72
f,9056,fx,-221.36
f,9076,fx,-143.58
f,9092,fx,-182.15
f,9110,fx,-126.23
f,9130,fx,-126.23
f,9146,fx,-126.23
f,9164,fx,-143.58
f,9184,fx,-221.36
f,9200,fx,-182.15
f,9222,fx,-392.34
f,9230,fx,-392.34
f,9254,fx,-392.34
f,9272,fx,-374.99
f,9292,fx,-297.21
f,9308,fx,-335.78
f,9326,fx,-279.86
f,9346,fx,-279.86
f,9362,fx,-279.86
f,9380,fx,-297.21
f,9400,fx,-374.99
f,9416,fx,-335.78
f,9438,fx,684.323
f,9446,fx,684.323
f,9470,fx,684.323
f,9488,fx,701.679
f,9508,fx,779.456
f,9524,fx,740.246
f,9542,fx,796.811
f,9562,fx,796.811
f,9578,fx,796.811
f,9596,fx,779.456
f,9616,fx,701.679
f,9632,fx,740.246
f,9654,fx,530.698
f,9662,fx,530.698
f,9686,fx,530.698
f,9704,fx,548.053
f,9724,fx,625.83
f,9740,fx,586.62
f,9758,fx,643.185
f,9778,fx,643.185
f,9794,fx,643.185
f,9812,fx,625.83
f,9832,fx,548.053
f,9848,fx,586.62
f,9870,fx,377.072
f,9878,fx,377.072
f,9902,fx,377.072
f,9920,fx,393.784
f,9940,fx,471.561
f,9956,fx,432.994
f,9974,fx,488.917
f,9994,fx,488.917
f,10010,fx,488.917
f,10028,fx,471.561
f,10048,fx,393.784
f,10064,fx,432.994
f,10086,fx,222.803
f,10094,fx,222.803
f,10118,fx,222.803
f,10136,fx,240.158
f,10156,fx,317.935
f,10172,fx,279.368
f,10190,fx,335.291
f,10210,fx,335.291
f,10226,fx,335.291
f,10244,fx,317.935
f,10264,fx,240.158
f,10280,fx,279.368
f,10302,fx,69.1773
f,10310,fx,69.1773
f,10334,fx,69.1773
f,10352,fx,86.5326
f,10372,fx,164.31
f,10388,fx,125.1
f,10406,fx,181.665
f,10426,fx,181.665
f,10442,fx,181.665
f,10460,fx,164.31
f,10480,fx,86.5326
f,10496,fx,125.1
f,10518,fx,-84.448
f,10526,fx,-84.448
f,10550,fx,-84.448
f,10568,fx,-67.093
f,10588,fx,10.6838
f,10604,fx,-28.526
f,10622,fx,27.3963
f,10642,fx,27.3963
f,10658,fx,27.3963
f,10676,fx,10.6838
f,10696,fx,-67.093
f,10712,fx,-28.526
f,10734,fx,-238.72
f,10742,fx,-238.72
f,10766,fx,-238.72
f,10784,fx,-221.36
f,10804,fx,-143.58
f,10820,fx,-182.15
f,10838,fx,-126.23
f,10858,fx,-126.23
f,10874,fx,-126.23
f,10892,fx,-143.58
f,10912,fx,-221.36
f,10928,fx,-182.15
f,10950,fx,-392.34
f,10958,fx,-392.34
f,10982,fx,-392.34
f,11000,fx,-374.99
f,11020,fx,-297.21
f,11036,fx,-335.78
f,11054,fx,-279.86
f,11074,fx,-279.86
f,11090,fx,-279.86
f,11108,fx,-297.21
f,11128,fx,-374.99
f,11144,fx,-335.78
f,11166,fx,684.323
f,11174,fx,684.323
f,11198,fx,684.323
f,11216,fx,701.679
f,11236,fx,779.456
f,11252,fx,740.246
f,11270,fx,796.811
f,11290,fx,796.811
f,11306,fx,796.811
f,11324,fx,779.456
f,11344,fx,701.679
f,11360,fx,740.246
f,11382,fx,530.698
f,11390,fx,530.698
f,11414,fx,530.698
f,11432,fx,548.053
f,11452,fx,625.83
f,11468,fx,586.62
f,11486,fx,643.185
f,11506,fx,643.185
f,11522,fx,643.185
f,11540,fx,625.83
f,11560,fx,548.053
f,11576,fx,586.62
f,11598,fx,377.072
f,11606,fx,377.072
f,11630,fx,377.072
f,11648,fx,393.784
f,11668,fx,471.561
f,11684,fx,432.994
f,11702,fx,488.917
f,11722,fx,488.917
f,11738,fx,488.917
f,11756,fx,471.561
f,11776,fx,393.784
f,11792,fx,432.994
f,11814,fx,222.803
f,11822,fx,222.803
f,11846,fx,222.803
f,11864,fx,240.158

f,11884,fx,317.935
f,11900,fx,279.368
f,11918,fx,335.291
f,11938,fx,335.291
f,11954,fx,335.291
f,11972,fx,317.935
f,11992,fx,240.158
f,12008,fx,279.368
f,12030,fx,69.1773
f,12038,fx,69.1773
f,12062,fx,69.1773
f,12080,fx,86.5326
f,12100,fx,164.31
f,12116,fx,125.1
f,12134,fx,181.665
f,12154,fx,181.665
f,12170,fx,181.665
f,12188,fx,164.31
f,12208,fx,86.5326
f,12224,fx,125.1
f,12246,fx,-84.448
f,12254,fx,-84.448
f,12278,fx,-84.448
f,12296,fx,-67.093
f,12316,fx,10.6838
f,12332,fx,-28.526
f,12350,fx,27.3963
f,12370,fx,27.3963
f,12386,fx,27.3963
f,12404,fx,10.6838
f,12424,fx,-67.093
f,12440,fx,-28.526
f,12462,fx,-238.72
f,12470,fx,-238.72
f,12494,fx,-238.72
f,12512,fx,-221.36
f,12532,fx,-143.58
f,12548,fx,-182.15
f,12566,fx,-126.23
f,12586,fx,-126.23
f,12602,fx,-126.23
f,12620,fx,-143.58
f,12640,fx,-221.36
f,12656,fx,-182.15
f,12678,fx,-392.34
f,12686,fx,-392.34
f,12710,fx,-392.34
f,12728,fx,-374.99
f,12748,fx,-297.21
f,12764,fx,-335.78
f,12782,fx,-279.86
f,12802,fx,-279.86
f,12818,fx,-279.86
f,12836,fx,-297.21
f,12856,fx,-374.99
f,12872,fx,-335.78
f,12894,fx,684.323
f,12902,fx,684.323
f,12926,fx,684.323
f,12944,fx,701.679
f,12964,fx,779.456
f,12960,fx,740.246
f,12998,fx,796.811
f,13018,fx,796.811
f,13034,fx,796.811
f,13052,fx,779.456
f,13072,fx,701.679
f,13088,fx,740.246
f,13110,fx,530.698
f,13118,fx,530.698
f,13142,fx,530.698
f,13160,fx,548.053
f,13180,fx,625.83
f,13196,fx,586.62
f,13214,fx,643.185
f,13234,fx,643.185
f,13250,fx,643.185
f,13268,fx,625.83
f,13288,fx,548.053
f,13304,fx,586.62
f,13326,fx,377.072
f,13334,fx,377.072
f,13358,fx,377.072
f,13376,fx,393.784
f,13396,fx,471.561
f,13412,fx,432.994
f,13430,fx,488.917
f,13450,fx,488.917
f,13466,fx,488.917
f,13484,fx,471.561
f,13504,fx,393.784
f,13520,fx,432.994
f,13542,fx,222.803
f,13550,fx,222.803
f,13574,fx,222.803
f,13592,fx,240.158
f,13612,fx,317.935
f,13628,fx,279.368
f,13646,fx,335.291
f,13666,fx,335.291
f,13682,fx,335.291
f,13700,fx,317.935
f,13720,fx,240.158
f,13736,fx,279.368
f,13758,fx,69.1773
f,13766,fx,69.1773
f,13790,fx,69.1773
f,13808,fx,86.5326
f,13828,fx,164.31
f,13844,fx,125.1
f,13862,fx,181.665
f,13882,fx,181.665
f,13898,fx,181.665
f,13916,fx,164.31
f,13936,fx,86.5326
f,13952,fx,125.1
f,13974,fx,-84.448
f,13982,fx,-84.448
f,14006,fx,-84.448
f,14024,fx,-67.093
f,14044,fx,10.6838
f,14060,fx,-28.526
f,14078,fx,27.3963
f,14098,fx,27.3963
f,14114,fx,27.3963
f,14132,fx,10.6838
f,14152,fx,-67.093
f,14168,fx,-28.526
f,14190,fx,-238.72
f,14198,fx,-238.72
f,14222,fx,-238.72
f,14240,fx,-221.36
f,14260,fx,-143.58
f,14276,fx,-182.15
f,14294,fx,-126.23
f,14314,fx,-126.23
f,14330,fx,-126.23
f,14348,fx,-143.58
f,14368,fx,-221.36
f,14384,fx,-182.15
f,14406,fx,-392.34
f,14414,fx,-392.34
f,14438,fx,-392.34
f,14456,fx,-374.99
f,14476,fx,-297.21
f,14492,fx,-335.78
f,14510,fx,-279.86
f,14530,fx,-279.86
f,14546,fx,-279.86
f,14564,fx,-297.21
f,14584,fx,-374.99
f,14600,fx,-335.78
f,14622,fx,684.323
f,14630,fx,684.323
f,14654,fx,684.323
f,14672,fx,701.679
f,14692,fx,779.456
f,14708,fx,740.246
f,14726,fx,796.811
f,14746,fx,796.811
f,14762,fx,796.811
f,14780,fx,779.456
f,14800,fx,701.679
f,14816,fx,740.246
f,14838,fx,530.698
f,14846,fx,530.698
f,14870,fx,530.698
f,14888,fx,548.053
f,14908,fx,625.83
f,14924,fx,586.62
f,14942,fx,643.185
f,14962,fx,643.185
f,14978,fx,643.185
f,14996,fx,625.83
f,15016,fx,548.053
f,15032,fx,586.62
f,15054,fx,377.072
f,15062,fx,377.072
f,15086,fx,377.072
f,15104,fx,393.784
f,15124,fx,471.561
f,15140,fx,432.994
f,15158,fx,488.917
f,15178,fx,488.917
f,15194,fx,488.917
f,15212,fx,471.561
f,15232,fx,393.784
f,15248,fx,432.994
f,15270,fx,222.803
f,15278,fx,222.803
f,15302,fx,222.803
f,15320,fx,240.158
f,15340,fx,317.935
f,15356,fx,279.368
f,15374,fx,335.291
f,15394,fx,335.291
f,15410,fx,335.291
f,15428,fx,317.935
f,15448,fx,240.158
f,15464,fx,279.368
f,15486,fx,69.1773
f,15494,fx,69.1773
f,15518,fx,69.1773
f,15536,fx,86.5326
f,15556,fx,164.31
f,15572,fx,125.1
f,15590,fx,181.665
f,15610,fx,181.665
f,15626,fx,181.665
f,15644,fx,164.31
f,15664,fx,86.5326
f,15680,fx,125.1
f,15702,fx,-84.448
f,15710,fx,-84.448
f,15734,fx,-84.448
f,15752,fx,-67.093
f,15772,fx,10.6838
f,15788,fx,-28.526
f,15806,fx,27.3963
f,15826,fx,27.3963
f,15842,fx,27.3963
f,15860,fx,10.6838
f,15880,fx,-67.093
f,15896,fx,-28.526
f,15918,fx,-238.72
f,15926,fx,-238.72
f,15950,fx,-238.72
f,15968,fx,-221.36
f,15988,fx,-143.58
f,16004,fx,-182.15
f,16022,fx,-126.23
f,16042,fx,-126.23
f,16058,fx,-126.23
f,16076,fx,-143.58
f,16096,fx,-221.36
f,16112,fx,-182.15
f,16134,fx,-392.34
f,16142,fx,-392.34
f,16166,fx,-392.34
f,16184,fx,-374.99
f,16204,fx,-297.21
f,16220,fx,-335.78
f,16238,fx,-279.86
f,16258,fx,-279.86
f,16274,fx,-279.86
f,16292,fx,-297.21
f,16312,fx,-374.99
f,16328,fx,-335.78
f,16350,fx,684.323
f,16358,fx,684.323
f,16382,fx,684.323
f,16400,fx,701.679
f,16420,fx,779.456
f,16436,fx,740.246
f,16454,fx,796.811
f,16474,fx,796.811
f,16490,fx,796.811
f,16508,fx,779.456
f,16528,fx,701.679
f,16544,fx,740.246
f,16566,fx,530.698
f,16574,fx,530.698
f,16598,fx,530.698
f,16616,fx,548.053
f,16636,fx,625.83
f,16652,fx,586.62
f,16670,fx,643.185
f,16690,fx,643.185
f,16706,fx,643.185
f,16724,fx,625.83
f,16744,fx,548.053
f,16760,fx,586.62
f,16782,fx,377.072
f,16790,fx,377.072
f,16814,fx,377.072
f,16832,fx,393.784
f,16852,fx,471.561
f,16868,fx,432.994
f,16886,fx,488.917
f,16906,fx,488.917
f,16922,fx,488.917
f,16940,fx,471.561
f,16960,fx,393.784
f,16976,fx,432.994
f,16998,fx,222.803
f,17006,fx,222.803
f,17030,fx,222.803
f,17048,fx,240.158
f,17068,fx,317.935
f,17084,fx,279.368
f,17102,fx,335.291
f,17122,fx,335.291
f,17138,fx,335.291
f,17156,fx,317.935
f,17176,fx,240.158
f,17192,fx,279.368
f,17214,fx,69.1773
f,17222,fx,69.1773
f,17246,fx,69.1773
f,17264,fx,86.5326
f,17284,fx,164.31
f,17300,fx,125.1
f,17318,fx,181.665
f,17338,fx,181.665
f,17354,fx,181.665
f,17372,fx,164.31
f,17392,fx,86.5326
f,17408,fx,125.1
f,17430,fx,-84.448
f,17438,fx,-84.448
f,17462,fx,-84.448
f,17480,fx,-67.093
f,17500,fx,10.6838
f,17516,fx,-28.526
f,17534,fx,27.3963
f,17554,fx,27.3963
f,17570,fx,27.3963
f,17588,fx,10.6838
f,17608,fx,-67.093
f,17624,fx,-28.526
f,17646,fx,-238.72
f,17654,fx,-238.72
f,17678,fx,-238.72
f,17696,fx,-221.36
f,17716,fx,-143.58
f,17732,fx,-182.15
f,17750,fx,-126.23
f,17770,fx,-126.23
f,17786,fx,-126.23
f,17804,fx,-143.58
f,17824,fx,-221.36
f,17840,fx,-182.15

f,17862,fx,-392.34
f,17870,fx,-392.34
f,17894,fx,-392.34
f,17912,fx,-374.99
f,17932,fx,-297.21
f,17948,fx,-335.78
f,17966,fx,-279.86
f,17986,fx,-279.86
f,18002,fx,-279.86
f,18020,fx,-297.21
f,18040,fx,-374.99
f,18056,fx,-335.78
f,18078,fx,684.323
f,18086,fx,684.323
f,18110,fx,684.323
f,18128,fx,701.679
f,18148,fx,779.456
f,18164,fx,740.246
f,18182,fx,796.811
f,18202,fx,796.811
f,18218,fx,796.811
f,18236,fx,779.456
f,18256,fx,701.679
f,18272,fx,740.246
f,18294,fx,530.698
f,18302,fx,530.698
f,18326,fx,530.698
f,18344,fx,548.053
f,18364,fx,625.83
f,18380,fx,586.62
f,18398,fx,643.185
f,18418,fx,643.185
f,18434,fx,643.185
f,18452,fx,625.83
f,18472,fx,548.053
f,18488,fx,586.62
f,18510,fx,377.072
f,18518,fx,377.072
f,18542,fx,377.072
f,18560,fx,393.784
f,18580,fx,471.561
f,18596,fx,432.994
f,18614,fx,488.917
f,18634,fx,488.917
f,18650,fx,488.917
f,18668,fx,471.561
f,18688,fx,393.784
f,18704,fx,432.994
f,18726,fx,222.803
f,18734,fx,222.803
f,18758,fx,222.803
f,18776,fx,240.158
f,18796,fx,317.935
f,18812,fx,279.368
f,18830,fx,335.291
f,18850,fx,335.291
f,18866,fx,335.291
f,18884,fx,317.935
f,18904,fx,240.158
f,18920,fx,279.368
f,18942,fx,69.1773
f,18950,fx,69.1773
f,18974,fx,69.1773
f,18992,fx,86.5326
f,19012,fx,164.31
f,19028,fx,125.1
f,19046,fx,181.665
f,19066,fx,181.665
f,19082,fx,181.665
f,19100,fx,164.31
f,19120,fx,86.5326
f,19136,fx,125.1
f,19158,fx,-84.448
f,19166,fx,-84.448
f,19190,fx,-84.448
f,19208,fx,-67.093
f,19228,fx,10.6838
f,19244,fx,-28.526
f,19262,fx,27.3963
f,19282,fx,27.3963
f,19298,fx,27.3963
f,19316,fx,10.6838
f,19336,fx,-67.093
f,19352,fx,-28.526
f,19374,fx,-238.72
f,19382,fx,-238.72
f,19406,fx,-238.72
f,19424,fx,-221.36
f,19444,fx,-143.58
f,19460,fx,-182.15
f,19478,fx,-126.23
f,19498,fx,-126.23
f,19514,fx,-126.23
f,19532,fx,-143.58
f,19552,fx,-221.36
f,19568,fx,-182.15
f,19590,fx,-392.34
f,19598,fx,-392.34
f,19622,fx,-392.34
f,19640,fx,-374.99
f,19660,fx,-297.21
f,19676,fx,-335.78
f,19694,fx,-279.86
f,19714,fx,-279.86
f,19730,fx,-279.86
f,19748,fx,-297.21
f,19768,fx,-374.99
f,19784,fx,-335.78
f,19806,fx,684.323
f,19814,fx,684.323
f,19838,fx,684.323
f,19856,fx,701.679
f,19876,fx,779.456
f,19892,fx,740.246
f,19910,fx,796.811
f,19930,fx,796.811
f,19946,fx,796.811
f,19964,fx,779.456
f,19984,fx,701.679
f,20000,fx,740.246
f,20022,fx,530.698
f,20030,fx,530.698
f,20054,fx,530.698
f,20072,fx,548.053
f,20092,fx,625.83
f,20108,fx,586.62
f,20126,fx,643.185
f,20146,fx,643.185
f,20162,fx,643.185
f,20180,fx,625.83
f,20200,fx,548.053
f,20216,fx,586.62
f,20238,fx,377.072
f,20246,fx,377.072
f,20270,fx,377.072
f,20288,fx,393.784
f,20308,fx,471.561
f,20324,fx,432.994
f,20342,fx,488.917
f,20362,fx,488.917
f,20378,fx,488.917
f,20396,fx,471.561
f,20416,fx,393.784
f,20432,fx,432.994
f,20454,fx,222.803
f,20462,fx,222.803
f,20486,fx,222.803
f,20504,fx,240.158
f,20524,fx,317.935
f,20540,fx,279.368
f,20558,fx,335.291
f,20578,fx,335.291
f,20594,fx,335.291
f,20612,fx,317.935
f,20632,fx,240.158
f,20648,fx,279.368
f,20670,fx,69.1773
f,20678,fx,69.1773
f,20702,fx,69.1773
f,20720,fx,86.5326
f,20740,fx,164.31
f,20756,fx,125.1
f,20774,fx,181.665
f,20794,fx,181.665
f,20810,fx,181.665
f,20828,fx,164.31
f,20848,fx,86.5326
f,20864,fx,125.1
f,20886,fx,-84.448
f,20894,fx,-84.448
f,20918,fx,-84.448
f,20936,fx,-67.093
f,20956,fx,10.6838
f,20972,fx,-28.526
f,20990,fx,27.3963
f,21010,fx,27.3963
f,21026,fx,27.3963
f,21044,fx,10.6838
f,21064,fx,-67.093
f,21080,fx,-28.526
f,21102,fx,-238.72
f,21110,fx,-238.72
f,21134,fx,-238.72
f,21152,fx,-221.36
f,21172,fx,-143.58
f,21188,fx,-182.15
f,21206,fx,-126.23
f,21226,fx,-126.23
f,21242,fx,-126.23
f,21260,fx,-143.58
f,21280,fx,-221.36
f,21296,fx,-182.15
f,21318,fx,-392.34
f,21326,fx,-392.34
f,21350,fx,-392.34
f,21368,fx,-374.99
f,21388,fx,-297.21
f,21404,fx,-335.78
f,21422,fx,-279.86
f,21442,fx,-279.86
f,21458,fx,-279.86
f,21476,fx,-297.21
f,21496,fx,-374.99
f,21512,fx,-335.78
f,21534,fx,684.323
f,21542,fx,684.323
f,21566,fx,684.323
f,21584,fx,701.679
f,21604,fx,779.456
f,21620,fx,740.246
f,21638,fx,796.811
f,21658,fx,796.811
f,21674,fx,796.811
f,21692,fx,779.456
f,21712,fx,701.679
f,21728,fx,740.246
f,21750,fx,530.698
f,21758,fx,530.698
f,21782,fx,530.698
f,21800,fx,548.053
f,21820,fx,625.83
f,21836,fx,586.62
f,21854,fx,643.185
f,21874,fx,643.185
f,21890,fx,643.185
f,21908,fx,625.83
f,21928,fx,548.053
f,21944,fx,586.62
f,21966,fx,377.072
f,21974,fx,377.072
f,21998,fx,377.072
f,22016,fx,393.784
f,22036,fx,471.561
f,22052,fx,432.994
f,22070,fx,488.917
f,22090,fx,488.917
f,22106,fx,488.917
f,22124,fx,471.561
f,22144,fx,393.784
f,22160,fx,432.994
f,22182,fx,222.803
f,22190,fx,222.803
f,22214,fx,222.803
f,22232,fx,240.158
f,22252,fx,317.935
f,22268,fx,279.368
f,22286,fx,335.291
f,22306,fx,335.291
f,22322,fx,335.291
f,22340,fx,317.935
f,22360,fx,240.158
f,22376,fx,279.368
f,22398,fx,69.1773
f,22406,fx,69.1773
f,22430,fx,69.1773
f,22448,fx,86.5326
f,22468,fx,164.31
f,22484,fx,125.1
f,22502,fx,181.665
f,22522,fx,181.665
f,22538,fx,181.665
f,22556,fx,164.31
f,22576,fx,86.5326
f,22592,fx,125.1
f,22614,fx,-84.448
f,22622,fx,-84.448
f,22646,fx,-84.448
f,22664,fx,-67.093
f,22684,fx,10.6838
f,22700,fx,-28.526
f,22718,fx,27.3963
f,22738,fx,27.3963
f,22754,fx,27.3963
f,22772,fx,10.6838
f,22792,fx,-67.093
f,22808,fx,-28.526
f,22830,fx,-238.72
f,22838,fx,-238.72
f,22862,fx,-238.72
f,22880,fx,-221.36
f,22900,fx,-143.58
f,22916,fx,-182.15
f,22934,fx,-126.23
f,22954,fx,-126.23
f,22970,fx,-126.23
f,22988,fx,-143.58
f,23008,fx,-221.36
f,23024,fx,-182.15
f,23046,fx,-392.34
f,23054,fx,-392.34
f,23078,fx,-392.34
f,23096,fx,-374.99
f,23116,fx,-297.21
f,23132,fx,-335.78
f,23150,fx,-279.86
f,23170,fx,-279.86
f,23186,fx,-279.86
f,23204,fx,-297.21
f,23224,fx,-374.99
f,23240,fx,-335.78
f,23262,fx,684.323
f,23270,fx,684.323
f,23294,fx,684.323
f,23312,fx,701.679
f,23332,fx,779.456
f,23348,fx,740.246
f,23366,fx,796.811
f,23386,fx,796.811
f,23402,fx,796.811
f,23420,fx,779.456
f,23440,fx,701.679
f,23456,fx,740.246
f,23478,fx,530.698
f,23486,fx,530.698
f,23510,fx,530.698
f,23528,fx,548.053
f,23548,fx,625.83
f,23564,fx,586.62
f,23582,fx,643.185
f,23602,fx,643.185
f,23618,fx,643.185
f,23636,fx,625.83
f,23656,fx,548.053
f,23672,fx,586.62
f,23694,fx,377.072
f,23702,fx,377.072
f,23726,fx,377.072
f,23744,fx,393.784
f,23764,fx,471.561
f,23780,fx,432.994
f,23798,fx,488.917
f,23818,fx,488.917

f.23834,fx,488.917
f.23852,fx,471.561
f.23872,fx,393.784
f.23888,fx,432.994
f.23910,fx,222.803
f.23918,fx,222.803
f.23942,fx,222.803
f.23960,fx,240.158
f.23980,fx,317.935
f.23996,fx,279.368
f.24014,fx,335.291
f.24034,fx,335.291
f.24050,fx,335.291
f.24068,fx,317.935
f.24088,fx,240.158
f.24104,fx,279.368
f.24126,fx,69.1773
f.24134,fx,69.1773
f.24158,fx,69.1773
f.24176,fx,86.5326
f.24196,fx,164.31
f.24212,fx,125.1
f.24230,fx,181.665
f.24250,fx,181.665
f.24266,fx,181.665
f.24284,fx,164.31
f.24304,fx,86.5326
f.24320,fx,125.1
f.24342,fx,-84.448
f.24350,fx,-84.448
f.24374,fx,-84.448
f.24392,fx,-67.093
f.24412,fx,10.6838
f.24428,fx,-28.526
f.24446,fx,27.3963
f.24466,fx,27.3963
f.24482,fx,27.3963
f.24500,fx,10.6838
f.24520,fx,-67.093
f.24536,fx,-28.526
f.24558,fx,-238.72
f.24566,fx,-238.72
f.24590,fx,-238.72
f.24608,fx,-221.36
f.24628,fx,-143.58
f.24644,fx,-182.15
f.24662,fx,-126.23
f.24682,fx,-126.23
f.24698,fx,-126.23
f.24716,fx,-143.58
f.24736,fx,-221.36
f.24752,fx,-182.15
f.24774,fx,-392.34
f.24782,fx,-392.34
f.24806,fx,-392.34
f.24824,fx,-374.99
f.24844,fx,-297.21
f.24860,fx,-335.78
f.24878,fx,-279.86
f.24898,fx,-279.86
f.24914,fx,-279.86
f.24932,fx,-297.21
f.24952,fx,-374.99
f.24968,fx,-335.78
f.24990,fx,684.323
f.24998,fx,684.323
f.25022,fx,684.323
f.25040,fx,701.679
f.25060,fx,779.456
f.25076,fx,740.246
f.25094,fx,796.811
f.25114,fx,796.811
f.25130,fx,796.811
f.25148,fx,779.456
f.25168,fx,701.679
f.25184,fx,740.246
f.25206,fx,530.698
f.25214,fx,530.698
f.25238,fx,530.698
f.25256,fx,548.053
f.25276,fx,625.83
f.25292,fx,586.62
f.25310,fx,643.185
f.25330,fx,643.185
f.25346,fx,643.185
f.25364,fx,625.83
f.25384,fx,548.053
f.25400,fx,586.62
f.25422,fx,377.072
f.25430,fx,377.072
f.25454,fx,377.072
f.25472,fx,393.784
f.25492,fx,471.561
f.25508,fx,432.994
f.25526,fx,488.917
f.25546,fx,488.917
f.25562,fx,488.917
f.25580,fx,471.561
f.25600,fx,393.784
f.25616,fx,432.994
f.25638,fx,222.803
f.25646,fx,222.803
f.25670,fx,222.803
f.25688,fx,240.158
f.25708,fx,317.935
f.25724,fx,279.368
f.25742,fx,335.291
f.25762,fx,335.291
f.25778,fx,335.291
f.25796,fx,317.935
f.25816,fx,240.158
f.25832,fx,279.368
f.25854,fx,69.1773
f.25862,fx,69.1773
f.25886,fx,69.1773
f.25904,fx,86.5326
f.25924,fx,164.31
f.25940,fx,125.1
f.25958,fx,181.665
f.25978,fx,181.665
f.25994,fx,181.665
f.26012,fx,164.31
f.26032,fx,86.5326
f.26048,fx,125.1
f.26070,fx,-84.448
f.26078,fx,-84.448
f.26102,fx,-84.448
f.26120,fx,-67.093
f.26140,fx,10.6838
f.26156,fx,-28.526
f.26174,fx,27.3963
f.26194,fx,27.3963
f.26210,fx,27.3963
f.26228,fx,10.6838
f.26248,fx,-67.093
f.26264,fx,-28.526
f.26286,fx,-238.72
f.26294,fx,-238.72
f.26318,fx,-238.72
f.26336,fx,-221.36
f.26356,fx,-143.58
f.26372,fx,-182.15
f.26390,fx,-126.23
f.26410,fx,-126.23
f.26426,fx,-126.23
f.26444,fx,-143.58
f.26464,fx,-221.36
f.26480,fx,-182.15
f.26502,fx,-392.34
f.26510,fx,-392.34
f.26534,fx,-392.34
f.26552,fx,-374.99
f.26572,fx,-297.21
f.26588,fx,-335.78
f.26606,fx,-279.86
f.26626,fx,-279.86
f.26642,fx,-279.86
f.26660,fx,-297.21
f.26680,fx,-374.99
f.26696,fx,-335.78
f.26718,fx,684.323
f.26726,fx,684.323
f.26750,fx,684.323
f.26768,fx,701.679
f.26788,fx,779.456
f.26804,fx,740.246
f.26822,fx,796.811
f.26842,fx,796.811
f.26858,fx,796.811
f.26876,fx,779.456
f.26896,fx,701.679
f.26912,fx,740.246
f.26934,fx,530.698
f.26942,fx,530.698
f.26966,fx,530.698
f.26984,fx,548.053
f.27004,fx,625.83
f.27020,fx,586.62
f.27038,fx,643.185
f.27058,fx,643.185
f.27074,fx,643.185
f.27092,fx,625.83
f.27112,fx,548.053
f.27128,fx,586.62
f.27150,fx,377.072
f.27158,fx,377.072
f.27182,fx,377.072
f.27200,fx,393.784
f.27220,fx,471.561
f.27236,fx,432.994
f.27254,fx,488.917
f.27274,fx,488.917
f.27290,fx,488.917
f.27308,fx,471.561
f.27328,fx,393.784
f.27344,fx,432.994
f.27366,fx,222.803
f.27374,fx,222.803
f.27398,fx,222.803
f.27416,fx,240.158
f.27436,fx,317.935
f.27452,fx,279.368
f.27470,fx,335.291
f.27490,fx,335.291
f.27506,fx,335.291
f.27524,fx,317.935
f.27544,fx,240.158
f.27560,fx,279.368
f.27582,fx,69.1773
f.27590,fx,69.1773
f.27614,fx,69.1773
f.27632,fx,86.5326
f.27652,fx,164.31
f.27668,fx,125.1
f.27686,fx,181.665
f.27706,fx,181.665
f.27722,fx,181.665
f.27740,fx,164.31
f.27760,fx,86.5326
f.27776,fx,125.1
f.27798,fx,-84.448
f.27806,fx,-84.448
f.27830,fx,-84.448
f.27848,fx,-67.093
f.27868,fx,10.6838
f.27884,fx,-28.526
f.27902,fx,27.3963
f.27922,fx,27.3963
f.27938,fx,27.3963
f.27956,fx,10.6838
f.27976,fx,-67.093
f.27992,fx,-28.526
f.28014,fx,-238.72
f.28022,fx,-238.72
f.28046,fx,-238.72
f.28064,fx,-221.36
f.28084,fx,-143.58
f.28100,fx,-182.15
f.28118,fx,-126.23
f.28138,fx,-126.23
f.28154,fx,-126.23
f.28172,fx,-143.58
f.28192,fx,-221.36
f.28208,fx,-182.15
f.28230,fx,-392.34
f.28238,fx,-392.34
f.28262,fx,-392.34
f.28280,fx,-374.99
f.28300,fx,-297.21
f.28316,fx,-335.78
f.28334,fx,-279.86
f.28354,fx,-279.86
f.28370,fx,-279.86
f.28388,fx,-297.21
f.28408,fx,-374.99
f.28424,fx,-335.78
f.28446,fx,684.323
f.28454,fx,684.323
f.28478,fx,684.323
f.28496,fx,701.679
f.28516,fx,779.456
f.28532,fx,740.246
f.28550,fx,796.811
f.28570,fx,796.811
f.28586,fx,796.811
f.28604,fx,779.456
f.28624,fx,701.679
f.28640,fx,740.246
f.28662,fx,530.698
f.28670,fx,530.698
f.28694,fx,530.698
f.28712,fx,548.053
f.28732,fx,625.83
f.28748,fx,586.62
f.28766,fx,643.185
f.28786,fx,643.185
f.28802,fx,643.185
f.28820,fx,625.83
f.28840,fx,548.053
f.28856,fx,586.62
f.28878,fx,377.072
f.28886,fx,377.072
f.28910,fx,377.072
f.28928,fx,393.784
f.28948,fx,471.561
f.28964,fx,432.994
f.28982,fx,488.917
f.29002,fx,488.917
f.29018,fx,488.917
f.29036,fx,471.561
f.29056,fx,393.784
f.29072,fx,432.994
f.29094,fx,222.803
f.29102,fx,222.803
f.29126,fx,222.803
f.29144,fx,240.158
f.29164,fx,317.935
f.29180,fx,279.368
f.29198,fx,335.291
f.29218,fx,335.291
f.29234,fx,335.291
f.29252,fx,317.935
f.29272,fx,240.158
f.29288,fx,279.368
f.29310,fx,69.1773
f.29318,fx,69.1773
f.29342,fx,69.1773
f.29360,fx,86.5326
f.29380,fx,164.31
f.29396,fx,125.1
f.29414,fx,181.665
f.29434,fx,181.665
f.29450,fx,181.665
f.29468,fx,164.31
f.29488,fx,86.5326
f.29504,fx,125.1
f.29526,fx,-84.448
f.29534,fx,-84.448
f.29558,fx,-84.448
f.29576,fx,-67.093
f.29596,fx,10.6838
f.29612,fx,-28.526
f.29630,fx,27.3963
f.29650,fx,27.3963
f.29666,fx,27.3963
f.29684,fx,10.6838
f.29704,fx,-67.093
f.29720,fx,-28.526
f.29742,fx,-238.72
f.29750,fx,-238.72
f.29774,fx,-238.72
f.29792,fx,-221.36

f,29812,fx,-143.58
f,29828,fx,-182.15
f,29846,fx,-126.23
f,29866,fx,-126.23
f,29882,fx,-126.23
f,29900,fx,-143.58
f,29920,fx,-221.36
f,29936,fx,-182.15
f,29958,fx,-392.34
f,29966,fx,-392.34
f,29990,fx,-392.34
f,30008,fx,-374.99
f,30028,fx,-297.21
f,30044,fx,-335.78
f,30062,fx,-279.86
f,30082,fx,-279.86
f,30098,fx,-279.86
f,30116,fx,-297.21
f,30136,fx,-374.99
f,30152,fx,-335.78
f,30174,fx,684.323
f,30182,fx,684.323
f,30206,fx,684.323
f,30224,fx,701.679
f,30244,fx,779.456
f,30260,fx,740.246
f,30278,fx,796.811
f,30298,fx,796.811
f,30314,fx,796.811
f,30332,fx,779.456
f,30352,fx,701.679
f,30368,fx,740.246
f,30390,fx,530.698
f,30398,fx,530.698
f,30422,fx,530.698
f,30440,fx,548.053
f,30460,fx,625.83
f,30476,fx,586.62
f,30494,fx,643.185
f,30514,fx,643.185
f,30530,fx,643.185
f,30548,fx,625.83
f,30568,fx,548.053
f,30584,fx,586.62
f,30606,fx,377.072
f,30614,fx,377.072
f,30638,fx,377.072
f,30656,fx,393.784
f,30676,fx,471.561
f,30692,fx,432.994
f,30710,fx,488.917
f,30730,fx,488.917
f,30746,fx,488.917
f,30764,fx,471.561
f,30784,fx,393.784
f,30800,fx,432.994
f,30822,fx,222.803
f,30830,fx,222.803
f,30854,fx,222.803
f,30872,fx,240.158
f,30892,fx,317.935
f,30908,fx,279.368
f,30926,fx,335.291
f,30946,fx,335.291
f,30962,fx,335.291
f,30980,fx,317.935
f,31000,fx,240.158
f,31016,fx,279.368
f,31038,fx,69.1773
f,31046,fx,69.1773
f,31070,fx,69.1773
f,31088,fx,86.5326
f,31108,fx,164.31
f,31124,fx,125.1
f,31142,fx,181.665
f,31162,fx,181.665
f,31178,fx,181.665
f,31196,fx,164.31
f,31216,fx,86.5326
f,31232,fx,125.1
f,31254,fx,-84.448
f,31262,fx,-84.448
f,31286,fx,-84.448
f,31304,fx,-67.093
f,31324,fx,10.6838
f,31340,fx,-28.526
f,31358,fx,27.3963
f,31378,fx,27.3963
f,31394,fx,27.3963
f,31412,fx,10.6838
f,31432,fx,-67.093
f,31448,fx,-28.526
f,31470,fx,-238.72
f,31478,fx,-238.72
f,31502,fx,-238.72
f,31520,fx,-221.36
f,31540,fx,-143.58
f,31556,fx,-182.15
f,31574,fx,-126.23
f,31594,fx,-126.23
f,31610,fx,-126.23
f,31628,fx,-143.58
f,31648,fx,-221.36
f,31664,fx,-182.15
f,31686,fx,-392.34
f,31694,fx,-392.34
f,31718,fx,-392.34
f,31736,fx,-374.99
f,31756,fx,-297.21
f,31772,fx,-335.78
f,31790,fx,-279.86
f,31810,fx,-279.86
f,31826,fx,-279.86
f,31844,fx,-297.21
f,31864,fx,-374.99
f,31880,fx,-335.78
f,31902,fx,684.323
f,31910,fx,684.323
f,31934,fx,684.323
f,31952,fx,701.679
f,31972,fx,779.456
f,31988,fx,740.246
f,32006,fx,796.811
f,32026,fx,796.811
f,32042,fx,796.811
f,32060,fx,779.456
f,32080,fx,701.679
f,32096,fx,740.246
f,32118,fx,530.698
f,32126,fx,530.698
f,32150,fx,530.698
f,32168,fx,548.053
f,32188,fx,625.83
f,32204,fx,586.62
f,32222,fx,643.185
f,32242,fx,643.185
f,32258,fx,643.185
f,32276,fx,625.83
f,32296,fx,548.053
f,32312,fx,586.62
f,32334,fx,377.072
f,32342,fx,377.072
f,32366,fx,377.072
f,32384,fx,393.784
f,32404,fx,471.561
f,32420,fx,432.994
f,32438,fx,488.917
f,32458,fx,488.917
f,32474,fx,488.917
f,32492,fx,471.561
f,32512,fx,393.784
f,32528,fx,432.994
f,32550,fx,222.803
f,32558,fx,222.803
f,32582,fx,222.803
f,32600,fx,240.158
f,32620,fx,317.935
f,32636,fx,279.368
f,32654,fx,335.291
f,32674,fx,335.291
f,32690,fx,335.291
f,32708,fx,317.935
f,32728,fx,240.158
f,32744,fx,279.368
f,32766,fx,69.1773
f,32774,fx,69.1773
f,32798,fx,69.1773
f,32816,fx,86.5326
f,32836,fx,164.31
f,32852,fx,125.1
f,32870,fx,181.665
f,32890,fx,181.665
f,32906,fx,181.665
f,32924,fx,164.31
f,32944,fx,86.5326
f,32960,fx,125.1
f,32982,fx,-84.448
f,32990,fx,-84.448
f,33014,fx,-84.448
f,33032,fx,-67.093
f,33052,fx,10.6838
f,33068,fx,-28.526
f,33086,fx,27.3963
f,33106,fx,27.3963
f,33122,fx,27.3963
f,33140,fx,10.6838
f,33160,fx,-67.093
f,33176,fx,-28.526
f,33198,fx,-238.72
f,33206,fx,-238.72
f,33230,fx,-238.72
f,33248,fx,-221.36
f,33268,fx,-143.58
f,33284,fx,-182.15
f,33302,fx,-126.23
f,33322,fx,-126.23
f,33338,fx,-126.23
f,33356,fx,-143.58
f,33376,fx,-221.36
f,33392,fx,-182.15
f,33414,fx,-392.34
f,33422,fx,-392.34
f,33446,fx,-392.34
f,33464,fx,-374.99
f,33484,fx,-297.21
f,33500,fx,-335.78
f,33518,fx,-279.86
f,33538,fx,-279.86
f,33554,fx,-279.86
f,33572,fx,-297.21
f,33592,fx,-374.99
f,33608,fx,-335.78
f,5983,fx,685.357
f,5991,fx,685.357
f,6015,fx,685.357
f,6033,fx,702.712
f,6053,fx,780.489
f,6069,fx,741.279
f,6087,fx,797.844
f,6107,fx,797.844
f,6123,fx,797.844
f,6141,fx,780.489
f,6161,fx,702.712
f,6177,fx,741.279
f,6199,fx,531.731
f,6207,fx,531.731
f,6231,fx,531.731
f,6249,fx,549.086
f,6269,fx,626.863
f,6285,fx,587.653
f,6303,fx,644.219
f,6323,fx,644.219
f,6339,fx,644.219
f,6357,fx,626.863
f,6377,fx,549.086
f,6393,fx,587.653
f,6415,fx,378.105
f,6423,fx,378.105
f,6447,fx,378.105
f,6465,fx,394.818
f,6485,fx,472.595
f,6501,fx,434.028
f,6519,fx,489.95
f,6539,fx,489.95
f,6555,fx,489.95
f,6573,fx,472.595
f,6593,fx,394.818
f,6609,fx,434.028
f,6631,fx,223.837
f,6639,fx,223.837
f,6663,fx,223.837
f,6681,fx,241.192
f,6701,fx,318.969
f,6717,fx,280.402
f,6735,fx,336.324
f,6755,fx,336.324
f,6771,fx,336.324
f,6789,fx,318.969
f,6809,fx,241.192
f,6825,fx,280.402
f,6847,fx,70.2108
f,6855,fx,70.2108
f,6879,fx,70.2108
f,6897,fx,87.566
f,6917,fx,165.343
f,6933,fx,126.133
f,6951,fx,182.698
f,6971,fx,182.698
f,6987,fx,182.698
f,7005,fx,165.343
f,7025,fx,87.566
f,7041,fx,126.133
f,7063,fx,-83.415
f,7071,fx,-83.415
f,7095,fx,-83.415
f,7113,fx,-66.06
f,7133,fx,11.7172
f,7149,fx,-27.493
f,7167,fx,28.4297
f,7187,fx,28.4297
f,7203,fx,28.4297
f,7221,fx,11.7172
f,7241,fx,-66.06
f,7257,fx,-27.493
f,7279,fx,-237.68
f,7287,fx,-237.68
f,7311,fx,-237.68
f,7329,fx,-220.33
f,7349,fx,-142.55
f,7365,fx,-181.12
f,7383,fx,-125.2
f,7403,fx,-125.2
f,7419,fx,-125.2
f,7437,fx,-142.55
f,7457,fx,-220.33
f,7473,fx,-181.12
f,7495,fx,-391.31
f,7503,fx,-391.31
f,7527,fx,-391.31
f,7545,fx,-373.95
f,7565,fx,-296.18
f,7581,fx,-334.74
f,7599,fx,-278.82
f,7619,fx,-278.82
f,7635,fx,-278.82
f,7653,fx,-296.18
f,7673,fx,-373.95
f,7689,fx,-334.74
f,7711,fx,685.357
f,7719,fx,685.357
f,7743,fx,685.357
f,7761,fx,702.712
f,7781,fx,780.489
f,7797,fx,741.279
f,7815,fx,797.844
f,7835,fx,797.844
f,7851,fx,797.844
f,7869,fx,780.489
f,7889,fx,702.712
f,7905,fx,741.279
f,7927,fx,531.731
f,7935,fx,531.731
f,7959,fx,531.731
f,7977,fx,549.086
f,7997,fx,626.863
f,8013,fx,587.653
f,8031,fx,644.219
f,8051,fx,644.219
f,8067,fx,644.219
f,8085,fx,626.863
f,8105,fx,549.086
f,8121,fx,587.653

f,8143,fx,378.105
f,8151,fx,378.105
f,8175,fx,378.105
f,8193,fx,394.818
f,8213,fx,472.595
f,8229,fx,434.028
f,8247,fx,489.95
f,8267,fx,489.95
f,8283,fx,489.95
f,8301,fx,472.595
f,8321,fx,394.818
f,8337,fx,434.028
f,8359,fx,223.837
f,8367,fx,223.837
f,8391,fx,223.837
f,8409,fx,241.192
f,8429,fx,318.969
f,8445,fx,280.402
f,8463,fx,336.324
f,8483,fx,336.324
f,8499,fx,336.324
f,8517,fx,318.969
f,8537,fx,241.192
f,8553,fx,280.402
f,8575,fx,70.2108
f,8583,fx,70.2108
f,8607,fx,70.2108
f,8625,fx,87.566
f,8645,fx,165.343
f,8661,fx,126.133
f,8679,fx,182.698
f,8699,fx,182.698
f,8715,fx,182.698
f,8733,fx,165.343
f,8753,fx,87.566
f,8769,fx,126.133
f,8791,fx,-83.415
f,8799,fx,-83.415
f,8823,fx,-83.415
f,8841,fx,-66.06
f,8861,fx,11.7172
f,8877,fx,-27.493
f,8895,fx,28.4297
f,8915,fx,28.4297
f,8931,fx,28.4297
f,8949,fx,11.7172
f,8969,fx,-66.06
f,8985,fx,-27.493
f,9007,fx,-237.68
f,9015,fx,-237.68
f,9039,fx,-237.68
f,9057,fx,-220.33
f,9077,fx,-142.55
f,9093,fx,-181.12
f,9111,fx,-125.2
f,9131,fx,-125.2
f,9147,fx,-125.2
f,9165,fx,-142.55
f,9185,fx,-220.33
f,9201,fx,-181.12
f,9223,fx,-391.31
f,9231,fx,-391.31
f,9255,fx,-391.31
f,9273,fx,-373.95
f,9293,fx,-296.18
f,9309,fx,-334.74
f,9327,fx,-278.82
f,9347,fx,-278.82
f,9363,fx,-278.82
f,9381,fx,-296.18
f,9401,fx,-373.95
f,9417,fx,-334.74
f,9439,fx,685.357
f,9447,fx,685.357
f,9471,fx,685.357
f,9489,fx,702.712
f,9509,fx,780.489
f,9525,fx,741.279
f,9543,fx,797.844
f,9563,fx,797.844
f,9579,fx,797.844
f,9597,fx,780.489
f,9617,fx,702.712
f,9633,fx,741.279
f,9655,fx,531.731
f,9663,fx,531.731
f,9687,fx,531.731
f,9705,fx,549.086
f,9725,fx,626.863
f,9741,fx,587.653
f,9759,fx,644.219
f,9779,fx,644.219
f,9795,fx,644.219
f,9813,fx,626.863
f,9833,fx,549.086
f,9849,fx,587.653
f,9871,fx,378.105
f,9879,fx,378.105
f,9903,fx,378.105
f,9921,fx,394.818
f,9941,fx,472.595
f,9957,fx,434.028
f,9975,fx,489.95
f,9995,fx,489.95
f,10011,fx,489.95
f,10029,fx,472.595
f,10049,fx,394.818
f,10065,fx,434.028
f,10087,fx,223.837
f,10095,fx,223.837
f,10119,fx,223.837
f,10137,fx,241.192
f,10157,fx,318.969
f,10173,fx,280.402
f,10191,fx,336.324
f,10211,fx,336.324
f,10227,fx,336.324
f,10245,fx,318.969
f,10265,fx,241.192
f,10281,fx,280.402
f,10303,fx,70.2108
f,10311,fx,70.2108
f,10335,fx,70.2108
f,10353,fx,87.566
f,10373,fx,165.343
f,10389,fx,126.133
f,10407,fx,182.698
f,10427,fx,182.698
f,10443,fx,182.698
f,10461,fx,165.343
f,10481,fx,87.566
f,10497,fx,126.133
f,10519,fx,-83.415
f,10527,fx,-83.415
f,10551,fx,-83.415
f,10569,fx,-66.06
f,10589,fx,11.7172
f,10605,fx,-27.493
f,10623,fx,28.4297
f,10643,fx,28.4297
f,10659,fx,28.4297
f,10677,fx,11.7172
f,10697,fx,-66.06
f,10713,fx,-27.493
f,10735,fx,-237.68
f,10743,fx,-237.68
f,10767,fx,-237.68
f,10785,fx,-220.33
f,10805,fx,-142.55
f,10821,fx,-181.12
f,10839,fx,-125.2
f,10859,fx,-125.2
f,10875,fx,-125.2
f,10893,fx,-142.55
f,10913,fx,-220.33
f,10929,fx,-181.12
f,10951,fx,-391.31
f,10959,fx,-391.31
f,10983,fx,-391.31
f,11001,fx,-373.95
f,11021,fx,-296.18
f,11037,fx,-334.74
f,11055,fx,-278.82
f,11075,fx,-278.82
f,11091,fx,-278.82
f,11109,fx,-296.18
f,11129,fx,-373.95
f,11145,fx,-334.74
f,11167,fx,685.357
f,11175,fx,685.357
f,11199,fx,685.357
f,11217,fx,702.712
f,11237,fx,780.489
f,11253,fx,741.279
f,11271,fx,797.844
f,11291,fx,797.844
f,11307,fx,797.844
f,11325,fx,780.489
f,11345,fx,702.712
f,11361,fx,741.279
f,11383,fx,531.731
f,11391,fx,531.731
f,11415,fx,531.731
f,11433,fx,549.086
f,11453,fx,626.863
f,11469,fx,587.653
f,11487,fx,644.219
f,11507,fx,644.219
f,11523,fx,644.219
f,11541,fx,626.863
f,11561,fx,549.086
f,11577,fx,587.653
f,11599,fx,378.105
f,11607,fx,378.105
f,11631,fx,378.105
f,11649,fx,394.818
f,11669,fx,472.595
f,11685,fx,434.028
f,11703,fx,489.95
f,11723,fx,489.95
f,11739,fx,489.95
f,11757,fx,472.595
f,11777,fx,394.818
f,11793,fx,434.028
f,11815,fx,223.837
f,11823,fx,223.837
f,11847,fx,223.837
f,11865,fx,241.192
f,11885,fx,318.969
f,11901,fx,280.402
f,11919,fx,336.324
f,11939,fx,336.324
f,11955,fx,336.324
f,11973,fx,318.969
f,11993,fx,241.192
f,12009,fx,280.402
f,12031,fx,70.2108
f,12039,fx,70.2108
f,12063,fx,70.2108
f,12081,fx,87.566
f,12101,fx,165.343
f,12117,fx,126.133
f,12135,fx,182.698
f,12155,fx,182.698
f,12171,fx,182.698
f,12189,fx,165.343
f,12209,fx,87.566
f,12225,fx,126.133
f,12247,fx,-83.415
f,12255,fx,-83.415
f,12279,fx,-83.415
f,12297,fx,-66.06
f,12317,fx,11.7172
f,12333,fx,-27.493
f,12351,fx,28.4297
f,12371,fx,28.4297
f,12387,fx,28.4297
f,12405,fx,11.7172
f,12425,fx,-66.06
f,12441,fx,-27.493
f,12463,fx,-237.68
f,12471,fx,-237.68
f,12495,fx,-237.68
f,12513,fx,-220.33
f,12533,fx,-142.55
f,12549,fx,-181.12
f,12567,fx,-125.2
f,12587,fx,-125.2
f,12603,fx,-125.2
f,12621,fx,-142.55
f,12641,fx,-220.33
f,12657,fx,-181.12
f,12679,fx,-391.31
f,12687,fx,-391.31
f,12711,fx,-391.31
f,12729,fx,-373.95
f,12749,fx,-296.18
f,12765,fx,-334.74
f,12783,fx,-278.82
f,12803,fx,-278.82
f,12819,fx,-278.82
f,12837,fx,-296.18
f,12857,fx,-373.95
f,12873,fx,-334.74
f,12895,fx,685.357
f,12903,fx,685.357
f,12927,fx,685.357
f,12945,fx,702.712
f,12965,fx,780.489
f,12981,fx,741.279
f,12999,fx,797.844
f,13019,fx,797.844
f,13035,fx,797.844
f,13053,fx,780.489
f,13073,fx,702.712
f,13089,fx,741.279
f,13111,fx,531.731
f,13119,fx,531.731
f,13143,fx,531.731
f,13161,fx,549.086
f,13181,fx,626.863
f,13197,fx,587.653
f,13215,fx,644.219
f,13235,fx,644.219
f,13251,fx,644.219
f,13269,fx,626.863
f,13289,fx,549.086
f,13305,fx,587.653
f,13327,fx,378.105
f,13335,fx,378.105
f,13359,fx,378.105
f,13377,fx,394.818
f,13397,fx,472.595
f,13413,fx,434.028
f,13431,fx,489.95
f,13451,fx,489.95
f,13467,fx,489.95
f,13485,fx,472.595
f,13505,fx,394.818
f,13521,fx,434.028
f,13543,fx,223.837
f,13551,fx,223.837
f,13575,fx,223.837
f,13593,fx,241.192
f,13613,fx,318.969
f,13629,fx,280.402
f,13647,fx,336.324
f,13667,fx,336.324
f,13683,fx,336.324
f,13701,fx,318.969
f,13721,fx,241.192
f,13737,fx,280.402
f,13759,fx,70.2108
f,13767,fx,70.2108
f,13791,fx,70.2108
f,13809,fx,87.566
f,13829,fx,165.343
f,13845,fx,126.133
f,13863,fx,182.698
f,13883,fx,182.698
f,13899,fx,182.698
f,13917,fx,165.343
f,13937,fx,87.566
f,13953,fx,126.133
f,13975,fx,-83.415
f,13983,fx,-83.415
f,14007,fx,-83.415
f,14025,fx,-66.06
f,14045,fx,11.7172
f,14061,fx,-27.493
f,14079,fx,28.4297
f,14099,fx,28.4297

f,14115,fx,28.4297
f,14133,fx,11.7172
f,14153,fx,-66.06
f,14169,fx,-27.493
f,14191,fx,-237.68
f,14199,fx,-237.68
f,14223,fx,-237.68
f,14241,fx,-220.33
f,14261,fx,-142.55
f,14277,fx,-181.12
f,14295,fx,-125.2
f,14315,fx,-125.2
f,14331,fx,-125.2
f,14349,fx,-142.55
f,14369,fx,-220.33
f,14385,fx,-181.12
f,14407,fx,-391.31
f,14415,fx,-391.31
f,14439,fx,-391.31
f,14457,fx,-373.95
f,14477,fx,-296.18
f,14493,fx,-334.74
f,14511,fx,-278.82
f,14531,fx,-278.82
f,14547,fx,-278.82
f,14565,fx,-296.18
f,14585,fx,-373.95
f,14601,fx,-334.74
f,14623,fx,685.357
f,14631,fx,685.357
f,14655,fx,685.357
f,14673,fx,702.712
f,14693,fx,780.489
f,14709,fx,741.279
f,14727,fx,797.844
f,14747,fx,797.844
f,14763,fx,797.844
f,14781,fx,780.489
f,14801,fx,702.712
f,14817,fx,741.279
f,14839,fx,531.731
f,14847,fx,531.731
f,14871,fx,531.731
f,14889,fx,549.086
f,14909,fx,626.863
f,14925,fx,587.653
f,14943,fx,644.219
f,14963,fx,644.219
f,14979,fx,644.219
f,14997,fx,626.863
f,15017,fx,549.086
f,15033,fx,587.653
f,15055,fx,378.105
f,15063,fx,378.105
f,15087,fx,378.105
f,15105,fx,394.818
f,15125,fx,472.595
f,15141,fx,434.028
f,15159,fx,489.95
f,15179,fx,489.95
f,15195,fx,489.95
f,15213,fx,472.595
f,15233,fx,394.818
f,15249,fx,434.028
f,15271,fx,223.837
f,15279,fx,223.837
f,15303,fx,223.837
f,15321,fx,241.192
f,15341,fx,318.969
f,15357,fx,280.402
f,15375,fx,336.324
f,15395,fx,336.324
f,15411,fx,336.324
f,15429,fx,318.969
f,15449,fx,241.192
f,15465,fx,280.402
f,15487,fx,70.2108
f,15495,fx,70.2108
f,15519,fx,70.2108
f,15537,fx,87.566
f,15557,fx,165.343
f,15573,fx,126.133
f,15591,fx,182.698
f,15611,fx,182.698
f,15627,fx,182.698
f,15645,fx,165.343
f,15665,fx,87.566
f,15681,fx,126.133
f,15703,fx,-83.415
f,15711,fx,-83.415
f,15735,fx,-83.415
f,15753,fx,-66.06
f,15773,fx,11.7172
f,15789,fx,-27.493
f,15807,fx,28.4297
f,15827,fx,28.4297
f,15843,fx,28.4297
f,15861,fx,11.7172
f,15881,fx,-66.06
f,15897,fx,-27.493
f,15919,fx,-237.68
f,15927,fx,-237.68
f,15951,fx,-237.68
f,15969,fx,-220.33
f,15989,fx,-142.55
f,16005,fx,-181.12
f,16023,fx,-125.2
f,16043,fx,-125.2
f,16059,fx,-125.2
f,16077,fx,-142.55
f,16097,fx,-220.33
f,16113,fx,-181.12
f,16135,fx,-391.31
f,16143,fx,-391.31
f,16167,fx,-391.31
f,16185,fx,-373.95
f,16205,fx,-296.18
f,16221,fx,-334.74
f,16239,fx,-278.82
f,16259,fx,-278.82
f,16275,fx,-278.82
f,16293,fx,-296.18
f,16313,fx,-373.95
f,16329,fx,-334.74
f,16351,fx,685.357
f,16359,fx,685.357
f,16383,fx,685.357
f,16401,fx,702.712
f,16421,fx,780.489
f,16437,fx,741.279
f,16455,fx,797.844
f,16475,fx,797.844
f,16491,fx,797.844
f,16509,fx,780.489
f,16529,fx,702.712
f,16545,fx,741.279
f,16567,fx,531.731
f,16575,fx,531.731
f,16599,fx,531.731
f,16617,fx,549.086
f,16637,fx,626.863
f,16653,fx,587.653
f,16671,fx,644.219
f,16691,fx,644.219
f,16707,fx,644.219
f,16725,fx,626.863
f,16745,fx,549.086
f,16761,fx,587.653
f,16783,fx,378.105
f,16791,fx,378.105
f,16815,fx,378.105
f,16833,fx,394.818
f,16853,fx,472.595
f,16869,fx,434.028
f,16887,fx,489.95
f,16907,fx,489.95
f,16923,fx,489.95
f,16941,fx,472.595
f,16961,fx,394.818
f,16977,fx,434.028
f,16999,fx,223.837
f,17007,fx,223.837
f,17031,fx,223.837
f,17049,fx,241.192
f,17069,fx,318.969
f,17085,fx,280.402
f,17103,fx,336.324
f,17123,fx,336.324
f,17139,fx,336.324
f,17157,fx,318.969
f,17177,fx,241.192
f,17193,fx,280.402
f,17215,fx,70.2108
f,17223,fx,70.2108
f,17247,fx,70.2108
f,17265,fx,87.566
f,17285,fx,165.343
f,17301,fx,126.133
f,17319,fx,182.698
f,17339,fx,182.698
f,17355,fx,182.698
f,17373,fx,165.343
f,17393,fx,87.566
f,17409,fx,126.133
f,17431,fx,-83.415
f,17439,fx,-83.415
f,17463,fx,-83.415
f,17481,fx,-66.06
f,17501,fx,11.7172
f,17517,fx,-27.493
f,17535,fx,28.4297
f,17555,fx,28.4297
f,17571,fx,28.4297
f,17589,fx,11.7172
f,17609,fx,-66.06
f,17625,fx,-27.493
f,17647,fx,-237.68
f,17655,fx,-237.68
f,17679,fx,-237.68
f,17697,fx,-220.33
f,17717,fx,-142.55
f,17733,fx,-181.12
f,17751,fx,-125.2
f,17771,fx,-125.2
f,17787,fx,-125.2
f,17805,fx,-142.55
f,17825,fx,-220.33
f,17841,fx,-181.12
f,17863,fx,-391.31
f,17871,fx,-391.31
f,17895,fx,-391.31
f,17913,fx,-373.95
f,17933,fx,-296.18
f,17949,fx,-334.74
f,17967,fx,-278.82
f,17987,fx,-278.82
f,18003,fx,-278.82
f,18021,fx,-296.18
f,18041,fx,-373.95
f,18057,fx,-334.74
f,18079,fx,685.357
f,18087,fx,685.357
f,18111,fx,685.357
f,18129,fx,702.712
f,18149,fx,780.489
f,18165,fx,741.279
f,18183,fx,797.844
f,18203,fx,797.844
f,18219,fx,797.844
f,18237,fx,780.489
f,18257,fx,702.712
f,18273,fx,741.279
f,18295,fx,531.731
f,18303,fx,531.731
f,18327,fx,531.731
f,18345,fx,549.086
f,18365,fx,626.863
f,18381,fx,587.653
f,18399,fx,644.219
f,18419,fx,644.219
f,18435,fx,644.219
f,18453,fx,626.863
f,18473,fx,549.086
f,18489,fx,587.653
f,18511,fx,378.105
f,18519,fx,378.105
f,18543,fx,378.105
f,18561,fx,394.818
f,18581,fx,472.595
f,18597,fx,434.028
f,18615,fx,489.95
f,18635,fx,489.95
f,18651,fx,489.95
f,18669,fx,472.595
f,18689,fx,394.818
f,18705,fx,434.028
f,18727,fx,223.837
f,18735,fx,223.837
f,18759,fx,223.837
f,18777,fx,241.192
f,18797,fx,318.969
f,18813,fx,280.402
f,18831,fx,336.324
f,18851,fx,336.324
f,18867,fx,336.324
f,18885,fx,318.969
f,18905,fx,241.192
f,18921,fx,280.402
f,18943,fx,70.2108
f,18951,fx,70.2108
f,18975,fx,70.2108
f,18993,fx,87.566
f,19013,fx,165.343
f,19029,fx,126.133
f,19047,fx,182.698
f,19067,fx,182.698
f,19083,fx,182.698
f,19101,fx,165.343
f,19121,fx,87.566
f,19137,fx,126.133
f,19159,fx,-83.415
f,19167,fx,-83.415
f,19191,fx,-83.415
f,19209,fx,-66.06
f,19229,fx,11.7172
f,19245,fx,-27.493
f,19263,fx,28.4297
f,19283,fx,28.4297
f,19299,fx,28.4297
f,19317,fx,11.7172
f,19337,fx,-66.06
f,19353,fx,-27.493
f,19375,fx,-237.68
f,19383,fx,-237.68
f,19407,fx,-237.68
f,19425,fx,-220.33
f,19445,fx,-142.55
f,19461,fx,-181.12
f,19479,fx,-125.2
f,19499,fx,-125.2
f,19515,fx,-125.2
f,19533,fx,-142.55
f,19553,fx,-220.33
f,19569,fx,-181.12
f,19591,fx,-391.31
f,19599,fx,-391.31
f,19623,fx,-391.31
f,19641,fx,-373.95
f,19661,fx,-296.18
f,19677,fx,-334.74
f,19695,fx,-278.82
f,19715,fx,-278.82
f,19731,fx,-278.82
f,19749,fx,-296.18
f,19769,fx,-373.95
f,19785,fx,-334.74
f,19807,fx,685.357
f,19815,fx,685.357
f,19839,fx,685.357
f,19857,fx,702.712
f,19877,fx,780.489
f,19893,fx,741.279
f,19911,fx,797.844
f,19931,fx,797.844
f,19947,fx,797.844
f,19965,fx,780.489
f,19985,fx,702.712
f,20001,fx,741.279
f,20023,fx,531.731
f,20031,fx,531.731
f,20055,fx,531.731
f,20073,fx,549.086

f,20093,fx,626.863
f,20109,fx,587.653
f,20127,fx,644.219
f,20147,fx,644.219
f,20163,fx,644.219
f,20181,fx,626.863
f,20201,fx,549.086
f,20217,fx,587.653
f,20239,fx,378.105
f,20247,fx,378.105
f,20271,fx,378.105
f,20289,fx,394.818
f,20309,fx,472.595
f,20325,fx,434.028
f,20343,fx,489.95
f,20363,fx,489.95
f,20379,fx,489.95
f,20397,fx,472.595
f,20417,fx,394.818
f,20433,fx,434.028
f,20455,fx,223.837
f,20463,fx,223.837
f,20487,fx,223.837
f,20505,fx,241.192
f,20525,fx,318.969
f,20541,fx,280.402
f,20559,fx,336.324
f,20579,fx,336.324
f,20595,fx,336.324
f,20613,fx,318.969
f,20633,fx,241.192
f,20649,fx,280.402
f,20671,fx,70.2108
f,20679,fx,70.2108
f,20703,fx,70.2108
f,20721,fx,87.566
f,20741,fx,165.343
f,20757,fx,126.133
f,20775,fx,182.698
f,20795,fx,182.698
f,20811,fx,182.698
f,20829,fx,165.343
f,20849,fx,87.566
f,20865,fx,126.133
f,20887,fx,-83.415
f,20895,fx,-83.415
f,20919,fx,-83.415
f,20937,fx,-66.06
f,20957,fx,11.7172
f,20973,fx,-27.493
f,20991,fx,28.4297
f,21011,fx,28.4297
f,21027,fx,28.4297
f,21045,fx,11.7172
f,21065,fx,-66.06
f,21081,fx,-27.493
f,21103,fx,-237.68
f,21111,fx,-237.68
f,21135,fx,-237.68
f,21153,fx,-220.33
f,21173,fx,-142.55
f,21189,fx,-181.12
f,21207,fx,-125.2
f,21227,fx,-125.2
f,21243,fx,-125.2
f,21261,fx,-142.55
f,21281,fx,-220.33
f,21297,fx,-181.12
f,21319,fx,-391.31
f,21327,fx,-391.31
f,21351,fx,-391.31
f,21369,fx,-373.95
f,21389,fx,-296.18
f,21405,fx,-334.74
f,21423,fx,-278.82
f,21443,fx,-278.82
f,21459,fx,-278.82
f,21477,fx,-296.18
f,21497,fx,-373.95
f,21513,fx,-334.74
f,21535,fx,685.357
f,21543,fx,685.357
f,21567,fx,685.357
f,21585,fx,702.712
f,21605,fx,780.489
f,21621,fx,741.279
f,21639,fx,797.844
f,21659,fx,797.844
f,21675,fx,797.844
f,21693,fx,780.489
f,21713,fx,702.712
f,21729,fx,741.279
f,21751,fx,531.731
f,21759,fx,531.731
f,21783,fx,531.731
f,21801,fx,549.086
f,21821,fx,626.863
f,21837,fx,587.653
f,21855,fx,644.219
f,21875,fx,644.219
f,21891,fx,644.219
f,21909,fx,626.863
f,21929,fx,549.086
f,21945,fx,587.653
f,21967,fx,378.105
f,21975,fx,378.105
f,21999,fx,378.105
f,22017,fx,394.818
f,22037,fx,472.595
f,22053,fx,434.028
f,22071,fx,489.95
f,22091,fx,489.95
f,22107,fx,489.95
f,22125,fx,472.595
f,22145,fx,394.818
f,22161,fx,434.028
f,22183,fx,223.837
f,22191,fx,223.837
f,22215,fx,223.837
f,22233,fx,241.192
f,22253,fx,318.969
f,22269,fx,280.402
f,22287,fx,336.324
f,22307,fx,336.324
f,22323,fx,336.324
f,22341,fx,318.969
f,22361,fx,241.192
f,22377,fx,280.402
f,22399,fx,70.2108
f,22407,fx,70.2108
f,22431,fx,70.2108
f,22449,fx,87.566
f,22469,fx,165.343
f,22485,fx,126.133
f,22503,fx,182.698
f,22523,fx,182.698
f,22539,fx,182.698
f,22557,fx,165.343
f,22577,fx,87.566
f,22593,fx,126.133
f,22615,fx,-83.415
f,22623,fx,-83.415
f,22647,fx,-83.415
f,22665,fx,-66.06
f,22685,fx,11.7172
f,22701,fx,-27.493
f,22719,fx,28.4297
f,22739,fx,28.4297
f,22755,fx,28.4297
f,22773,fx,11.7172
f,22793,fx,-66.06
f,22809,fx,-27.493
f,22831,fx,-237.68
f,22839,fx,-237.68
f,22863,fx,-237.68
f,22881,fx,-220.33
f,22901,fx,-142.55
f,22917,fx,-181.12
f,22935,fx,-125.2
f,22955,fx,-125.2
f,22971,fx,-125.2
f,22989,fx,-142.55
f,23009,fx,-220.33
f,23025,fx,-181.12
f,23047,fx,-391.31
f,23055,fx,-391.31
f,23079,fx,-391.31
f,23097,fx,-373.95
f,23117,fx,-296.18
f,23133,fx,-334.74
f,23151,fx,-278.82
f,23171,fx,-278.82
f,23187,fx,-278.82
f,23205,fx,-296.18
f,23225,fx,-373.95
f,23241,fx,-334.74
f,23263,fx,685.357
f,23271,fx,685.357
f,23295,fx,685.357
f,23313,fx,702.712
f,23333,fx,780.489
f,23349,fx,741.279
f,23367,fx,797.844
f,23387,fx,797.844
f,23403,fx,797.844
f,23421,fx,780.489
f,23441,fx,702.712
f,23457,fx,741.279
f,23479,fx,531.731
f,23487,fx,531.731
f,23511,fx,531.731
f,23529,fx,549.086
f,23549,fx,626.863
f,23565,fx,587.653
f,23583,fx,644.219
f,23603,fx,644.219
f,23619,fx,644.219
f,23637,fx,626.863
f,23657,fx,549.086
f,23673,fx,587.653
f,23695,fx,378.105
f,23703,fx,378.105
f,23727,fx,378.105
f,23745,fx,394.818
f,23765,fx,472.595
f,23781,fx,434.028
f,23799,fx,489.95
f,23819,fx,489.95
f,23835,fx,489.95
f,23853,fx,472.595
f,23873,fx,394.818
f,23889,fx,434.028
f,23911,fx,223.837
f,23919,fx,223.837
f,23943,fx,223.837
f,23961,fx,241.192
f,23981,fx,318.969
f,23997,fx,280.402
f,24015,fx,336.324
f,24035,fx,336.324
f,24051,fx,336.324
f,24069,fx,318.969
f,24089,fx,241.192
f,24105,fx,280.402
f,24127,fx,70.2108
f,24135,fx,70.2108
f,24159,fx,70.2108
f,24177,fx,87.566
f,24197,fx,165.343
f,24213,fx,126.133
f,24231,fx,182.698
f,24251,fx,182.698
f,24267,fx,182.698
f,24285,fx,165.343
f,24305,fx,87.566
f,24321,fx,126.133
f,24343,fx,-83.415
f,24351,fx,-83.415
f,24375,fx,-83.415
f,24393,fx,-66.06
f,24413,fx,11.7172
f,24429,fx,-27.493
f,24447,fx,28.4297
f,24467,fx,28.4297
f,24483,fx,28.4297
f,24501,fx,11.7172
f,24521,fx,-66.06
f,24537,fx,-27.493
f,24559,fx,-237.68
f,24567,fx,-237.68
f,24591,fx,-237.68
f,24609,fx,-220.33
f,24629,fx,-142.55
f,24645,fx,-181.12
f,24663,fx,-125.2
f,24683,fx,-125.2
f,24699,fx,-125.2
f,24717,fx,-142.55
f,24737,fx,-220.33
f,24753,fx,-181.12
f,24775,fx,-391.31
f,24783,fx,-391.31
f,24807,fx,-391.31
f,24825,fx,-373.95
f,24845,fx,-296.18
f,24861,fx,-334.74
f,24879,fx,-278.82
f,24899,fx,-278.82
f,24915,fx,-278.82
f,24933,fx,-296.18
f,24953,fx,-373.95
f,24969,fx,-334.74
f,24991,fx,685.357
f,24999,fx,685.357
f,25023,fx,685.357
f,25041,fx,702.712
f,25061,fx,780.489
f,25077,fx,741.279
f,25095,fx,797.844
f,25115,fx,797.844
f,25131,fx,797.844
f,25149,fx,780.489
f,25169,fx,702.712
f,25185,fx,741.279
f,25207,fx,531.731
f,25215,fx,531.731
f,25239,fx,531.731
f,25257,fx,549.086
f,25277,fx,626.863
f,25293,fx,587.653
f,25311,fx,644.219
f,25331,fx,644.219
f,25347,fx,644.219
f,25365,fx,626.863
f,25385,fx,549.086
f,25401,fx,587.653
f,25423,fx,378.105
f,25431,fx,378.105
f,25455,fx,378.105
f,25473,fx,394.818
f,25493,fx,472.595
f,25509,fx,434.028
f,25527,fx,489.95
f,25547,fx,489.95
f,25563,fx,489.95
f,25581,fx,472.595
f,25601,fx,394.818
f,25617,fx,434.028
f,25639,fx,223.837
f,25647,fx,223.837
f,25671,fx,223.837
f,25689,fx,241.192
f,25709,fx,318.969
f,25725,fx,280.402
f,25743,fx,336.324
f,25763,fx,336.324
f,25779,fx,336.324
f,25797,fx,318.969
f,25817,fx,241.192
f,25833,fx,280.402
f,25855,fx,70.2108
f,25863,fx,70.2108
f,25887,fx,70.2108
f,25905,fx,87.566
f,25925,fx,165.343
f,25941,fx,126.133
f,25959,fx,182.698
f,25979,fx,182.698
f,25995,fx,182.698
f,26013,fx,165.343
f,26033,fx,87.566
f,26049,fx,126.133

f,26071,fx,-83.415
f,26079,fx,-83.415
f,26103,fx,-83.415
f,26121,fx,-66.06
f,26141,fx,11.7172
f,26157,fx,-27.493
f,26175,fx,28.4297
f,26195,fx,28.4297
f,26211,fx,28.4297
f,26229,fx,11.7172
f,26249,fx,-66.06
f,26265,fx,-27.493
f,26287,fx,-237.68
f,26295,fx,-237.68
f,26319,fx,-237.68
f,26337,fx,-220.33
f,26357,fx,-142.55
f,26373,fx,-181.12
f,26391,fx,-125.2
f,26411,fx,-125.2
f,26427,fx,-125.2
f,26445,fx,-142.55
f,26465,fx,-220.33
f,26481,fx,-181.12
f,26503,fx,-391.31
f,26511,fx,-391.31
f,26535,fx,-391.31
f,26553,fx,-373.95
f,26573,fx,-296.18
f,26589,fx,-334.74
f,26607,fx,-278.82
f,26627,fx,-278.82
f,26643,fx,-278.82
f,26661,fx,-296.18
f,26681,fx,-373.95
f,26697,fx,-334.74
f,26719,fx,685.357
f,26727,fx,685.357
f,26751,fx,685.357
f,26769,fx,702.712
f,26789,fx,780.489
f,26805,fx,741.279
f,26823,fx,797.844
f,26843,fx,797.844
f,26859,fx,797.844
f,26877,fx,780.489
f,26897,fx,702.712
f,26913,fx,741.279
f,26935,fx,531.731
f,26943,fx,531.731
f,26967,fx,531.731
f,26985,fx,549.086
f,27005,fx,626.863
f,27021,fx,587.653
f,27039,fx,644.219
f,27059,fx,644.219
f,27075,fx,644.219
f,27093,fx,626.863
f,27113,fx,549.086
f,27129,fx,587.653
f,27151,fx,378.105
f,27159,fx,378.105
f,27183,fx,378.105
f,27201,fx,394.818
f,27221,fx,472.595
f,27237,fx,434.028
f,27255,fx,489.95
f,27275,fx,489.95
f,27291,fx,489.95
f,27309,fx,472.595
f,27329,fx,394.818
f,27345,fx,434.028
f,27367,fx,223.837
f,27375,fx,223.837
f,27399,fx,223.837
f,27417,fx,241.192
f,27437,fx,318.969
f,27453,fx,280.402
f,27471,fx,336.324
f,27491,fx,336.324
f,27507,fx,336.324
f,27525,fx,318.969
f,27545,fx,241.192
f,27561,fx,280.402
f,27583,fx,70.2108
f,27591,fx,70.2108
f,27615,fx,70.2108
f,27633,fx,87.566
f,27653,fx,165.343
f,27669,fx,126.133
f,27687,fx,182.698
f,27707,fx,182.698
f,27723,fx,182.698
f,27741,fx,165.343
f,27761,fx,87.566
f,27777,fx,126.133
f,27799,fx,-83.415
f,27807,fx,-83.415
f,27831,fx,-83.415
f,27849,fx,-66.06
f,27869,fx,11.7172
f,27885,fx,-27.493
f,27903,fx,28.4297
f,27923,fx,28.4297
f,27939,fx,28.4297
f,27957,fx,11.7172
f,27977,fx,-66.06
f,27993,fx,-27.493
f,28015,fx,-237.68
f,28023,fx,-237.68
f,28047,fx,-237.68
f,28065,fx,-220.33
f,28085,fx,-142.55
f,28101,fx,-181.12
f,28119,fx,-125.2
f,28139,fx,-125.2
f,28155,fx,-125.2
f,28173,fx,-142.55
f,28193,fx,-220.33
f,28209,fx,-181.12
f,28231,fx,-391.31
f,28239,fx,-391.31
f,28263,fx,-391.31
f,28281,fx,-373.95
f,28301,fx,-296.18
f,28317,fx,-334.74
f,28335,fx,-278.82
f,28355,fx,-278.82
f,28371,fx,-278.82
f,28389,fx,-296.18
f,28409,fx,-373.95
f,28425,fx,-334.74
f,28447,fx,685.357
f,28455,fx,685.357
f,28479,fx,685.357
f,28497,fx,702.712
f,28517,fx,780.489
f,28533,fx,741.279
f,28551,fx,797.844
f,28571,fx,797.844
f,28587,fx,797.844
f,28605,fx,780.489
f,28625,fx,702.712
f,28641,fx,741.279
f,28663,fx,531.731
f,28671,fx,531.731
f,28695,fx,531.731
f,28713,fx,549.086
f,28733,fx,626.863
f,28749,fx,587.653
f,28767,fx,644.219
f,28787,fx,644.219
f,28803,fx,644.219
f,28821,fx,626.863
f,28841,fx,549.086
f,28857,fx,587.653
f,28879,fx,378.105
f,28887,fx,378.105
f,28911,fx,378.105
f,28929,fx,394.818
f,28949,fx,472.595
f,28965,fx,434.028
f,28983,fx,489.95
f,29003,fx,489.95
f,29019,fx,489.95
f,29037,fx,472.595
f,29057,fx,394.818
f,29073,fx,434.028
f,29095,fx,223.837
f,29103,fx,223.837
f,29127,fx,223.837
f,29145,fx,241.192
f,29165,fx,318.969
f,29181,fx,280.402
f,29199,fx,336.324
f,29219,fx,336.324
f,29235,fx,336.324
f,29253,fx,318.969
f,29273,fx,241.192
f,29289,fx,280.402
f,29311,fx,70.2108
f,29319,fx,70.2108
f,29343,fx,70.2108
f,29361,fx,87.566
f,29381,fx,165.343
f,29397,fx,126.133
f,29415,fx,182.698
f,29435,fx,182.698
f,29451,fx,182.698
f,29469,fx,165.343
f,29489,fx,87.566
f,29505,fx,126.133
f,29527,fx,-83.415
f,29535,fx,-83.415
f,29559,fx,-83.415
f,29577,fx,-66.06
f,29597,fx,11.7172
f,29613,fx,-27.493
f,29631,fx,28.4297
f,29651,fx,28.4297
f,29667,fx,28.4297
f,29685,fx,11.7172
f,29705,fx,-66.06
f,29721,fx,-27.493
f,29743,fx,-237.68
f,29751,fx,-237.68
f,29775,fx,-237.68
f,29793,fx,-220.33
f,29813,fx,-142.55
f,29829,fx,-181.12
f,29847,fx,-125.2
f,29867,fx,-125.2
f,29883,fx,-125.2
f,29901,fx,-142.55
f,29921,fx,-220.33
f,29937,fx,-181.12
f,29959,fx,-391.31
f,29967,fx,-391.31
f,29991,fx,-391.31
f,30009,fx,-373.95
f,30029,fx,-296.18
f,30045,fx,-334.74
f,30063,fx,-278.82
f,30083,fx,-278.82
f,30099,fx,-278.82
f,30117,fx,-296.18
f,30137,fx,-373.95
f,30153,fx,-334.74
f,30175,fx,685.357
f,30183,fx,685.357
f,30207,fx,685.357
f,30225,fx,702.712
f,30245,fx,780.489
f,30261,fx,741.279
f,30279,fx,797.844
f,30299,fx,797.844
f,30315,fx,797.844
f,30333,fx,780.489
f,30353,fx,702.712
f,30369,fx,741.279
f,30391,fx,531.731
f,30399,fx,531.731
f,30423,fx,531.731
f,30441,fx,549.086
f,30461,fx,626.863
f,30477,fx,587.653
f,30495,fx,644.219
f,30515,fx,644.219
f,30531,fx,644.219
f,30549,fx,626.863
f,30569,fx,549.086
f,30585,fx,587.653
f,30607,fx,378.105
f,30615,fx,378.105
f,30639,fx,378.105
f,30657,fx,394.818
f,30677,fx,472.595
f,30693,fx,434.028
f,30711,fx,489.95
f,30731,fx,489.95
f,30747,fx,489.95
f,30765,fx,472.595
f,30785,fx,394.818
f,30801,fx,434.028
f,30823,fx,223.837
f,30831,fx,223.837
f,30855,fx,223.837
f,30873,fx,241.192
f,30893,fx,318.969
f,30909,fx,280.402
f,30927,fx,336.324
f,30947,fx,336.324
f,30963,fx,336.324
f,30981,fx,318.969
f,31001,fx,241.192
f,31017,fx,280.402
f,31039,fx,70.2108
f,31047,fx,70.2108
f,31071,fx,70.2108
f,31089,fx,87.566
f,31109,fx,165.343
f,31125,fx,126.133
f,31143,fx,182.698
f,31163,fx,182.698
f,31179,fx,182.698
f,31197,fx,165.343
f,31217,fx,87.566
f,31233,fx,126.133
f,31255,fx,-83.415
f,31263,fx,-83.415
f,31287,fx,-83.415
f,31305,fx,-66.06
f,31325,fx,11.7172
f,31341,fx,-27.493
f,31359,fx,28.4297
f,31379,fx,28.4297
f,31395,fx,28.4297
f,31413,fx,11.7172
f,31433,fx,-66.06
f,31449,fx,-27.493
f,31471,fx,-237.68
f,31479,fx,-237.68
f,31503,fx,-237.68
f,31521,fx,-220.33
f,31541,fx,-142.55
f,31557,fx,-181.12
f,31575,fx,-125.2
f,31595,fx,-125.2
f,31611,fx,-125.2
f,31629,fx,-142.55
f,31649,fx,-220.33
f,31665,fx,-181.12
f,31687,fx,-391.31
f,31695,fx,-391.31
f,31719,fx,-391.31
f,31737,fx,-373.95
f,31757,fx,-296.18
f,31773,fx,-334.74
f,31791,fx,-278.82
f,31811,fx,-278.82
f,31827,fx,-278.82
f,31845,fx,-296.18
f,31865,fx,-373.95
f,31881,fx,-334.74
f,31903,fx,685.357
f,31911,fx,685.357
f,31935,fx,685.357
f,31953,fx,702.712
f,31973,fx,780.489
f,31989,fx,741.279
f,32007,fx,797.844
f,32027,fx,797.844

f,32043,fx,797.844
f,32061,fx,780.489
f,32081,fx,702.712
f,32097,fx,741.279
f,32119,fx,531.731
f,32127,fx,531.731
f,32151,fx,531.731
f,32169,fx,549.086
f,32189,fx,626.863
f,32205,fx,587.653
f,32223,fx,644.219
f,32243,fx,644.219
f,32259,fx,644.219
f,32277,fx,626.863
f,32297,fx,549.086
f,32313,fx,587.653
f,32335,fx,378.105
f,32343,fx,378.105
f,32367,fx,378.105
f,32385,fx,394.818
f,32405,fx,472.595
f,32421,fx,434.028
f,32439,fx,489.95
f,32459,fx,489.95
f,32475,fx,489.95
f,32493,fx,472.595
f,32513,fx,394.818
f,32529,fx,434.028
f,32551,fx,223.837
f,32559,fx,223.837
f,32583,fx,223.837
f,32601,fx,241.192
f,32621,fx,318.969
f,32637,fx,280.402
f,32655,fx,336.324
f,32675,fx,336.324
f,32691,fx,336.324
f,32709,fx,318.969
f,32729,fx,241.192
f,32745,fx,280.402
f,32767,fx,70.2108
f,32775,fx,70.2108
f,32799,fx,70.2108
f,32817,fx,87.566
f,32837,fx,165.343
f,32853,fx,126.133
f,32871,fx,182.698
f,32891,fx,182.698
f,32907,fx,182.698
f,32925,fx,165.343
f,32945,fx,87.566
f,32961,fx,126.133
f,32983,fx,-83.415
f,32991,fx,-83.415
f,33015,fx,-83.415
f,33033,fx,-66.06
f,33053,fx,11.7172
f,33069,fx,-27.493
f,33087,fx,28.4297
f,33107,fx,28.4297
f,33123,fx,28.4297
f,33141,fx,11.7172
f,33161,fx,-66.06
f,33177,fx,-27.493
f,33199,fx,-237.68
f,33207,fx,-237.68
f,33231,fx,-237.68
f,33249,fx,-220.33
f,33269,fx,-142.55
f,33285,fx,-181.12
f,33303,fx,-125.2
f,33323,fx,-125.2
f,33339,fx,-125.2
f,33357,fx,-142.55
f,33377,fx,-220.33
f,33393,fx,-181.12
f,33415,fx,-391.31
f,33423,fx,-391.31
f,33447,fx,-391.31
f,33465,fx,-373.95
f,33485,fx,-296.18
f,33501,fx,-334.74
f,33519,fx,-278.82
f,33539,fx,-278.82
f,33555,fx,-278.82
f,33573,fx,-296.18
f,33593,fx,-373.95
f,33609,fx,-334.74
f,5984,fx,679.765
f,5992,fx,679.765
f,6016,fx,679.765
f,6034,fx,697.12
f,6054,fx,774.897
f,6070,fx,735.687
f,6088,fx,792.252
f,6108,fx,792.252
f,6124,fx,792.252
f,6142,fx,774.897
f,6162,fx,697.12
f,6178,fx,735.687
f,6200,fx,526.139
f,6208,fx,526.139
f,6232,fx,526.139
f,6250,fx,543.494
f,6270,fx,621.271
f,6286,fx,582.061
f,6304,fx,638.626
f,6324,fx,638.626
f,6340,fx,638.626
f,6358,fx,621.271
f,6378,fx,543.494
f,6394,fx,582.061
f,6416,fx,372.513
f,6424,fx,372.513
f,6448,fx,372.513
f,6466,fx,389.225
f,6486,fx,467.002
f,6502,fx,428.435
f,6520,fx,484.358
f,6540,fx,484.358
f,6556,fx,484.358
f,6574,fx,467.002
f,6594,fx,389.225
f,6610,fx,428.435
f,6632,fx,218.244
f,6640,fx,218.244
f,6664,fx,218.244
f,6682,fx,235.6
f,6702,fx,313.377
f,6718,fx,274.809
f,6736,fx,330.732
f,6756,fx,330.732
f,6772,fx,330.732
f,6790,fx,313.377
f,6810,fx,235.6
f,6826,fx,274.809
f,6848,fx,64.6184
f,6856,fx,64.6184
f,6880,fx,64.6184
f,6898,fx,81.9737
f,6918,fx,159.751
f,6934,fx,120.541
f,6952,fx,177.106
f,6972,fx,177.106
f,6988,fx,177.106
f,7006,fx,159.751
f,7026,fx,81.9737
f,7042,fx,120.541
f,7064,fx,-89.007
f,7072,fx,-89.007
f,7096,fx,-89.007
f,7114,fx,-71.652
f,7134,fx,6.12493
f,7150,fx,-33.085
f,7168,fx,22.8374
f,7188,fx,22.8374
f,7204,fx,22.8374
f,7222,fx,6.12493
f,7242,fx,-71.652
f,7258,fx,-33.085
f,7280,fx,-243.28
f,7288,fx,-243.28
f,7312,fx,-243.28
f,7330,fx,-225.92
f,7350,fx,-148.14
f,7366,fx,-186.71
f,7384,fx,-130.79
f,7404,fx,-130.79
f,7420,fx,-130.79
f,7438,fx,-148.14
f,7458,fx,-225.92
f,7474,fx,-186.71
f,7496,fx,-396.9
f,7504,fx,-396.9
f,7528,fx,-396.9
f,7546,fx,-379.55
f,7566,fx,-301.77
f,7582,fx,-340.34
f,7600,fx,-284.41
f,7620,fx,-284.41
f,7636,fx,-284.41
f,7654,fx,-301.77
f,7674,fx,-379.55
f,7690,fx,-340.34
f,7712,fx,679.765
f,7720,fx,679.765
f,7744,fx,679.765
f,7762,fx,697.12
f,7782,fx,774.897
f,7798,fx,735.687
f,7816,fx,792.252
f,7836,fx,792.252
f,7852,fx,792.252
f,7870,fx,774.897
f,7890,fx,697.12
f,7906,fx,735.687
f,7928,fx,526.139
f,7936,fx,526.139
f,7960,fx,526.139
f,7978,fx,543.494
f,7998,fx,621.271
f,8014,fx,582.061
f,8032,fx,638.626
f,8052,fx,638.626
f,8068,fx,638.626
f,8086,fx,621.271
f,8106,fx,543.494
f,8122,fx,582.061
f,8144,fx,372.513
f,8152,fx,372.513
f,8176,fx,372.513
f,8194,fx,389.225
f,8214,fx,467.002
f,8230,fx,428.435
f,8248,fx,484.358
f,8268,fx,484.358
f,8284,fx,484.358
f,8302,fx,467.002
f,8322,fx,389.225
f,8338,fx,428.435
f,8360,fx,218.244
f,8368,fx,218.244
f,8392,fx,218.244
f,8410,fx,235.6
f,8430,fx,313.377
f,8446,fx,274.809
f,8464,fx,330.732
f,8484,fx,330.732
f,8500,fx,330.732
f,8518,fx,313.377
f,8538,fx,235.6
f,8554,fx,274.809
f,8576,fx,64.6184
f,8584,fx,64.6184
f,8608,fx,64.6184
f,8626,fx,81.9737
f,8646,fx,159.751
f,8662,fx,120.541
f,8680,fx,177.106
f,8700,fx,177.106
f,8716,fx,177.106
f,8734,fx,159.751
f,8754,fx,81.9737
f,8770,fx,120.541
f,8792,fx,-89.007
f,8800,fx,-89.007
f,8824,fx,-89.007
f,8842,fx,-71.652
f,8862,fx,6.12493
f,8878,fx,-33.085
f,8896,fx,22.8374
f,8916,fx,22.8374
f,8932,fx,22.8374
f,8950,fx,6.12493
f,8970,fx,-71.652
f,8986,fx,-33.085
f,9008,fx,-243.28
f,9016,fx,-243.28
f,9040,fx,-243.28
f,9058,fx,-225.92
f,9078,fx,-148.14
f,9094,fx,-186.71
f,9112,fx,-130.79
f,9132,fx,-130.79
f,9148,fx,-130.79
f,9166,fx,-148.14
f,9186,fx,-225.92
f,9202,fx,-186.71
f,9224,fx,-396.9
f,9232,fx,-396.9
f,9256,fx,-396.9
f,9274,fx,-379.55
f,9294,fx,-301.77
f,9310,fx,-340.34
f,9328,fx,-284.41
f,9348,fx,-284.41
f,9364,fx,-284.41
f,9382,fx,-301.77
f,9402,fx,-379.55
f,9418,fx,-340.34
f,9440,fx,679.765
f,9448,fx,679.765
f,9472,fx,679.765
f,9490,fx,697.12
f,9510,fx,774.897
f,9526,fx,735.687
f,9544,fx,792.252
f,9564,fx,792.252
f,9580,fx,792.252
f,9598,fx,774.897
f,9618,fx,697.12
f,9634,fx,735.687
f,9656,fx,526.139
f,9664,fx,526.139
f,9688,fx,526.139
f,9706,fx,543.494
f,9726,fx,621.271
f,9742,fx,582.061
f,9760,fx,638.626
f,9780,fx,638.626
f,9796,fx,638.626
f,9814,fx,621.271
f,9834,fx,543.494
f,9850,fx,582.061
f,9872,fx,372.513
f,9880,fx,372.513
f,9904,fx,372.513
f,9922,fx,389.225
f,9942,fx,467.002
f,9958,fx,428.435
f,9976,fx,484.358
f,9996,fx,484.358
f,10012,fx,484.358
f,10030,fx,467.002
f,10050,fx,389.225
f,10066,fx,428.435
f,10088,fx,218.244
f,10096,fx,218.244
f,10120,fx,218.244
f,10138,fx,235.6
f,10158,fx,313.377
f,10174,fx,274.809
f,10192,fx,330.732
f,10212,fx,330.732
f,10228,fx,330.732
f,10246,fx,313.377
f,10266,fx,235.6
f,10282,fx,274.809
f,10304,fx,64.6184
f,10312,fx,64.6184
f,10336,fx,64.6184
f,10354,fx,81.9737

f,10374,fx,159.751
f,10390,fx,120.541
f,10408,fx,177.106
f,10428,fx,177.106
f,10444,fx,177.106
f,10462,fx,159.751
f,10482,fx,81.9737
f,10498,fx,120.541
f,10520,fx,-89.007
f,10528,fx,-89.007
f,10552,fx,-89.007
f,10570,fx,-71.652
f,10590,fx,6.12493
f,10606,fx,-33.085
f,10624,fx,22.8374
f,10644,fx,22.8374
f,10660,fx,22.8374
f,10678,fx,6.12493
f,10698,fx,-71.652
f,10714,fx,-33.085
f,10736,fx,-243.28
f,10744,fx,-243.28
f,10768,fx,-243.28
f,10786,fx,-225.92
f,10806,fx,-148.14
f,10822,fx,-186.71
f,10840,fx,-130.79
f,10860,fx,-130.79
f,10876,fx,-130.79
f,10894,fx,-148.14
f,10914,fx,-225.92
f,10930,fx,-186.71
f,10952,fx,-396.9
f,10960,fx,-396.9
f,10984,fx,-396.9
f,11002,fx,-379.55
f,11022,fx,-301.77
f,11038,fx,-340.34
f,11056,fx,-284.41
f,11076,fx,-284.41
f,11092,fx,-284.41
f,11110,fx,-301.77
f,11130,fx,-379.55
f,11146,fx,-340.34
f,11168,fx,679.765
f,11176,fx,679.765
f,11200,fx,679.765
f,11218,fx,697.12
f,11238,fx,774.897
f,11254,fx,735.687
f,11272,fx,792.252
f,11292,fx,792.252
f,11308,fx,792.252
f,11326,fx,774.897
f,11346,fx,697.12
f,11362,fx,735.687
f,11384,fx,526.139
f,11392,fx,526.139
f,11416,fx,526.139
f,11434,fx,543.494
f,11454,fx,621.271
f,11470,fx,582.061
f,11488,fx,638.626
f,11508,fx,638.626
f,11524,fx,638.626
f,11542,fx,621.271
f,11562,fx,543.494
f,11578,fx,582.061
f,11600,fx,372.513
f,11608,fx,372.513
f,11632,fx,372.513
f,11650,fx,389.225
f,11670,fx,467.002
f,11686,fx,428.435
f,11704,fx,484.358
f,11724,fx,484.358
f,11740,fx,484.358
f,11758,fx,467.002
f,11778,fx,389.225
f,11794,fx,428.435
f,11816,fx,218.244
f,11824,fx,218.244
f,11848,fx,218.244
f,11866,fx,235.6
f,11886,fx,313.377
f,11902,fx,274.809
f,11920,fx,330.732
f,11940,fx,330.732
f,11956,fx,330.732
f,11974,fx,313.377
f,11994,fx,235.6
f,12010,fx,274.809
f,12032,fx,64.6184
f,12040,fx,64.6184
f,12064,fx,64.6184
f,12082,fx,81.9737
f,12102,fx,159.751
f,12118,fx,120.541
f,12136,fx,177.106
f,12156,fx,177.106
f,12172,fx,177.106
f,12190,fx,159.751
f,12210,fx,81.9737
f,12226,fx,120.541
f,12248,fx,-89.007
f,12256,fx,-89.007
f,12280,fx,-89.007
f,12298,fx,-71.652
f,12318,fx,6.12493
f,12334,fx,-33.085
f,12352,fx,22.8374
f,12372,fx,22.8374
f,12388,fx,22.8374
f,12406,fx,6.12493
f,12426,fx,-71.652
f,12442,fx,-33.085
f,12464,fx,-243.28
f,12472,fx,-243.28
f,12496,fx,-243.28
f,12514,fx,-225.92
f,12534,fx,-148.14
f,12550,fx,-186.71
f,12568,fx,-130.79
f,12588,fx,-130.79
f,12604,fx,-130.79
f,12622,fx,-148.14
f,12642,fx,-225.92
f,12658,fx,-186.71
f,12680,fx,-396.9
f,12688,fx,-396.9
f,12712,fx,-396.9
f,12730,fx,-379.55
f,12750,fx,-301.77
f,12766,fx,-340.34
f,12784,fx,-284.41
f,12804,fx,-284.41
f,12820,fx,-284.41
f,12838,fx,-301.77
f,12858,fx,-379.55
f,12874,fx,-340.34
f,12896,fx,679.765
f,12904,fx,679.765
f,12928,fx,679.765
f,12946,fx,697.12
f,12966,fx,774.897
f,12982,fx,735.687
f,13000,fx,792.252
f,13020,fx,792.252
f,13036,fx,792.252
f,13054,fx,774.897
f,13074,fx,697.12
f,13090,fx,735.687
f,13112,fx,526.139
f,13120,fx,526.139
f,13144,fx,526.139
f,13162,fx,543.494
f,13182,fx,621.271
f,13198,fx,582.061
f,13216,fx,638.626
f,13236,fx,638.626
f,13252,fx,638.626
f,13270,fx,621.271
f,13290,fx,543.494
f,13306,fx,582.061
f,13328,fx,372.513
f,13336,fx,372.513
f,13360,fx,372.513
f,13378,fx,389.225
f,13398,fx,467.002
f,13414,fx,428.435
f,13432,fx,484.358
f,13452,fx,484.358
f,13468,fx,484.358
f,13486,fx,467.002
f,13506,fx,389.225
f,13522,fx,428.435
f,13544,fx,218.244
f,13552,fx,218.244
f,13576,fx,218.244
f,13594,fx,235.6
f,13614,fx,313.377
f,13630,fx,274.809
f,13648,fx,330.732
f,13668,fx,330.732
f,13684,fx,330.732
f,13702,fx,313.377
f,13722,fx,235.6
f,13738,fx,274.809
f,13760,fx,64.6184
f,13768,fx,64.6184
f,13792,fx,64.6184
f,13810,fx,81.9737
f,13830,fx,159.751
f,13846,fx,120.541
f,13864,fx,177.106
f,13884,fx,177.106
f,13900,fx,177.106
f,13918,fx,159.751
f,13938,fx,81.9737
f,13954,fx,120.541
f,13976,fx,-89.007
f,13984,fx,-89.007
f,14008,fx,-89.007
f,14026,fx,-71.652
f,14046,fx,6.12493
f,14062,fx,-33.085
f,14080,fx,22.8374
f,14100,fx,22.8374
f,14116,fx,22.8374
f,14134,fx,6.12493
f,14154,fx,-71.652
f,14170,fx,-33.085
f,14192,fx,-243.28
f,14200,fx,-243.28
f,14224,fx,-243.28
f,14242,fx,-225.92
f,14262,fx,-148.14
f,14278,fx,-186.71
f,14296,fx,-130.79
f,14316,fx,-130.79
f,14332,fx,-130.79
f,14350,fx,-148.14
f,14370,fx,-225.92
f,14386,fx,-186.71
f,14408,fx,-396.9
f,14416,fx,-396.9
f,14440,fx,-396.9
f,14458,fx,-379.55
f,14478,fx,-301.77
f,14494,fx,-340.34
f,14512,fx,-284.41
f,14532,fx,-284.41
f,14548,fx,-284.41
f,14566,fx,-301.77
f,14586,fx,-379.55
f,14602,fx,-340.34
f,14624,fx,679.765
f,14632,fx,679.765
f,14656,fx,679.765
f,14674,fx,697.12
f,14694,fx,774.897
f,14710,fx,735.687
f,14728,fx,792.252
f,14748,fx,792.252
f,14764,fx,792.252
f,14782,fx,774.897
f,14802,fx,697.12
f,14818,fx,735.687
f,14840,fx,526.139
f,14848,fx,526.139
f,14872,fx,526.139
f,14890,fx,543.494
f,14910,fx,621.271
f,14926,fx,582.061
f,14944,fx,638.626
f,14964,fx,638.626
f,14980,fx,638.626
f,14998,fx,621.271
f,15018,fx,543.494
f,15034,fx,582.061
f,15056,fx,372.513
f,15064,fx,372.513
f,15088,fx,372.513
f,15106,fx,389.225
f,15126,fx,467.002
f,15142,fx,428.435
f,15160,fx,484.358
f,15180,fx,484.358
f,15196,fx,484.358
f,15214,fx,467.002
f,15234,fx,389.225
f,15250,fx,428.435
f,15272,fx,218.244
f,15280,fx,218.244
f,15304,fx,218.244
f,15322,fx,235.6
f,15342,fx,313.377
f,15358,fx,274.809
f,15376,fx,330.732
f,15396,fx,330.732
f,15412,fx,330.732
f,15430,fx,313.377
f,15450,fx,235.6
f,15466,fx,274.809
f,15488,fx,64.6184
f,15496,fx,64.6184
f,15520,fx,64.6184
f,15538,fx,81.9737
f,15558,fx,159.751
f,15574,fx,120.541
f,15592,fx,177.106
f,15612,fx,177.106
f,15628,fx,177.106
f,15646,fx,159.751
f,15666,fx,81.9737
f,15682,fx,120.541
f,15704,fx,-89.007
f,15712,fx,-89.007
f,15736,fx,-89.007
f,15754,fx,-71.652
f,15774,fx,6.12493
f,15790,fx,-33.085
f,15808,fx,22.8374
f,15828,fx,22.8374
f,15844,fx,22.8374
f,15862,fx,6.12493
f,15882,fx,-71.652
f,15898,fx,-33.085
f,15920,fx,-243.28
f,15928,fx,-243.28
f,15952,fx,-243.28
f,15970,fx,-225.92
f,15990,fx,-148.14
f,16006,fx,-186.71
f,16024,fx,-130.79
f,16044,fx,-130.79
f,16060,fx,-130.79
f,16078,fx,-148.14
f,16098,fx,-225.92
f,16114,fx,-186.71
f,16136,fx,-396.9
f,16144,fx,-396.9
f,16168,fx,-396.9
f,16186,fx,-379.55
f,16206,fx,-301.77
f,16222,fx,-340.34
f,16240,fx,-284.41
f,16260,fx,-284.41
f,16276,fx,-284.41
f,16294,fx,-301.77
f,16314,fx,-379.55
f,16330,fx,-340.34

f,16352,fx,679.765
f,16360,fx,679.765
f,16384,fx,679.765
f,16402,fx,697.12
f,16422,fx,774.897
f,16438,fx,735.687
f,16456,fx,792.252
f,16476,fx,792.252
f,16492,fx,792.252
f,16510,fx,774.897
f,16530,fx,697.12
f,16546,fx,735.687
f,16568,fx,526.139
f,16576,fx,526.139
f,16600,fx,526.139
f,16618,fx,543.494
f,16638,fx,621.271
f,16654,fx,582.061
f,16672,fx,638.626
f,16692,fx,638.626
f,16708,fx,638.626
f,16726,fx,621.271
f,16746,fx,543.494
f,16762,fx,582.061
f,16784,fx,372.513
f,16792,fx,372.513
f,16816,fx,372.513
f,16834,fx,389.225
f,16854,fx,467.002
f,16870,fx,428.435
f,16888,fx,484.358
f,16908,fx,484.358
f,16924,fx,484.358
f,16942,fx,467.002
f,16962,fx,389.225
f,16978,fx,428.435
f,17000,fx,218.244
f,17008,fx,218.244
f,17032,fx,218.244
f,17050,fx,235.6
f,17070,fx,313.377
f,17086,fx,274.809
f,17104,fx,330.732
f,17124,fx,330.732
f,17140,fx,330.732
f,17158,fx,313.377
f,17178,fx,235.6
f,17194,fx,274.809
f,17216,fx,64.6184
f,17224,fx,64.6184
f,17248,fx,64.6184
f,17266,fx,81.9737
f,17286,fx,159.751
f,17302,fx,120.541
f,17320,fx,177.106
f,17340,fx,177.106
f,17356,fx,177.106
f,17374,fx,159.751
f,17394,fx,81.9737
f,17410,fx,120.541
f,17432,fx,-89.007
f,17440,fx,-89.007
f,17464,fx,-89.007
f,17482,fx,-71.652
f,17502,fx,6.12493
f,17518,fx,-33.085
f,17536,fx,22.8374
f,17556,fx,22.8374
f,17572,fx,22.8374
f,17590,fx,6.12493
f,17610,fx,-71.652
f,17626,fx,-33.085
f,17648,fx,-243.28
f,17656,fx,-243.28
f,17680,fx,-243.28
f,17698,fx,-225.92
f,17718,fx,-148.14
f,17734,fx,-186.71
f,17752,fx,-130.79
f,17772,fx,-130.79
f,17788,fx,-130.79
f,17806,fx,-148.14
f,17826,fx,-225.92
f,17842,fx,-186.71
f,17864,fx,-396.9
f,17872,fx,-396.9
f,17896,fx,-396.9
f,17914,fx,-379.55
f,17934,fx,-301.77
f,17950,fx,-340.34
f,17968,fx,-284.41
f,17968,fx,-284.41
f,18004,fx,-284.41
f,18022,fx,-301.77
f,18042,fx,-379.55
f,18058,fx,-340.34
f,18080,fx,679.765
f,18088,fx,679.765
f,18112,fx,679.765
f,18130,fx,697.12
f,18150,fx,774.897
f,18166,fx,735.687
f,18184,fx,792.252
f,18204,fx,792.252
f,18220,fx,792.252
f,18238,fx,774.897
f,18258,fx,697.12
f,18274,fx,735.687
f,18296,fx,526.139
f,18304,fx,526.139
f,18328,fx,526.139
f,18346,fx,543.494
f,18366,fx,621.271
f,18382,fx,582.061
f,18400,fx,638.626
f,18420,fx,638.626
f,18436,fx,638.626
f,18454,fx,621.271
f,18474,fx,543.494
f,18490,fx,582.061
f,18512,fx,372.513
f,18520,fx,372.513
f,18544,fx,372.513
f,18562,fx,389.225
f,18582,fx,467.002
f,18598,fx,428.435
f,18616,fx,484.358
f,18636,fx,484.358
f,18652,fx,484.358
f,18670,fx,467.002
f,18690,fx,389.225
f,18706,fx,428.435
f,18728,fx,218.244
f,18736,fx,218.244
f,18760,fx,218.244
f,18778,fx,235.6
f,18798,fx,313.377
f,18814,fx,274.809
f,18832,fx,330.732
f,18852,fx,330.732
f,18868,fx,330.732
f,18886,fx,313.377
f,18906,fx,235.6
f,18922,fx,274.809
f,18944,fx,64.6184
f,18952,fx,64.6184
f,18976,fx,64.6184
f,18994,fx,81.9737
f,19014,fx,159.751
f,19030,fx,120.541
f,19048,fx,177.106
f,19068,fx,177.106
f,19084,fx,177.106
f,19102,fx,159.751
f,19122,fx,81.9737
f,19138,fx,120.541
f,19160,fx,-89.007
f,19168,fx,-89.007
f,19192,fx,-89.007
f,19210,fx,-71.652
f,19230,fx,6.12493
f,19246,fx,-33.085
f,19264,fx,22.8374
f,19284,fx,22.8374
f,19300,fx,22.8374
f,19318,fx,6.12493
f,19338,fx,-71.652
f,19354,fx,-33.085
f,19376,fx,-243.28
f,19384,fx,-243.28
f,19408,fx,-243.28
f,19426,fx,-225.92
f,19446,fx,-148.14
f,19462,fx,-186.71
f,19480,fx,-130.79
f,19500,fx,-130.79
f,19516,fx,-130.79
f,19534,fx,-148.14
f,19554,fx,-225.92
f,19570,fx,-186.71
f,19592,fx,-396.9
f,19600,fx,-396.9
f,19624,fx,-396.9
f,19642,fx,-379.55
f,19662,fx,-301.77
f,19678,fx,-340.34
f,19696,fx,-284.41
f,19716,fx,-284.41
f,19732,fx,-284.41
f,19750,fx,-301.77
f,19770,fx,-379.55
f,19786,fx,-340.34
f,19808,fx,679.765
f,19816,fx,679.765
f,19840,fx,679.765
f,19858,fx,697.12
f,19878,fx,774.897
f,19894,fx,735.687
f,19912,fx,792.252
f,19932,fx,792.252
f,19948,fx,792.252
f,19966,fx,774.897
f,19986,fx,697.12
f,20002,fx,735.687
f,20024,fx,526.139
f,20032,fx,526.139
f,20056,fx,526.139
f,20074,fx,543.494
f,20094,fx,621.271
f,20110,fx,582.061
f,20128,fx,638.626
f,20148,fx,638.626
f,20164,fx,638.626
f,20182,fx,621.271
f,20202,fx,543.494
f,20218,fx,582.061
f,20240,fx,372.513
f,20248,fx,372.513
f,20272,fx,372.513
f,20290,fx,389.225
f,20310,fx,467.002
f,20326,fx,428.435
f,20344,fx,484.358
f,20364,fx,484.358
f,20380,fx,484.358
f,20398,fx,467.002
f,20418,fx,389.225
f,20434,fx,428.435
f,20456,fx,218.244
f,20464,fx,218.244
f,20488,fx,218.244
f,20506,fx,235.6
f,20526,fx,313.377
f,20542,fx,274.809
f,20560,fx,330.732
f,20580,fx,330.732
f,20596,fx,330.732
f,20614,fx,313.377
f,20634,fx,235.6
f,20650,fx,274.809
f,20672,fx,64.6184
f,20680,fx,64.6184
f,20704,fx,64.6184
f,20722,fx,81.9737
f,20742,fx,159.751
f,20758,fx,120.541
f,20776,fx,177.106
f,20796,fx,177.106
f,20812,fx,177.106
f,20830,fx,159.751
f,20850,fx,81.9737
f,20866,fx,120.541
f,20888,fx,-89.007
f,20896,fx,-89.007
f,20920,fx,-89.007
f,20938,fx,-71.652
f,20958,fx,6.12493
f,20974,fx,-33.085
f,20992,fx,22.8374
f,21012,fx,22.8374
f,21028,fx,22.8374
f,21046,fx,6.12493
f,21066,fx,-71.652
f,21082,fx,-33.085
f,21104,fx,-243.28
f,21112,fx,-243.28
f,21136,fx,-243.28
f,21154,fx,-225.92
f,21174,fx,-148.14
f,21190,fx,-186.71
f,21208,fx,-130.79
f,21228,fx,-130.79
f,21244,fx,-130.79
f,21262,fx,-148.14
f,21282,fx,-225.92
f,21298,fx,-186.71
f,21320,fx,-396.9
f,21328,fx,-396.9
f,21352,fx,-396.9
f,21370,fx,-379.55
f,21390,fx,-301.77
f,21406,fx,-340.34
f,21424,fx,-284.41
f,21444,fx,-284.41
f,21460,fx,-284.41
f,21478,fx,-301.77
f,21498,fx,-379.55
f,21514,fx,-340.34
f,21536,fx,679.765
f,21544,fx,679.765
f,21568,fx,679.765
f,21586,fx,697.12
f,21606,fx,774.897
f,21622,fx,735.687
f,21640,fx,792.252
f,21660,fx,792.252
f,21676,fx,792.252
f,21694,fx,774.897
f,21714,fx,697.12
f,21730,fx,735.687
f,21752,fx,526.139
f,21760,fx,526.139
f,21784,fx,526.139
f,21802,fx,543.494
f,21822,fx,621.271
f,21838,fx,582.061
f,21856,fx,638.626
f,21876,fx,638.626
f,21892,fx,638.626
f,21910,fx,621.271
f,21930,fx,543.494
f,21946,fx,582.061
f,21968,fx,372.513
f,21976,fx,372.513
f,22000,fx,372.513
f,22018,fx,389.225
f,22038,fx,467.002
f,22054,fx,428.435
f,22072,fx,484.358
f,22092,fx,484.358
f,22108,fx,484.358
f,22126,fx,467.002
f,22146,fx,389.225
f,22162,fx,428.435
f,22184,fx,218.244
f,22192,fx,218.244
f,22216,fx,218.244
f,22234,fx,235.6
f,22254,fx,313.377
f,22270,fx,274.809
f,22288,fx,330.732
f,22308,fx,330.732

f,22324,fx,330.732
f,22342,fx,313.377
f,22362,fx,235.6
f,22378,fx,274.809
f,22400,fx,64.6184
f,22408,fx,64.6184
f,22432,fx,64.6184
f,22450,fx,81.9737
f,22470,fx,159.751
f,22486,fx,120.541
f,22504,fx,177.106
f,22524,fx,177.106
f,22540,fx,177.106
f,22558,fx,159.751
f,22578,fx,81.9737
f,22594,fx,120.541
f,22616,fx,-89.007
f,22624,fx,-89.007
f,22648,fx,-89.007
f,22666,fx,-71.652
f,22686,fx,6.12493
f,22702,fx,-33.085
f,22720,fx,22.8374
f,22740,fx,22.8374
f,22756,fx,22.8374
f,22774,fx,6.12493
f,22794,fx,-71.652
f,22810,fx,-33.085
f,22832,fx,-243.28
f,22840,fx,-243.28
f,22864,fx,-243.28
f,22882,fx,-225.92
f,22902,fx,-148.14
f,22918,fx,-186.71
f,22936,fx,-130.79
f,22956,fx,-130.79
f,22972,fx,-130.79
f,22990,fx,-148.14
f,23010,fx,-225.92
f,23026,fx,-186.71
f,23048,fx,-396.9
f,23056,fx,-396.9
f,23080,fx,-396.9
f,23098,fx,-379.55
f,23118,fx,-301.77
f,23134,fx,-340.34
f,23152,fx,-284.41
f,23172,fx,-284.41
f,23188,fx,-284.41
f,23206,fx,-301.77
f,23226,fx,-379.55
f,23242,fx,-340.34
f,23264,fx,679.765
f,23272,fx,679.765
f,23296,fx,679.765
f,23314,fx,697.12
f,23334,fx,774.897
f,23350,fx,735.687
f,23368,fx,792.252
f,23388,fx,792.252
f,23404,fx,792.252
f,23422,fx,774.897
f,23442,fx,697.12
f,23458,fx,735.687
f,23480,fx,526.139
f,23488,fx,526.139
f,23512,fx,526.139
f,23530,fx,543.494
f,23550,fx,621.271
f,23566,fx,582.061
f,23584,fx,638.626
f,23604,fx,638.626
f,23620,fx,638.626
f,23638,fx,621.271
f,23658,fx,543.494
f,23674,fx,582.061
f,23696,fx,372.513
f,23704,fx,372.513
f,23728,fx,372.513
f,23746,fx,389.225
f,23766,fx,467.002
f,23782,fx,428.435
f,23800,fx,484.358
f,23820,fx,484.358
f,23836,fx,484.358
f,23854,fx,467.002
f,23874,fx,389.225
f,23890,fx,428.435
f,23912,fx,218.244
f,23920,fx,218.244
f,23944,fx,218.244
f,23962,fx,235.6
f,23982,fx,313.377
f,23998,fx,274.809
f,24016,fx,330.732
f,24036,fx,330.732
f,24052,fx,330.732
f,24070,fx,313.377
f,24090,fx,235.6
f,24106,fx,274.809
f,24128,fx,64.6184
f,24136,fx,64.6184
f,24160,fx,64.6184
f,24178,fx,81.9737
f,24198,fx,159.751
f,24214,fx,120.541
f,24232,fx,177.106
f,24252,fx,177.106
f,24268,fx,177.106
f,24286,fx,159.751
f,24306,fx,81.9737
f,24322,fx,120.541
f,24344,fx,-89.007
f,24352,fx,-89.007
f,24376,fx,-89.007
f,24394,fx,-71.652
f,24414,fx,6.12493
f,24430,fx,-33.085
f,24448,fx,22.8374
f,24468,fx,22.8374
f,24484,fx,22.8374
f,24502,fx,6.12493
f,24522,fx,-71.652
f,24538,fx,-33.085
f,24560,fx,-243.28
f,24568,fx,-243.28
f,24592,fx,-243.28
f,24610,fx,-225.92
f,24630,fx,-148.14
f,24646,fx,-186.71
f,24664,fx,-130.79
f,24684,fx,-130.79
f,24700,fx,-130.79
f,24718,fx,-148.14
f,24738,fx,-225.92
f,24754,fx,-186.71
f,24776,fx,-396.9
f,24784,fx,-396.9
f,24808,fx,-396.9
f,24826,fx,-379.55
f,24846,fx,-301.77
f,24862,fx,-340.34
f,24880,fx,-284.41
f,24900,fx,-284.41
f,24916,fx,-284.41
f,24934,fx,-301.77
f,24954,fx,-379.55
f,24970,fx,-340.34
f,24992,fx,679.765
f,25000,fx,679.765
f,25024,fx,679.765
f,25042,fx,697.12
f,25062,fx,774.897
f,25078,fx,735.687
f,25096,fx,792.252
f,25116,fx,792.252
f,25132,fx,792.252
f,25150,fx,774.897
f,25170,fx,697.12
f,25186,fx,735.687
f,25208,fx,526.139
f,25216,fx,526.139
f,25240,fx,526.139
f,25258,fx,543.494
f,25278,fx,621.271
f,25294,fx,582.061
f,25312,fx,638.626
f,25332,fx,638.626
f,25348,fx,638.626
f,25366,fx,621.271
f,25386,fx,543.494
f,25402,fx,582.061
f,25424,fx,372.513
f,25432,fx,372.513
f,25456,fx,372.513
f,25474,fx,389.225
f,25494,fx,467.002
f,25510,fx,428.435
f,25528,fx,484.358
f,25548,fx,484.358
f,25564,fx,484.358
f,25582,fx,467.002
f,25602,fx,389.225
f,25618,fx,428.435
f,25640,fx,218.244
f,25648,fx,218.244
f,25672,fx,218.244
f,25690,fx,235.6
f,25710,fx,313.377
f,25726,fx,274.809
f,25744,fx,330.732
f,25764,fx,330.732
f,25780,fx,330.732
f,25798,fx,313.377
f,25818,fx,235.6
f,25834,fx,274.809
f,25856,fx,64.6184
f,25864,fx,64.6184
f,25888,fx,64.6184
f,25906,fx,81.9737
f,25926,fx,159.751
f,25942,fx,120.541
f,25960,fx,177.106
f,25980,fx,177.106
f,25996,fx,177.106
f,26014,fx,159.751
f,26034,fx,81.9737
f,26050,fx,120.541
f,26072,fx,-89.007
f,26080,fx,-89.007
f,26104,fx,-89.007
f,26122,fx,-71.652
f,26142,fx,6.12493
f,26158,fx,-33.085
f,26176,fx,22.8374
f,26196,fx,22.8374
f,26212,fx,22.8374
f,26230,fx,6.12493
f,26250,fx,-71.652
f,26266,fx,-33.085
f,26288,fx,-243.28
f,26296,fx,-243.28
f,26320,fx,-243.28
f,26338,fx,-225.92
f,26358,fx,-148.14
f,26374,fx,-186.71
f,26392,fx,-130.79
f,26412,fx,-130.79
f,26428,fx,-130.79
f,26446,fx,-148.14
f,26466,fx,-225.92
f,26482,fx,-186.71
f,26504,fx,-396.9
f,26512,fx,-396.9
f,26536,fx,-396.9
f,26554,fx,-379.55
f,26574,fx,-301.77
f,26590,fx,-340.34
f,26608,fx,-284.41
f,26628,fx,-284.41
f,26644,fx,-284.41
f,26662,fx,-301.77
f,26682,fx,-379.55
f,26698,fx,-340.34
f,26720,fx,679.765
f,26728,fx,679.765
f,26752,fx,679.765
f,26770,fx,697.12
f,26790,fx,774.897
f,26806,fx,735.687
f,26824,fx,792.252
f,26844,fx,792.252
f,26860,fx,792.252
f,26878,fx,774.897
f,26898,fx,697.12
f,26914,fx,735.687
f,26936,fx,526.139
f,26944,fx,526.139
f,26968,fx,526.139
f,26986,fx,543.494
f,27006,fx,621.271
f,27022,fx,582.061
f,27040,fx,638.626
f,27060,fx,638.626
f,27076,fx,638.626
f,27094,fx,621.271
f,27114,fx,543.494
f,27130,fx,582.061
f,27152,fx,372.513
f,27160,fx,372.513
f,27184,fx,372.513
f,27202,fx,389.225
f,27222,fx,467.002
f,27238,fx,428.435
f,27256,fx,484.358
f,27276,fx,484.358
f,27292,fx,484.358
f,27310,fx,467.002
f,27330,fx,389.225
f,27346,fx,428.435
f,27368,fx,218.244
f,27376,fx,218.244
f,27400,fx,218.244
f,27418,fx,235.6
f,27438,fx,313.377
f,27454,fx,274.809
f,27472,fx,330.732
f,27492,fx,330.732
f,27508,fx,330.732
f,27526,fx,313.377
f,27546,fx,235.6
f,27562,fx,274.809
f,27584,fx,64.6184
f,27592,fx,64.6184
f,27616,fx,64.6184
f,27634,fx,81.9737
f,27654,fx,159.751
f,27670,fx,120.541
f,27688,fx,177.106
f,27708,fx,177.106
f,27724,fx,177.106
f,27742,fx,159.751
f,27762,fx,81.9737
f,27778,fx,120.541
f,27800,fx,-89.007
f,27808,fx,-89.007
f,27832,fx,-89.007
f,27850,fx,-71.652
f,27870,fx,6.12493
f,27886,fx,-33.085
f,27904,fx,22.8374
f,27924,fx,22.8374
f,27940,fx,22.8374
f,27958,fx,6.12493
f,27978,fx,-71.652
f,27994,fx,-33.085
f,28016,fx,-243.28
f,28024,fx,-243.28
f,28048,fx,-243.28
f,28066,fx,-225.92
f,28086,fx,-148.14
f,28102,fx,-186.71
f,28120,fx,-130.79
f,28140,fx,-130.79
f,28156,fx,-130.79
f,28174,fx,-148.14
f,28194,fx,-225.92
f,28210,fx,-186.71
f,28232,fx,-396.9
f,28240,fx,-396.9
f,28264,fx,-396.9
f,28282,fx,-379.55

f,28302,fx,-301.77
f,28318,fx,-340.34
f,28336,fx,-284.41
f,28356,fx,-284.41
f,28372,fx,-284.41
f,28390,fx,-301.77
f,28410,fx,-379.55
f,28426,fx,-340.34
f,28448,fx,679.765
f,28456,fx,679.765
f,28480,fx,679.765
f,28498,fx,697.12
f,28518,fx,774.897
f,28534,fx,735.687
f,28552,fx,792.252
f,28572,fx,792.252
f,28588,fx,792.252
f,28606,fx,774.897
f,28626,fx,697.12
f,28642,fx,735.687
f,28664,fx,526.139
f,28672,fx,526.139
f,28696,fx,526.139
f,28714,fx,543.494
f,28734,fx,621.271
f,28750,fx,582.061
f,28768,fx,638.626
f,28788,fx,638.626
f,28804,fx,638.626
f,28822,fx,621.271
f,28842,fx,543.494
f,28858,fx,582.061
f,28880,fx,372.513
f,28888,fx,372.513
f,28912,fx,372.513
f,28930,fx,389.225
f,28950,fx,467.002
f,28966,fx,428.435
f,28984,fx,484.358
f,29004,fx,484.358
f,29020,fx,484.358
f,29038,fx,467.002
f,29058,fx,389.225
f,29074,fx,428.435
f,29096,fx,218.244
f,29104,fx,218.244
f,29128,fx,218.244
f,29146,fx,235.6
f,29166,fx,313.377
f,29182,fx,274.809
f,29200,fx,330.732
f,29220,fx,330.732
f,29236,fx,330.732
f,29254,fx,313.377
f,29274,fx,235.6
f,29290,fx,274.809
f,29312,fx,64.6184
f,29320,fx,64.6184
f,29344,fx,64.6184
f,29362,fx,81.9737
f,29382,fx,159.751
f,29398,fx,120.541
f,29416,fx,177.106
f,29436,fx,177.106
f,29452,fx,177.106
f,29470,fx,159.751
f,29490,fx,81.9737
f,29506,fx,120.541
f,29528,fx,-89.007
f,29536,fx,-89.007
f,29560,fx,-89.007
f,29578,fx,-71.652
f,29598,fx,6.12493
f,29614,fx,-33.085
f,29632,fx,22.8374
f,29652,fx,22.8374
f,29668,fx,22.8374
f,29686,fx,6.12493
f,29706,fx,-71.652
f,29722,fx,-33.085
f,29744,fx,-243.28
f,29752,fx,-243.28
f,29776,fx,-243.28
f,29794,fx,-225.92
f,29814,fx,-148.14
f,29830,fx,-186.71
f,29848,fx,-130.79
f,29868,fx,-130.79
f,29884,fx,-130.79
f,29902,fx,-148.14
f,29922,fx,-225.92
f,29938,fx,-186.71
f,29960,fx,-396.9
f,29968,fx,-396.9
f,29992,fx,-396.9
f,30010,fx,-379.55
f,30030,fx,-301.77
f,30046,fx,-340.34
f,30064,fx,-284.41
f,30084,fx,-284.41
f,30100,fx,-284.41
f,30118,fx,-301.77
f,30138,fx,-379.55
f,30154,fx,-340.34
f,30176,fx,679.765
f,30184,fx,679.765
f,30208,fx,679.765
f,30226,fx,697.12
f,30246,fx,774.897
f,30262,fx,735.687
f,30280,fx,792.252
f,30300,fx,792.252
f,30316,fx,792.252
f,30334,fx,774.897
f,30354,fx,697.12
f,30370,fx,735.687
f,30392,fx,526.139
f,30400,fx,526.139
f,30424,fx,526.139
f,30442,fx,543.494
f,30462,fx,621.271
f,30478,fx,582.061
f,30496,fx,638.626
f,30516,fx,638.626
f,30532,fx,638.626
f,30550,fx,621.271
f,30570,fx,543.494
f,30586,fx,582.061
f,30608,fx,372.513
f,30616,fx,372.513
f,30640,fx,372.513
f,30658,fx,389.225
f,30678,fx,467.002
f,30694,fx,428.435
f,30712,fx,484.358
f,30732,fx,484.358
f,30748,fx,484.358
f,30766,fx,467.002
f,30786,fx,389.225
f,30802,fx,428.435
f,30824,fx,218.244
f,30832,fx,218.244
f,30856,fx,218.244
f,30874,fx,235.6
f,30894,fx,313.377
f,30910,fx,274.809
f,30928,fx,330.732
f,30948,fx,330.732
f,30964,fx,330.732
f,30982,fx,313.377
f,31002,fx,235.6
f,31018,fx,274.809
f,31040,fx,64.6184
f,31048,fx,64.6184
f,31072,fx,64.6184
f,31090,fx,81.9737
f,31110,fx,159.751
f,31126,fx,120.541
f,31144,fx,177.106
f,31164,fx,177.106
f,31180,fx,177.106
f,31198,fx,159.751
f,31218,fx,81.9737
f,31234,fx,120.541
f,31256,fx,-89.007
f,31264,fx,-89.007
f,31288,fx,-89.007
f,31306,fx,-71.652
f,31326,fx,6.12493
f,31342,fx,-33.085
f,31360,fx,22.8374
f,31380,fx,22.8374
f,31396,fx,22.8374
f,31414,fx,6.12493
f,31434,fx,-71.652
f,31450,fx,-33.085
f,31472,fx,-243.28
f,31480,fx,-243.28
f,31504,fx,-243.28
f,31522,fx,-225.92
f,31542,fx,-148.14
f,31558,fx,-186.71
f,31576,fx,-130.79
f,31596,fx,-130.79
f,31612,fx,-130.79
f,31630,fx,-148.14
f,31650,fx,-225.92
f,31666,fx,-186.71
f,31688,fx,-396.9
f,31696,fx,-396.9
f,31720,fx,-396.9
f,31738,fx,-379.55
f,31758,fx,-301.77
f,31774,fx,-340.34
f,31792,fx,-284.41
f,31812,fx,-284.41
f,31828,fx,-284.41
f,31846,fx,-301.77
f,31866,fx,-379.55
f,31882,fx,-340.34
f,31904,fx,679.765
f,31912,fx,679.765
f,31936,fx,679.765
f,31954,fx,697.12
f,31974,fx,774.897
f,31990,fx,735.687
f,32008,fx,792.252
f,32028,fx,792.252
f,32044,fx,792.252
f,32062,fx,774.897
f,32082,fx,697.12
f,32098,fx,735.687
f,32120,fx,526.139
f,32128,fx,526.139
f,32152,fx,526.139
f,32170,fx,543.494
f,32190,fx,621.271
f,32206,fx,582.061
f,32224,fx,638.626
f,32244,fx,638.626
f,32260,fx,638.626
f,32278,fx,621.271
f,32298,fx,543.494
f,32314,fx,582.061
f,32336,fx,372.513
f,32344,fx,372.513
f,32368,fx,372.513
f,32386,fx,389.225
f,32406,fx,467.002
f,32422,fx,428.435
f,32440,fx,484.358
f,32460,fx,484.358
f,32476,fx,484.358
f,32494,fx,467.002
f,32514,fx,389.225
f,32530,fx,428.435
f,32552,fx,218.244
f,32560,fx,218.244
f,32584,fx,218.244
f,32602,fx,235.6
f,32622,fx,313.377
f,32638,fx,274.809
f,32656,fx,330.732
f,32676,fx,330.732
f,32692,fx,330.732
f,32710,fx,313.377
f,32730,fx,235.6
f,32746,fx,274.809
f,32768,fx,64.6184
f,32776,fx,64.6184
f,32800,fx,64.6184
f,32818,fx,81.9737
f,32838,fx,159.751
f,32854,fx,120.541
f,32872,fx,177.106
f,32892,fx,177.106
f,32908,fx,177.106
f,32926,fx,159.751
f,32946,fx,81.9737
f,32962,fx,120.541
f,32984,fx,-89.007
f,32992,fx,-89.007
f,33016,fx,-89.007
f,33034,fx,-71.652
f,33054,fx,6.12493
f,33070,fx,-33.085
f,33088,fx,22.8374
f,33108,fx,22.8374
f,33124,fx,22.8374
f,33142,fx,6.12493
f,33162,fx,-71.652
f,33178,fx,-33.085
f,33200,fx,-243.28
f,33208,fx,-243.28
f,33232,fx,-243.28
f,33250,fx,-225.92
f,33270,fx,-148.14
f,33286,fx,-186.71
f,33304,fx,-130.79
f,33324,fx,-130.79
f,33340,fx,-130.79
f,33358,fx,-148.14
f,33378,fx,-225.92
f,33394,fx,-186.71
f,33416,fx,-396.9
f,33424,fx,-396.9
f,33448,fx,-396.9
f,33466,fx,-379.55
f,33486,fx,-301.77
f,33502,fx,-340.34
f,33520,fx,-284.41
f,33540,fx,-284.41
f,33556,fx,-284.41
f,33574,fx,-301.77
f,33594,fx,-379.55
f,33610,fx,-340.34
f,5985,fx,676.789
f,5993,fx,676.789
f,6017,fx,676.789
f,6035,fx,694.144
f,6055,fx,771.921
f,6071,fx,732.711
f,6089,fx,789.277
f,6109,fx,789.277
f,6125,fx,789.277
f,6143,fx,771.921
f,6163,fx,694.144
f,6179,fx,732.711
f,6201,fx,523.163
f,6209,fx,523.163
f,6233,fx,523.163
f,6251,fx,540.518
f,6271,fx,618.295
f,6287,fx,579.086
f,6305,fx,635.651
f,6325,fx,635.651
f,6341,fx,635.651
f,6359,fx,618.295
f,6379,fx,540.518
f,6395,fx,579.086
f,6417,fx,369.537
f,6425,fx,369.537
f,6449,fx,369.537
f,6467,fx,386.25
f,6487,fx,464.027
f,6503,fx,425.46
f,6521,fx,481.382
f,6541,fx,481.382
f,6557,fx,481.382
f,6575,fx,464.027
f,6595,fx,386.25
f,6611,fx,425.46

f,6633,fx,215.269
f,6641,fx,215.269
f,6665,fx,215.269
f,6683,fx,232.624
f,6703,fx,310.401
f,6719,fx,271.834
f,6737,fx,327.756
f,6757,fx,327.756
f,6773,fx,327.756
f,6791,fx,310.401
f,6811,fx,232.624
f,6827,fx,271.834
f,6849,fx,61.6428
f,6857,fx,61.6428
f,6881,fx,61.6428
f,6899,fx,78.9981
f,6919,fx,156.775
f,6935,fx,117.565
f,6953,fx,174.13
f,6973,fx,174.13
f,6989,fx,174.13
f,7007,fx,156.775
f,7027,fx,78.9981
f,7043,fx,117.565
f,7065,fx,-91.983
f,7073,fx,-91.983
f,7097,fx,-91.983
f,7115,fx,-74.628
f,7135,fx,3.14932
f,7151,fx,-36.061
f,7169,fx,19.8618
f,7189,fx,19.8618
f,7205,fx,19.8618
f,7223,fx,3.14932
f,7243,fx,-74.628
f,7259,fx,-36.061
f,7281,fx,-246.25
f,7289,fx,-246.25
f,7313,fx,-246.25
f,7331,fx,-228.9
f,7351,fx,-151.12
f,7367,fx,-189.69
f,7385,fx,-133.76
f,7405,fx,-133.76
f,7421,fx,-133.76
f,7439,fx,-151.12
f,7459,fx,-228.9
f,7475,fx,-189.69
f,7497,fx,-399.88
f,7505,fx,-399.88
f,7529,fx,-399.88
f,7547,fx,-382.52
f,7567,fx,-304.75
f,7583,fx,-343.31
f,7601,fx,-287.39
f,7621,fx,-287.39
f,7637,fx,-287.39
f,7655,fx,-304.75
f,7675,fx,-382.52
f,7691,fx,-343.31
f,7713,fx,676.789
f,7721,fx,676.789
f,7745,fx,676.789
f,7763,fx,694.144
f,7783,fx,771.921
f,7799,fx,732.711
f,7817,fx,789.277
f,7837,fx,789.277
f,7853,fx,789.277
f,7871,fx,771.921
f,7891,fx,694.144
f,7907,fx,732.711
f,7929,fx,523.163
f,7937,fx,523.163
f,7961,fx,523.163
f,7979,fx,540.518
f,7999,fx,618.295
f,8015,fx,579.086
f,8033,fx,635.651
f,8053,fx,635.651
f,8069,fx,635.651
f,8087,fx,618.295
f,8107,fx,540.518
f,8123,fx,579.086
f,8145,fx,369.537
f,8153,fx,369.537
f,8177,fx,369.537
f,8195,fx,386.25
f,8215,fx,464.027
f,8231,fx,425.46
f,8249,fx,481.382
f,8269,fx,481.382
f,8285,fx,481.382
f,8303,fx,464.027
f,8323,fx,386.25
f,8339,fx,425.46
f,8361,fx,215.269
f,8369,fx,215.269
f,8393,fx,215.269
f,8411,fx,232.624
f,8431,fx,310.401
f,8447,fx,271.834
f,8465,fx,327.756
f,8485,fx,327.756
f,8501,fx,327.756
f,8519,fx,310.401
f,8539,fx,232.624
f,8555,fx,271.834
f,8577,fx,61.6428
f,8585,fx,61.6428
f,8609,fx,61.6428
f,8627,fx,78.9981
f,8647,fx,156.775
f,8663,fx,117.565
f,8681,fx,174.13
f,8701,fx,174.13
f,8717,fx,174.13
f,8735,fx,156.775
f,8755,fx,78.9981
f,8771,fx,117.565
f,8793,fx,-91.983
f,8801,fx,-91.983
f,8825,fx,-91.983
f,8843,fx,-74.628
f,8863,fx,3.14932
f,8879,fx,-36.061
f,8897,fx,19.8618
f,8917,fx,19.8618
f,8933,fx,19.8618
f,8951,fx,3.14932
f,8971,fx,-74.628
f,8987,fx,-36.061
f,9009,fx,-246.25
f,9017,fx,-246.25
f,9041,fx,-246.25
f,9059,fx,-228.9
f,9079,fx,-151.12
f,9095,fx,-189.69
f,9113,fx,-133.76
f,9133,fx,-133.76
f,9149,fx,-133.76
f,9167,fx,-151.12
f,9187,fx,-228.9
f,9203,fx,-189.69
f,9225,fx,-399.88
f,9233,fx,-399.88
f,9257,fx,-399.88
f,9275,fx,-382.52
f,9295,fx,-304.75
f,9311,fx,-343.31
f,9329,fx,-287.39
f,9349,fx,-287.39
f,9365,fx,-287.39
f,9383,fx,-304.75
f,9403,fx,-382.52
f,9419,fx,-343.31
f,9441,fx,676.789
f,9449,fx,676.789
f,9473,fx,676.789
f,9491,fx,694.144
f,9511,fx,771.921
f,9527,fx,732.711
f,9545,fx,789.277
f,9565,fx,789.277
f,9581,fx,789.277
f,9599,fx,771.921
f,9619,fx,694.144
f,9635,fx,732.711
f,9657,fx,523.163
f,9665,fx,523.163
f,9689,fx,523.163
f,9707,fx,540.518
f,9727,fx,618.295
f,9743,fx,579.086
f,9761,fx,635.651
f,9781,fx,635.651
f,9797,fx,635.651
f,9815,fx,618.295
f,9835,fx,540.518
f,9851,fx,579.086
f,9873,fx,369.537
f,9881,fx,369.537
f,9905,fx,369.537
f,9923,fx,386.25
f,9943,fx,464.027
f,9959,fx,425.46
f,9977,fx,481.382
f,9997,fx,481.382
f,10013,fx,481.382
f,10031,fx,464.027
f,10051,fx,386.25
f,10067,fx,425.46
f,10089,fx,215.269
f,10097,fx,215.269
f,10121,fx,215.269
f,10139,fx,232.624
f,10159,fx,310.401
f,10175,fx,271.834
f,10193,fx,327.756
f,10213,fx,327.756
f,10229,fx,327.756
f,10247,fx,310.401
f,10267,fx,232.624
f,10283,fx,271.834
f,10305,fx,61.6428
f,10313,fx,61.6428
f,10337,fx,61.6428
f,10355,fx,78.9981
f,10375,fx,156.775
f,10391,fx,117.565
f,10409,fx,174.13
f,10429,fx,174.13
f,10445,fx,174.13
f,10463,fx,156.775
f,10483,fx,78.9981
f,10499,fx,117.565
f,10521,fx,-91.983
f,10529,fx,-91.983
f,10553,fx,-91.983
f,10571,fx,-74.628
f,10591,fx,3.14932
f,10607,fx,-36.061
f,10625,fx,19.8618
f,10645,fx,19.8618
f,10661,fx,19.8618
f,10679,fx,3.14932
f,10699,fx,-74.628
f,10715,fx,-36.061
f,10737,fx,-246.25
f,10745,fx,-246.25
f,10769,fx,-246.25
f,10787,fx,-228.9
f,10807,fx,-151.12
f,10823,fx,-189.69
f,10841,fx,-133.76
f,10861,fx,-133.76
f,10877,fx,-133.76
f,10895,fx,-151.12
f,10915,fx,-228.9
f,10931,fx,-189.69
f,10953,fx,-399.88
f,10961,fx,-399.88
f,10985,fx,-399.88
f,11003,fx,-382.52
f,11023,fx,-304.75
f,11039,fx,-343.31
f,11057,fx,-287.39
f,11077,fx,-287.39
f,11093,fx,-287.39
f,11111,fx,-304.75
f,11131,fx,-382.52
f,11147,fx,-343.31
f,11169,fx,676.789
f,11177,fx,676.789
f,11201,fx,676.789
f,11219,fx,694.144
f,11239,fx,771.921
f,11255,fx,732.711
f,11273,fx,789.277
f,11293,fx,789.277
f,11309,fx,789.277
f,11327,fx,771.921
f,11347,fx,694.144
f,11363,fx,732.711
f,11385,fx,523.163
f,11393,fx,523.163
f,11417,fx,523.163
f,11435,fx,540.518
f,11455,fx,618.295
f,11471,fx,579.086
f,11489,fx,635.651
f,11509,fx,635.651
f,11525,fx,635.651
f,11543,fx,618.295
f,11563,fx,540.518
f,11579,fx,579.086
f,11601,fx,369.537
f,11609,fx,369.537
f,11633,fx,369.537
f,11651,fx,386.25
f,11671,fx,464.027
f,11687,fx,425.46
f,11705,fx,481.382
f,11725,fx,481.382
f,11741,fx,481.382
f,11759,fx,464.027
f,11779,fx,386.25
f,11795,fx,425.46
f,11817,fx,215.269
f,11825,fx,215.269
f,11849,fx,215.269
f,11867,fx,232.624
f,11887,fx,310.401
f,11903,fx,271.834
f,11921,fx,327.756
f,11941,fx,327.756
f,11957,fx,327.756
f,11975,fx,310.401
f,11995,fx,232.624
f,12011,fx,271.834
f,12033,fx,61.6428
f,12041,fx,61.6428
f,12065,fx,61.6428
f,12083,fx,78.9981
f,12103,fx,156.775
f,12119,fx,117.565
f,12137,fx,174.13
f,12157,fx,174.13
f,12173,fx,174.13
f,12191,fx,156.775
f,12211,fx,78.9981
f,12227,fx,117.565
f,12249,fx,-91.983
f,12257,fx,-91.983
f,12281,fx,-91.983
f,12299,fx,-74.628
f,12319,fx,3.14932
f,12335,fx,-36.061
f,12353,fx,19.8618
f,12373,fx,19.8618
f,12389,fx,19.8618
f,12407,fx,3.14932
f,12427,fx,-74.628
f,12443,fx,-36.061
f,12465,fx,-246.25
f,12473,fx,-246.25
f,12497,fx,-246.25
f,12515,fx,-228.9
f,12535,fx,-151.12
f,12551,fx,-189.69
f,12569,fx,-133.76
f,12589,fx,-133.76

f,12605,fx,-133.76
f,12623,fx,-151.12
f,12643,fx,-228.9
f,12659,fx,-189.69
f,12681,fx,-399.88
f,12689,fx,-399.88
f,12713,fx,-399.88
f,12731,fx,-382.52
f,12751,fx,-304.75
f,12767,fx,-343.31
f,12785,fx,-287.39
f,12805,fx,-287.39
f,12821,fx,-287.39
f,12839,fx,-304.75
f,12859,fx,-382.52
f,12875,fx,-343.31
f,12897,fx,676.789
f,12905,fx,676.789
f,12929,fx,676.789
f,12947,fx,694.144
f,12967,fx,771.921
f,12983,fx,732.711
f,13001,fx,789.277
f,13021,fx,789.277
f,13037,fx,789.277
f,13055,fx,771.921
f,13075,fx,694.144
f,13091,fx,732.711
f,13113,fx,523.163
f,13121,fx,523.163
f,13145,fx,523.163
f,13163,fx,540.518
f,13183,fx,618.295
f,13199,fx,579.086
f,13217,fx,635.651
f,13237,fx,635.651
f,13253,fx,635.651
f,13271,fx,618.295
f,13291,fx,540.518
f,13307,fx,579.086
f,13329,fx,369.537
f,13337,fx,369.537
f,13361,fx,369.537
f,13379,fx,386.25
f,13399,fx,464.027
f,13415,fx,425.46
f,13433,fx,481.382
f,13453,fx,481.382
f,13469,fx,481.382
f,13487,fx,464.027
f,13507,fx,386.25
f,13523,fx,425.46
f,13545,fx,215.269
f,13553,fx,215.269
f,13577,fx,215.269
f,13595,fx,232.624
f,13615,fx,310.401
f,13631,fx,271.834
f,13649,fx,327.756
f,13669,fx,327.756
f,13685,fx,327.756
f,13703,fx,310.401
f,13723,fx,232.624
f,13739,fx,271.834
f,13761,fx,61.6428
f,13769,fx,61.6428
f,13793,fx,61.6428
f,13811,fx,78.9981
f,13831,fx,156.775
f,13847,fx,117.565
f,13865,fx,174.13
f,13885,fx,174.13
f,13901,fx,174.13
f,13919,fx,156.775
f,13939,fx,78.9981
f,13955,fx,117.565
f,13977,fx,-91.983
f,13985,fx,-91.983
f,14009,fx,-91.983
f,14027,fx,-74.628
f,14047,fx,3.14932
f,14063,fx,-36.061
f,14081,fx,19.8618
f,14101,fx,19.8618
f,14117,fx,19.8618
f,14135,fx,3.14932
f,14155,fx,-74.628
f,14171,fx,-36.061
f,14193,fx,-246.25
f,14201,fx,-246.25
f,14225,fx,-246.25
f,14243,fx,-228.9
f,14263,fx,-151.12
f,14279,fx,-189.69
f,14297,fx,-133.76
f,14317,fx,-133.76
f,14333,fx,-133.76
f,14351,fx,-151.12
f,14371,fx,-228.9
f,14387,fx,-189.69
f,14409,fx,-399.88
f,14417,fx,-399.88
f,14441,fx,-399.88
f,14459,fx,-382.52
f,14479,fx,-304.75
f,14495,fx,-343.31
f,14513,fx,-287.39
f,14533,fx,-287.39
f,14549,fx,-287.39
f,14567,fx,-304.75
f,14587,fx,-382.52
f,14603,fx,-343.31
f,14625,fx,676.789
f,14633,fx,676.789
f,14657,fx,676.789
f,14675,fx,694.144
f,14695,fx,771.921
f,14711,fx,732.711
f,14729,fx,789.277
f,14749,fx,789.277
f,14765,fx,789.277
f,14783,fx,771.921
f,14803,fx,694.144
f,14819,fx,732.711
f,14841,fx,523.163
f,14849,fx,523.163
f,14873,fx,523.163
f,14891,fx,540.518
f,14911,fx,618.295
f,14927,fx,579.086
f,14945,fx,635.651
f,14965,fx,635.651
f,14981,fx,635.651
f,14999,fx,618.295
f,15019,fx,540.518
f,15035,fx,579.086
f,15057,fx,369.537
f,15065,fx,369.537
f,15089,fx,369.537
f,15107,fx,386.25
f,15127,fx,464.027
f,15143,fx,425.46
f,15161,fx,481.382
f,15181,fx,481.382
f,15197,fx,481.382
f,15215,fx,464.027
f,15235,fx,386.25
f,15251,fx,425.46
f,15273,fx,215.269
f,15281,fx,215.269
f,15305,fx,215.269
f,15323,fx,232.624
f,15343,fx,310.401
f,15359,fx,271.834
f,15377,fx,327.756
f,15397,fx,327.756
f,15413,fx,327.756
f,15431,fx,310.401
f,15451,fx,232.624
f,15467,fx,271.834
f,15489,fx,61.6428
f,15497,fx,61.6428
f,15521,fx,61.6428
f,15539,fx,78.9981
f,15559,fx,156.775
f,15575,fx,117.565
f,15593,fx,174.13
f,15613,fx,174.13
f,15629,fx,174.13
f,15647,fx,156.775
f,15667,fx,78.9981
f,15683,fx,117.565
f,15705,fx,-91.983
f,15713,fx,-91.983
f,15737,fx,-91.983
f,15755,fx,-74.628
f,15775,fx,3.14932
f,15791,fx,-36.061
f,15809,fx,19.8618
f,15829,fx,19.8618
f,15845,fx,19.8618
f,15863,fx,3.14932
f,15883,fx,-74.628
f,15899,fx,-36.061
f,15921,fx,-246.25
f,15929,fx,-246.25
f,15953,fx,-246.25
f,15971,fx,-228.9
f,15991,fx,-151.12
f,16007,fx,-189.69
f,16025,fx,-133.76
f,16045,fx,-133.76
f,16061,fx,-133.76
f,16079,fx,-151.12
f,16099,fx,-228.9
f,16115,fx,-189.69
f,16137,fx,-399.88
f,16145,fx,-399.88
f,16169,fx,-399.88
f,16187,fx,-382.52
f,16207,fx,-304.75
f,16223,fx,-343.31
f,16241,fx,-287.39
f,16261,fx,-287.39
f,16277,fx,-287.39
f,16295,fx,-304.75
f,16315,fx,-382.52
f,16331,fx,-343.31
f,16353,fx,676.789
f,16361,fx,676.789
f,16385,fx,676.789
f,16403,fx,694.144
f,16423,fx,771.921
f,16439,fx,732.711
f,16457,fx,789.277
f,16477,fx,789.277
f,16493,fx,789.277
f,16511,fx,771.921
f,16531,fx,694.144
f,16547,fx,732.711
f,16569,fx,523.163
f,16577,fx,523.163
f,16601,fx,523.163
f,16619,fx,540.518
f,16639,fx,618.295
f,16655,fx,579.086
f,16673,fx,635.651
f,16693,fx,635.651
f,16709,fx,635.651
f,16727,fx,618.295
f,16747,fx,540.518
f,16763,fx,579.086
f,16785,fx,369.537
f,16793,fx,369.537
f,16817,fx,369.537
f,16835,fx,386.25
f,16855,fx,464.027
f,16871,fx,425.46
f,16889,fx,481.382
f,16909,fx,481.382
f,16925,fx,481.382
f,16943,fx,464.027
f,16963,fx,386.25
f,16979,fx,425.46
f,17001,fx,215.269
f,17009,fx,215.269
f,17033,fx,215.269
f,17051,fx,232.624
f,17071,fx,310.401
f,17087,fx,271.834
f,17105,fx,327.756
f,17125,fx,327.756
f,17141,fx,327.756
f,17159,fx,310.401
f,17179,fx,232.624
f,17195,fx,271.834
f,17217,fx,61.6428
f,17225,fx,61.6428
f,17249,fx,61.6428
f,17267,fx,78.9981
f,17287,fx,156.775
f,17303,fx,117.565
f,17321,fx,174.13
f,17341,fx,174.13
f,17357,fx,174.13
f,17375,fx,156.775
f,17395,fx,78.9981
f,17411,fx,117.565
f,17433,fx,-91.983
f,17441,fx,-91.983
f,17465,fx,-91.983
f,17483,fx,-74.628
f,17503,fx,3.14932
f,17519,fx,-36.061
f,17537,fx,19.8618
f,17557,fx,19.8618
f,17573,fx,19.8618
f,17591,fx,3.14932
f,17611,fx,-74.628
f,17627,fx,-36.061
f,17649,fx,-246.25
f,17657,fx,-246.25
f,17681,fx,-246.25
f,17699,fx,-228.9
f,17719,fx,-151.12
f,17735,fx,-189.69
f,17753,fx,-133.76
f,17773,fx,-133.76
f,17789,fx,-133.76
f,17807,fx,-151.12
f,17827,fx,-228.9
f,17843,fx,-189.69
f,17865,fx,-399.88
f,17873,fx,-399.88
f,17897,fx,-399.88
f,17915,fx,-382.52
f,17935,fx,-304.75
f,17951,fx,-343.31
f,17969,fx,-287.39
f,17989,fx,-287.39
f,18005,fx,-287.39
f,18023,fx,-304.75
f,18043,fx,-382.52
f,18059,fx,-343.31
f,18081,fx,676.789
f,18089,fx,676.789
f,18113,fx,676.789
f,18131,fx,694.144
f,18151,fx,771.921
f,18167,fx,732.711
f,18185,fx,789.277
f,18205,fx,789.277
f,18221,fx,789.277
f,18239,fx,771.921
f,18259,fx,694.144
f,18275,fx,732.711
f,18297,fx,523.163
f,18305,fx,523.163
f,18329,fx,523.163
f,18347,fx,540.518
f,18367,fx,618.295
f,18383,fx,579.086
f,18401,fx,635.651
f,18421,fx,635.651
f,18437,fx,635.651
f,18455,fx,618.295
f,18475,fx,540.518
f,18491,fx,579.086
f,18513,fx,369.537
f,18521,fx,369.537
f,18545,fx,369.537
f,18563,fx,386.25

f,18583,fx,464.027
f,18599,fx,425.46
f,18617,fx,481.382
f,18637,fx,481.382
f,18653,fx,481.382
f,18671,fx,464.027
f,18691,fx,386.25
f,18707,fx,425.46
f,18729,fx,215.269
f,18737,fx,215.269
f,18761,fx,215.269
f,18779,fx,232.624
f,18799,fx,310.401
f,18815,fx,271.834
f,18833,fx,327.756
f,18853,fx,327.756
f,18869,fx,327.756
f,18887,fx,310.401
f,18907,fx,232.624
f,18923,fx,271.834
f,18945,fx,61.6428
f,18953,fx,61.6428
f,18977,fx,61.6428
f,18995,fx,78.9981
f,19015,fx,156.775
f,19031,fx,117.565
f,19049,fx,174.13
f,19069,fx,174.13
f,19085,fx,174.13
f,19103,fx,156.775
f,19123,fx,78.9981
f,19139,fx,117.565
f,19161,fx,-91.983
f,19169,fx,-91.983
f,19193,fx,-91.983
f,19211,fx,-74.628
f,19231,fx,3.14932
f,19247,fx,-36.061
f,19265,fx,19.8618
f,19285,fx,19.8618
f,19301,fx,19.8618
f,19319,fx,3.14932
f,19339,fx,-74.628
f,19355,fx,-36.061
f,19377,fx,-246.25
f,19385,fx,-246.25
f,19409,fx,-246.25
f,19427,fx,-228.9
f,19447,fx,-151.12
f,19463,fx,-189.69
f,19481,fx,-133.76
f,19501,fx,-133.76
f,19517,fx,-133.76
f,19535,fx,-151.12
f,19555,fx,-228.9
f,19571,fx,-189.69
f,19593,fx,-399.88
f,19601,fx,-399.88
f,19625,fx,-399.88
f,19643,fx,-382.52
f,19663,fx,-304.75
f,19679,fx,-343.31
f,19697,fx,-287.39
f,19717,fx,-287.39
f,19733,fx,-287.39
f,19751,fx,-304.75
f,19771,fx,-382.52
f,19787,fx,-343.31
f,19809,fx,676.789
f,19817,fx,676.789
f,19841,fx,676.789
f,19859,fx,694.144
f,19879,fx,771.921
f,19895,fx,732.711
f,19913,fx,789.277
f,19933,fx,789.277
f,19949,fx,789.277
f,19967,fx,771.921
f,19987,fx,694.144
f,20003,fx,732.711
f,20025,fx,523.163
f,20033,fx,523.163
f,20057,fx,523.163
f,20075,fx,540.518
f,20095,fx,618.295
f,20111,fx,579.086
f,20129,fx,635.651
f,20149,fx,635.651
f,20165,fx,635.651
f,20183,fx,618.295
f,20203,fx,540.518
f,20219,fx,579.086
f,20241,fx,369.537
f,20249,fx,369.537
f,20273,fx,369.537
f,20291,fx,386.25
f,20311,fx,464.027
f,20327,fx,425.46
f,20345,fx,481.382
f,20365,fx,481.382
f,20381,fx,481.382
f,20399,fx,464.027
f,20419,fx,386.25
f,20435,fx,425.46
f,20457,fx,215.269
f,20465,fx,215.269
f,20489,fx,215.269
f,20507,fx,232.624
f,20527,fx,310.401
f,20543,fx,271.834
f,20561,fx,327.756
f,20581,fx,327.756
f,20597,fx,327.756
f,20615,fx,310.401
f,20635,fx,232.624
f,20651,fx,271.834
f,20673,fx,61.6428
f,20681,fx,61.6428
f,20705,fx,61.6428
f,20723,fx,78.9981
f,20743,fx,156.775
f,20759,fx,117.565
f,20777,fx,174.13
f,20797,fx,174.13
f,20813,fx,174.13
f,20831,fx,156.775
f,20851,fx,78.9981
f,20867,fx,117.565
f,20889,fx,-91.983
f,20897,fx,-91.983
f,20921,fx,-91.983
f,20939,fx,-74.628
f,20959,fx,3.14932
f,20975,fx,-36.061
f,20993,fx,19.8618
f,21013,fx,19.8618
f,21029,fx,19.8618
f,21047,fx,3.14932
f,21067,fx,-74.628
f,21083,fx,-36.061
f,21105,fx,-246.25
f,21113,fx,-246.25
f,21137,fx,-246.25
f,21155,fx,-228.9
f,21175,fx,-151.12
f,21191,fx,-189.69
f,21209,fx,-133.76
f,21229,fx,-133.76
f,21245,fx,-133.76
f,21263,fx,-151.12
f,21283,fx,-228.9
f,21299,fx,-189.69
f,21321,fx,-399.88
f,21329,fx,-399.88
f,21353,fx,-399.88
f,21371,fx,-382.52
f,21391,fx,-304.75
f,21407,fx,-343.31
f,21425,fx,-287.39
f,21445,fx,-287.39
f,21461,fx,-287.39
f,21479,fx,-304.75
f,21499,fx,-382.52
f,21515,fx,-343.31
f,21537,fx,676.789
f,21545,fx,676.789
f,21569,fx,676.789
f,21587,fx,694.144
f,21607,fx,771.921
f,21623,fx,732.711
f,21641,fx,789.277
f,21661,fx,789.277
f,21677,fx,789.277
f,21695,fx,771.921
f,21715,fx,694.144
f,21731,fx,732.711
f,21753,fx,523.163
f,21761,fx,523.163
f,21785,fx,523.163
f,21803,fx,540.518
f,21823,fx,618.295
f,21839,fx,579.086
f,21857,fx,635.651
f,21877,fx,635.651
f,21893,fx,635.651
f,21911,fx,618.295
f,21931,fx,540.518
f,21947,fx,579.086
f,21969,fx,369.537
f,21977,fx,369.537
f,22001,fx,369.537
f,22019,fx,386.25
f,22039,fx,464.027
f,22055,fx,425.46
f,22073,fx,481.382
f,22093,fx,481.382
f,22109,fx,481.382
f,22127,fx,464.027
f,22147,fx,386.25
f,22163,fx,425.46
f,22185,fx,215.269
f,22193,fx,215.269
f,22217,fx,215.269
f,22235,fx,232.624
f,22255,fx,310.401
f,22271,fx,271.834
f,22289,fx,327.756
f,22309,fx,327.756
f,22325,fx,327.756
f,22343,fx,310.401
f,22363,fx,232.624
f,22379,fx,271.834
f,22401,fx,61.6428
f,22409,fx,61.6428
f,22433,fx,61.6428
f,22451,fx,78.9981
f,22471,fx,156.775
f,22487,fx,117.565
f,22505,fx,174.13
f,22525,fx,174.13
f,22541,fx,174.13
f,22559,fx,156.775
f,22579,fx,78.9981
f,22595,fx,117.565
f,22617,fx,-91.983
f,22625,fx,-91.983
f,22649,fx,-91.983
f,22667,fx,-74.628
f,22687,fx,3.14932
f,22703,fx,-36.061
f,22721,fx,19.8618
f,22741,fx,19.8618
f,22757,fx,19.8618
f,22775,fx,3.14932
f,22795,fx,-74.628
f,22811,fx,-36.061
f,22833,fx,-246.25
f,22841,fx,-246.25
f,22865,fx,-246.25
f,22883,fx,-228.9
f,22903,fx,-151.12
f,22919,fx,-189.69
f,22937,fx,-133.76
f,22957,fx,-133.76
f,22973,fx,-133.76
f,22991,fx,-151.12
f,23011,fx,-228.9
f,23027,fx,-189.69
f,23049,fx,-399.88
f,23057,fx,-399.88
f,23081,fx,-399.88
f,23099,fx,-382.52
f,23119,fx,-304.75
f,23135,fx,-343.31
f,23153,fx,-287.39
f,23173,fx,-287.39
f,23189,fx,-287.39
f,23207,fx,-304.75
f,23227,fx,-382.52
f,23243,fx,-343.31
f,23265,fx,676.789
f,23273,fx,676.789
f,23297,fx,676.789
f,23315,fx,694.144
f,23335,fx,771.921
f,23351,fx,732.711
f,23369,fx,789.277
f,23389,fx,789.277
f,23405,fx,789.277
f,23423,fx,771.921
f,23443,fx,694.144
f,23459,fx,732.711
f,23481,fx,523.163
f,23489,fx,523.163
f,23513,fx,523.163
f,23531,fx,540.518
f,23551,fx,618.295
f,23567,fx,579.086
f,23585,fx,635.651
f,23605,fx,635.651
f,23621,fx,635.651
f,23639,fx,618.295
f,23659,fx,540.518
f,23675,fx,579.086
f,23697,fx,369.537
f,23705,fx,369.537
f,23729,fx,369.537
f,23747,fx,386.25
f,23767,fx,464.027
f,23783,fx,425.46
f,23801,fx,481.382
f,23821,fx,481.382
f,23837,fx,481.382
f,23855,fx,464.027
f,23875,fx,386.25
f,23891,fx,425.46
f,23913,fx,215.269
f,23921,fx,215.269
f,23945,fx,215.269
f,23963,fx,232.624
f,23983,fx,310.401
f,23999,fx,271.834
f,24017,fx,327.756
f,24037,fx,327.756
f,24053,fx,327.756
f,24071,fx,310.401
f,24091,fx,232.624
f,24107,fx,271.834
f,24129,fx,61.6428
f,24137,fx,61.6428
f,24161,fx,61.6428
f,24179,fx,78.9981
f,24199,fx,156.775
f,24215,fx,117.565
f,24233,fx,174.13
f,24253,fx,174.13
f,24269,fx,174.13
f,24287,fx,156.775
f,24307,fx,78.9981
f,24323,fx,117.565
f,24345,fx,-91.983
f,24353,fx,-91.983
f,24377,fx,-91.983
f,24395,fx,-74.628
f,24415,fx,3.14932
f,24431,fx,-36.061
f,24449,fx,19.8618
f,24469,fx,19.8618
f,24485,fx,19.8618
f,24503,fx,3.14932
f,24523,fx,-74.628
f,24539,fx,-36.061

f.24561,fx,-246.25
f.24569,fx,-246.25
f.24593,fx,-246.25
f.24611,fx,-228.9
f.24631,fx,-151.12
f.24647,fx,-189.69
f.24665,fx,-133.76
f.24685,fx,-133.76
f.24701,fx,-133.76
f.24719,fx,-151.12
f.24739,fx,-228.9
f.24755,fx,-189.69
f.24777,fx,-399.88
f.24785,fx,-399.88
f.24809,fx,-399.88
f.24827,fx,-382.52
f.24847,fx,-304.75
f.24863,fx,-343.31
f.24881,fx,-287.39
f.24901,fx,-287.39
f.24917,fx,-287.39
f.24935,fx,-304.75
f.24955,fx,-382.52
f.24971,fx,-343.31
f.24993,fx,676.789
f.25001,fx,676.789
f.25025,fx,676.789
f.25043,fx,694.144
f.25063,fx,771.921
f.25079,fx,732.711
f.25097,fx,789.277
f.25117,fx,789.277
f.25133,fx,789.277
f.25151,fx,771.921
f.25171,fx,694.144
f.25187,fx,732.711
f.25209,fx,523.163
f.25217,fx,523.163
f.25241,fx,523.163
f.25259,fx,540.518
f.25279,fx,618.295
f.25295,fx,579.086
f.25313,fx,635.651
f.25333,fx,635.651
f.25349,fx,635.651
f.25367,fx,618.295
f.25387,fx,540.518
f.25403,fx,579.086
f.25425,fx,369.537
f.25433,fx,369.537
f.25457,fx,369.537
f.25475,fx,386.25
f.25495,fx,464.027
f.25511,fx,425.46
f.25529,fx,481.382
f.25549,fx,481.382
f.25565,fx,481.382
f.25583,fx,464.027
f.25603,fx,386.25
f.25619,fx,425.46
f.25641,fx,215.269
f.25649,fx,215.269
f.25673,fx,215.269
f.25691,fx,232.624
f.25711,fx,310.401
f.25727,fx,271.834
f.25745,fx,327.756
f.25765,fx,327.756
f.25781,fx,327.756
f.25799,fx,310.401
f.25819,fx,232.624
f.25835,fx,271.834
f.25857,fx,61.6428
f.25865,fx,61.6428
f.25889,fx,61.6428
f.25907,fx,78.9981
f.25927,fx,156.775
f.25943,fx,117.565
f.25961,fx,174.13
f.25981,fx,174.13
f.25997,fx,174.13
f.26015,fx,156.775
f.26035,fx,78.9981
f.26051,fx,117.565
f.26073,fx,-91.983
f.26081,fx,-91.983
f.26105,fx,-91.983
f.26123,fx,-74.628
f.26143,fx,3.14932
f.26159,fx,-36.061
f.26177,fx,19.8618
f.26197,fx,19.8618
f.26213,fx,19.8618
f.26231,fx,3.14932
f.26251,fx,-74.628
f.26267,fx,-36.061
f.26289,fx,-246.25
f.26297,fx,-246.25
f.26321,fx,-246.25
f.26339,fx,-228.9
f.26359,fx,-151.12
f.26375,fx,-189.69
f.26393,fx,-133.76
f.26413,fx,-133.76
f.26429,fx,-133.76
f.26447,fx,-151.12
f.26467,fx,-228.9
f.26483,fx,-189.69
f.26505,fx,-399.88
f.26513,fx,-399.88
f.26537,fx,-399.88
f.26555,fx,-382.52
f.26575,fx,-304.75
f.26591,fx,-343.31
f.26609,fx,-287.39
f.26629,fx,-287.39
f.26645,fx,-287.39
f.26663,fx,-304.75
f.26683,fx,-382.52
f.26699,fx,-343.31
f.26721,fx,676.789
f.26729,fx,676.789
f.26753,fx,676.789
f.26771,fx,694.144
f.26791,fx,771.921
f.26807,fx,732.711
f.26825,fx,789.277
f.26845,fx,789.277
f.26861,fx,789.277
f.26879,fx,771.921
f.26899,fx,694.144
f.26915,fx,732.711
f.26937,fx,523.163
f.26945,fx,523.163
f.26969,fx,523.163
f.26987,fx,540.518
f.27007,fx,618.295
f.27023,fx,579.086
f.27041,fx,635.651
f.27061,fx,635.651
f.27077,fx,635.651
f.27095,fx,618.295
f.27115,fx,540.518
f.27131,fx,579.086
f.27153,fx,369.537
f.27161,fx,369.537
f.27185,fx,369.537
f.27203,fx,386.25
f.27223,fx,464.027
f.27239,fx,425.46
f.27257,fx,481.382
f.27277,fx,481.382
f.27293,fx,481.382
f.27311,fx,464.027
f.27331,fx,386.25
f.27347,fx,425.46
f.27369,fx,215.269
f.27377,fx,215.269
f.27401,fx,215.269
f.27419,fx,232.624
f.27439,fx,310.401
f.27455,fx,271.834
f.27473,fx,327.756
f.27493,fx,327.756
f.27509,fx,327.756
f.27527,fx,310.401
f.27547,fx,232.624
f.27563,fx,271.834
f.27585,fx,61.6428
f.27593,fx,61.6428
f.27617,fx,61.6428
f.27635,fx,78.9981
f.27655,fx,156.775
f.27671,fx,117.565
f.27689,fx,174.13
f.27709,fx,174.13
f.27725,fx,174.13
f.27743,fx,156.775
f.27763,fx,78.9981
f.27779,fx,117.565
f.27801,fx,-91.983
f.27809,fx,-91.983
f.27833,fx,-91.983
f.27851,fx,-74.628
f.27871,fx,3.14932
f.27887,fx,-36.061
f.27905,fx,19.8618
f.27925,fx,19.8618
f.27941,fx,19.8618
f.27959,fx,3.14932
f.27979,fx,-74.628
f.27995,fx,-36.061
f.28017,fx,-246.25
f.28025,fx,-246.25
f.28049,fx,-246.25
f.28067,fx,-228.9
f.28087,fx,-151.12
f.28103,fx,-189.69
f.28121,fx,-133.76
f.28141,fx,-133.76
f.28157,fx,-133.76
f.28175,fx,-151.12
f.28195,fx,-228.9
f.28211,fx,-189.69
f.28233,fx,-399.88
f.28241,fx,-399.88
f.28265,fx,-399.88
f.28283,fx,-382.52
f.28303,fx,-304.75
f.28319,fx,-343.31
f.28337,fx,-287.39
f.28357,fx,-287.39
f.28373,fx,-287.39
f.28391,fx,-304.75
f.28411,fx,-382.52
f.28427,fx,-343.31
f.28449,fx,676.789
f.28457,fx,676.789
f.28481,fx,676.789
f.28499,fx,694.144
f.28519,fx,771.921
f.28535,fx,732.711
f.28553,fx,789.277
f.28573,fx,789.277
f.28589,fx,789.277
f.28607,fx,771.921
f.28627,fx,694.144
f.28643,fx,732.711
f.28665,fx,523.163
f.28673,fx,523.163
f.28697,fx,523.163
f.28715,fx,540.518
f.28735,fx,618.295
f.28751,fx,579.086
f.28769,fx,635.651
f.28789,fx,635.651
f.28805,fx,635.651
f.28823,fx,618.295
f.28843,fx,540.518
f.28859,fx,579.086
f.28881,fx,369.537
f.28889,fx,369.537
f.28913,fx,369.537
f.28931,fx,386.25
f.28951,fx,464.027
f.28967,fx,425.46
f.28985,fx,481.382
f.29005,fx,481.382
f.29021,fx,481.382
f.29039,fx,464.027
f.29059,fx,386.25
f.29075,fx,425.46
f.29097,fx,215.269
f.29105,fx,215.269
f.29129,fx,215.269
f.29147,fx,232.624
f.29167,fx,310.401
f.29183,fx,271.834
f.29201,fx,327.756
f.29221,fx,327.756
f.29237,fx,327.756
f.29255,fx,310.401
f.29275,fx,232.624
f.29291,fx,271.834
f.29313,fx,61.6428
f.29321,fx,61.6428
f.29345,fx,61.6428
f.29363,fx,78.9981
f.29383,fx,156.775
f.29399,fx,117.565
f.29417,fx,174.13
f.29437,fx,174.13
f.29453,fx,174.13
f.29471,fx,156.775
f.29491,fx,78.9981
f.29507,fx,117.565
f.29529,fx,-91.983
f.29537,fx,-91.983
f.29561,fx,-91.983
f.29579,fx,-74.628
f.29599,fx,3.14932
f.29615,fx,-36.061
f.29633,fx,19.8618
f.29653,fx,19.8618
f.29669,fx,19.8618
f.29687,fx,3.14932
f.29707,fx,-74.628
f.29723,fx,-36.061
f.29745,fx,-246.25
f.29753,fx,-246.25
f.29777,fx,-246.25
f.29795,fx,-228.9
f.29815,fx,-151.12
f.29831,fx,-189.69
f.29849,fx,-133.76
f.29869,fx,-133.76
f.29885,fx,-133.76
f.29903,fx,-151.12
f.29923,fx,-228.9
f.29939,fx,-189.69
f.29961,fx,-399.88
f.29969,fx,-399.88
f.29993,fx,-399.88
f.30011,fx,-382.52
f.30031,fx,-304.75
f.30047,fx,-343.31
f.30065,fx,-287.39
f.30085,fx,-287.39
f.30101,fx,-287.39
f.30119,fx,-304.75
f.30139,fx,-382.52
f.30155,fx,-343.31
f.30177,fx,676.789
f.30185,fx,676.789
f.30209,fx,676.789
f.30227,fx,694.144
f.30247,fx,771.921
f.30263,fx,732.711
f.30281,fx,789.277
f.30301,fx,789.277
f.30317,fx,789.277
f.30335,fx,771.921
f.30355,fx,694.144
f.30371,fx,732.711
f.30393,fx,523.163
f.30401,fx,523.163
f.30425,fx,523.163
f.30443,fx,540.518
f.30463,fx,618.295
f.30479,fx,579.086
f.30497,fx,635.651
f.30517,fx,635.651

f,30533,fx,635.651
f,30551,fx,618.295
f,30571,fx,540.518
f,30587,fx,579.086
f,30609,fx,369.537
f,30617,fx,369.537
f,30641,fx,369.537
f,30659,fx,386.25
f,30679,fx,464.027
f,30695,fx,425.46
f,30713,fx,481.382
f,30733,fx,481.382
f,30749,fx,481.382
f,30767,fx,464.027
f,30787,fx,386.25
f,30803,fx,425.46
f,30825,fx,215.269
f,30833,fx,215.269
f,30857,fx,215.269
f,30875,fx,232.624
f,30895,fx,310.401
f,30911,fx,271.834
f,30929,fx,327.756
f,30949,fx,327.756
f,30965,fx,327.756
f,30983,fx,310.401
f,31003,fx,232.624
f,31019,fx,271.834
f,31041,fx,61.6428
f,31049,fx,61.6428
f,31073,fx,61.6428
f,31091,fx,78.9981
f,31111,fx,156.775
f,31127,fx,117.565
f,31145,fx,174.13
f,31165,fx,174.13
f,31181,fx,174.13
f,31199,fx,156.775
f,31219,fx,78.9981
f,31235,fx,117.565
f,31257,fx,-91.983
f,31265,fx,-91.983
f,31289,fx,-91.983
f,31307,fx,-74.628
f,31327,fx,3.14932
f,31343,fx,-36.061
f,31361,fx,19.8618
f,31381,fx,19.8618
f,31397,fx,19.8618
f,31415,fx,3.14932
f,31435,fx,-74.628
f,31451,fx,-36.061
f,31473,fx,-246.25
f,31481,fx,-246.25
f,31505,fx,-246.25
f,31523,fx,-228.9
f,31543,fx,-151.12
f,31559,fx,-189.69
f,31577,fx,-133.76
f,31597,fx,-133.76
f,31613,fx,-133.76
f,31631,fx,-151.12
f,31651,fx,-228.9
f,31667,fx,-189.69
f,31689,fx,-399.88
f,31697,fx,-399.88
f,31721,fx,-399.88
f,31739,fx,-382.52
f,31759,fx,-304.75
f,31775,fx,-343.31
f,31793,fx,-287.39
f,31813,fx,-287.39
f,31829,fx,-287.39
f,31847,fx,-304.75
f,31867,fx,-382.52
f,31883,fx,-343.31
f,31905,fx,676.789
f,31913,fx,676.789
f,31937,fx,676.789
f,31955,fx,694.144
f,31975,fx,771.921
f,31991,fx,732.711
f,32009,fx,789.277
f,32029,fx,789.277
f,32045,fx,789.277
f,32063,fx,771.921
f,32083,fx,694.144
f,32099,fx,732.711
f,32121,fx,523.163
f,32129,fx,523.163
f,32153,fx,523.163
f,32171,fx,540.518
f,32191,fx,618.295
f,32207,fx,579.086
f,32225,fx,635.651
f,32245,fx,635.651
f,32261,fx,635.651
f,32279,fx,618.295
f,32299,fx,540.518
f,32315,fx,579.086
f,32337,fx,369.537
f,32345,fx,369.537
f,32369,fx,369.537
f,32387,fx,386.25
f,32407,fx,464.027
f,32423,fx,425.46
f,32441,fx,481.382
f,32461,fx,481.382
f,32477,fx,481.382
f,32495,fx,464.027
f,32515,fx,386.25
f,32531,fx,425.46
f,32553,fx,215.269
f,32561,fx,215.269
f,32585,fx,215.269
f,32603,fx,232.624
f,32623,fx,310.401
f,32639,fx,271.834
f,32657,fx,327.756
f,32677,fx,327.756
f,32693,fx,327.756
f,32711,fx,310.401
f,32731,fx,232.624
f,32747,fx,271.834
f,32769,fx,61.6428
f,32777,fx,61.6428
f,32801,fx,61.6428
f,32819,fx,78.9981
f,32839,fx,156.775
f,32855,fx,117.565
f,32873,fx,174.13
f,32893,fx,174.13
f,32909,fx,174.13
f,32927,fx,156.775
f,32947,fx,78.9981
f,32963,fx,117.565
f,32985,fx,-91.983
f,32993,fx,-91.983
f,33017,fx,-91.983
f,33035,fx,-74.628
f,33055,fx,3.14932
f,33071,fx,-36.061
f,33089,fx,19.8618
f,33109,fx,19.8618
f,33125,fx,19.8618
f,33143,fx,3.14932
f,33163,fx,-74.628
f,33179,fx,-36.061
f,33201,fx,-246.25
f,33209,fx,-246.25
f,33233,fx,-246.25
f,33251,fx,-228.9
f,33271,fx,-151.12
f,33287,fx,-189.69
f,33305,fx,-133.76
f,33325,fx,-133.76
f,33341,fx,-133.76
f,33359,fx,-151.12
f,33379,fx,-228.9
f,33395,fx,-189.69
f,33417,fx,-399.88
f,33425,fx,-399.88
f,33449,fx,-399.88
f,33467,fx,-382.52
f,33487,fx,-304.75
f,33503,fx,-343.31
f,33521,fx,-287.39
f,33541,fx,-287.39
f,33557,fx,-287.39
f,33575,fx,-304.75
f,33595,fx,-382.52
f,33611,fx,-343.31
f,5972,fx,340.674
f,5973,fx,340.674
f,5974,fx,340.674
f,6026,fx,349.352
f,6044,fx,388.24
f,6045,fx,368.635
f,6080,fx,396.918
f,6098,fx,396.918
f,6099,fx,396.918
f,6134,fx,388.24
f,6152,fx,349.352
f,6153,fx,368.635
f,6188,fx,263.861
f,6189,fx,263.861
f,6190,fx,263.861
f,6242,fx,272.539
f,6260,fx,311.427
f,6261,fx,291.822
f,6296,fx,320.105
f,6314,fx,320.105
f,6315,fx,320.105
f,6350,fx,311.427
f,6368,fx,272.539
f,6369,fx,291.822
f,6404,fx,187.048
f,6405,fx,187.048
f,6406,fx,187.048
f,6458,fx,195.404
f,6476,fx,234.293
f,6477,fx,215.009
f,6512,fx,242.97
f,6530,fx,242.97
f,6531,fx,242.97
f,6566,fx,234.293
f,6584,fx,195.404
f,6585,fx,215.009
f,6620,fx,109.914
f,6621,fx,109.914
f,6622,fx,109.914
f,6674,fx,118.591
f,6692,fx,157.48
f,6693,fx,138.196
f,6728,fx,166.158
f,6746,fx,166.158
f,6747,fx,166.158
f,6782,fx,157.48
f,6800,fx,118.591
f,6801,fx,138.196
f,6836,fx,33.1009
f,6837,fx,33.1009
f,6838,fx,33.1009
f,6890,fx,41.7785
f,6908,fx,80.667
f,6909,fx,61.0621
f,6944,fx,89.3446
f,6962,fx,89.3446
f,6963,fx,89.3446
f,6998,fx,80.667
f,7016,fx,41.7785
f,7017,fx,61.0621
f,7052,fx,-43.712
f,7053,fx,-43.712
f,7054,fx,-43.712
f,7106,fx,-35.034
f,7124,fx,3.85411
f,7125,fx,-15.751
f,7160,fx,12.2103
f,7178,fx,12.2103
f,7179,fx,12.2103
f,7214,fx,3.85411
f,7232,fx,-35.034
f,7233,fx,-15.751
f,7268,fx,-120.85
f,7269,fx,-120.85
f,7270,fx,-120.85
f,7322,fx,-112.17
f,7340,fx,-73.28
f,7341,fx,-92.564
f,7376,fx,-64.603
f,7394,fx,-64.603
f,7395,fx,-64.603
f,7430,fx,-73.28
f,7448,fx,-112.17
f,7449,fx,-92.564
f,7484,fx,-197.66
f,7485,fx,-197.66
f,7486,fx,-197.66
f,7538,fx,-188.98
f,7556,fx,-150.09
f,7557,fx,-169.38
f,7592,fx,-141.42
f,7610,fx,-141.42
f,7611,fx,-141.42
f,7646,fx,-150.09
f,7664,fx,-188.98
f,7665,fx,-169.38
f,7700,fx,340.674
f,7701,fx,340.674
f,7702,fx,340.674
f,7754,fx,349.352
f,7772,fx,388.24
f,7773,fx,368.635
f,7808,fx,396.918
f,7826,fx,396.918
f,7827,fx,396.918
f,7862,fx,388.24
f,7880,fx,349.352
f,7881,fx,368.635
f,7916,fx,263.861
f,7917,fx,263.861
f,7918,fx,263.861
f,7970,fx,272.539
f,7988,fx,311.427
f,7989,fx,291.822
f,8024,fx,320.105
f,8042,fx,320.105
f,8043,fx,320.105
f,8078,fx,311.427
f,8096,fx,272.539
f,8097,fx,291.822
f,8132,fx,187.048
f,8133,fx,187.048
f,8134,fx,187.048
f,8186,fx,195.404
f,8204,fx,234.293
f,8205,fx,215.009
f,8240,fx,242.97
f,8258,fx,242.97
f,8259,fx,242.97
f,8294,fx,234.293
f,8312,fx,195.404
f,8313,fx,215.009
f,8348,fx,109.914
f,8349,fx,109.914
f,8350,fx,109.914
f,8402,fx,118.591
f,8420,fx,157.48
f,8421,fx,138.196
f,8456,fx,166.158
f,8474,fx,166.158
f,8475,fx,166.158
f,8510,fx,157.48
f,8528,fx,118.591
f,8529,fx,138.196
f,8564,fx,33.1009
f,8565,fx,33.1009
f,8566,fx,33.1009
f,8618,fx,41.7785
f,8636,fx,80.667
f,8637,fx,61.0621
f,8672,fx,89.3446
f,8690,fx,89.3446
f,8691,fx,89.3446
f,8726,fx,80.667
f,8744,fx,41.7785
f,8745,fx,61.0621
f,8780,fx,-43.712
f,8781,fx,-43.712
f,8782,fx,-43.712
f,8834,fx,-35.034

f,8852,fx,3.85411
f,8853,fx,-15.751
f,8888,fx,12.2103
f,8906,fx,12.2103
f,8907,fx,12.2103
f,8942,fx,3.85411
f,8960,fx,-35.034
f,8961,fx,-15.751
f,8996,fx,-120.85
f,8997,fx,-120.85
f,8998,fx,-120.85
f,9050,fx,-112.17
f,9068,fx,-73.28
f,9069,fx,-92.564
f,9104,fx,-64.603
f,9122,fx,-64.603
f,9123,fx,-64.603
f,9158,fx,-73.28
f,9176,fx,-112.17
f,9177,fx,-92.564
f,9212,fx,-197.66
f,9213,fx,-197.66
f,9214,fx,-197.66
f,9266,fx,-188.98
f,9284,fx,-150.09
f,9285,fx,-169.38
f,9320,fx,-141.42
f,9338,fx,-141.42
f,9339,fx,-141.42
f,9374,fx,-150.09
f,9392,fx,-188.98
f,9393,fx,-169.38
f,9428,fx,340.674
f,9429,fx,340.674
f,9430,fx,340.674
f,9482,fx,349.352
f,9500,fx,388.24
f,9501,fx,368.635
f,9536,fx,396.918
f,9554,fx,396.918
f,9555,fx,396.918
f,9590,fx,388.24
f,9608,fx,349.352
f,9609,fx,368.635
f,9644,fx,263.861
f,9645,fx,263.861
f,9646,fx,263.861
f,9698,fx,272.539
f,9716,fx,311.427
f,9717,fx,291.822
f,9752,fx,320.105
f,9770,fx,320.105
f,9771,fx,320.105
f,9806,fx,311.427
f,9824,fx,272.539
f,9825,fx,291.822
f,9860,fx,187.048
f,9861,fx,187.048
f,9862,fx,187.048
f,9914,fx,195.404
f,9932,fx,234.293
f,9933,fx,215.009
f,9968,fx,242.97
f,9986,fx,242.97
f,9987,fx,242.97
f,10022,fx,234.293
f,10040,fx,195.404
f,10041,fx,215.009
f,10076,fx,109.914
f,10077,fx,109.914
f,10078,fx,109.914
f,10130,fx,118.591
f,10148,fx,157.48
f,10149,fx,138.196
f,10184,fx,166.158
f,10202,fx,166.158
f,10203,fx,166.158
f,10238,fx,157.48
f,10256,fx,118.591
f,10257,fx,138.196
f,10292,fx,33.1009
f,10293,fx,33.1009
f,10294,fx,33.1009
f,10346,fx,41.7785
f,10364,fx,80.667
f,10365,fx,61.0621
f,10400,fx,89.3446
f,10418,fx,89.3446
f,10419,fx,89.3446
f,10454,fx,80.667
f,10472,fx,41.7785
f,10473,fx,61.0621
f,10508,fx,-43.712
f,10509,fx,-43.712
f,10510,fx,-43.712
f,10562,fx,-35.034
f,10580,fx,3.85411
f,10581,fx,-15.751
f,10616,fx,12.2103
f,10634,fx,12.2103
f,10635,fx,12.2103
f,10670,fx,3.85411
f,10688,fx,-35.034
f,10689,fx,-15.751
f,10724,fx,-120.85
f,10725,fx,-120.85
f,10726,fx,-120.85
f,10778,fx,-112.17
f,10796,fx,-73.28
f,10797,fx,-92.564
f,10832,fx,-64.603
f,10850,fx,-64.603
f,10851,fx,-64.603
f,10886,fx,-73.28
f,10904,fx,-112.17
f,10905,fx,-92.564
f,10940,fx,-197.66
f,10941,fx,-197.66
f,10942,fx,-197.66
f,10994,fx,-188.98
f,11012,fx,-150.09
f,11013,fx,-169.38
f,11048,fx,-141.42
f,11066,fx,-141.42
f,11067,fx,-141.42
f,11102,fx,-150.09
f,11120,fx,-188.98
f,11121,fx,-169.38
f,11156,fx,340.674
f,11157,fx,340.674
f,11158,fx,340.674
f,11210,fx,349.352
f,11228,fx,388.24
f,11229,fx,368.635
f,11264,fx,396.918
f,11282,fx,396.918
f,11283,fx,396.918
f,11318,fx,388.24
f,11336,fx,349.352
f,11337,fx,368.635
f,11372,fx,263.861
f,11373,fx,263.861
f,11374,fx,263.861
f,11426,fx,272.539
f,11444,fx,311.427
f,11445,fx,291.822
f,11480,fx,320.105
f,11498,fx,320.105
f,11499,fx,320.105
f,11534,fx,311.427
f,11552,fx,272.539
f,11553,fx,291.822
f,11588,fx,187.048
f,11589,fx,187.048
f,11590,fx,187.048
f,11642,fx,195.404
f,11660,fx,234.293
f,11661,fx,215.009
f,11696,fx,242.97
f,11714,fx,242.97
f,11715,fx,242.97
f,11750,fx,234.293
f,11768,fx,195.404
f,11769,fx,215.009
f,11804,fx,109.914
f,11805,fx,109.914
f,11806,fx,109.914
f,11858,fx,118.591
f,11876,fx,157.48
f,11877,fx,138.196
f,11912,fx,166.158
f,11930,fx,166.158
f,11931,fx,166.158
f,11966,fx,157.48
f,11984,fx,118.591
f,11985,fx,138.196
f,12020,fx,33.1009
f,12021,fx,33.1009
f,12022,fx,33.1009
f,12074,fx,41.7785
f,12092,fx,80.667
f,12093,fx,61.0621
f,12128,fx,89.3446
f,12146,fx,89.3446
f,12147,fx,89.3446
f,12182,fx,80.667
f,12200,fx,41.7785
f,12201,fx,61.0621
f,12236,fx,-43.712
f,12237,fx,-43.712
f,12238,fx,-43.712
f,12290,fx,-35.034
f,12308,fx,3.85411
f,12309,fx,-15.751
f,12344,fx,12.2103
f,12362,fx,12.2103
f,12363,fx,12.2103
f,12398,fx,3.85411
f,12416,fx,-35.034
f,12417,fx,-15.751
f,12452,fx,-120.85
f,12453,fx,-120.85
f,12454,fx,-120.85
f,12506,fx,-112.17
f,12524,fx,-73.28
f,12525,fx,-92.564
f,12560,fx,-64.603
f,12578,fx,-64.603
f,12579,fx,-64.603
f,12614,fx,-73.28
f,12632,fx,-112.17
f,12633,fx,-92.564
f,12668,fx,-197.66
f,12669,fx,-197.66
f,12670,fx,-197.66
f,12722,fx,-188.98
f,12740,fx,-150.09
f,12741,fx,-169.38
f,12776,fx,-141.42
f,12794,fx,-141.42
f,12795,fx,-141.42
f,12830,fx,-150.09
f,12848,fx,-188.98
f,12849,fx,-169.38
f,12884,fx,340.674
f,12885,fx,340.674
f,12886,fx,340.674
f,12938,fx,349.352
f,12956,fx,388.24
f,12957,fx,368.635
f,12992,fx,396.918
f,13010,fx,396.918
f,13011,fx,396.918
f,13046,fx,388.24
f,13064,fx,349.352
f,13065,fx,368.635
f,13100,fx,263.861
f,13101,fx,263.861
f,13102,fx,263.861
f,13154,fx,272.539
f,13172,fx,311.427
f,13173,fx,291.822
f,13208,fx,320.105
f,13226,fx,320.105
f,13227,fx,320.105
f,13262,fx,311.427
f,13280,fx,272.539
f,13281,fx,291.822
f,13316,fx,187.048
f,13317,fx,187.048
f,13318,fx,187.048
f,13370,fx,195.404
f,13388,fx,234.293
f,13389,fx,215.009
f,13424,fx,242.97
f,13442,fx,242.97
f,13443,fx,242.97
f,13478,fx,234.293
f,13496,fx,195.404
f,13497,fx,215.009
f,13532,fx,109.914
f,13533,fx,109.914
f,13534,fx,109.914
f,13586,fx,118.591
f,13604,fx,157.48
f,13605,fx,138.196
f,13640,fx,166.158
f,13658,fx,166.158
f,13659,fx,166.158
f,13694,fx,157.48
f,13712,fx,118.591
f,13713,fx,138.196
f,13748,fx,33.1009
f,13749,fx,33.1009
f,13750,fx,33.1009
f,13802,fx,41.7785
f,13820,fx,80.667
f,13821,fx,61.0621
f,13856,fx,89.3446
f,13874,fx,89.3446
f,13875,fx,89.3446
f,13910,fx,80.667
f,13928,fx,41.7785
f,13929,fx,61.0621
f,13964,fx,-43.712
f,13965,fx,-43.712
f,13966,fx,-43.712
f,14018,fx,-35.034
f,14036,fx,3.85411
f,14037,fx,-15.751
f,14072,fx,12.2103
f,14090,fx,12.2103
f,14091,fx,12.2103
f,14126,fx,3.85411
f,14144,fx,-35.034
f,14145,fx,-15.751
f,14180,fx,-120.85
f,14181,fx,-120.85
f,14182,fx,-120.85
f,14234,fx,-112.17
f,14252,fx,-73.28
f,14253,fx,-92.564
f,14288,fx,-64.603
f,14306,fx,-64.603
f,14307,fx,-64.603
f,14342,fx,-73.28
f,14360,fx,-112.17
f,14361,fx,-92.564
f,14396,fx,-197.66
f,14397,fx,-197.66
f,14398,fx,-197.66
f,14450,fx,-188.98
f,14468,fx,-150.09
f,14469,fx,-169.38
f,14504,fx,-141.42
f,14522,fx,-141.42
f,14523,fx,-141.42
f,14558,fx,-150.09
f,14576,fx,-188.98
f,14577,fx,-169.38
f,14612,fx,340.674
f,14613,fx,340.674
f,14614,fx,340.674
f,14666,fx,349.352
f,14684,fx,388.24
f,14685,fx,368.635
f,14720,fx,396.918
f,14738,fx,396.918
f,14739,fx,396.918
f,14774,fx,388.24
f,14792,fx,349.352
f,14793,fx,368.635

f,14828,fx,263.861
f,14829,fx,263.861
f,14830,fx,263.861
f,14882,fx,272.539
f,14900,fx,311.427
f,14901,fx,291.822
f,14936,fx,320.105
f,14954,fx,320.105
f,14955,fx,320.105
f,14990,fx,311.427
f,15008,fx,272.539
f,15009,fx,291.822
f,15044,fx,187.048
f,15045,fx,187.048
f,15046,fx,187.048
f,15098,fx,195.404
f,15116,fx,234.293
f,15117,fx,215.009
f,15152,fx,242.97
f,15170,fx,242.97
f,15171,fx,242.97
f,15206,fx,234.293
f,15224,fx,195.404
f,15225,fx,215.009
f,15260,fx,109.914
f,15261,fx,109.914
f,15262,fx,109.914
f,15314,fx,118.591
f,15332,fx,157.48
f,15333,fx,138.196
f,15368,fx,166.158
f,15386,fx,166.158
f,15387,fx,166.158
f,15422,fx,157.48
f,15440,fx,118.591
f,15441,fx,138.196
f,15476,fx,33.1009
f,15477,fx,33.1009
f,15478,fx,33.1009
f,15530,fx,41.7785
f,15548,fx,80.667
f,15549,fx,61.0621
f,15584,fx,89.3446
f,15602,fx,89.3446
f,15603,fx,89.3446
f,15638,fx,80.667
f,15656,fx,41.7785
f,15657,fx,61.0621
f,15692,fx,-43.712
f,15693,fx,-43.712
f,15694,fx,-43.712
f,15746,fx,-35.034
f,15764,fx,3.85411
f,15765,fx,-15.751
f,15800,fx,12.2103
f,15818,fx,12.2103
f,15819,fx,12.2103
f,15854,fx,3.85411
f,15872,fx,-35.034
f,15873,fx,-15.751
f,15908,fx,-120.85
f,15909,fx,-120.85
f,15910,fx,-120.85
f,15962,fx,-112.17
f,15980,fx,-73.28
f,15981,fx,-92.564
f,16016,fx,-64.603
f,16034,fx,-64.603
f,16035,fx,-64.603
f,16070,fx,-73.28
f,16088,fx,-112.17
f,16089,fx,-92.564
f,16124,fx,-197.66
f,16125,fx,-197.66
f,16126,fx,-197.66
f,16178,fx,-188.98
f,16196,fx,-150.09
f,16197,fx,-169.38
f,16232,fx,-141.42
f,16250,fx,-141.42
f,16251,fx,-141.42
f,16286,fx,-150.09
f,16304,fx,-188.98
f,16305,fx,-169.38
f,16340,fx,340.674
f,16341,fx,340.674
f,16342,fx,340.674
f,16394,fx,349.352
f,16412,fx,388.24
f,16413,fx,368.635
f,16448,fx,396.918
f,16466,fx,396.918
f,16467,fx,396.918
f,16502,fx,388.24
f,16520,fx,349.352
f,16521,fx,368.635
f,16556,fx,263.861
f,16557,fx,263.861
f,16558,fx,263.861
f,16610,fx,272.539
f,16628,fx,311.427
f,16629,fx,291.822
f,16664,fx,320.105
f,16682,fx,320.105
f,16683,fx,320.105
f,16718,fx,311.427
f,16736,fx,272.539
f,16737,fx,291.822
f,16772,fx,187.048
f,16773,fx,187.048
f,16774,fx,187.048
f,16826,fx,195.404
f,16844,fx,234.293
f,16845,fx,215.009
f,16880,fx,242.97
f,16898,fx,242.97
f,16899,fx,242.97
f,16934,fx,234.293
f,16952,fx,195.404
f,16953,fx,215.009
f,16988,fx,109.914
f,16989,fx,109.914
f,16990,fx,109.914
f,17042,fx,118.591
f,17060,fx,157.48
f,17061,fx,138.196
f,17096,fx,166.158
f,17114,fx,166.158
f,17115,fx,166.158
f,17150,fx,157.48
f,17168,fx,118.591
f,17169,fx,138.196
f,17204,fx,33.1009
f,17205,fx,33.1009
f,17206,fx,33.1009
f,17258,fx,41.7785
f,17276,fx,80.667
f,17277,fx,61.0621
f,17312,fx,89.3446
f,17330,fx,89.3446
f,17331,fx,89.3446
f,17366,fx,80.667
f,17384,fx,41.7785
f,17385,fx,61.0621
f,17420,fx,-43.712
f,17421,fx,-43.712
f,17422,fx,-43.712
f,17474,fx,-35.034
f,17492,fx,3.85411
f,17493,fx,-15.751
f,17528,fx,12.2103
f,17546,fx,12.2103
f,17547,fx,12.2103
f,17582,fx,3.85411
f,17600,fx,-35.034
f,17601,fx,-15.751
f,17636,fx,-120.85
f,17637,fx,-120.85
f,17638,fx,-120.85
f,17690,fx,-112.17
f,17708,fx,-73.28
f,17709,fx,-92.564
f,17744,fx,-64.603
f,17762,fx,-64.603
f,17763,fx,-64.603
f,17798,fx,-73.28
f,17816,fx,-112.17
f,17817,fx,-92.564
f,17852,fx,-197.66
f,17853,fx,-197.66
f,17854,fx,-197.66
f,17906,fx,-188.98
f,17924,fx,-150.09
f,17925,fx,-169.38
f,17960,fx,-141.42
f,17978,fx,-141.42
f,17979,fx,-141.42
f,18014,fx,-150.09
f,18032,fx,-188.98
f,18033,fx,-169.38
f,18068,fx,340.674
f,18069,fx,340.674
f,18070,fx,340.674
f,18122,fx,349.352
f,18140,fx,388.24
f,18141,fx,368.635
f,18176,fx,396.918
f,18194,fx,396.918
f,18195,fx,396.918
f,18230,fx,388.24
f,18248,fx,349.352
f,18249,fx,368.635
f,18284,fx,263.861
f,18285,fx,263.861
f,18286,fx,263.861
f,18338,fx,272.539
f,18356,fx,311.427
f,18357,fx,291.822
f,18392,fx,320.105
f,18410,fx,320.105
f,18411,fx,320.105
f,18446,fx,311.427
f,18464,fx,272.539
f,18465,fx,291.822
f,18500,fx,187.048
f,18501,fx,187.048
f,18502,fx,187.048
f,18554,fx,195.404
f,18572,fx,234.293
f,18573,fx,215.009
f,18608,fx,242.97
f,18626,fx,242.97
f,18627,fx,242.97
f,18662,fx,234.293
f,18680,fx,195.404
f,18681,fx,215.009
f,18716,fx,109.914
f,18717,fx,109.914
f,18718,fx,109.914
f,18770,fx,118.591
f,18788,fx,157.48
f,18789,fx,138.196
f,18824,fx,166.158
f,18842,fx,166.158
f,18843,fx,166.158
f,18878,fx,157.48
f,18896,fx,118.591
f,18897,fx,138.196
f,18932,fx,33.1009
f,18933,fx,33.1009
f,18934,fx,33.1009
f,18986,fx,41.7785
f,19004,fx,80.667
f,19005,fx,61.0621
f,19040,fx,89.3446
f,19058,fx,89.3446
f,19059,fx,89.3446
f,19094,fx,80.667
f,19112,fx,41.7785
f,19113,fx,61.0621
f,19148,fx,-43.712
f,19149,fx,-43.712
f,19150,fx,-43.712
f,19202,fx,-35.034
f,19220,fx,3.85411
f,19221,fx,-15.751
f,19256,fx,12.2103
f,19274,fx,12.2103
f,19275,fx,12.2103
f,19310,fx,3.85411
f,19328,fx,-35.034
f,19329,fx,-15.751
f,19364,fx,-120.85
f,19365,fx,-120.85
f,19366,fx,-120.85
f,19418,fx,-112.17
f,19436,fx,-73.28
f,19437,fx,-92.564
f,19472,fx,-64.603
f,19490,fx,-64.603
f,19491,fx,-64.603
f,19526,fx,-73.28
f,19544,fx,-112.17
f,19545,fx,-92.564
f,19580,fx,-197.66
f,19581,fx,-197.66
f,19582,fx,-197.66
f,19634,fx,-188.98
f,19652,fx,-150.09
f,19653,fx,-169.38
f,19688,fx,-141.42
f,19706,fx,-141.42
f,19707,fx,-141.42
f,19742,fx,-150.09
f,19760,fx,-188.98
f,19761,fx,-169.38
f,19796,fx,340.674
f,19797,fx,340.674
f,19798,fx,340.674
f,19850,fx,349.352
f,19868,fx,388.24
f,19869,fx,368.635
f,19904,fx,396.918
f,19922,fx,396.918
f,19923,fx,396.918
f,19958,fx,388.24
f,19976,fx,349.352
f,19977,fx,368.635
f,20012,fx,263.861
f,20013,fx,263.861
f,20014,fx,263.861
f,20066,fx,272.539
f,20084,fx,311.427
f,20085,fx,291.822
f,20120,fx,320.105
f,20138,fx,320.105
f,20139,fx,320.105
f,20174,fx,311.427
f,20192,fx,272.539
f,20193,fx,291.822
f,20228,fx,187.048
f,20229,fx,187.048
f,20230,fx,187.048
f,20282,fx,195.404
f,20300,fx,234.293
f,20301,fx,215.009
f,20336,fx,242.97
f,20354,fx,242.97
f,20355,fx,242.97
f,20390,fx,234.293
f,20408,fx,195.404
f,20409,fx,215.009
f,20444,fx,109.914
f,20445,fx,109.914
f,20446,fx,109.914
f,20498,fx,118.591
f,20516,fx,157.48
f,20517,fx,138.196
f,20552,fx,166.158
f,20570,fx,166.158
f,20571,fx,166.158
f,20606,fx,157.48
f,20624,fx,118.591
f,20625,fx,138.196
f,20660,fx,33.1009
f,20661,fx,33.1009
f,20662,fx,33.1009
f,20714,fx,41.7785
f,20732,fx,80.667
f,20733,fx,61.0621
f,20768,fx,89.3446
f,20786,fx,89.3446

f,20787,fx,89.3446
f,20822,fx,80.667
f,20840,fx,41.7785
f,20841,fx,61.0621
f,20876,fx,-43.712
f,20877,fx,-43.712
f,20878,fx,-43.712
f,20930,fx,-35.034
f,20948,fx,3.85411
f,20949,fx,-15.751
f,20984,fx,12.2103
f,21002,fx,12.2103
f,21003,fx,12.2103
f,21038,fx,3.85411
f,21056,fx,-35.034
f,21057,fx,-15.751
f,21092,fx,-120.85
f,21093,fx,-120.85
f,21094,fx,-120.85
f,21146,fx,-112.17
f,21164,fx,-73.28
f,21165,fx,-92.564
f,21200,fx,-64.603
f,21218,fx,-64.603
f,21219,fx,-64.603
f,21254,fx,-73.28
f,21272,fx,-112.17
f,21273,fx,-92.564
f,21308,fx,-197.66
f,21309,fx,-197.66
f,21310,fx,-197.66
f,21362,fx,-188.98
f,21380,fx,-150.09
f,21381,fx,-169.38
f,21416,fx,-141.42
f,21434,fx,-141.42
f,21435,fx,-141.42
f,21470,fx,-150.09
f,21488,fx,-188.98
f,21489,fx,-169.38
f,21524,fx,340.674
f,21525,fx,340.674
f,21526,fx,340.674
f,21578,fx,349.352
f,21596,fx,388.24
f,21597,fx,368.635
f,21632,fx,396.918
f,21650,fx,396.918
f,21651,fx,396.918
f,21686,fx,388.24
f,21704,fx,349.352
f,21705,fx,368.635
f,21740,fx,263.861
f,21741,fx,263.861
f,21742,fx,263.861
f,21794,fx,272.539
f,21812,fx,311.427
f,21813,fx,291.822
f,21848,fx,320.105
f,21866,fx,320.105
f,21867,fx,320.105
f,21902,fx,311.427
f,21920,fx,272.539
f,21921,fx,291.822
f,21956,fx,187.048
f,21957,fx,187.048
f,21958,fx,187.048
f,22010,fx,195.404
f,22028,fx,234.293
f,22029,fx,215.009
f,22064,fx,242.97
f,22082,fx,242.97
f,22083,fx,242.97
f,22118,fx,234.293
f,22136,fx,195.404
f,22137,fx,215.009
f,22172,fx,109.914
f,22173,fx,109.914
f,22174,fx,109.914
f,22226,fx,118.591
f,22244,fx,157.48
f,22245,fx,138.196
f,22280,fx,166.158
f,22298,fx,166.158
f,22299,fx,166.158
f,22334,fx,157.48
f,22352,fx,118.591
f,22353,fx,138.196
f,22388,fx,33.1009
f,22389,fx,33.1009
f,22390,fx,33.1009
f,22442,fx,41.7785
f,22460,fx,80.667
f,22461,fx,61.0621
f,22496,fx,89.3446
f,22514,fx,89.3446
f,22515,fx,89.3446
f,22550,fx,80.667
f,22568,fx,41.7785
f,22569,fx,61.0621
f,22604,fx,-43.712
f,22605,fx,-43.712
f,22606,fx,-43.712
f,22658,fx,-35.034
f,22676,fx,3.85411
f,22677,fx,-15.751
f,22712,fx,12.2103
f,22730,fx,12.2103
f,22731,fx,12.2103
f,22766,fx,3.85411
f,22784,fx,-35.034
f,22785,fx,-15.751
f,22820,fx,-120.85
f,22821,fx,-120.85
f,22822,fx,-120.85
f,22874,fx,-112.17
f,22892,fx,-73.28
f,22893,fx,-92.564
f,22928,fx,-64.603
f,22946,fx,-64.603
f,22947,fx,-64.603
f,22982,fx,-73.28
f,23000,fx,-112.17
f,23001,fx,-92.564
f,23036,fx,-197.66
f,23037,fx,-197.66
f,23038,fx,-197.66
f,23090,fx,-188.98
f,23108,fx,-150.09
f,23109,fx,-169.38
f,23144,fx,-141.42
f,23162,fx,-141.42
f,23163,fx,-141.42
f,23198,fx,-150.09
f,23216,fx,-188.98
f,23217,fx,-169.38
f,23252,fx,340.674
f,23253,fx,340.674
f,23254,fx,340.674
f,23306,fx,349.352
f,23324,fx,388.24
f,23325,fx,368.635
f,23360,fx,396.918
f,23378,fx,396.918
f,23379,fx,396.918
f,23414,fx,388.24
f,23432,fx,349.352
f,23433,fx,368.635
f,23468,fx,263.861
f,23469,fx,263.861
f,23470,fx,263.861
f,23522,fx,272.539
f,23540,fx,311.427
f,23541,fx,291.822
f,23576,fx,320.105
f,23594,fx,320.105
f,23595,fx,320.105
f,23630,fx,311.427
f,23648,fx,272.539
f,23649,fx,291.822
f,23684,fx,187.048
f,23685,fx,187.048
f,23686,fx,187.048
f,23738,fx,195.404
f,23756,fx,234.293
f,23757,fx,215.009
f,23792,fx,242.97
f,23810,fx,242.97
f,23811,fx,242.97
f,23846,fx,234.293
f,23864,fx,195.404
f,23865,fx,215.009
f,23900,fx,109.914
f,23901,fx,109.914
f,23902,fx,109.914
f,23954,fx,118.591
f,23972,fx,157.48
f,23973,fx,138.196
f,24008,fx,166.158
f,24026,fx,166.158
f,24027,fx,166.158
f,24062,fx,157.48
f,24080,fx,118.591
f,24081,fx,138.196
f,24116,fx,33.1009
f,24117,fx,33.1009
f,24118,fx,33.1009
f,24170,fx,41.7785
f,24188,fx,80.667
f,24189,fx,61.0621
f,24224,fx,89.3446
f,24242,fx,89.3446
f,24243,fx,89.3446
f,24278,fx,80.667
f,24296,fx,41.7785
f,24297,fx,61.0621
f,24332,fx,-43.712
f,24333,fx,-43.712
f,24334,fx,-43.712
f,24386,fx,-35.034
f,24404,fx,3.85411
f,24405,fx,-15.751
f,24440,fx,12.2103
f,24458,fx,12.2103
f,24459,fx,12.2103
f,24494,fx,3.85411
f,24512,fx,-35.034
f,24513,fx,-15.751
f,24548,fx,-120.85
f,24549,fx,-120.85
f,24550,fx,-120.85
f,24602,fx,-112.17
f,24620,fx,-73.28
f,24621,fx,-92.564
f,24656,fx,-64.603
f,24674,fx,-64.603
f,24675,fx,-64.603
f,24710,fx,-73.28
f,24728,fx,-112.17
f,24729,fx,-92.564
f,24764,fx,-197.66
f,24765,fx,-197.66
f,24766,fx,-197.66
f,24818,fx,-188.98
f,24836,fx,-150.09
f,24837,fx,-169.38
f,24872,fx,-141.42
f,24890,fx,-141.42
f,24891,fx,-141.42
f,24926,fx,-150.09
f,24944,fx,-188.98
f,24945,fx,-169.38
f,24980,fx,340.674
f,24981,fx,340.674
f,24982,fx,340.674
f,25034,fx,349.352
f,25052,fx,388.24
f,25053,fx,368.635
f,25088,fx,396.918
f,25106,fx,396.918
f,25107,fx,396.918
f,25142,fx,388.24
f,25160,fx,349.352
f,25161,fx,368.635
f,25196,fx,263.861
f,25197,fx,263.861
f,25198,fx,263.861
f,25250,fx,272.539
f,25268,fx,311.427
f,25269,fx,291.822
f,25304,fx,320.105
f,25322,fx,320.105
f,25323,fx,320.105
f,25358,fx,311.427
f,25376,fx,272.539
f,25377,fx,291.822
f,25412,fx,187.048
f,25413,fx,187.048
f,25414,fx,187.048
f,25466,fx,195.404
f,25484,fx,234.293
f,25485,fx,215.009
f,25520,fx,242.97
f,25538,fx,242.97
f,25539,fx,242.97
f,25574,fx,234.293
f,25592,fx,195.404
f,25593,fx,215.009
f,25628,fx,109.914
f,25629,fx,109.914
f,25630,fx,109.914
f,25682,fx,118.591
f,25700,fx,157.48
f,25701,fx,138.196
f,25736,fx,166.158
f,25754,fx,166.158
f,25755,fx,166.158
f,25790,fx,157.48
f,25808,fx,118.591
f,25809,fx,138.196
f,25844,fx,33.1009
f,25845,fx,33.1009
f,25846,fx,33.1009
f,25898,fx,41.7785
f,25916,fx,80.667
f,25917,fx,61.0621
f,25952,fx,89.3446
f,25970,fx,89.3446
f,25971,fx,89.3446
f,26006,fx,80.667
f,26024,fx,41.7785
f,26025,fx,61.0621
f,26060,fx,-43.712
f,26061,fx,-43.712
f,26062,fx,-43.712
f,26114,fx,-35.034
f,26132,fx,3.85411
f,26133,fx,-15.751
f,26168,fx,12.2103
f,26186,fx,12.2103
f,26187,fx,12.2103
f,26222,fx,3.85411
f,26240,fx,-35.034
f,26241,fx,-15.751
f,26276,fx,-120.85
f,26277,fx,-120.85
f,26278,fx,-120.85
f,26330,fx,-112.17
f,26348,fx,-73.28
f,26349,fx,-92.564
f,26384,fx,-64.603
f,26402,fx,-64.603
f,26403,fx,-64.603
f,26438,fx,-73.28
f,26456,fx,-112.17
f,26457,fx,-92.564
f,26492,fx,-197.66
f,26493,fx,-197.66
f,26494,fx,-197.66
f,26546,fx,-188.98
f,26564,fx,-150.09
f,26565,fx,-169.38
f,26600,fx,-141.42
f,26618,fx,-141.42
f,26619,fx,-141.42
f,26654,fx,-150.09
f,26672,fx,-188.98
f,26673,fx,-169.38
f,26708,fx,340.674
f,26709,fx,340.674
f,26710,fx,340.674
f,26762,fx,349.352

f,26780,fx,388.24
f,26781,fx,368.635
f,26816,fx,396.918
f,26834,fx,396.918
f,26835,fx,396.918
f,26870,fx,388.24
f,26888,fx,349.352
f,26889,fx,368.635
f,26924,fx,263.861
f,26925,fx,263.861
f,26926,fx,263.861
f,26978,fx,272.539
f,26996,fx,311.427
f,26997,fx,291.822
f,27032,fx,320.105
f,27050,fx,320.105
f,27051,fx,320.105
f,27086,fx,311.427
f,27104,fx,272.539
f,27105,fx,291.822
f,27140,fx,187.048
f,27141,fx,187.048
f,27142,fx,187.048
f,27194,fx,195.404
f,27212,fx,234.293
f,27213,fx,215.009
f,27248,fx,242.97
f,27266,fx,242.97
f,27267,fx,242.97
f,27302,fx,234.293
f,27320,fx,195.404
f,27321,fx,215.009
f,27356,fx,109.914
f,27357,fx,109.914
f,27358,fx,109.914
f,27410,fx,118.591
f,27428,fx,157.48
f,27429,fx,138.196
f,27464,fx,166.158
f,27482,fx,166.158
f,27483,fx,166.158
f,27518,fx,157.48
f,27536,fx,118.591
f,27537,fx,138.196
f,27572,fx,33.1009
f,27573,fx,33.1009
f,27574,fx,33.1009
f,27626,fx,41.7785
f,27644,fx,80.667
f,27645,fx,61.0621
f,27680,fx,89.3446
f,27698,fx,89.3446
f,27699,fx,89.3446
f,27734,fx,80.667
f,27752,fx,41.7785
f,27753,fx,61.0621
f,27788,fx,-43.712
f,27789,fx,-43.712
f,27790,fx,-43.712
f,27842,fx,-35.034
f,27860,fx,3.85411
f,27861,fx,-15.751
f,27896,fx,12.2103
f,27914,fx,12.2103
f,27915,fx,12.2103
f,27950,fx,3.85411
f,27968,fx,-35.034
f,27969,fx,-15.751
f,28004,fx,-120.85
f,28005,fx,-120.85
f,28006,fx,-120.85
f,28058,fx,-112.17
f,28076,fx,-73.28
f,28077,fx,-92.564
f,28112,fx,-64.603
f,28130,fx,-64.603
f,28131,fx,-64.603
f,28166,fx,-73.28
f,28184,fx,-112.17
f,28185,fx,-92.564
f,28220,fx,-197.66
f,28221,fx,-197.66
f,28222,fx,-197.66
f,28274,fx,-188.98
f,28292,fx,-150.09
f,28293,fx,-169.38
f,28328,fx,-141.42
f,28346,fx,-141.42
f,28347,fx,-141.42
f,28382,fx,-150.09
f,28400,fx,-188.98
f,28401,fx,-169.38
f,28436,fx,340.674
f,28437,fx,340.674
f,28438,fx,340.674
f,28490,fx,349.352
f,28508,fx,388.24
f,28509,fx,368.635
f,28544,fx,396.918
f,28562,fx,396.918
f,28563,fx,396.918
f,28598,fx,388.24
f,28616,fx,349.352
f,28617,fx,368.635
f,28652,fx,263.861
f,28653,fx,263.861
f,28654,fx,263.861
f,28706,fx,272.539
f,28724,fx,311.427
f,28725,fx,291.822
f,28760,fx,320.105
f,28778,fx,320.105
f,28779,fx,320.105
f,28814,fx,311.427
f,28832,fx,272.539
f,28833,fx,291.822
f,28868,fx,187.048
f,28869,fx,187.048
f,28870,fx,187.048
f,28922,fx,195.404
f,28940,fx,234.293
f,28941,fx,215.009
f,28976,fx,242.97
f,28994,fx,242.97
f,28995,fx,242.97
f,29030,fx,234.293
f,29048,fx,195.404
f,29049,fx,215.009
f,29084,fx,109.914
f,29085,fx,109.914
f,29086,fx,109.914
f,29138,fx,118.591
f,29156,fx,157.48
f,29157,fx,138.196
f,29192,fx,166.158
f,29210,fx,166.158
f,29211,fx,166.158
f,29246,fx,157.48
f,29264,fx,118.591
f,29265,fx,138.196
f,29300,fx,33.1009
f,29301,fx,33.1009
f,29302,fx,33.1009
f,29354,fx,41.7785
f,29372,fx,80.667
f,29373,fx,61.0621
f,29408,fx,89.3446
f,29426,fx,89.3446
f,29427,fx,89.3446
f,29462,fx,80.667
f,29480,fx,41.7785
f,29481,fx,61.0621
f,29516,fx,-43.712
f,29517,fx,-43.712
f,29518,fx,-43.712
f,29570,fx,-35.034
f,29588,fx,3.85411
f,29589,fx,-15.751
f,29624,fx,12.2103
f,29642,fx,12.2103
f,29643,fx,12.2103
f,29678,fx,3.85411
f,29696,fx,-35.034
f,29697,fx,-15.751
f,29732,fx,-120.85
f,29733,fx,-120.85
f,29734,fx,-120.85
f,29786,fx,-112.17
f,29804,fx,-73.28
f,29805,fx,-92.564
f,29840,fx,-64.603
f,29858,fx,-64.603
f,29859,fx,-64.603
f,29894,fx,-73.28
f,29912,fx,-112.17
f,29913,fx,-92.564
f,29948,fx,-197.66
f,29949,fx,-197.66
f,29950,fx,-197.66
f,30002,fx,-188.98
f,30020,fx,-150.09
f,30021,fx,-169.38
f,30056,fx,-141.42
f,30074,fx,-141.42
f,30075,fx,-141.42
f,30110,fx,-150.09
f,30128,fx,-188.98
f,30129,fx,-169.38
f,30164,fx,340.674
f,30165,fx,340.674
f,30166,fx,340.674
f,30218,fx,349.352
f,30236,fx,388.24
f,30237,fx,368.635
f,30272,fx,396.918
f,30290,fx,396.918
f,30291,fx,396.918
f,30326,fx,388.24
f,30344,fx,349.352
f,30345,fx,368.635
f,30380,fx,263.861
f,30381,fx,263.861
f,30382,fx,263.861
f,30434,fx,272.539
f,30452,fx,311.427
f,30453,fx,291.822
f,30488,fx,320.105
f,30506,fx,320.105
f,30507,fx,320.105
f,30542,fx,311.427
f,30560,fx,272.539
f,30561,fx,291.822
f,30596,fx,187.048
f,30597,fx,187.048
f,30598,fx,187.048
f,30650,fx,195.404
f,30668,fx,234.293
f,30669,fx,215.009
f,30704,fx,242.97
f,30722,fx,242.97
f,30723,fx,242.97
f,30758,fx,234.293
f,30776,fx,195.404
f,30777,fx,215.009
f,30812,fx,109.914
f,30813,fx,109.914
f,30814,fx,109.914
f,30866,fx,118.591
f,30884,fx,157.48
f,30885,fx,138.196
f,30920,fx,166.158
f,30938,fx,166.158
f,30939,fx,166.158
f,30974,fx,157.48
f,30992,fx,118.591
f,30993,fx,138.196
f,31028,fx,33.1009
f,31029,fx,33.1009
f,31030,fx,33.1009
f,31082,fx,41.7785
f,31100,fx,80.667
f,31101,fx,61.0621
f,31136,fx,89.3446
f,31154,fx,89.3446
f,31155,fx,89.3446
f,31190,fx,80.667
f,31208,fx,41.7785
f,31209,fx,61.0621
f,31244,fx,-43.712
f,31245,fx,-43.712
f,31246,fx,-43.712
f,31298,fx,-35.034
f,31316,fx,3.85411
f,31317,fx,-15.751
f,31352,fx,12.2103
f,31370,fx,12.2103
f,31371,fx,12.2103
f,31406,fx,3.85411
f,31424,fx,-35.034
f,31425,fx,-15.751
f,31460,fx,-120.85
f,31461,fx,-120.85
f,31462,fx,-120.85
f,31514,fx,-112.17
f,31532,fx,-73.28
f,31533,fx,-92.564
f,31568,fx,-64.603
f,31586,fx,-64.603
f,31587,fx,-64.603
f,31622,fx,-73.28
f,31640,fx,-112.17
f,31641,fx,-92.564
f,31676,fx,-197.66
f,31677,fx,-197.66
f,31678,fx,-197.66
f,31730,fx,-188.98
f,31748,fx,-150.09
f,31749,fx,-169.38
f,31784,fx,-141.42
f,31802,fx,-141.42
f,31803,fx,-141.42
f,31838,fx,-150.09
f,31856,fx,-188.98
f,31857,fx,-169.38
f,31892,fx,340.674
f,31893,fx,340.674
f,31894,fx,340.674
f,31946,fx,349.352
f,31964,fx,388.24
f,31965,fx,368.635
f,32000,fx,396.918
f,32018,fx,396.918
f,32019,fx,396.918
f,32054,fx,388.24
f,32072,fx,349.352
f,32073,fx,368.635
f,32108,fx,263.861
f,32109,fx,263.861
f,32110,fx,263.861
f,32162,fx,272.539
f,32180,fx,311.427
f,32181,fx,291.822
f,32216,fx,320.105
f,32234,fx,320.105
f,32235,fx,320.105
f,32270,fx,311.427
f,32288,fx,272.539
f,32289,fx,291.822
f,32324,fx,187.048
f,32325,fx,187.048
f,32326,fx,187.048
f,32378,fx,195.404
f,32396,fx,234.293
f,32397,fx,215.009
f,32432,fx,242.97
f,32450,fx,242.97
f,32451,fx,242.97
f,32486,fx,234.293
f,32504,fx,195.404
f,32505,fx,215.009
f,32540,fx,109.914
f,32541,fx,109.914
f,32542,fx,109.914
f,32594,fx,118.591
f,32612,fx,157.48
f,32613,fx,138.196
f,32648,fx,166.158
f,32666,fx,166.158
f,32667,fx,166.158
f,32702,fx,157.48
f,32720,fx,118.591
f,32721,fx,138.196

f,32756,fx,33.1009
f,32757,fx,33.1009
f,32758,fx,33.1009
f,32810,fx,41.7785
f,32828,fx,80.667
f,32829,fx,61.0621
f,32864,fx,89.3446
f,32882,fx,89.3446
f,32883,fx,89.3446
f,32918,fx,80.667
f,32936,fx,41.7785
f,32937,fx,61.0621
f,32972,fx,-43.712
f,32973,fx,-43.712
f,32974,fx,-43.712
f,33026,fx,-35.034
f,33044,fx,3.85411
f,33045,fx,-15.751
f,33080,fx,12.2103
f,33098,fx,12.2103
f,33099,fx,12.2103
f,33134,fx,3.85411
f,33152,fx,-35.034
f,33153,fx,-15.751
f,33188,fx,-120.85
f,33189,fx,-120.85
f,33190,fx,-120.85
f,33242,fx,-112.17
f,33260,fx,-73.28
f,33261,fx,-92.564
f,33296,fx,-64.603
f,33314,fx,-64.603
f,33315,fx,-64.603
f,33350,fx,-73.28
f,33368,fx,-112.17
f,33369,fx,-92.564
f,33404,fx,-197.66
f,33405,fx,-197.66
f,33406,fx,-197.66
f,33458,fx,-188.98
f,33476,fx,-150.09
f,33477,fx,-169.38
f,33512,fx,-141.42
f,33530,fx,-141.42
f,33531,fx,-141.42
f,33566,fx,-150.09
f,33584,fx,-188.98
f,33585,fx,-169.38
f,1,fz,283.5
f,2,fz,263.144
f,3,fz,273.406
f,7,fz,258.601
f,9,fz,258.601
f,10,fz,258.601
f,13,fz,263.144
f,15,fz,283.5
f,16,fz,273.406
f,19,fz,288.042
f,21,fz,288.042
f,22,fz,288.042
f,53,fz,283.5
f,54,fz,263.144
f,55,fz,273.406
f,59,fz,258.601
f,61,fz,258.601
f,62,fz,258.601
f,65,fz,263.144
f,67,fz,283.5
f,68,fz,273.406
f,71,fz,288.042
f,73,fz,288.042
f,74,fz,288.042
f,100,fz,283.5
f,101,fz,263.144
f,102,fz,273.406
f,106,fz,258.601
f,108,fz,258.601
f,109,fz,258.601
f,112,fz,263.144
f,114,fz,283.5
f,115,fz,273.406
f,118,fz,288.042
f,120,fz,288.042
f,121,fz,288.042
f,147,fz,283.5
f,148,fz,263.144
f,149,fz,273.406
f,153,fz,258.601
f,155,fz,258.601
f,156,fz,258.601
f,159,fz,263.144
f,161,fz,283.5
f,162,fz,273.406
f,165,fz,288.042
f,167,fz,288.042
f,168,fz,288.042
f,194,fz,283.5
f,195,fz,263.144
f,196,fz,273.406
f,200,fz,258.601
f,202,fz,258.601
f,203,fz,258.601
f,206,fz,263.144
f,208,fz,283.5
f,209,fz,273.406
f,212,fz,288.042
f,214,fz,288.042
f,215,fz,288.042
f,241,fz,283.5
f,242,fz,263.144
f,243,fz,273.406
f,247,fz,258.601
f,249,fz,258.601
f,250,fz,258.601
f,253,fz,263.144
f,255,fz,283.5
f,256,fz,273.406
f,259,fz,288.042
f,261,fz,288.042
f,262,fz,288.042
f,288,fz,283.5
f,289,fz,263.144
f,290,fz,273.406
f,294,fz,258.601
f,296,fz,258.601
f,297,fz,258.601
f,300,fz,263.144
f,302,fz,283.5
f,303,fz,273.406
f,306,fz,288.042
f,308,fz,288.042
f,309,fz,288.042
f,335,fz,283.5
f,336,fz,263.144
f,337,fz,273.406
f,341,fz,258.601
f,343,fz,258.601
f,344,fz,258.601
f,347,fz,263.144
f,349,fz,283.5
f,350,fz,273.406
f,353,fz,288.042
f,355,fz,288.042
f,356,fz,288.042
f,382,fz,243.292
f,383,fz,222.936
f,384,fz,233.03
f,388,fz,218.394
f,390,fz,218.394
f,391,fz,218.394
f,394,fz,222.936
f,396,fz,243.292
f,397,fz,233.03
f,400,fz,247.834
f,402,fz,247.834
f,403,fz,247.834
f,429,fz,243.292
f,430,fz,222.936
f,431,fz,233.03
f,435,fz,218.394
f,437,fz,218.394
f,438,fz,218.394
f,441,fz,222.936
f,443,fz,243.292
f,444,fz,233.03
f,447,fz,247.834
f,449,fz,247.834
f,450,fz,247.834
f,472,fz,243.292
f,473,fz,222.936
f,474,fz,233.03
f,478,fz,218.394
f,480,fz,218.394
f,481,fz,218.394
f,484,fz,222.936
f,486,fz,243.292
f,487,fz,233.03
f,490,fz,247.834
f,492,fz,247.834
f,493,fz,247.834
f,515,fz,243.292
f,516,fz,222.936
f,517,fz,233.03
f,521,fz,218.394
f,523,fz,218.394
f,524,fz,218.394
f,527,fz,222.936
f,529,fz,243.292
f,530,fz,233.03
f,533,fz,247.834
f,535,fz,247.834
f,536,fz,247.834
f,558,fz,243.292
f,559,fz,222.936
f,560,fz,233.03
f,564,fz,218.394
f,566,fz,218.394
f,567,fz,218.394
f,570,fz,222.936
f,572,fz,243.292
f,573,fz,233.03
f,576,fz,247.834
f,578,fz,247.834
f,579,fz,247.834
f,601,fz,243.292
f,602,fz,222.936
f,603,fz,233.03
f,607,fz,218.394
f,609,fz,218.394
f,610,fz,218.394
f,613,fz,222.936
f,615,fz,243.292
f,616,fz,233.03
f,619,fz,247.834
f,621,fz,247.834
f,622,fz,247.834
f,644,fz,243.292
f,645,fz,222.936
f,646,fz,233.03
f,650,fz,218.394
f,652,fz,218.394
f,653,fz,218.394
f,656,fz,222.936
f,658,fz,243.292
f,659,fz,233.03
f,662,fz,247.834
f,664,fz,247.834
f,665,fz,247.834
f,687,fz,243.292
f,688,fz,222.936
f,689,fz,233.03
f,693,fz,218.394
f,695,fz,218.394
f,696,fz,218.394
f,699,fz,222.936
f,701,fz,243.292
f,702,fz,233.03
f,705,fz,247.834
f,707,fz,247.834
f,708,fz,247.834
f,730,fz,202.916
f,731,fz,182.728
f,732,fz,192.822
f,736,fz,178.186
f,738,fz,178.186
f,739,fz,178.186
f,742,fz,182.728
f,744,fz,202.916
f,745,fz,192.822
f,748,fz,207.458
f,750,fz,207.458
f,751,fz,207.458
f,777,fz,202.916
f,778,fz,182.728
f,779,fz,192.822
f,783,fz,178.186
f,785,fz,178.186
f,786,fz,178.186
f,789,fz,182.728
f,791,fz,202.916
f,792,fz,192.822
f,795,fz,207.458
f,797,fz,207.458
f,798,fz,207.458
f,820,fz,202.916
f,821,fz,182.728
f,822,fz,192.822
f,826,fz,178.186
f,828,fz,178.186
f,829,fz,178.186
f,832,fz,182.728
f,834,fz,202.916
f,835,fz,192.822
f,838,fz,207.458
f,840,fz,207.458
f,841,fz,207.458
f,863,fz,202.916
f,864,fz,182.728
f,865,fz,192.822
f,869,fz,178.186
f,871,fz,178.186
f,872,fz,178.186
f,875,fz,182.728
f,877,fz,202.916
f,878,fz,192.822
f,881,fz,207.458
f,883,fz,207.458
f,884,fz,207.458
f,906,fz,202.916
f,907,fz,182.728
f,908,fz,192.822
f,912,fz,178.186
f,914,fz,178.186
f,915,fz,178.186
f,918,fz,182.728
f,920,fz,202.916
f,921,fz,192.822
f,924,fz,207.458
f,926,fz,207.458
f,927,fz,207.458
f,949,fz,202.916
f,950,fz,182.728
f,951,fz,192.822
f,955,fz,178.186
f,957,fz,178.186
f,958,fz,178.186
f,961,fz,182.728
f,963,fz,202.916
f,964,fz,192.822
f,967,fz,207.458
f,969,fz,207.458
f,970,fz,207.458
f,992,fz,202.916
f,993,fz,182.728
f,994,fz,192.822
f,998,fz,178.186
f,1000,fz,178.186
f,1001,fz,178.186
f,1004,fz,182.728
f,1006,fz,202.916
f,1007,fz,192.822
f,1010,fz,207.458
f,1012,fz,207.458
f,1013,fz,207.458
f,1035,fz,202.916
f,1036,fz,182.728
f,1037,fz,192.822
f,1041,fz,178.186
f,1043,fz,178.186
f,1044,fz,178.186
f,1047,fz,182.728
f,1049,fz,202.916

f,1050,fz,192.822
f,1053,fz,207.458
f,1055,fz,207.458
f,1056,fz,207.458
f,1078,fz,162.708
f,1079,fz,142.352
f,1080,fz,152.614
f,1084,fz,137.81
f,1086,fz,137.81
f,1087,fz,137.81
f,1090,fz,142.352
f,1092,fz,162.708
f,1093,fz,152.614
f,1096,fz,167.251
f,1098,fz,167.251
f,1099,fz,167.251
f,1125,fz,162.708
f,1126,fz,142.352
f,1127,fz,152.614
f,1131,fz,137.81
f,1133,fz,137.81
f,1134,fz,137.81
f,1137,fz,142.352
f,1139,fz,162.708
f,1140,fz,152.614
f,1143,fz,167.251
f,1145,fz,167.251
f,1146,fz,167.251
f,1168,fz,162.708
f,1169,fz,142.352
f,1170,fz,152.614
f,1174,fz,137.81
f,1176,fz,137.81
f,1177,fz,137.81
f,1180,fz,142.352
f,1182,fz,162.708
f,1183,fz,152.614
f,1186,fz,167.251
f,1188,fz,167.251
f,1189,fz,167.251
f,1211,fz,162.708
f,1212,fz,142.352
f,1213,fz,152.614
f,1217,fz,137.81
f,1219,fz,137.81
f,1220,fz,137.81
f,1223,fz,142.352
f,1225,fz,162.708
f,1226,fz,152.614
f,1229,fz,167.251
f,1231,fz,167.251
f,1232,fz,167.251
f,1254,fz,162.708
f,1255,fz,142.352
f,1256,fz,152.614
f,1260,fz,137.81
f,1262,fz,137.81
f,1263,fz,137.81
f,1266,fz,142.352
f,1268,fz,162.708
f,1269,fz,152.614
f,1272,fz,167.251
f,1274,fz,167.251
f,1275,fz,167.251
f,1297,fz,162.708
f,1298,fz,142.352
f,1299,fz,152.614
f,1303,fz,137.81
f,1305,fz,137.81
f,1306,fz,137.81
f,1309,fz,142.352
f,1311,fz,162.708
f,1312,fz,152.614
f,1315,fz,167.251
f,1317,fz,167.251
f,1318,fz,167.251
f,1340,fz,162.708
f,1341,fz,142.352
f,1342,fz,152.614
f,1346,fz,137.81
f,1348,fz,137.81
f,1349,fz,137.81
f,1352,fz,142.352
f,1354,fz,162.708
f,1355,fz,152.614
f,1358,fz,167.251
f,1360,fz,167.251
f,1361,fz,167.251
f,1383,fz,162.708
f,1384,fz,142.352
f,1385,fz,152.614
f,1389,fz,137.81
f,1391,fz,137.81
f,1392,fz,137.81
f,1395,fz,142.352
f,1397,fz,162.708
f,1398,fz,152.614
f,1401,fz,167.251
f,1403,fz,167.251
f,1404,fz,167.251
f,1426,fz,122.5
f,1427,fz,102.144
f,1428,fz,112.238
f,1432,fz,97.6018
f,1434,fz,97.6018
f,1435,fz,97.6018
f,1438,fz,102.144
f,1440,fz,122.5
f,1441,fz,112.238
f,1444,fz,127.043
f,1446,fz,127.043
f,1447,fz,127.043
f,1473,fz,122.5
f,1474,fz,102.144
f,1475,fz,112.238
f,1479,fz,97.6018
f,1481,fz,97.6018
f,1482,fz,97.6018
f,1485,fz,102.144
f,1487,fz,122.5
f,1488,fz,112.238
f,1491,fz,127.043
f,1493,fz,127.043
f,1494,fz,127.043
f,1516,fz,122.5
f,1517,fz,102.144
f,1518,fz,112.238
f,1522,fz,97.6018
f,1524,fz,97.6018
f,1525,fz,97.6018
f,1528,fz,102.144
f,1530,fz,122.5
f,1531,fz,112.238
f,1534,fz,127.043
f,1536,fz,127.043
f,1537,fz,127.043
f,1559,fz,122.5
f,1560,fz,102.144
f,1561,fz,112.238
f,1565,fz,97.6018
f,1567,fz,97.6018
f,1568,fz,97.6018
f,1571,fz,102.144
f,1573,fz,122.5
f,1574,fz,112.238
f,1577,fz,127.043
f,1579,fz,127.043
f,1580,fz,127.043
f,1602,fz,122.5
f,1603,fz,102.144
f,1604,fz,112.238
f,1608,fz,97.6018
f,1610,fz,97.6018
f,1611,fz,97.6018
f,1614,fz,102.144
f,1616,fz,122.5
f,1617,fz,112.238
f,1620,fz,127.043
f,1622,fz,127.043
f,1623,fz,127.043
f,1645,fz,122.5
f,1646,fz,102.144
f,1647,fz,112.238
f,1651,fz,97.6018
f,1653,fz,97.6018
f,1654,fz,97.6018
f,1657,fz,102.144
f,1659,fz,122.5
f,1660,fz,112.238
f,1663,fz,127.043
f,1665,fz,127.043
f,1666,fz,127.043
f,1688,fz,122.5
f,1689,fz,102.144
f,1690,fz,112.238
f,1694,fz,97.6018
f,1696,fz,97.6018
f,1697,fz,97.6018
f,1700,fz,102.144
f,1702,fz,122.5
f,1703,fz,112.238
f,1706,fz,127.043
f,1708,fz,127.043
f,1709,fz,127.043
f,1731,fz,122.5
f,1732,fz,102.144
f,1733,fz,112.238
f,1737,fz,97.6018
f,1739,fz,97.6018
f,1740,fz,97.6018
f,1743,fz,102.144
f,1745,fz,122.5
f,1746,fz,112.238
f,1749,fz,127.043
f,1751,fz,127.043
f,1752,fz,127.043
f,1774,fz,82.2925
f,1775,fz,61.9362
f,1776,fz,72.0303
f,1780,fz,57.3939
f,1782,fz,57.3939
f,1783,fz,57.3939
f,1786,fz,61.9362
f,1788,fz,82.2925
f,1789,fz,72.0303
f,1792,fz,86.8348
f,1794,fz,86.8348
f,1795,fz,86.8348
f,1821,fz,82.2925
f,1822,fz,61.9362
f,1823,fz,72.0303
f,1827,fz,57.3939
f,1829,fz,57.3939
f,1830,fz,57.3939
f,1833,fz,61.9362
f,1835,fz,82.2925
f,1836,fz,72.0303
f,1839,fz,86.8348
f,1841,fz,86.8348
f,1842,fz,86.8348
f,1864,fz,82.2925
f,1865,fz,61.9362
f,1866,fz,72.0303
f,1870,fz,57.3939
f,1872,fz,57.3939
f,1873,fz,57.3939
f,1876,fz,61.9362
f,1878,fz,82.2925
f,1879,fz,72.0303
f,1882,fz,86.8348
f,1884,fz,86.8348
f,1885,fz,86.8348
f,1907,fz,82.2925
f,1908,fz,61.9362
f,1909,fz,72.0303
f,1913,fz,57.3939
f,1915,fz,57.3939
f,1916,fz,57.3939
f,1919,fz,61.9362
f,1921,fz,82.2925
f,1922,fz,72.0303
f,1925,fz,86.8348
f,1927,fz,86.8348
f,1928,fz,86.8348
f,1950,fz,82.2925
f,1951,fz,61.9362
f,1952,fz,72.0303
f,1956,fz,57.3939
f,1958,fz,57.3939
f,1959,fz,57.3939
f,1962,fz,61.9362
f,1964,fz,82.2925
f,1965,fz,72.0303
f,1968,fz,86.8348
f,1970,fz,86.8348
f,1971,fz,86.8348
f,1993,fz,82.2925
f,1994,fz,61.9362
f,1995,fz,72.0303
f,1999,fz,57.3939
f,2001,fz,57.3939
f,2002,fz,57.3939
f,2005,fz,61.9362
f,2007,fz,82.2925
f,2008,fz,72.0303
f,2011,fz,86.8348
f,2013,fz,86.8348
f,2014,fz,86.8348
f,2036,fz,82.2925
f,2037,fz,61.9362
f,2038,fz,72.0303
f,2042,fz,57.3939
f,2044,fz,57.3939
f,2045,fz,57.3939
f,2048,fz,61.9362
f,2050,fz,82.2925
f,2051,fz,72.0303
f,2054,fz,86.8348
f,2056,fz,86.8348
f,2057,fz,86.8348
f,2079,fz,82.2925
f,2080,fz,61.9362
f,2081,fz,72.0303
f,2085,fz,57.3939
f,2087,fz,57.3939
f,2088,fz,57.3939
f,2091,fz,61.9362
f,2093,fz,82.2925
f,2094,fz,72.0303
f,2097,fz,86.8348
f,2099,fz,86.8348
f,2100,fz,86.8348
f,2122,fz,41.9164
f,2123,fz,21.5601
f,2124,fz,31.8224
f,2128,fz,17.1861
f,2130,fz,17.1861
f,2131,fz,17.1861
f,2134,fz,21.5601
f,2136,fz,41.9164
f,2137,fz,31.8224
f,2140,fz,46.4587
f,2142,fz,46.4587
f,2143,fz,46.4587
f,2169,fz,41.9164
f,2170,fz,21.5601
f,2171,fz,31.8224
f,2175,fz,17.1861
f,2177,fz,17.1861
f,2178,fz,17.1861
f,2181,fz,21.5601
f,2183,fz,41.9164
f,2184,fz,31.8224
f,2187,fz,46.4587
f,2189,fz,46.4587
f,2190,fz,46.4587
f,2212,fz,41.9164
f,2213,fz,21.5601
f,2214,fz,31.8224
f,2218,fz,17.1861
f,2220,fz,17.1861
f,2221,fz,17.1861
f,2224,fz,21.5601
f,2226,fz,41.9164
f,2227,fz,31.8224
f,2230,fz,46.4587
f,2232,fz,46.4587
f,2233,fz,46.4587
f,2255,fz,41.9164
f,2256,fz,21.5601
f,2257,fz,31.8224
f,2261,fz,17.1861

f.2263,fz.17.1861
f.2264,fz.17.1861
f.2267,fz.21.5601
f.2269,fz.41.9164
f.2270,fz.31.8224
f.2273,fz.46.4587
f.2275,fz.46.4587
f.2276,fz.46.4587
f.2298,fz.41.9164
f.2299,fz.21.5601
f.2300,fz.31.8224
f.2304,fz.17.1861
f.2306,fz.17.1861
f.2307,fz.17.1861
f.2310,fz.21.5601
f.2312,fz.41.9164
f.2313,fz.31.8224
f.2316,fz.46.4587
f.2318,fz.46.4587
f.2319,fz.46.4587
f.2341,fz.41.9164
f.2342,fz.21.5601
f.2343,fz.31.8224
f.2347,fz.17.1861
f.2349,fz.17.1861
f.2350,fz.17.1861
f.2353,fz.21.5601
f.2355,fz.41.9164
f.2356,fz.31.8224
f.2359,fz.46.4587
f.2361,fz.46.4587
f.2362,fz.46.4587
f.2384,fz.41.9164
f.2385,fz.21.5601
f.2386,fz.31.8224
f.2390,fz.17.1861
f.2392,fz.17.1861
f.2393,fz.17.1861
f.2396,fz.21.5601
f.2398,fz.41.9164
f.2399,fz.31.8224
f.2402,fz.46.4587
f.2404,fz.46.4587
f.2405,fz.46.4587
f.2427,fz.41.9164
f.2428,fz.21.5601
f.2429,fz.31.8224
f.2433,fz.17.1861
f.2435,fz.17.1861
f.2436,fz.17.1861
f.2439,fz.21.5601
f.2441,fz.41.9164
f.2442,fz.31.8224
f.2445,fz.46.4587
f.2447,fz.46.4587
f.2448,fz.46.4587
f.2470,fz.1.70857
f.2471,fz.-18.648
f.2472,fz.-8.3855
f.2476,fz.-23.19
f.2478,fz.-23.19
f.2479,fz.-23.19
f.2482,fz.-18.648
f.2484,fz.1.70857
f.2485,fz.-8.3855
f.2488,fz.6.25088
f.2490,fz.6.25088
f.2491,fz.6.25088
f.2517,fz.1.70857
f.2518,fz.-18.648
f.2519,fz.-8.3855
f.2523,fz.-23.19
f.2525,fz.-23.19
f.2526,fz.-23.19
f.2529,fz.-18.648
f.2531,fz.1.70857
f.2532,fz.-8.3855
f.2535,fz.6.25088
f.2537,fz.6.25088
f.2538,fz.6.25088
f.2560,fz.1.70857
f.2561,fz.-18.648
f.2562,fz.-8.3855
f.2566,fz.-23.19
f.2568,fz.-23.19
f.2569,fz.-23.19
f.2572,fz.-18.648
f.2574,fz.1.70857
f.2575,fz.-8.3855
f.2578,fz.6.25088
f.2580,fz.6.25088
f.2581,fz.6.25088
f.2603,fz.1.70857
f.2604,fz.-18.648
f.2605,fz.-8.3855
f.2609,fz.-23.19
f.2611,fz.-23.19
f.2612,fz.-23.19
f.2615,fz.-18.648
f.2617,fz.1.70857
f.2618,fz.-8.3855
f.2621,fz.6.25088
f.2623,fz.6.25088
f.2624,fz.6.25088
f.2646,fz.1.70857
f.2647,fz.-18.648
f.2648,fz.-8.3855
f.2652,fz.-23.19
f.2654,fz.-23.19
f.2655,fz.-23.19
f.2658,fz.-18.648
f.2660,fz.1.70857
f.2661,fz.-8.3855
f.2664,fz.6.25088
f.2666,fz.6.25088
f.2667,fz.6.25088
f.2689,fz.1.70857
f.2690,fz.-18.648
f.2691,fz.-8.3855
f.2695,fz.-23.19
f.2697,fz.-23.19
f.2698,fz.-23.19
f.2701,fz.-18.648
f.2703,fz.1.70857
f.2704,fz.-8.3855
f.2707,fz.6.25088
f.2709,fz.6.25088
f.2710,fz.6.25088
f.2732,fz.1.70857
f.2733,fz.-18.648
f.2734,fz.-8.3855
f.2738,fz.-23.19
f.2740,fz.-23.19
f.2741,fz.-23.19
f.2744,fz.-18.648
f.2746,fz.1.70857
f.2747,fz.-8.3855
f.2750,fz.6.25088
f.2752,fz.6.25088
f.2753,fz.6.25088
f.2775,fz.1.70857
f.2776,fz.-18.648
f.2777,fz.-8.3855
f.2781,fz.-23.19
f.2783,fz.-23.19
f.2784,fz.-23.19
f.2787,fz.-18.648
f.2789,fz.1.70857
f.2790,fz.-8.3855
f.2793,fz.6.25088
f.2795,fz.6.25088
f.2796,fz.6.25088
f.2818,fz.-38.499
f.2819,fz.-58.856
f.2820,fz.-48.762
f.2824,fz.-63.398
f.2826,fz.-63.398
f.2827,fz.-63.398
f.2830,fz.-58.856
f.2832,fz.-38.499
f.2833,fz.-48.762
f.2836,fz.-33.957
f.2838,fz.-33.957
f.2839,fz.-33.957
f.2865,fz.-38.499
f.2866,fz.-58.856
f.2867,fz.-48.762
f.2871,fz.-63.398
f.2873,fz.-63.398
f.2874,fz.-63.398
f.2877,fz.-58.856
f.2879,fz.-38.499
f.2880,fz.-48.762
f.2883,fz.-33.957
f.2885,fz.-33.957
f.2886,fz.-33.957
f.2908,fz.-38.499
f.2909,fz.-58.856
f.2910,fz.-48.762
f.2914,fz.-63.398
f.2916,fz.-63.398
f.2917,fz.-63.398
f.2920,fz.-58.856
f.2922,fz.-38.499
f.2923,fz.-48.762
f.2926,fz.-33.957
f.2928,fz.-33.957
f.2929,fz.-33.957
f.2951,fz.-38.499
f.2952,fz.-58.856
f.2953,fz.-48.762
f.2957,fz.-63.398
f.2959,fz.-63.398
f.2960,fz.-63.398
f.2963,fz.-58.856
f.2965,fz.-38.499
f.2966,fz.-48.762
f.2969,fz.-33.957
f.2971,fz.-33.957
f.2972,fz.-33.957
f.2994,fz.-38.499
f.2995,fz.-58.856
f.2996,fz.-48.762
f.3000,fz.-63.398
f.3002,fz.-63.398
f.3003,fz.-63.398
f.3006,fz.-58.856
f.3008,fz.-38.499
f.3009,fz.-48.762
f.3012,fz.-33.957
f.3014,fz.-33.957
f.3015,fz.-33.957
f.3037,fz.-38.499
f.3038,fz.-58.856
f.3039,fz.-48.762
f.3043,fz.-63.398
f.3045,fz.-63.398
f.3046,fz.-63.398
f.3049,fz.-58.856
f.3051,fz.-38.499
f.3052,fz.-48.762
f.3055,fz.-33.957
f.3057,fz.-33.957
f.3058,fz.-33.957
f.3080,fz.-38.499
f.3081,fz.-58.856
f.3082,fz.-48.762
f.3086,fz.-63.398
f.3088,fz.-63.398
f.3089,fz.-63.398
f.3092,fz.-58.856
f.3094,fz.-38.499
f.3095,fz.-48.762
f.3098,fz.-33.957
f.3100,fz.-33.957
f.3101,fz.-33.957
f.3123,fz.-38.499
f.3124,fz.-58.856
f.3125,fz.-48.762
f.3129,fz.-63.398
f.3131,fz.-63.398
f.3132,fz.-63.398
f.3135,fz.-58.856
f.3137,fz.-38.499
f.3138,fz.-48.762
f.3141,fz.-33.957
f.3143,fz.-33.957
f.3144,fz.-33.957
f.3166,fz.-78.707
f.3167,fz.-99.063
f.3168,fz.-88.969
f.3172,fz.-103.61
f.3174,fz.-103.61
f.3175,fz.-103.61
f.3178,fz.-99.063
f.3180,fz.-78.707
f.3181,fz.-88.969
f.3184,fz.-74.333
f.3186,fz.-74.333
f.3187,fz.-74.333
f.3213,fz.-78.707
f.3214,fz.-99.063
f.3215,fz.-88.969
f.3219,fz.-103.61
f.3221,fz.-103.61
f.3222,fz.-103.61
f.3225,fz.-99.063
f.3227,fz.-78.707
f.3228,fz.-88.969
f.3231,fz.-74.333
f.3233,fz.-74.333
f.3234,fz.-74.333
f.3256,fz.-78.707
f.3257,fz.-99.063
f.3258,fz.-88.969
f.3262,fz.-103.61
f.3264,fz.-103.61
f.3265,fz.-103.61
f.3268,fz.-99.063
f.3270,fz.-78.707
f.3271,fz.-88.969
f.3274,fz.-74.333
f.3276,fz.-74.333
f.3277,fz.-74.333
f.3299,fz.-78.707
f.3300,fz.-99.063
f.3301,fz.-88.969
f.3305,fz.-103.61
f.3307,fz.-103.61
f.3308,fz.-103.61
f.3311,fz.-99.063
f.3313,fz.-78.707
f.3314,fz.-88.969
f.3317,fz.-74.333
f.3319,fz.-74.333
f.3320,fz.-74.333
f.3342,fz.-78.707
f.3343,fz.-99.063
f.3344,fz.-88.969
f.3348,fz.-103.61
f.3350,fz.-103.61
f.3351,fz.-103.61
f.3354,fz.-99.063
f.3356,fz.-78.707
f.3357,fz.-88.969
f.3360,fz.-74.333
f.3362,fz.-74.333
f.3363,fz.-74.333
f.3385,fz.-78.707
f.3386,fz.-99.063
f.3387,fz.-88.969
f.3391,fz.-103.61
f.3393,fz.-103.61
f.3394,fz.-103.61
f.3397,fz.-99.063
f.3399,fz.-78.707
f.3400,fz.-88.969
f.3403,fz.-74.333
f.3405,fz.-74.333
f.3406,fz.-74.333
f.3428,fz.-78.707
f.3429,fz.-99.063
f.3430,fz.-88.969
f.3434,fz.-103.61
f.3436,fz.-103.61
f.3437,fz.-103.61
f.3440,fz.-99.063
f.3442,fz.-78.707
f.3443,fz.-88.969
f.3446,fz.-74.333
f.3448,fz.-74.333
f.3449,fz.-74.333

f,3471,fz,-78.707
f,3472,fz,-99.063
f,3473,fz,-88.969
f,3477,fz,-103.61
f,3479,fz,-103.61
f,3480,fz,-103.61
f,3483,fz,-99.063
f,3485,fz,-78.707
f,3486,fz,-88.969
f,3489,fz,-74.333
f,3491,fz,-74.333
f,3492,fz,-74.333
f,3514,fz,-119.08
f,3515,fz,-139.44
f,3516,fz,-129.18
f,3520,fz,-143.98
f,3522,fz,-143.98
f,3523,fz,-143.98
f,3526,fz,-139.44
f,3528,fz,-119.08
f,3529,fz,-129.18
f,3532,fz,-114.54
f,3534,fz,-114.54
f,3535,fz,-114.54
f,3561,fz,-119.08
f,3562,fz,-139.44
f,3563,fz,-129.18
f,3567,fz,-143.98
f,3569,fz,-143.98
f,3570,fz,-143.98
f,3573,fz,-139.44
f,3575,fz,-119.08
f,3576,fz,-129.18
f,3579,fz,-114.54
f,3581,fz,-114.54
f,3582,fz,-114.54
f,3604,fz,-119.08
f,3605,fz,-139.44
f,3606,fz,-129.18
f,3610,fz,-143.98
f,3612,fz,-143.98
f,3613,fz,-143.98
f,3616,fz,-139.44
f,3618,fz,-119.08
f,3619,fz,-129.18
f,3622,fz,-114.54
f,3624,fz,-114.54
f,3625,fz,-114.54
f,3647,fz,-119.08
f,3648,fz,-139.44
f,3649,fz,-129.18
f,3653,fz,-143.98
f,3655,fz,-143.98
f,3656,fz,-143.98
f,3659,fz,-139.44
f,3661,fz,-119.08
f,3662,fz,-129.18
f,3665,fz,-114.54
f,3667,fz,-114.54
f,3668,fz,-114.54
f,3690,fz,-119.08
f,3691,fz,-139.44
f,3692,fz,-129.18
f,3696,fz,-143.98
f,3698,fz,-143.98
f,3699,fz,-143.98
f,3702,fz,-139.44
f,3704,fz,-119.08
f,3705,fz,-129.18
f,3708,fz,-114.54
f,3710,fz,-114.54
f,3711,fz,-114.54
f,3733,fz,-119.08
f,3734,fz,-139.44
f,3735,fz,-129.18
f,3739,fz,-143.98
f,3741,fz,-143.98
f,3742,fz,-143.98
f,3745,fz,-139.44
f,3747,fz,-119.08
f,3748,fz,-129.18
f,3751,fz,-114.54
f,3753,fz,-114.54
f,3754,fz,-114.54
f,3776,fz,-119.08
f,3777,fz,-139.44
f,3778,fz,-129.18
f,3782,fz,-143.98
f,3784,fz,-143.98
f,3785,fz,-143.98
f,3788,fz,-139.44
f,3790,fz,-119.08
f,3791,fz,-129.18
f,3794,fz,-114.54
f,3796,fz,-114.54
f,3797,fz,-114.54
f,3819,fz,-119.08
f,3820,fz,-139.44
f,3821,fz,-129.18
f,3825,fz,-143.98
f,3827,fz,-143.98
f,3828,fz,-143.98
f,3831,fz,-139.44
f,3833,fz,-119.08
f,3834,fz,-129.18
f,3837,fz,-114.54
f,3839,fz,-114.54
f,3840,fz,-114.54
f,3862,fz,-159.29
f,3863,fz,-179.65
f,3864,fz,-169.39
f,3868,fz,-184.19
f,3870,fz,-184.19
f,3871,fz,-184.19
f,3874,fz,-179.65
f,3876,fz,-159.29
f,3877,fz,-169.39
f,3880,fz,-154.75
f,3882,fz,-154.75
f,3883,fz,-154.75
f,3909,fz,-159.29
f,3910,fz,-179.65
f,3911,fz,-169.39
f,3915,fz,-184.19
f,3917,fz,-184.19
f,3918,fz,-184.19
f,3921,fz,-179.65
f,3923,fz,-159.29
f,3924,fz,-169.39
f,3927,fz,-154.75
f,3929,fz,-154.75
f,3930,fz,-154.75
f,3952,fz,-159.29
f,3953,fz,-179.65
f,3954,fz,-169.39
f,3958,fz,-184.19
f,3960,fz,-184.19
f,3961,fz,-184.19
f,3964,fz,-179.65
f,3966,fz,-159.29
f,3967,fz,-169.39
f,3970,fz,-154.75
f,3972,fz,-154.75
f,3973,fz,-154.75
f,3995,fz,-159.29
f,3996,fz,-179.65
f,3997,fz,-169.39
f,4001,fz,-184.19
f,4003,fz,-184.19
f,4004,fz,-184.19
f,4007,fz,-179.65
f,4009,fz,-159.29
f,4010,fz,-169.39
f,4013,fz,-154.75
f,4015,fz,-154.75
f,4016,fz,-154.75
f,4038,fz,-159.29
f,4039,fz,-179.65
f,4040,fz,-169.39
f,4044,fz,-184.19
f,4046,fz,-184.19
f,4047,fz,-184.19
f,4050,fz,-179.65
f,4052,fz,-159.29
f,4053,fz,-169.39
f,4056,fz,-154.75
f,4058,fz,-154.75
f,4059,fz,-154.75
f,4081,fz,-159.29
f,4082,fz,-179.65
f,4083,fz,-169.39
f,4087,fz,-184.19
f,4089,fz,-184.19
f,4090,fz,-184.19
f,4093,fz,-179.65
f,4095,fz,-159.29
f,4096,fz,-169.39
f,4099,fz,-154.75
f,4101,fz,-154.75
f,4102,fz,-154.75
f,4124,fz,-159.29
f,4125,fz,-179.65
f,4126,fz,-169.39
f,4130,fz,-184.19
f,4132,fz,-184.19
f,4133,fz,-184.19
f,4136,fz,-179.65
f,4138,fz,-159.29
f,4139,fz,-169.39
f,4142,fz,-154.75
f,4144,fz,-154.75
f,4145,fz,-154.75
f,4167,fz,-159.29
f,4168,fz,-179.65
f,4169,fz,-169.39
f,4173,fz,-184.19
f,4175,fz,-184.19
f,4176,fz,-184.19
f,4179,fz,-179.65
f,4181,fz,-159.29
f,4182,fz,-169.39
f,4185,fz,-154.75
f,4187,fz,-154.75
f,4188,fz,-154.75
f,4210,fz,-199.5
f,4211,fz,-219.86
f,4212,fz,-209.76
f,4216,fz,-224.4
f,4218,fz,-224.4
f,4219,fz,-224.4
f,4222,fz,-219.86
f,4224,fz,-199.5
f,4225,fz,-209.76
f,4228,fz,-194.96
f,4230,fz,-194.96
f,4231,fz,-194.96
f,4257,fz,-199.5
f,4258,fz,-219.86
f,4259,fz,-209.76
f,4263,fz,-224.4
f,4265,fz,-224.4
f,4266,fz,-224.4
f,4269,fz,-219.86
f,4271,fz,-199.5
f,4272,fz,-209.76
f,4275,fz,-194.96
f,4277,fz,-194.96
f,4278,fz,-194.96
f,4300,fz,-199.5
f,4301,fz,-219.86
f,4302,fz,-209.76
f,4306,fz,-224.4
f,4308,fz,-224.4
f,4309,fz,-224.4
f,4312,fz,-219.86
f,4314,fz,-199.5
f,4315,fz,-209.76
f,4318,fz,-194.96
f,4320,fz,-194.96
f,4321,fz,-194.96
f,4343,fz,-199.5
f,4344,fz,-219.86
f,4345,fz,-209.76
f,4349,fz,-224.4
f,4351,fz,-224.4
f,4352,fz,-224.4
f,4355,fz,-219.86
f,4357,fz,-199.5
f,4358,fz,-209.76
f,4361,fz,-194.96
f,4363,fz,-194.96
f,4364,fz,-194.96
f,4386,fz,-199.5
f,4387,fz,-219.86
f,4388,fz,-209.76
f,4392,fz,-224.4
f,4394,fz,-224.4
f,4395,fz,-224.4
f,4398,fz,-219.86
f,4400,fz,-199.5
f,4401,fz,-209.76
f,4404,fz,-194.96
f,4406,fz,-194.96
f,4407,fz,-194.96
f,4429,fz,-199.5
f,4430,fz,-219.86
f,4431,fz,-209.76
f,4435,fz,-224.4
f,4437,fz,-224.4
f,4438,fz,-224.4
f,4441,fz,-219.86
f,4443,fz,-199.5
f,4444,fz,-209.76
f,4447,fz,-194.96
f,4449,fz,-194.96
f,4450,fz,-194.96
f,4472,fz,-199.5
f,4473,fz,-219.86
f,4474,fz,-209.76
f,4478,fz,-224.4
f,4480,fz,-224.4
f,4481,fz,-224.4
f,4484,fz,-219.86
f,4486,fz,-199.5
f,4487,fz,-209.76
f,4490,fz,-194.96
f,4492,fz,-194.96
f,4493,fz,-194.96
f,4515,fz,-199.5
f,4516,fz,-219.86
f,4517,fz,-209.76
f,4521,fz,-224.4
f,4523,fz,-224.4
f,4524,fz,-224.4
f,4527,fz,-219.86
f,4529,fz,-199.5
f,4530,fz,-209.76
f,4533,fz,-194.96
f,4535,fz,-194.96
f,4536,fz,-194.96
f,4558,fz,-239.88
f,4559,fz,-260.06
f,4560,fz,-249.97
f,4564,fz,-264.61
f,4566,fz,-264.61
f,4567,fz,-264.61
f,4570,fz,-260.06
f,4572,fz,-239.88
f,4573,fz,-249.97
f,4576,fz,-235.33
f,4578,fz,-235.33
f,4579,fz,-235.33
f,4605,fz,-239.88
f,4606,fz,-260.06
f,4607,fz,-249.97
f,4611,fz,-264.61
f,4613,fz,-264.61
f,4614,fz,-264.61
f,4617,fz,-260.06
f,4619,fz,-239.88
f,4620,fz,-249.97
f,4623,fz,-235.33
f,4625,fz,-235.33
f,4626,fz,-235.33
f,4648,fz,-239.88
f,4649,fz,-260.06
f,4650,fz,-249.97
f,4654,fz,-264.61
f,4656,fz,-264.61
f,4657,fz,-264.61
f,4660,fz,-260.06
f,4662,fz,-239.88

f,4663,fz,-249.97
f,4666,fz,-235.33
f,4668,fz,-235.33
f,4669,fz,-235.33
f,4691,fz,-239.88
f,4692,fz,-260.06
f,4693,fz,-249.97
f,4697,fz,-264.61
f,4699,fz,-264.61
f,4700,fz,-264.61
f,4703,fz,-260.06
f,4705,fz,-239.88
f,4706,fz,-249.97
f,4709,fz,-235.33
f,4711,fz,-235.33
f,4712,fz,-235.33
f,4734,fz,-239.88
f,4735,fz,-260.06
f,4736,fz,-249.97
f,4740,fz,-264.61
f,4742,fz,-264.61
f,4743,fz,-264.61
f,4746,fz,-260.06
f,4748,fz,-239.88
f,4749,fz,-249.97
f,4752,fz,-235.33
f,4754,fz,-235.33
f,4755,fz,-235.33
f,4777,fz,-239.88
f,4778,fz,-260.06
f,4779,fz,-249.97
f,4783,fz,-264.61
f,4785,fz,-264.61
f,4786,fz,-264.61
f,4789,fz,-260.06
f,4791,fz,-239.88
f,4792,fz,-249.97
f,4795,fz,-235.33
f,4797,fz,-235.33
f,4798,fz,-235.33
f,4820,fz,-239.88
f,4821,fz,-260.06
f,4822,fz,-249.97
f,4826,fz,-264.61
f,4828,fz,-264.61
f,4829,fz,-264.61
f,4832,fz,-260.06
f,4834,fz,-239.88
f,4835,fz,-249.97
f,4838,fz,-235.33
f,4840,fz,-235.33
f,4841,fz,-235.33
f,4863,fz,-239.88
f,4864,fz,-260.06
f,4865,fz,-249.97
f,4869,fz,-264.61
f,4871,fz,-264.61
f,4872,fz,-264.61
f,4875,fz,-260.06
f,4877,fz,-239.88
f,4878,fz,-249.97
f,4881,fz,-235.33
f,4883,fz,-235.33
f,4884,fz,-235.33
f,4906,fz,-280.08
f,4907,fz,-300.44
f,4908,fz,-290.18
f,4912,fz,-304.98
f,4914,fz,-304.98
f,4915,fz,-304.98
f,4918,fz,-300.44
f,4920,fz,-280.08
f,4921,fz,-290.18
f,4924,fz,-275.54
f,4926,fz,-275.54
f,4927,fz,-275.54
f,4953,fz,-280.08
f,4954,fz,-300.44
f,4955,fz,-290.18
f,4959,fz,-304.98
f,4961,fz,-304.98
f,4962,fz,-304.98
f,4965,fz,-300.44
f,4967,fz,-280.08
f,4968,fz,-290.18
f,4971,fz,-275.54
f,4973,fz,-275.54
f,4974,fz,-275.54
f,4996,fz,-280.08
f,4997,fz,-300.44
f,4998,fz,-290.18
f,5002,fz,-304.98
f,5004,fz,-304.98
f,5005,fz,-304.98
f,5008,fz,-300.44
f,5010,fz,-280.08
f,5011,fz,-290.18
f,5014,fz,-275.54
f,5016,fz,-275.54
f,5017,fz,-275.54
f,5039,fz,-280.08
f,5040,fz,-300.44
f,5041,fz,-290.18
f,5045,fz,-304.98
f,5047,fz,-304.98
f,5048,fz,-304.98
f,5051,fz,-300.44
f,5053,fz,-280.08
f,5054,fz,-290.18
f,5057,fz,-275.54
f,5059,fz,-275.54
f,5060,fz,-275.54
f,5082,fz,-280.08
f,5083,fz,-300.44
f,5084,fz,-290.18
f,5088,fz,-304.98
f,5090,fz,-304.98
f,5091,fz,-304.98
f,5094,fz,-300.44
f,5096,fz,-280.08
f,5097,fz,-290.18
f,5100,fz,-275.54
f,5102,fz,-275.54
f,5103,fz,-275.54
f,5125,fz,-280.08
f,5126,fz,-300.44
f,5127,fz,-290.18
f,5131,fz,-304.98
f,5133,fz,-304.98
f,5134,fz,-304.98
f,5137,fz,-300.44
f,5139,fz,-280.08
f,5140,fz,-290.18
f,5143,fz,-275.54
f,5145,fz,-275.54
f,5146,fz,-275.54
f,5168,fz,-280.08
f,5169,fz,-300.44
f,5170,fz,-290.18
f,5174,fz,-304.98
f,5176,fz,-304.98
f,5177,fz,-304.98
f,5180,fz,-300.44
f,5182,fz,-280.08
f,5183,fz,-290.18
f,5186,fz,-275.54
f,5188,fz,-275.54
f,5189,fz,-275.54
f,5211,fz,-280.08
f,5212,fz,-300.44
f,5213,fz,-290.18
f,5217,fz,-304.98
f,5219,fz,-304.98
f,5220,fz,-304.98
f,5223,fz,-300.44
f,5225,fz,-280.08
f,5226,fz,-290.18
f,5229,fz,-275.54
f,5231,fz,-275.54
f,5232,fz,-275.54
f,5254,fz,-320.29
f,5255,fz,-340.65
f,5256,fz,-330.55
f,5260,fz,-345.19
f,5262,fz,-345.19
f,5263,fz,-345.19
f,5266,fz,-340.65
f,5268,fz,-320.29
f,5269,fz,-330.55
f,5272,fz,-315.75
f,5274,fz,-315.75
f,5275,fz,-315.75
f,5301,fz,-320.29
f,5302,fz,-340.65
f,5303,fz,-330.55
f,5307,fz,-345.19
f,5309,fz,-345.19
f,5310,fz,-345.19
f,5313,fz,-340.65
f,5315,fz,-320.29
f,5316,fz,-330.55
f,5319,fz,-315.75
f,5321,fz,-315.75
f,5322,fz,-315.75
f,5344,fz,-320.29
f,5345,fz,-340.65
f,5346,fz,-330.55
f,5350,fz,-345.19
f,5352,fz,-345.19
f,5353,fz,-345.19
f,5356,fz,-340.65
f,5358,fz,-320.29
f,5359,fz,-330.55
f,5362,fz,-315.75
f,5364,fz,-315.75
f,5365,fz,-315.75
f,5387,fz,-320.29
f,5388,fz,-340.65
f,5389,fz,-330.55
f,5393,fz,-345.19
f,5395,fz,-345.19
f,5396,fz,-345.19
f,5399,fz,-340.65
f,5401,fz,-320.29
f,5402,fz,-330.55
f,5405,fz,-315.75
f,5407,fz,-315.75
f,5408,fz,-315.75
f,5430,fz,-320.29
f,5431,fz,-340.65
f,5432,fz,-330.55
f,5436,fz,-345.19
f,5438,fz,-345.19
f,5439,fz,-345.19
f,5442,fz,-340.65
f,5444,fz,-320.29
f,5445,fz,-330.55
f,5448,fz,-315.75
f,5450,fz,-315.75
f,5451,fz,-315.75
f,5473,fz,-320.29
f,5474,fz,-340.65
f,5475,fz,-330.55
f,5479,fz,-345.19
f,5481,fz,-345.19
f,5482,fz,-345.19
f,5485,fz,-340.65
f,5487,fz,-320.29
f,5488,fz,-330.55
f,5491,fz,-315.75
f,5493,fz,-315.75
f,5494,fz,-315.75
f,5516,fz,-320.29
f,5517,fz,-340.65
f,5518,fz,-330.55
f,5522,fz,-345.19
f,5524,fz,-345.19
f,5525,fz,-345.19
f,5528,fz,-340.65
f,5530,fz,-320.29
f,5531,fz,-330.55
f,5534,fz,-315.75
f,5536,fz,-315.75
f,5537,fz,-315.75
f,5559,fz,-320.29
f,5560,fz,-340.65
f,5561,fz,-330.55
f,5565,fz,-345.19
f,5567,fz,-345.19
f,5568,fz,-345.19
f,5571,fz,-340.65
f,5573,fz,-320.29
f,5574,fz,-330.55
f,5577,fz,-315.75
f,5579,fz,-315.75
f,5580,fz,-315.75
f,5978,fz,532.459
f,5986,fz,573.172
f,6010,fz,552.984
f,6028,fz,523.375
f,6048,fz,523.375
f,6064,fz,523.375
f,6082,fz,532.459
f,6102,fz,573.172
f,6118,fz,552.984
f,6136,fz,582.257
f,6156,fz,582.257
f,6172,fz,582.257
f,6194,fz,532.459
f,6202,fz,573.172
f,6226,fz,552.984
f,6244,fz,523.375
f,6264,fz,523.375
f,6280,fz,523.375
f,6298,fz,532.459
f,6318,fz,573.172
f,6334,fz,552.984
f,6352,fz,582.257
f,6372,fz,582.257
f,6388,fz,582.257
f,6410,fz,532.459
f,6418,fz,573.172
f,6442,fz,552.984
f,6460,fz,523.375
f,6480,fz,523.375
f,6496,fz,523.375
f,6514,fz,532.459
f,6534,fz,573.172
f,6550,fz,552.984
f,6568,fz,582.257
f,6588,fz,582.257
f,6604,fz,582.257
f,6626,fz,532.459
f,6634,fz,573.172
f,6658,fz,552.984
f,6676,fz,523.375
f,6696,fz,523.375
f,6712,fz,523.375
f,6730,fz,532.459
f,6750,fz,573.172
f,6766,fz,552.984
f,6784,fz,582.257
f,6804,fz,582.257
f,6820,fz,582.257
f,6842,fz,532.459
f,6850,fz,573.172
f,6874,fz,552.984
f,6892,fz,523.375
f,6912,fz,523.375
f,6928,fz,523.375
f,6946,fz,532.459
f,6966,fz,573.172
f,6982,fz,552.984
f,7000,fz,582.257
f,7020,fz,582.257
f,7036,fz,582.257
f,7058,fz,532.459
f,7066,fz,573.172
f,7090,fz,552.984
f,7108,fz,523.375
f,7128,fz,523.375
f,7144,fz,523.375
f,7162,fz,532.459
f,7182,fz,573.172
f,7198,fz,552.984
f,7216,fz,582.257
f,7236,fz,582.257
f,7252,fz,582.257
f,7274,fz,532.459
f,7282,fz,573.172
f,7306,fz,552.984
f,7324,fz,523.375

f,7344,fz,523.375
f,7360,fz,523.375
f,7378,fz,532.459
f,7398,fz,573.172
f,7414,fz,552.984
f,7432,fz,582.257
f,7452,fz,582.257
f,7468,fz,582.257
f,7490,fz,532.459
f,7498,fz,573.172
f,7522,fz,552.984
f,7540,fz,523.375
f,7560,fz,523.375
f,7576,fz,523.375
f,7594,fz,532.459
f,7614,fz,573.172
f,7630,fz,552.984
f,7648,fz,582.257
f,7668,fz,582.257
f,7684,fz,582.257
f,7706,fz,452.044
f,7714,fz,492.756
f,7738,fz,472.232
f,7756,fz,442.959
f,7776,fz,442.959
f,7792,fz,442.959
f,7810,fz,452.044
f,7830,fz,492.756
f,7846,fz,472.232
f,7864,fz,501.841
f,7884,fz,501.841
f,7900,fz,501.841
f,7922,fz,452.044
f,7930,fz,492.756
f,7954,fz,472.232
f,7972,fz,442.959
f,7992,fz,442.959
f,8008,fz,442.959
f,8026,fz,452.044
f,8046,fz,492.756
f,8062,fz,472.232
f,8080,fz,501.841
f,8100,fz,501.841
f,8116,fz,501.841
f,8138,fz,452.044
f,8146,fz,492.756
f,8170,fz,472.232
f,8188,fz,442.959
f,8208,fz,442.959
f,8224,fz,442.959
f,8242,fz,452.044
f,8262,fz,492.756
f,8278,fz,472.232
f,8296,fz,501.841
f,8316,fz,501.841
f,8332,fz,501.841
f,8354,fz,452.044
f,8362,fz,492.756
f,8386,fz,472.232
f,8404,fz,442.959
f,8424,fz,442.959
f,8440,fz,442.959
f,8458,fz,452.044
f,8478,fz,492.756
f,8494,fz,472.232
f,8512,fz,501.841
f,8532,fz,501.841
f,8548,fz,501.841
f,8570,fz,452.044
f,8578,fz,492.756
f,8602,fz,472.232
f,8620,fz,442.959
f,8640,fz,442.959
f,8656,fz,442.959
f,8674,fz,452.044
f,8694,fz,492.756
f,8710,fz,472.232
f,8728,fz,501.841
f,8748,fz,501.841
f,8764,fz,501.841
f,8786,fz,452.044
f,8794,fz,492.756
f,8818,fz,472.232
f,8836,fz,442.959
f,8856,fz,442.959
f,8872,fz,442.959
f,8890,fz,452.044
f,8910,fz,492.756
f,8926,fz,472.232
f,8944,fz,501.841
f,8964,fz,501.841
f,8980,fz,501.841
f,9002,fz,452.044
f,9010,fz,492.756
f,9034,fz,472.232
f,9052,fz,442.959
f,9072,fz,442.959
f,9088,fz,442.959
f,9106,fz,452.044
f,9126,fz,492.756
f,9142,fz,472.232
f,9160,fz,501.841
f,9180,fz,501.841
f,9196,fz,501.841
f,9218,fz,452.044
f,9226,fz,492.756
f,9250,fz,472.232
f,9268,fz,442.959
f,9288,fz,442.959
f,9304,fz,442.959
f,9322,fz,452.044
f,9342,fz,492.756
f,9358,fz,472.232
f,9376,fz,501.841
f,9396,fz,501.841
f,9412,fz,501.841
f,9434,fz,371.628
f,9442,fz,412.004
f,9466,fz,391.816
f,9484,fz,362.543
f,9504,fz,362.543
f,9520,fz,362.543
f,9538,fz,371.628
f,9558,fz,412.004
f,9574,fz,391.816
f,9592,fz,421.089
f,9612,fz,421.089
f,9628,fz,421.089
f,9650,fz,371.628
f,9658,fz,412.004
f,9682,fz,391.816
f,9700,fz,362.543
f,9720,fz,362.543
f,9736,fz,362.543
f,9754,fz,371.628
f,9774,fz,412.004
f,9790,fz,391.816
f,9808,fz,421.089
f,9828,fz,421.089
f,9844,fz,421.089
f,9866,fz,371.628
f,9874,fz,412.004
f,9898,fz,391.816
f,9916,fz,362.543
f,9936,fz,362.543
f,9952,fz,362.543
f,9970,fz,371.628
f,9990,fz,412.004
f,10006,fz,391.816
f,10024,fz,421.089
f,10044,fz,421.089
f,10060,fz,421.089
f,10082,fz,371.628
f,10090,fz,412.004
f,10114,fz,391.816
f,10132,fz,362.543
f,10152,fz,362.543
f,10168,fz,362.543
f,10186,fz,371.628
f,10206,fz,412.004
f,10222,fz,391.816
f,10240,fz,421.089
f,10260,fz,421.089
f,10276,fz,421.089
f,10298,fz,371.628
f,10306,fz,412.004
f,10330,fz,391.816
f,10348,fz,362.543
f,10368,fz,362.543
f,10384,fz,362.543
f,10402,fz,371.628
f,10422,fz,412.004
f,10438,fz,391.816
f,10456,fz,421.089
f,10476,fz,421.089
f,10492,fz,421.089
f,10514,fz,371.628
f,10522,fz,412.004
f,10546,fz,391.816
f,10564,fz,362.543
f,10584,fz,362.543
f,10600,fz,362.543
f,10618,fz,371.628
f,10638,fz,412.004
f,10654,fz,391.816
f,10672,fz,421.089
f,10692,fz,421.089
f,10708,fz,421.089
f,10730,fz,371.628
f,10738,fz,412.004
f,10762,fz,391.816
f,10780,fz,362.543
f,10800,fz,362.543
f,10816,fz,362.543
f,10834,fz,371.628
f,10854,fz,412.004
f,10870,fz,391.816
f,10888,fz,421.089
f,10908,fz,421.089
f,10924,fz,421.089
f,10946,fz,371.628
f,10954,fz,412.004
f,10978,fz,391.816
f,10996,fz,362.543
f,11016,fz,362.543
f,11032,fz,362.543
f,11050,fz,371.628
f,11070,fz,412.004
f,11086,fz,391.816
f,11104,fz,421.089
f,11124,fz,421.089
f,11140,fz,421.089
f,11162,fz,290.876
f,11170,fz,331.588
f,11194,fz,311.4
f,11212,fz,281.791
f,11232,fz,281.791
f,11248,fz,281.791
f,11266,fz,290.876
f,11286,fz,331.588
f,11302,fz,311.4
f,11320,fz,340.673
f,11340,fz,340.673
f,11356,fz,340.673
f,11378,fz,290.876
f,11386,fz,331.588
f,11410,fz,311.4
f,11428,fz,281.791
f,11448,fz,281.791
f,11464,fz,281.791
f,11482,fz,290.876
f,11502,fz,331.588
f,11518,fz,311.4
f,11536,fz,340.673
f,11556,fz,340.673
f,11572,fz,340.673
f,11594,fz,290.876
f,11602,fz,331.588
f,11626,fz,311.4
f,11644,fz,281.791
f,11664,fz,281.791
f,11680,fz,281.791
f,11698,fz,290.876
f,11718,fz,331.588
f,11734,fz,311.4
f,11752,fz,340.673
f,11772,fz,340.673
f,11788,fz,340.673
f,11810,fz,290.876
f,11818,fz,331.588
f,11842,fz,311.4
f,11860,fz,281.791
f,11880,fz,281.791
f,11896,fz,281.791
f,11914,fz,290.876
f,11934,fz,331.588
f,11950,fz,311.4
f,11968,fz,340.673
f,11988,fz,340.673
f,12004,fz,340.673
f,12026,fz,290.876
f,12034,fz,331.588
f,12058,fz,311.4
f,12076,fz,281.791
f,12096,fz,281.791
f,12112,fz,281.791
f,12130,fz,290.876
f,12150,fz,331.588
f,12166,fz,311.4
f,12184,fz,340.673
f,12204,fz,340.673
f,12220,fz,340.673
f,12242,fz,290.876
f,12250,fz,331.588
f,12274,fz,311.4
f,12292,fz,281.791
f,12312,fz,281.791
f,12328,fz,281.791
f,12346,fz,290.876
f,12366,fz,331.588
f,12382,fz,311.4
f,12400,fz,340.673
f,12420,fz,340.673
f,12436,fz,340.673
f,12458,fz,290.876
f,12466,fz,331.588
f,12490,fz,311.4
f,12508,fz,281.791
f,12528,fz,281.791
f,12544,fz,281.791
f,12562,fz,290.876
f,12582,fz,331.588
f,12598,fz,311.4
f,12616,fz,340.673
f,12636,fz,340.673
f,12652,fz,340.673
f,12674,fz,290.876
f,12682,fz,331.588
f,12706,fz,311.4
f,12724,fz,281.791
f,12744,fz,281.791
f,12760,fz,281.791
f,12778,fz,290.876
f,12798,fz,331.588
f,12814,fz,311.4
f,12832,fz,340.673
f,12852,fz,340.673
f,12868,fz,340.673
f,12890,fz,210.46
f,12898,fz,251.173
f,12922,fz,230.648
f,12940,fz,201.375
f,12960,fz,201.375
f,12976,fz,201.375
f,12994,fz,210.46
f,13014,fz,251.173
f,13030,fz,230.648
f,13048,fz,260.257
f,13068,fz,260.257
f,13084,fz,260.257
f,13106,fz,210.46
f,13114,fz,251.173
f,13138,fz,230.648
f,13156,fz,201.375
f,13176,fz,201.375
f,13192,fz,201.375
f,13210,fz,210.46
f,13230,fz,251.173
f,13246,fz,230.648
f,13264,fz,260.257
f,13284,fz,260.257
f,13300,fz,260.257

f,13322,fz,210.46
f,13330,fz,251.173
f,13354,fz,230.648
f,13372,fz,201.375
f,13392,fz,201.375
f,13408,fz,201.375
f,13426,fz,210.46
f,13446,fz,251.173
f,13462,fz,230.648
f,13480,fz,260.257
f,13500,fz,260.257
f,13516,fz,260.257
f,13538,fz,210.46
f,13546,fz,251.173
f,13570,fz,230.648
f,13588,fz,201.375
f,13608,fz,201.375
f,13624,fz,201.375
f,13642,fz,210.46
f,13662,fz,251.173
f,13678,fz,230.648
f,13696,fz,260.257
f,13716,fz,260.257
f,13732,fz,260.257
f,13754,fz,210.46
f,13762,fz,251.173
f,13786,fz,230.648
f,13804,fz,201.375
f,13824,fz,201.375
f,13840,fz,201.375
f,13858,fz,210.46
f,13878,fz,251.173
f,13894,fz,230.648
f,13912,fz,260.257
f,13932,fz,260.257
f,13948,fz,260.257
f,13970,fz,210.46
f,13978,fz,251.173
f,14002,fz,230.648
f,14020,fz,201.375
f,14040,fz,201.375
f,14056,fz,201.375
f,14074,fz,210.46
f,14094,fz,251.173
f,14110,fz,230.648
f,14128,fz,260.257
f,14148,fz,260.257
f,14164,fz,260.257
f,14186,fz,210.46
f,14194,fz,251.173
f,14218,fz,230.648
f,14236,fz,201.375
f,14256,fz,201.375
f,14272,fz,201.375
f,14290,fz,210.46
f,14310,fz,251.173
f,14326,fz,230.648
f,14344,fz,260.257
f,14364,fz,260.257
f,14380,fz,260.257
f,14402,fz,210.46
f,14410,fz,251.173
f,14434,fz,230.648
f,14452,fz,201.375
f,14472,fz,201.375
f,14488,fz,201.375
f,14506,fz,210.46
f,14526,fz,251.173
f,14542,fz,230.648
f,14560,fz,260.257
f,14580,fz,260.257
f,14596,fz,260.257
f,14618,fz,130.044
f,14626,fz,170.757
f,14650,fz,150.232
f,14668,fz,120.96
f,14688,fz,120.96
f,14704,fz,120.96
f,14722,fz,130.044
f,14742,fz,170.757
f,14758,fz,150.232
f,14776,fz,179.842
f,14796,fz,179.842
f,14812,fz,179.842
f,14834,fz,130.044
f,14842,fz,170.757
f,14866,fz,150.232
f,14884,fz,120.96
f,14904,fz,120.96
f,14920,fz,120.96
f,14938,fz,130.044
f,14958,fz,170.757
f,14974,fz,150.232
f,14992,fz,179.842
f,15012,fz,179.842
f,15028,fz,179.842
f,15050,fz,130.044
f,15058,fz,170.757
f,15082,fz,150.232
f,15100,fz,120.96
f,15120,fz,120.96
f,15136,fz,120.96
f,15154,fz,130.044
f,15174,fz,170.757
f,15190,fz,150.232
f,15208,fz,179.842
f,15228,fz,179.842
f,15244,fz,179.842
f,15266,fz,130.044
f,15274,fz,170.757
f,15298,fz,150.232
f,15316,fz,120.96
f,15336,fz,120.96
f,15352,fz,120.96
f,15370,fz,130.044
f,15390,fz,170.757
f,15406,fz,150.232
f,15424,fz,179.842
f,15444,fz,179.842
f,15460,fz,179.842
f,15482,fz,130.044
f,15490,fz,170.757
f,15514,fz,150.232
f,15532,fz,120.96
f,15552,fz,120.96
f,15568,fz,120.96
f,15586,fz,130.044
f,15606,fz,170.757
f,15622,fz,150.232
f,15640,fz,179.842
f,15660,fz,179.842
f,15676,fz,179.842
f,15698,fz,130.044
f,15706,fz,170.757
f,15730,fz,150.232
f,15748,fz,120.96
f,15768,fz,120.96
f,15784,fz,120.96
f,15802,fz,130.044
f,15822,fz,170.757
f,15838,fz,150.232
f,15856,fz,179.842
f,15876,fz,179.842
f,15892,fz,179.842
f,15914,fz,130.044
f,15922,fz,170.757
f,15946,fz,150.232
f,15964,fz,120.96
f,15984,fz,120.96
f,16000,fz,120.96
f,16018,fz,130.044
f,16038,fz,170.757
f,16054,fz,150.232
f,16072,fz,179.842
f,16092,fz,179.842
f,16108,fz,179.842
f,16130,fz,130.044
f,16138,fz,170.757
f,16162,fz,150.232
f,16180,fz,120.96
f,16200,fz,120.96
f,16216,fz,120.96
f,16234,fz,130.044
f,16254,fz,170.757
f,16270,fz,150.232
f,16288,fz,179.842
f,16308,fz,179.842
f,16324,fz,179.842
f,16346,fz,49.2922
f,16354,fz,90.0047
f,16378,fz,69.8167
f,16396,fz,40.544
f,16416,fz,40.544
f,16432,fz,40.544
f,16450,fz,49.2922
f,16470,fz,90.0047
f,16486,fz,69.8167
f,16504,fz,99.0894
f,16524,fz,99.0894
f,16540,fz,99.0894
f,16562,fz,49.2922
f,16570,fz,90.0047
f,16594,fz,69.8167
f,16612,fz,40.544
f,16632,fz,40.544
f,16648,fz,40.544
f,16666,fz,49.2922
f,16686,fz,90.0047
f,16702,fz,69.8167
f,16720,fz,99.0894
f,16740,fz,99.0894
f,16756,fz,99.0894
f,16778,fz,49.2922
f,16786,fz,90.0047
f,16810,fz,69.8167
f,16828,fz,40.544
f,16848,fz,40.544
f,16864,fz,40.544
f,16882,fz,49.2922
f,16902,fz,90.0047
f,16918,fz,69.8167
f,16936,fz,99.0894
f,16956,fz,99.0894
f,16972,fz,99.0894
f,16994,fz,49.2922
f,17002,fz,90.0047
f,17026,fz,69.8167
f,17044,fz,40.544
f,17064,fz,40.544
f,17080,fz,40.544
f,17098,fz,49.2922
f,17118,fz,90.0047
f,17134,fz,69.8167
f,17152,fz,99.0894
f,17172,fz,99.0894
f,17188,fz,99.0894
f,17210,fz,49.2922
f,17218,fz,90.0047
f,17242,fz,69.8167
f,17260,fz,40.544
f,17280,fz,40.544
f,17296,fz,40.544
f,17314,fz,49.2922
f,17334,fz,90.0047
f,17350,fz,69.8167
f,17368,fz,99.0894
f,17388,fz,99.0894
f,17404,fz,99.0894
f,17426,fz,49.2922
f,17434,fz,90.0047
f,17458,fz,69.8167
f,17476,fz,40.544
f,17496,fz,40.544
f,17512,fz,40.544
f,17530,fz,49.2922
f,17550,fz,90.0047
f,17566,fz,69.8167
f,17584,fz,99.0894
f,17604,fz,99.0894
f,17620,fz,99.0894
f,17642,fz,49.2922
f,17650,fz,90.0047
f,17674,fz,69.8167
f,17692,fz,40.544
f,17712,fz,40.544
f,17728,fz,40.544
f,17746,fz,49.2922
f,17766,fz,90.0047
f,17782,fz,69.8167
f,17800,fz,99.0894
f,17820,fz,99.0894
f,17836,fz,99.0894
f,17858,fz,49.2922
f,17866,fz,90.0047
f,17890,fz,69.8167
f,17908,fz,40.544
f,17928,fz,40.544
f,17944,fz,40.544
f,17962,fz,49.2922
f,17982,fz,90.0047
f,17998,fz,69.8167
f,18016,fz,99.0894
f,18036,fz,99.0894
f,18052,fz,99.0894
f,18074,fz,-31.124
f,18082,fz,9.58903
f,18106,fz,-10.599
f,18124,fz,-40.208
f,18144,fz,-40.208
f,18160,fz,-40.208
f,18178,fz,-31.124
f,18198,fz,9.58903
f,18214,fz,-10.599
f,18232,fz,18.6737
f,18252,fz,18.6737
f,18268,fz,18.6737
f,18290,fz,-31.124
f,18298,fz,9.58903
f,18322,fz,-10.599
f,18340,fz,-40.208
f,18360,fz,-40.208
f,18376,fz,-40.208
f,18394,fz,-31.124
f,18414,fz,9.58903
f,18430,fz,-10.599
f,18448,fz,18.6737
f,18468,fz,18.6737
f,18484,fz,18.6737
f,18506,fz,-31.124
f,18514,fz,9.58903
f,18538,fz,-10.599
f,18556,fz,-40.208
f,18576,fz,-40.208
f,18592,fz,-40.208
f,18610,fz,-31.124
f,18630,fz,9.58903
f,18646,fz,-10.599
f,18664,fz,18.6737
f,18684,fz,18.6737
f,18700,fz,18.6737
f,18722,fz,-31.124
f,18730,fz,9.58903
f,18754,fz,-10.599
f,18772,fz,-40.208
f,18792,fz,-40.208
f,18808,fz,-40.208
f,18826,fz,-31.124
f,18846,fz,9.58903
f,18862,fz,-10.599
f,18880,fz,18.6737
f,18900,fz,18.6737
f,18916,fz,18.6737
f,18938,fz,-31.124
f,18946,fz,9.58903
f,18970,fz,-10.599
f,18988,fz,-40.208
f,19008,fz,-40.208
f,19024,fz,-40.208
f,19042,fz,-31.124
f,19062,fz,9.58903
f,19078,fz,-10.599
f,19096,fz,18.6737
f,19116,fz,18.6737
f,19132,fz,18.6737
f,19154,fz,-31.124
f,19162,fz,9.58903
f,19186,fz,-10.599
f,19204,fz,-40.208
f,19224,fz,-40.208
f,19240,fz,-40.208
f,19258,fz,-31.124
f,19278,fz,9.58903

f,19294,fz,-10.599
f,19312,fz,18.6737
f,19332,fz,18.6737
f,19348,fz,18.6737
f,19370,fz,-31.124
f,19378,fz,9.58903
f,19402,fz,-10.599
f,19420,fz,-40.208
f,19440,fz,-40.208
f,19456,fz,-40.208
f,19474,fz,-31.124
f,19494,fz,9.58903
f,19510,fz,-10.599
f,19528,fz,18.6737
f,19548,fz,18.6737
f,19564,fz,18.6737
f,19586,fz,-31.124
f,19594,fz,9.58903
f,19618,fz,-10.599
f,19636,fz,-40.208
f,19656,fz,-40.208
f,19672,fz,-40.208
f,19690,fz,-31.124
f,19710,fz,9.58903
f,19726,fz,-10.599
f,19744,fz,18.6737
f,19764,fz,18.6737
f,19780,fz,18.6737
f,19802,fz,-111.54
f,19810,fz,-70.827
f,19834,fz,-91.351
f,19852,fz,-120.62
f,19872,fz,-120.62
f,19888,fz,-120.62
f,19906,fz,-111.54
f,19926,fz,-70.827
f,19942,fz,-91.351
f,19960,fz,-61.742
f,19980,fz,-61.742
f,19996,fz,-61.742
f,20018,fz,-111.54
f,20026,fz,-70.827
f,20050,fz,-91.351
f,20068,fz,-120.62
f,20088,fz,-120.62
f,20104,fz,-120.62
f,20122,fz,-111.54
f,20142,fz,-70.827
f,20158,fz,-91.351
f,20176,fz,-61.742
f,20196,fz,-61.742
f,20212,fz,-61.742
f,20234,fz,-111.54
f,20242,fz,-70.827
f,20266,fz,-91.351
f,20284,fz,-120.62
f,20304,fz,-120.62
f,20320,fz,-120.62
f,20338,fz,-111.54
f,20358,fz,-70.827
f,20374,fz,-91.351
f,20392,fz,-61.742
f,20412,fz,-61.742
f,20428,fz,-61.742
f,20450,fz,-111.54
f,20458,fz,-70.827
f,20482,fz,-91.351
f,20500,fz,-120.62
f,20520,fz,-120.62
f,20536,fz,-120.62
f,20554,fz,-111.54
f,20574,fz,-70.827
f,20590,fz,-91.351
f,20608,fz,-61.742
f,20628,fz,-61.742
f,20644,fz,-61.742
f,20666,fz,-111.54
f,20674,fz,-70.827
f,20698,fz,-91.351
f,20716,fz,-120.62
f,20736,fz,-120.62
f,20752,fz,-120.62
f,20770,fz,-111.54
f,20790,fz,-70.827
f,20806,fz,-91.351
f,20824,fz,-61.742
f,20844,fz,-61.742
f,20860,fz,-61.742
f,20882,fz,-111.54
f,20890,fz,-70.827
f,20914,fz,-91.351
f,20932,fz,-120.62
f,20952,fz,-120.62
f,20968,fz,-120.62
f,20986,fz,-111.54
f,21006,fz,-70.827
f,21022,fz,-91.351
f,21040,fz,-61.742
f,21060,fz,-61.742
f,21076,fz,-61.742
f,21098,fz,-111.54
f,21106,fz,-70.827
f,21130,fz,-91.351
f,21148,fz,-120.62
f,21168,fz,-120.62
f,21184,fz,-120.62
f,21202,fz,-111.54
f,21222,fz,-70.827
f,21238,fz,-91.351
f,21256,fz,-61.742
f,21276,fz,-61.742
f,21292,fz,-61.742
f,21314,fz,-111.54
f,21322,fz,-70.827
f,21346,fz,-91.351
f,21364,fz,-120.62
f,21384,fz,-120.62
f,21400,fz,-120.62
f,21418,fz,-111.54
f,21438,fz,-70.827
f,21454,fz,-91.351
f,21472,fz,-61.742
f,21492,fz,-61.742
f,21508,fz,-61.742
f,21530,fz,-191.95
f,21538,fz,-151.24
f,21562,fz,-171.77
f,21580,fz,-201.04
f,21600,fz,-201.04
f,21616,fz,-201.04
f,21634,fz,-191.95
f,21654,fz,-151.24
f,21670,fz,-171.77
f,21688,fz,-142.49
f,21708,fz,-142.49
f,21724,fz,-142.49
f,21746,fz,-191.95
f,21754,fz,-151.24
f,21778,fz,-171.77
f,21796,fz,-201.04
f,21816,fz,-201.04
f,21832,fz,-201.04
f,21850,fz,-191.95
f,21870,fz,-151.24
f,21886,fz,-171.77
f,21904,fz,-142.49
f,21924,fz,-142.49
f,21940,fz,-142.49
f,21962,fz,-191.95
f,21970,fz,-151.24
f,21994,fz,-171.77
f,22012,fz,-201.04
f,22032,fz,-201.04
f,22048,fz,-201.04
f,22066,fz,-191.95
f,22086,fz,-151.24
f,22102,fz,-171.77
f,22120,fz,-142.49
f,22140,fz,-142.49
f,22156,fz,-142.49
f,22178,fz,-191.95
f,22186,fz,-151.24
f,22210,fz,-171.77
f,22228,fz,-201.04
f,22248,fz,-201.04
f,22264,fz,-201.04
f,22282,fz,-191.95
f,22302,fz,-151.24
f,22318,fz,-171.77
f,22336,fz,-142.49
f,22356,fz,-142.49
f,22372,fz,-142.49
f,22394,fz,-191.95
f,22402,fz,-151.24
f,22426,fz,-171.77
f,22444,fz,-201.04
f,22464,fz,-201.04
f,22480,fz,-201.04
f,22498,fz,-191.95
f,22518,fz,-151.24
f,22534,fz,-171.77
f,22552,fz,-142.49
f,22572,fz,-142.49
f,22588,fz,-142.49
f,22610,fz,-191.95
f,22618,fz,-151.24
f,22642,fz,-171.77
f,22660,fz,-201.04
f,22680,fz,-201.04
f,22696,fz,-201.04
f,22714,fz,-191.95
f,22734,fz,-151.24
f,22750,fz,-171.77
f,22768,fz,-142.49
f,22788,fz,-142.49
f,22804,fz,-142.49
f,22826,fz,-191.95
f,22834,fz,-151.24
f,22858,fz,-171.77
f,22876,fz,-201.04
f,22896,fz,-201.04
f,22912,fz,-201.04
f,22930,fz,-191.95
f,22950,fz,-151.24
f,22966,fz,-171.77
f,22984,fz,-142.49
f,23004,fz,-142.49
f,23020,fz,-142.49
f,23042,fz,-191.95
f,23050,fz,-151.24
f,23074,fz,-171.77
f,23092,fz,-201.04
f,23112,fz,-201.04
f,23128,fz,-201.04
f,23146,fz,-191.95
f,23166,fz,-151.24
f,23182,fz,-171.77
f,23200,fz,-142.49
f,23220,fz,-142.49
f,23236,fz,-142.49
f,23258,fz,-272.71
f,23266,fz,-231.99
f,23290,fz,-252.18
f,23308,fz,-281.79
f,23328,fz,-281.79
f,23344,fz,-281.79
f,23362,fz,-272.71
f,23382,fz,-231.99
f,23398,fz,-252.18
f,23416,fz,-222.91
f,23436,fz,-222.91
f,23452,fz,-222.91
f,23474,fz,-272.71
f,23482,fz,-231.99
f,23506,fz,-252.18
f,23524,fz,-281.79
f,23544,fz,-281.79
f,23560,fz,-281.79
f,23578,fz,-272.71
f,23598,fz,-231.99
f,23614,fz,-252.18
f,23632,fz,-222.91
f,23652,fz,-222.91
f,23668,fz,-222.91
f,23690,fz,-272.71
f,23698,fz,-231.99
f,23722,fz,-252.18
f,23740,fz,-281.79
f,23760,fz,-281.79
f,23776,fz,-281.79
f,23794,fz,-272.71
f,23814,fz,-231.99
f,23830,fz,-252.18
f,23848,fz,-222.91
f,23868,fz,-222.91
f,23884,fz,-222.91
f,23906,fz,-272.71
f,23914,fz,-231.99
f,23938,fz,-252.18
f,23956,fz,-281.79
f,23976,fz,-281.79
f,23992,fz,-281.79
f,24010,fz,-272.71
f,24030,fz,-231.99
f,24046,fz,-252.18
f,24064,fz,-222.91
f,24084,fz,-222.91
f,24100,fz,-222.91
f,24122,fz,-272.71
f,24130,fz,-231.99
f,24154,fz,-252.18
f,24172,fz,-281.79
f,24192,fz,-281.79
f,24208,fz,-281.79
f,24226,fz,-272.71
f,24246,fz,-231.99
f,24262,fz,-252.18
f,24280,fz,-222.91
f,24300,fz,-222.91
f,24316,fz,-222.91
f,24338,fz,-272.71
f,24346,fz,-231.99
f,24370,fz,-252.18
f,24388,fz,-281.79
f,24408,fz,-281.79
f,24424,fz,-281.79
f,24442,fz,-272.71
f,24462,fz,-231.99
f,24478,fz,-252.18
f,24496,fz,-222.91
f,24516,fz,-222.91
f,24532,fz,-222.91
f,24554,fz,-272.71
f,24562,fz,-231.99
f,24586,fz,-252.18
f,24604,fz,-281.79
f,24624,fz,-281.79
f,24640,fz,-281.79
f,24658,fz,-272.71
f,24678,fz,-231.99
f,24694,fz,-252.18
f,24712,fz,-222.91
f,24732,fz,-222.91
f,24748,fz,-222.91
f,24770,fz,-272.71
f,24778,fz,-231.99
f,24802,fz,-252.18
f,24820,fz,-281.79
f,24840,fz,-281.79
f,24856,fz,-281.79
f,24874,fz,-272.71
f,24894,fz,-231.99
f,24910,fz,-252.18
f,24928,fz,-222.91
f,24948,fz,-222.91
f,24964,fz,-222.91
f,24986,fz,-353.12
f,24994,fz,-312.41
f,25018,fz,-332.6
f,25036,fz,-362.21
f,25056,fz,-362.21
f,25072,fz,-362.21
f,25090,fz,-353.12
f,25110,fz,-312.41
f,25126,fz,-332.6
f,25144,fz,-303.33
f,25164,fz,-303.33
f,25180,fz,-303.33
f,25202,fz,-353.12
f,25210,fz,-312.41
f,25234,fz,-332.6
f,25252,fz,-362.21

f,25272,fz,-362.21
f,25288,fz,-362.21
f,25306,fz,-353.12
f,25326,fz,-312.41
f,25342,fz,-332.6
f,25360,fz,-303.33
f,25380,fz,-303.33
f,25396,fz,-303.33
f,25418,fz,-353.12
f,25426,fz,-312.41
f,25450,fz,-332.6
f,25468,fz,-362.21
f,25488,fz,-362.21
f,25504,fz,-362.21
f,25522,fz,-353.12
f,25542,fz,-312.41
f,25558,fz,-332.6
f,25576,fz,-303.33
f,25596,fz,-303.33
f,25612,fz,-303.33
f,25634,fz,-353.12
f,25642,fz,-312.41
f,25666,fz,-332.6
f,25684,fz,-362.21
f,25704,fz,-362.21
f,25720,fz,-362.21
f,25738,fz,-353.12
f,25758,fz,-312.41
f,25774,fz,-332.6
f,25792,fz,-303.33
f,25812,fz,-303.33
f,25828,fz,-303.33
f,25850,fz,-353.12
f,25858,fz,-312.41
f,25882,fz,-332.6
f,25900,fz,-362.21
f,25920,fz,-362.21
f,25936,fz,-362.21
f,25954,fz,-353.12
f,25974,fz,-312.41
f,25990,fz,-332.6
f,26008,fz,-303.33
f,26028,fz,-303.33
f,26044,fz,-303.33
f,26066,fz,-353.12
f,26074,fz,-312.41
f,26098,fz,-332.6
f,26116,fz,-362.21
f,26136,fz,-362.21
f,26152,fz,-362.21
f,26170,fz,-353.12
f,26190,fz,-312.41
f,26206,fz,-332.6
f,26224,fz,-303.33
f,26244,fz,-303.33
f,26260,fz,-303.33
f,26282,fz,-353.12
f,26290,fz,-312.41
f,26314,fz,-332.6
f,26332,fz,-362.21
f,26352,fz,-362.21
f,26368,fz,-362.21
f,26386,fz,-353.12
f,26406,fz,-312.41
f,26422,fz,-332.6
f,26440,fz,-303.33
f,26460,fz,-303.33
f,26476,fz,-303.33
f,26498,fz,-353.12
f,26506,fz,-312.41
f,26530,fz,-332.6
f,26548,fz,-362.21
f,26568,fz,-362.21
f,26584,fz,-362.21
f,26602,fz,-353.12
f,26622,fz,-312.41
f,26638,fz,-332.6
f,26656,fz,-303.33
f,26676,fz,-303.33
f,26692,fz,-303.33
f,26714,fz,-433.54
f,26722,fz,-392.83
f,26746,fz,-413.35
f,26764,fz,-442.62
f,26784,fz,-442.62
f,26800,fz,-442.62
f,26818,fz,-433.54
f,26838,fz,-392.83
f,26854,fz,-413.35
f,26872,fz,-383.74
f,26892,fz,-383.74
f,26908,fz,-383.74
f,26930,fz,-433.54
f,26938,fz,-392.83
f,26962,fz,-413.35
f,26980,fz,-442.62
f,27000,fz,-442.62
f,27016,fz,-442.62
f,27034,fz,-433.54
f,27054,fz,-392.83
f,27070,fz,-413.35
f,27088,fz,-383.74
f,27108,fz,-383.74
f,27124,fz,-383.74
f,27146,fz,-433.54
f,27154,fz,-392.83
f,27178,fz,-413.35
f,27196,fz,-442.62
f,27216,fz,-442.62
f,27232,fz,-442.62
f,27250,fz,-433.54
f,27270,fz,-392.83
f,27286,fz,-413.35
f,27304,fz,-383.74
f,27324,fz,-383.74
f,27340,fz,-383.74
f,27362,fz,-433.54
f,27370,fz,-392.83
f,27394,fz,-413.35
f,27412,fz,-442.62
f,27432,fz,-442.62
f,27448,fz,-442.62
f,27466,fz,-433.54
f,27486,fz,-392.83
f,27502,fz,-413.35
f,27520,fz,-383.74
f,27540,fz,-383.74
f,27556,fz,-383.74
f,27578,fz,-433.54
f,27586,fz,-392.83
f,27610,fz,-413.35
f,27628,fz,-442.62
f,27648,fz,-442.62
f,27664,fz,-442.62
f,27682,fz,-433.54
f,27702,fz,-392.83
f,27718,fz,-413.35
f,27736,fz,-383.74
f,27756,fz,-383.74
f,27772,fz,-383.74
f,27794,fz,-433.54
f,27802,fz,-392.83
f,27826,fz,-413.35
f,27844,fz,-442.62
f,27864,fz,-442.62
f,27880,fz,-442.62
f,27898,fz,-433.54
f,27918,fz,-392.83
f,27934,fz,-413.35
f,27952,fz,-383.74
f,27972,fz,-383.74
f,27988,fz,-383.74
f,28010,fz,-433.54
f,28018,fz,-392.83
f,28042,fz,-413.35
f,28060,fz,-442.62
f,28080,fz,-442.62
f,28096,fz,-442.62
f,28114,fz,-433.54
f,28134,fz,-392.83
f,28150,fz,-413.35
f,28168,fz,-383.74
f,28188,fz,-383.74
f,28204,fz,-383.74
f,28226,fz,-433.54
f,28234,fz,-392.83
f,28258,fz,-413.35
f,28276,fz,-442.62
f,28296,fz,-442.62
f,28312,fz,-442.62
f,28330,fz,-433.54
f,28350,fz,-392.83
f,28366,fz,-413.35
f,28384,fz,-383.74
f,28404,fz,-383.74
f,28420,fz,-383.74
f,28442,fz,-513.95
f,28450,fz,-473.58
f,28474,fz,-493.77
f,28492,fz,-523.04
f,28512,fz,-523.04
f,28528,fz,-523.04
f,28546,fz,-513.95
f,28566,fz,-473.58
f,28582,fz,-493.77
f,28600,fz,-464.49
f,28620,fz,-464.49
f,28636,fz,-464.49
f,28658,fz,-513.95
f,28666,fz,-473.58
f,28690,fz,-493.77
f,28708,fz,-523.04
f,28728,fz,-523.04
f,28744,fz,-523.04
f,28762,fz,-513.95
f,28782,fz,-473.58
f,28798,fz,-493.77
f,28816,fz,-464.49
f,28836,fz,-464.49
f,28852,fz,-464.49
f,28874,fz,-513.95
f,28882,fz,-473.58
f,28906,fz,-493.77
f,28924,fz,-523.04
f,28944,fz,-523.04
f,28960,fz,-523.04
f,28978,fz,-513.95
f,28998,fz,-473.58
f,29014,fz,-493.77
f,29032,fz,-464.49
f,29052,fz,-464.49
f,29068,fz,-464.49
f,29090,fz,-513.95
f,29098,fz,-473.58
f,29122,fz,-493.77
f,29140,fz,-523.04
f,29160,fz,-523.04
f,29176,fz,-523.04
f,29194,fz,-513.95
f,29214,fz,-473.58
f,29230,fz,-493.77
f,29248,fz,-464.49
f,29268,fz,-464.49
f,29284,fz,-464.49
f,29306,fz,-513.95
f,29314,fz,-473.58
f,29338,fz,-493.77
f,29356,fz,-523.04
f,29376,fz,-523.04
f,29392,fz,-523.04
f,29410,fz,-513.95
f,29430,fz,-473.58
f,29446,fz,-493.77
f,29464,fz,-464.49
f,29484,fz,-464.49
f,29500,fz,-464.49
f,29522,fz,-513.95
f,29530,fz,-473.58
f,29554,fz,-493.77
f,29572,fz,-523.04
f,29592,fz,-523.04
f,29608,fz,-523.04
f,29626,fz,-513.95
f,29646,fz,-473.58
f,29662,fz,-493.77
f,29680,fz,-464.49
f,29700,fz,-464.49
f,29716,fz,-464.49
f,29738,fz,-513.95
f,29746,fz,-473.58
f,29770,fz,-493.77
f,29788,fz,-523.04
f,29808,fz,-523.04
f,29824,fz,-523.04
f,29842,fz,-513.95
f,29862,fz,-473.58
f,29878,fz,-493.77
f,29896,fz,-464.49
f,29916,fz,-464.49
f,29932,fz,-464.49
f,29954,fz,-513.95
f,29962,fz,-473.58
f,29986,fz,-493.77
f,30004,fz,-523.04
f,30024,fz,-523.04
f,30040,fz,-523.04
f,30058,fz,-513.95
f,30078,fz,-473.58
f,30094,fz,-493.77
f,30112,fz,-464.49
f,30132,fz,-464.49
f,30148,fz,-464.49
f,30170,fz,-594.71
f,30178,fz,-553.99
f,30202,fz,-574.18
f,30220,fz,-603.79
f,30240,fz,-603.79
f,30256,fz,-603.79
f,30274,fz,-594.71
f,30294,fz,-553.99
f,30310,fz,-574.18
f,30328,fz,-544.91
f,30348,fz,-544.91
f,30364,fz,-544.91
f,30386,fz,-594.71
f,30394,fz,-553.99
f,30418,fz,-574.18
f,30436,fz,-603.79
f,30456,fz,-603.79
f,30472,fz,-603.79
f,30490,fz,-594.71
f,30510,fz,-553.99
f,30526,fz,-574.18
f,30544,fz,-544.91
f,30564,fz,-544.91
f,30580,fz,-544.91
f,30602,fz,-594.71
f,30610,fz,-553.99
f,30634,fz,-574.18
f,30652,fz,-603.79
f,30672,fz,-603.79
f,30688,fz,-603.79
f,30706,fz,-594.71
f,30726,fz,-553.99
f,30742,fz,-574.18
f,30760,fz,-544.91
f,30780,fz,-544.91
f,30796,fz,-544.91
f,30818,fz,-594.71
f,30826,fz,-553.99
f,30850,fz,-574.18
f,30868,fz,-603.79
f,30888,fz,-603.79
f,30904,fz,-603.79
f,30922,fz,-594.71
f,30942,fz,-553.99
f,30958,fz,-574.18
f,30976,fz,-544.91
f,30996,fz,-544.91
f,31012,fz,-544.91
f,31034,fz,-594.71
f,31042,fz,-553.99
f,31066,fz,-574.18
f,31084,fz,-603.79
f,31104,fz,-603.79
f,31120,fz,-603.79
f,31138,fz,-594.71
f,31158,fz,-553.99
f,31174,fz,-574.18
f,31192,fz,-544.91
f,31212,fz,-544.91
f,31228,fz,-544.91

f,31250,fz,-594.71
f,31258,fz,-553.99
f,31282,fz,-574.18
f,31300,fz,-603.79
f,31320,fz,-603.79
f,31336,fz,-603.79
f,31354,fz,-594.71
f,31374,fz,-553.99
f,31390,fz,-574.18
f,31408,fz,-544.91
f,31428,fz,-544.91
f,31444,fz,-544.91
f,31466,fz,-594.71
f,31474,fz,-553.99
f,31498,fz,-574.18
f,31516,fz,-603.79
f,31536,fz,-603.79
f,31552,fz,-603.79
f,31570,fz,-594.71
f,31590,fz,-553.99
f,31606,fz,-574.18
f,31624,fz,-544.91
f,31644,fz,-544.91
f,31660,fz,-544.91
f,31682,fz,-594.71
f,31690,fz,-553.99
f,31714,fz,-574.18
f,31732,fz,-603.79
f,31752,fz,-603.79
f,31768,fz,-603.79
f,31786,fz,-594.71
f,31806,fz,-553.99
f,31822,fz,-574.18
f,31840,fz,-544.91
f,31860,fz,-544.91
f,31876,fz,-544.91
f,31898,fz,-675.12
f,31906,fz,-634.41
f,31930,fz,-654.93
f,31948,fz,-684.21
f,31968,fz,-684.21
f,31984,fz,-684.21
f,32002,fz,-675.12
f,32022,fz,-634.41
f,32038,fz,-654.93
f,32056,fz,-625.32
f,32076,fz,-625.32
f,32092,fz,-625.32
f,32114,fz,-675.12
f,32122,fz,-634.41
f,32146,fz,-654.93
f,32164,fz,-684.21
f,32184,fz,-684.21
f,32200,fz,-684.21
f,32218,fz,-675.12
f,32238,fz,-634.41
f,32254,fz,-654.93
f,32272,fz,-625.32
f,32292,fz,-625.32
f,32308,fz,-625.32
f,32330,fz,-675.12
f,32338,fz,-634.41
f,32362,fz,-654.93
f,32380,fz,-684.21
f,32400,fz,-684.21
f,32416,fz,-684.21
f,32434,fz,-675.12
f,32454,fz,-634.41
f,32470,fz,-654.93
f,32488,fz,-625.32
f,32508,fz,-625.32
f,32524,fz,-625.32
f,32546,fz,-675.12
f,32554,fz,-634.41
f,32578,fz,-654.93
f,32596,fz,-684.21
f,32616,fz,-684.21
f,32632,fz,-684.21
f,32650,fz,-675.12
f,32670,fz,-634.41
f,32686,fz,-654.93
f,32704,fz,-625.32
f,32724,fz,-625.32
f,32740,fz,-625.32
f,32762,fz,-675.12
f,32770,fz,-634.41
f,32794,fz,-654.93
f,32812,fz,-684.21
f,32832,fz,-684.21
f,32848,fz,-684.21
f,32866,fz,-675.12
f,32886,fz,-634.41
f,32902,fz,-654.93
f,32920,fz,-625.32
f,32940,fz,-625.32
f,32956,fz,-625.32
f,32978,fz,-675.12
f,32986,fz,-634.41
f,33010,fz,-654.93
f,33028,fz,-684.21
f,33048,fz,-684.21
f,33064,fz,-684.21
f,33082,fz,-675.12
f,33102,fz,-634.41
f,33118,fz,-654.93
f,33136,fz,-625.32
f,33156,fz,-625.32
f,33172,fz,-625.32
f,33194,fz,-675.12
f,33202,fz,-634.41
f,33226,fz,-654.93
f,33244,fz,-684.21
f,33264,fz,-684.21
f,33280,fz,-684.21
f,33298,fz,-675.12
f,33318,fz,-634.41
f,33334,fz,-654.93
f,33352,fz,-625.32
f,33372,fz,-625.32
f,33388,fz,-625.32
f,33410,fz,-675.12
f,33418,fz,-634.41
f,33442,fz,-654.93
f,33460,fz,-684.21
f,33480,fz,-684.21
f,33496,fz,-684.21
f,33514,fz,-675.12
f,33534,fz,-634.41
f,33550,fz,-654.93
f,33568,fz,-625.32
f,33588,fz,-625.32
f,33604,fz,-625.32
f,5979,fz,528.431
f,5987,fz,569.143
f,6011,fz,548.955
f,6029,fz,519.346
f,6049,fz,519.346
f,6065,fz,519.346
f,6083,fz,528.431
f,6103,fz,569.143
f,6119,fz,548.955
f,6137,fz,578.228
f,6157,fz,578.228
f,6173,fz,578.228
f,6195,fz,528.431
f,6203,fz,569.143
f,6227,fz,548.955
f,6245,fz,519.346
f,6265,fz,519.346
f,6281,fz,519.346
f,6299,fz,528.431
f,6319,fz,569.143
f,6335,fz,548.955
f,6353,fz,578.228
f,6373,fz,578.228
f,6389,fz,578.228
f,6411,fz,528.431
f,6419,fz,569.143
f,6443,fz,548.955
f,6461,fz,519.346
f,6481,fz,519.346
f,6497,fz,519.346
f,6515,fz,528.431
f,6535,fz,569.143
f,6551,fz,548.955
f,6569,fz,578.228
f,6589,fz,578.228
f,6605,fz,578.228
f,6627,fz,528.431
f,6635,fz,569.143
f,6659,fz,548.955
f,6677,fz,519.346
f,6697,fz,519.346
f,6713,fz,519.346
f,6731,fz,528.431
f,6751,fz,569.143
f,6767,fz,548.955
f,6785,fz,578.228
f,6805,fz,578.228
f,6821,fz,578.228
f,6843,fz,528.431
f,6851,fz,569.143
f,6875,fz,548.955
f,6893,fz,519.346
f,6913,fz,519.346
f,6929,fz,519.346
f,6947,fz,528.431
f,6967,fz,569.143
f,6983,fz,548.955
f,7001,fz,578.228
f,7021,fz,578.228
f,7037,fz,578.228
f,7059,fz,528.431
f,7067,fz,569.143
f,7091,fz,548.955
f,7109,fz,519.346
f,7129,fz,519.346
f,7145,fz,519.346
f,7163,fz,528.431
f,7183,fz,569.143
f,7199,fz,548.955
f,7217,fz,578.228
f,7237,fz,578.228
f,7253,fz,578.228
f,7275,fz,528.431
f,7283,fz,569.143
f,7307,fz,548.955
f,7325,fz,519.346
f,7345,fz,519.346
f,7361,fz,519.346
f,7379,fz,528.431
f,7399,fz,569.143
f,7415,fz,548.955
f,7433,fz,578.228
f,7453,fz,578.228
f,7469,fz,578.228
f,7491,fz,528.431
f,7499,fz,569.143
f,7523,fz,548.955
f,7541,fz,519.346
f,7561,fz,519.346
f,7577,fz,519.346
f,7595,fz,528.431
f,7615,fz,569.143
f,7631,fz,548.955
f,7649,fz,578.228
f,7669,fz,578.228
f,7685,fz,578.228
f,7707,fz,448.015
f,7715,fz,488.728
f,7739,fz,468.203
f,7757,fz,438.931
f,7777,fz,438.931
f,7793,fz,438.931
f,7811,fz,448.015
f,7831,fz,488.728
f,7847,fz,468.203
f,7865,fz,497.812
f,7885,fz,497.812
f,7901,fz,497.812
f,7923,fz,448.015
f,7931,fz,488.728
f,7955,fz,468.203
f,7973,fz,438.931
f,7993,fz,438.931
f,8009,fz,438.931
f,8027,fz,448.015
f,8047,fz,488.728
f,8063,fz,468.203
f,8081,fz,497.812
f,8101,fz,497.812
f,8117,fz,497.812
f,8139,fz,448.015
f,8147,fz,488.728
f,8171,fz,468.203
f,8189,fz,438.931
f,8209,fz,438.931
f,8225,fz,438.931
f,8243,fz,448.015
f,8263,fz,488.728
f,8279,fz,468.203
f,8297,fz,497.812
f,8317,fz,497.812
f,8333,fz,497.812
f,8355,fz,448.015
f,8363,fz,488.728
f,8387,fz,468.203
f,8405,fz,438.931
f,8425,fz,438.931
f,8441,fz,438.931
f,8459,fz,448.015
f,8479,fz,488.728
f,8495,fz,468.203
f,8513,fz,497.812
f,8533,fz,497.812
f,8549,fz,497.812
f,8571,fz,448.015
f,8579,fz,488.728
f,8603,fz,468.203
f,8621,fz,438.931
f,8641,fz,438.931
f,8657,fz,438.931
f,8675,fz,448.015
f,8695,fz,488.728
f,8711,fz,468.203
f,8729,fz,497.812
f,8749,fz,497.812
f,8765,fz,497.812
f,8787,fz,448.015
f,8795,fz,488.728
f,8819,fz,468.203
f,8837,fz,438.931
f,8857,fz,438.931
f,8873,fz,438.931
f,8891,fz,448.015
f,8911,fz,488.728
f,8927,fz,468.203
f,8945,fz,497.812
f,8965,fz,497.812
f,8981,fz,497.812
f,9003,fz,448.015
f,9011,fz,488.728
f,9035,fz,468.203
f,9053,fz,438.931
f,9073,fz,438.931
f,9089,fz,438.931
f,9107,fz,448.015
f,9127,fz,488.728
f,9143,fz,468.203
f,9161,fz,497.812
f,9181,fz,497.812
f,9197,fz,497.812
f,9219,fz,448.015
f,9227,fz,488.728
f,9251,fz,468.203
f,9269,fz,438.931
f,9289,fz,438.931
f,9305,fz,438.931
f,9323,fz,448.015
f,9343,fz,488.728
f,9359,fz,468.203
f,9377,fz,497.812
f,9397,fz,497.812
f,9413,fz,497.812
f,9435,fz,367.6
f,9443,fz,407.976
f,9467,fz,387.788
f,9485,fz,358.515
f,9505,fz,358.515
f,9521,fz,358.515
f,9539,fz,367.6
f,9559,fz,407.976

f,9575,fr,387.788
f,9593,fr,417.06
f,9613,fr,417.06
f,9629,fr,417.06
f,9651,fr,367.6
f,9659,fr,407.976
f,9683,fr,387.788
f,9701,fr,358.515
f,9721,fr,358.515
f,9737,fr,358.515
f,9755,fr,367.6
f,9775,fr,407.976
f,9791,fr,387.788
f,9809,fr,417.06
f,9829,fr,417.06
f,9845,fr,417.06
f,9867,fr,367.6
f,9875,fr,407.976
f,9899,fr,387.788
f,9917,fr,358.515
f,9937,fr,358.515
f,9953,fr,358.515
f,9971,fr,367.6
f,9991,fr,407.976
f,10007,fr,387.788
f,10025,fr,417.06
f,10045,fr,417.06
f,10061,fr,417.06
f,10083,fr,367.6
f,10091,fr,407.976
f,10115,fr,387.788
f,10133,fr,358.515
f,10153,fr,358.515
f,10169,fr,358.515
f,10187,fr,367.6
f,10207,fr,407.976
f,10223,fr,387.788
f,10241,fr,417.06
f,10261,fr,417.06
f,10277,fr,417.06
f,10299,fr,367.6
f,10307,fr,407.976
f,10331,fr,387.788
f,10349,fr,358.515
f,10369,fr,358.515
f,10385,fr,358.515
f,10403,fr,367.6
f,10423,fr,407.976
f,10439,fr,387.788
f,10457,fr,417.06
f,10477,fr,417.06
f,10493,fr,417.06
f,10515,fr,367.6
f,10523,fr,407.976
f,10547,fr,387.788
f,10565,fr,358.515
f,10585,fr,358.515
f,10501,fr,358.515
f,10619,fr,367.6
f,10639,fr,407.976
f,10655,fr,387.788
f,10673,fr,417.06
f,10693,fr,417.06
f,10709,fr,417.06
f,10731,fr,367.6
f,10739,fr,407.976
f,10763,fr,387.788
f,10781,fr,358.515
f,10801,fr,358.515
f,10817,fr,358.515
f,10835,fr,367.6
f,10855,fr,407.976
f,10871,fr,387.788
f,10889,fr,417.06
f,10909,fr,417.06
f,10925,fr,417.06
f,10947,fr,367.6
f,10955,fr,407.976
f,10979,fr,387.788
f,10997,fr,358.515
f,11017,fr,358.515
f,11033,fr,358.515
f,11051,fr,367.6
f,11071,fr,407.976
f,11087,fr,387.788
f,11105,fr,417.06
f,11125,fr,417.06
f,11141,fr,417.06
f,11163,fr,286.847
f,11171,fr,327.56
f,11195,fr,307.372
f,11213,fr,277.763
f,11233,fr,277.763
f,11249,fr,277.763
f,11267,fr,286.847
f,11287,fr,327.56
f,11303,fr,307.372
f,11321,fr,336.645
f,11341,fr,336.645
f,11357,fr,336.645
f,11379,fr,286.847
f,11387,fr,327.56
f,11411,fr,307.372
f,11429,fr,277.763
f,11449,fr,277.763
f,11465,fr,277.763
f,11483,fr,286.847
f,11503,fr,327.56
f,11519,fr,307.372
f,11537,fr,336.645
f,11557,fr,336.645
f,11573,fr,336.645
f,11595,fr,286.847
f,11603,fr,327.56
f,11627,fr,307.372
f,11645,fr,277.763
f,11665,fr,277.763
f,11681,fr,277.763
f,11699,fr,286.847
f,11719,fr,327.56
f,11735,fr,307.372
f,11753,fr,336.645
f,11773,fr,336.645
f,11789,fr,336.645
f,11811,fr,286.847
f,11819,fr,327.56
f,11843,fr,307.372
f,11861,fr,277.763
f,11881,fr,277.763
f,11897,fr,277.763
f,11915,fr,286.847
f,11935,fr,327.56
f,11951,fr,307.372
f,11969,fr,336.645
f,11989,fr,336.645
f,12005,fr,336.645
f,12027,fr,286.847
f,12035,fr,327.56
f,12059,fr,307.372
f,12077,fr,277.763
f,12097,fr,277.763
f,12113,fr,277.763
f,12131,fr,286.847
f,12151,fr,327.56
f,12167,fr,307.372
f,12185,fr,336.645
f,12205,fr,336.645
f,12221,fr,336.645
f,12243,fr,286.847
f,12251,fr,327.56
f,12275,fr,307.372
f,12293,fr,277.763
f,12313,fr,277.763
f,12329,fr,277.763
f,12347,fr,286.847
f,12367,fr,327.56
f,12383,fr,307.372
f,12401,fr,336.645
f,12421,fr,336.645
f,12437,fr,336.645
f,12459,fr,286.847
f,12467,fr,327.56
f,12491,fr,307.372
f,12509,fr,277.763
f,12529,fr,277.763
f,12545,fr,277.763
f,12563,fr,286.847
f,12583,fr,327.56
f,12599,fr,307.372
f,12617,fr,336.645
f,12637,fr,336.645
f,12653,fr,336.645
f,12675,fr,286.847
f,12683,fr,327.56
f,12707,fr,307.372
f,12725,fr,277.763
f,12745,fr,277.763
f,12761,fr,277.763
f,12779,fr,286.847
f,12799,fr,327.56
f,12815,fr,307.372
f,12833,fr,336.645
f,12853,fr,336.645
f,12869,fr,336.645
f,12891,fr,206.432
f,12899,fr,247.144
f,12923,fr,226.62
f,12941,fr,197.347
f,12961,fr,197.347
f,12977,fr,197.347
f,12995,fr,206.432
f,13015,fr,247.144
f,13031,fr,226.62
f,13049,fr,256.229
f,13069,fr,256.229
f,13085,fr,256.229
f,13107,fr,206.432
f,13115,fr,247.144
f,13139,fr,226.62
f,13157,fr,197.347
f,13177,fr,197.347
f,13193,fr,197.347
f,13211,fr,206.432
f,13231,fr,247.144
f,13247,fr,226.62
f,13265,fr,256.229
f,13285,fr,256.229
f,13301,fr,256.229
f,13323,fr,206.432
f,13331,fr,247.144
f,13355,fr,226.62
f,13373,fr,197.347
f,13393,fr,197.347
f,13409,fr,197.347
f,13427,fr,206.432
f,13447,fr,247.144
f,13463,fr,226.62
f,13481,fr,256.229
f,13501,fr,256.229
f,13517,fr,256.229
f,13539,fr,206.432
f,13547,fr,247.144
f,13571,fr,226.62
f,13589,fr,197.347
f,13609,fr,197.347
f,13625,fr,197.347
f,13643,fr,206.432
f,13663,fr,247.144
f,13679,fr,226.62
f,13697,fr,256.229
f,13717,fr,256.229
f,13733,fr,256.229
f,13755,fr,206.432
f,13763,fr,247.144
f,13787,fr,226.62
f,13805,fr,197.347
f,13825,fr,197.347
f,13841,fr,197.347
f,13859,fr,206.432
f,13879,fr,247.144
f,13895,fr,226.62
f,13913,fr,256.229
f,13933,fr,256.229
f,13949,fr,256.229
f,13971,fr,206.432
f,13979,fr,247.144
f,14003,fr,226.62
f,14021,fr,197.347
f,14041,fr,197.347
f,14057,fr,197.347
f,14075,fr,206.432
f,14095,fr,247.144
f,14111,fr,226.62
f,14129,fr,256.229
f,14149,fr,256.229
f,14165,fr,256.229
f,14187,fr,206.432
f,14195,fr,247.144
f,14219,fr,226.62
f,14237,fr,197.347
f,14257,fr,197.347
f,14273,fr,197.347
f,14291,fr,206.432
f,14311,fr,247.144
f,14327,fr,226.62
f,14345,fr,256.229
f,14365,fr,256.229
f,14381,fr,256.229
f,14403,fr,206.432
f,14411,fr,247.144
f,14435,fr,226.62
f,14453,fr,197.347
f,14473,fr,197.347
f,14489,fr,197.347
f,14507,fr,206.432
f,14527,fr,247.144
f,14543,fr,226.62
f,14561,fr,256.229
f,14581,fr,256.229
f,14597,fr,256.229
f,14619,fr,126.016
f,14627,fr,166.728
f,14651,fr,146.204
f,14669,fr,116.931
f,14689,fr,116.931
f,14705,fr,116.931
f,14723,fr,126.016
f,14743,fr,166.728
f,14759,fr,146.204
f,14777,fr,175.813
f,14797,fr,175.813
f,14813,fr,175.813
f,14835,fr,126.016
f,14843,fr,166.728
f,14867,fr,146.204
f,14885,fr,116.931
f,14905,fr,116.931
f,14921,fr,116.931
f,14939,fr,126.016
f,14959,fr,166.728
f,14975,fr,146.204
f,14993,fr,175.813
f,15013,fr,175.813
f,15029,fr,175.813
f,15051,fr,126.016
f,15059,fr,166.728
f,15083,fr,146.204
f,15101,fr,116.931
f,15121,fr,116.931
f,15137,fr,116.931
f,15155,fr,126.016
f,15175,fr,166.728
f,15191,fr,146.204
f,15209,fr,175.813
f,15229,fr,175.813
f,15245,fr,175.813
f,15267,fr,126.016
f,15275,fr,166.728
f,15299,fr,146.204
f,15317,fr,116.931
f,15337,fr,116.931
f,15353,fr,116.931
f,15371,fr,126.016
f,15391,fr,166.728
f,15407,fr,146.204
f,15425,fr,175.813
f,15445,fr,175.813
f,15461,fr,175.813
f,15483,fr,126.016
f,15491,fr,166.728
f,15515,fr,146.204
f,15533,fr,116.931

f,15553,fz,116.931
f,15569,fz,116.931
f,15587,fz,126.016
f,15607,fz,166.728
f,15623,fz,146.204
f,15641,fz,175.813
f,15661,fz,175.813
f,15677,fz,175.813
f,15699,fz,126.016
f,15707,fz,166.728
f,15731,fz,146.204
f,15749,fz,116.931
f,15769,fz,116.931
f,15785,fz,116.931
f,15803,fz,126.016
f,15823,fz,166.728
f,15839,fz,146.204
f,15857,fz,175.813
f,15877,fz,175.813
f,15893,fz,175.813
f,15915,fz,126.016
f,15923,fz,166.728
f,15947,fz,146.204
f,15965,fz,116.931
f,15985,fz,116.931
f,16001,fz,116.931
f,16019,fz,126.016
f,16039,fz,166.728
f,16055,fz,146.204
f,16073,fz,175.813
f,16093,fz,175.813
f,16109,fz,175.813
f,16131,fz,126.016
f,16139,fz,166.728
f,16163,fz,146.204
f,16181,fz,116.931
f,16201,fz,116.931
f,16217,fz,116.931
f,16235,fz,126.016
f,16255,fz,166.728
f,16271,fz,146.204
f,16289,fz,175.813
f,16309,fz,175.813
f,16325,fz,175.813
f,16347,fz,45.2638
f,16355,fz,85.9763
f,16379,fz,65.7883
f,16397,fz,36.5156
f,16417,fz,36.5156
f,16433,fz,36.5156
f,16451,fz,45.2638
f,16471,fz,85.9763
f,16487,fz,65.7883
f,16505,fz,95.0609
f,16525,fz,95.0609
f,16541,fz,95.0609
f,16563,fz,45.2638
f,16571,fz,85.9763
f,16595,fz,65.7883
f,16613,fz,36.5156
f,16633,fz,36.5156
f,16649,fz,36.5156
f,16667,fz,45.2638
f,16687,fz,85.9763
f,16703,fz,65.7883
f,16721,fz,95.0609
f,16741,fz,95.0609
f,16757,fz,95.0609
f,16779,fz,45.2638
f,16787,fz,85.9763
f,16811,fz,65.7883
f,16829,fz,36.5156
f,16849,fz,36.5156
f,16865,fz,36.5156
f,16883,fz,45.2638
f,16903,fz,85.9763
f,16919,fz,65.7883
f,16937,fz,95.0609
f,16957,fz,95.0609
f,16973,fz,95.0609
f,16995,fz,45.2638
f,17003,fz,85.9763
f,17027,fz,65.7883
f,17045,fz,36.5156
f,17065,fz,36.5156
f,17081,fz,36.5156
f,17099,fz,45.2638
f,17119,fz,85.9763
f,17135,fz,65.7883
f,17153,fz,95.0609
f,17173,fz,95.0609
f,17189,fz,95.0609
f,17211,fz,45.2638
f,17219,fz,85.9763
f,17243,fz,65.7883
f,17261,fz,36.5156
f,17281,fz,36.5156
f,17297,fz,36.5156
f,17315,fz,45.2638
f,17335,fz,85.9763
f,17351,fz,65.7883
f,17369,fz,95.0609
f,17389,fz,95.0609
f,17405,fz,95.0609
f,17427,fz,45.2638
f,17435,fz,85.9763
f,17459,fz,65.7883
f,17477,fz,36.5156
f,17497,fz,36.5156
f,17513,fz,36.5156
f,17531,fz,45.2638
f,17551,fz,85.9763
f,17567,fz,65.7883
f,17585,fz,95.0609
f,17605,fz,95.0609
f,17621,fz,95.0609
f,17643,fz,45.2638
f,17651,fz,85.9763
f,17675,fz,65.7883
f,17693,fz,36.5156
f,17713,fz,36.5156
f,17729,fz,36.5156
f,17747,fz,45.2638
f,17767,fz,85.9763
f,17783,fz,65.7883
f,17801,fz,95.0609
f,17821,fz,95.0609
f,17837,fz,95.0609
f,17859,fz,45.2638
f,17867,fz,85.9763
f,17891,fz,65.7883
f,17909,fz,36.5156
f,17929,fz,36.5156
f,17945,fz,36.5156
f,17963,fz,45.2638
f,17983,fz,85.9763
f,17999,fz,65.7883
f,18017,fz,95.0609
f,18037,fz,95.0609
f,18053,fz,95.0609
f,18075,fz,-35.152
f,18083,fz,5.56062
f,18107,fz,-14.627
f,18125,fz,-44.237
f,18145,fz,-44.237
f,18161,fz,-44.237
f,18179,fz,-35.152
f,18199,fz,5.56062
f,18215,fz,-14.627
f,18233,fz,14.6452
f,18253,fz,14.6452
f,18269,fz,14.6452
f,18291,fz,-35.152
f,18299,fz,5.56062
f,18323,fz,-14.627
f,18341,fz,-44.237
f,18361,fz,-44.237
f,18377,fz,-44.237
f,18395,fz,-35.152
f,18415,fz,5.56062
f,18431,fz,-14.627
f,18449,fz,14.6452
f,18469,fz,14.6452
f,18485,fz,14.6452
f,18507,fz,-35.152
f,18515,fz,5.56062
f,18539,fz,-14.627
f,18557,fz,-44.237
f,18577,fz,-44.237
f,18593,fz,-44.237
f,18611,fz,-35.152
f,18631,fz,5.56062
f,18647,fz,-14.627
f,18665,fz,14.6452
f,18685,fz,14.6452
f,18701,fz,14.6452
f,18723,fz,-35.152
f,18731,fz,5.56062
f,18755,fz,-14.627
f,18773,fz,-44.237
f,18793,fz,-44.237
f,18809,fz,-44.237
f,18827,fz,-35.152
f,18847,fz,5.56062
f,18863,fz,-14.627
f,18881,fz,14.6452
f,18901,fz,14.6452
f,18917,fz,14.6452
f,18939,fz,-35.152
f,18947,fz,5.56062
f,18971,fz,-14.627
f,18989,fz,-44.237
f,19009,fz,-44.237
f,19025,fz,-44.237
f,19043,fz,-35.152
f,19063,fz,5.56062
f,19079,fz,-14.627
f,19097,fz,14.6452
f,19117,fz,14.6452
f,19133,fz,14.6452
f,19155,fz,-35.152
f,19163,fz,5.56062
f,19187,fz,-14.627
f,19205,fz,-44.237
f,19225,fz,-44.237
f,19241,fz,-44.237
f,19259,fz,-35.152
f,19279,fz,5.56062
f,19295,fz,-14.627
f,19313,fz,14.6452
f,19333,fz,14.6452
f,19349,fz,14.6452
f,19371,fz,-35.152
f,19379,fz,5.56062
f,19403,fz,-14.627
f,19421,fz,-44.237
f,19441,fz,-44.237
f,19457,fz,-44.237
f,19475,fz,-35.152
f,19495,fz,5.56062
f,19511,fz,-14.627
f,19529,fz,14.6452
f,19549,fz,14.6452
f,19565,fz,14.6452
f,19587,fz,-35.152
f,19595,fz,5.56062
f,19619,fz,-14.627
f,19637,fz,-44.237
f,19657,fz,-44.237
f,19673,fz,-44.237
f,19691,fz,-35.152
f,19711,fz,5.56062
f,19727,fz,-14.627
f,19745,fz,14.6452
f,19765,fz,14.6452
f,19781,fz,14.6452
f,19803,fz,-115.57
f,19811,fz,-74.855
f,19835,fz,-95.38
f,19853,fz,-124.65
f,19873,fz,-124.65
f,19889,fz,-124.65
f,19907,fz,-115.57
f,19927,fz,-74.855
f,19943,fz,-95.38
f,19961,fz,-65.77
f,19981,fz,-65.77
f,19997,fz,-65.77
f,20019,fz,-115.57
f,20027,fz,-74.855
f,20051,fz,-95.38
f,20069,fz,-124.65
f,20089,fz,-124.65
f,20105,fz,-124.65
f,20123,fz,-115.57
f,20143,fz,-74.855
f,20159,fz,-95.38
f,20177,fz,-65.77
f,20197,fz,-65.77
f,20213,fz,-65.77
f,20235,fz,-115.57
f,20243,fz,-74.855
f,20267,fz,-95.38
f,20285,fz,-124.65
f,20305,fz,-124.65
f,20321,fz,-124.65
f,20339,fz,-115.57
f,20359,fz,-74.855
f,20375,fz,-95.38
f,20393,fz,-65.77
f,20413,fz,-65.77
f,20429,fz,-65.77
f,20451,fz,-115.57
f,20459,fz,-74.855
f,20483,fz,-95.38
f,20501,fz,-124.65
f,20521,fz,-124.65
f,20537,fz,-124.65
f,20555,fz,-115.57
f,20575,fz,-74.855
f,20591,fz,-95.38
f,20609,fz,-65.77
f,20629,fz,-65.77
f,20645,fz,-65.77
f,20667,fz,-115.57
f,20675,fz,-74.855
f,20699,fz,-95.38
f,20717,fz,-124.65
f,20737,fz,-124.65
f,20753,fz,-124.65
f,20771,fz,-115.57
f,20791,fz,-74.855
f,20807,fz,-95.38
f,20825,fz,-65.77
f,20845,fz,-65.77
f,20861,fz,-65.77
f,20883,fz,-115.57
f,20891,fz,-74.855
f,20915,fz,-95.38
f,20933,fz,-124.65
f,20953,fz,-124.65
f,20969,fz,-124.65
f,20987,fz,-115.57
f,21007,fz,-74.855
f,21023,fz,-95.38
f,21041,fz,-65.77
f,21061,fz,-65.77
f,21077,fz,-65.77
f,21099,fz,-115.57
f,21107,fz,-74.855
f,21131,fz,-95.38
f,21149,fz,-124.65
f,21169,fz,-124.65
f,21185,fz,-124.65
f,21203,fz,-115.57
f,21223,fz,-74.855
f,21239,fz,-95.38
f,21257,fz,-65.77
f,21277,fz,-65.77
f,21293,fz,-65.77
f,21315,fz,-115.57
f,21323,fz,-74.855
f,21347,fz,-95.38
f,21365,fz,-124.65
f,21385,fz,-124.65
f,21401,fz,-124.65
f,21419,fz,-115.57
f,21439,fz,-74.855
f,21455,fz,-95.38
f,21473,fz,-65.77
f,21493,fz,-65.77
f,21509,fz,-65.77

f,21531,fz,-195.98
f,21539,fz,-155.27
f,21563,fz,-175.8
f,21581,fz,-205.07
f,21601,fz,-205.07
f,21617,fz,-205.07
f,21635,fz,-195.98
f,21655,fz,-155.27
f,21671,fz,-175.8
f,21689,fz,-146.52
f,21709,fz,-146.52
f,21725,fz,-146.52
f,21747,fz,-195.98
f,21755,fz,-155.27
f,21779,fz,-175.8
f,21797,fz,-205.07
f,21817,fz,-205.07
f,21833,fz,-205.07
f,21851,fz,-195.98
f,21871,fz,-155.27
f,21887,fz,-175.8
f,21905,fz,-146.52
f,21925,fz,-146.52
f,21941,fz,-146.52
f,21963,fz,-195.98
f,21971,fz,-155.27
f,21995,fz,-175.8
f,22013,fz,-205.07
f,22033,fz,-205.07
f,22049,fz,-205.07
f,22067,fz,-195.98
f,22087,fz,-155.27
f,22103,fz,-175.8
f,22121,fz,-146.52
f,22141,fz,-146.52
f,22157,fz,-146.52
f,22179,fz,-195.98
f,22187,fz,-155.27
f,22211,fz,-175.8
f,22229,fz,-205.07
f,22249,fz,-205.07
f,22265,fz,-205.07
f,22283,fz,-195.98
f,22303,fz,-155.27
f,22319,fz,-175.8
f,22337,fz,-146.52
f,22357,fz,-146.52
f,22373,fz,-146.52
f,22395,fz,-195.98
f,22403,fz,-155.27
f,22427,fz,-175.8
f,22445,fz,-205.07
f,22465,fz,-205.07
f,22481,fz,-205.07
f,22499,fz,-195.98
f,22519,fz,-155.27
f,22535,fz,-175.8
f,22553,fz,-146.52
f,22573,fz,-146.52
f,22589,fz,-146.52
f,22611,fz,-195.98
f,22619,fz,-155.27
f,22643,fz,-175.8
f,22661,fz,-205.07
f,22681,fz,-205.07
f,22697,fz,-205.07
f,22715,fz,-195.98
f,22735,fz,-155.27
f,22751,fz,-175.8
f,22769,fz,-146.52
f,22789,fz,-146.52
f,22805,fz,-146.52
f,22827,fz,-195.98
f,22835,fz,-155.27
f,22859,fz,-175.8
f,22877,fz,-205.07
f,22897,fz,-205.07
f,22913,fz,-205.07
f,22931,fz,-195.98
f,22951,fz,-155.27
f,22967,fz,-175.8
f,22985,fz,-146.52
f,23005,fz,-146.52
f,23021,fz,-146.52
f,23043,fz,-195.98
f,23051,fz,-155.27
f,23075,fz,-175.8
f,23093,fz,-205.07
f,23113,fz,-205.07
f,23129,fz,-205.07
f,23147,fz,-195.98
f,23167,fz,-155.27
f,23183,fz,-175.8
f,23201,fz,-146.52
f,23221,fz,-146.52
f,23237,fz,-146.52
f,23259,fz,-276.74
f,23267,fz,-236.02
f,23291,fz,-256.21
f,23309,fz,-285.82
f,23329,fz,-285.82
f,23345,fz,-285.82
f,23363,fz,-276.74
f,23383,fz,-236.02
f,23399,fz,-256.21
f,23417,fz,-226.94
f,23437,fz,-226.94
f,23453,fz,-226.94
f,23475,fz,-276.74
f,23483,fz,-236.02
f,23507,fz,-256.21
f,23525,fz,-285.82
f,23545,fz,-285.82
f,23561,fz,-285.82
f,23579,fz,-276.74
f,23599,fz,-236.02
f,23615,fz,-256.21
f,23633,fz,-226.94
f,23653,fz,-226.94
f,23669,fz,-226.94
f,23691,fz,-276.74
f,23699,fz,-236.02
f,23723,fz,-256.21
f,23741,fz,-285.82
f,23761,fz,-285.82
f,23777,fz,-285.82
f,23795,fz,-276.74
f,23815,fz,-236.02
f,23831,fz,-256.21
f,23849,fz,-226.94
f,23869,fz,-226.94
f,23885,fz,-226.94
f,23907,fz,-276.74
f,23915,fz,-236.02
f,23939,fz,-256.21
f,23957,fz,-285.82
f,23977,fz,-285.82
f,23993,fz,-285.82
f,24011,fz,-276.74
f,24031,fz,-236.02
f,24047,fz,-256.21
f,24065,fz,-226.94
f,24085,fz,-226.94
f,24101,fz,-226.94
f,24123,fz,-276.74
f,24131,fz,-236.02
f,24155,fz,-256.21
f,24173,fz,-285.82
f,24193,fz,-285.82
f,24209,fz,-285.82
f,24227,fz,-276.74
f,24247,fz,-236.02
f,24263,fz,-256.21
f,24281,fz,-226.94
f,24301,fz,-226.94
f,24317,fz,-226.94
f,24339,fz,-276.74
f,24347,fz,-236.02
f,24371,fz,-256.21
f,24389,fz,-285.82
f,24409,fz,-285.82
f,24425,fz,-285.82
f,24443,fz,-276.74
f,24463,fz,-236.02
f,24479,fz,-256.21
f,24497,fz,-226.94
f,24517,fz,-226.94
f,24533,fz,-226.94
f,24555,fz,-276.74
f,24563,fz,-236.02
f,24587,fz,-256.21
f,24605,fz,-285.82
f,24625,fz,-285.82
f,24641,fz,-285.82
f,24659,fz,-276.74
f,24679,fz,-236.02
f,24695,fz,-256.21
f,24713,fz,-226.94
f,24733,fz,-226.94
f,24749,fz,-226.94
f,24771,fz,-276.74
f,24779,fz,-236.02
f,24803,fz,-256.21
f,24821,fz,-285.82
f,24841,fz,-285.82
f,24857,fz,-285.82
f,24875,fz,-276.74
f,24895,fz,-236.02
f,24911,fz,-256.21
f,24929,fz,-226.94
f,24949,fz,-226.94
f,24965,fz,-226.94
f,24987,fz,-357.15
f,24995,fz,-316.44
f,25019,fz,-336.63
f,25037,fz,-366.24
f,25057,fz,-366.24
f,25073,fz,-366.24
f,25091,fz,-357.15
f,25111,fz,-316.44
f,25127,fz,-336.63
f,25145,fz,-307.35
f,25165,fz,-307.35
f,25181,fz,-307.35
f,25203,fz,-357.15
f,25211,fz,-316.44
f,25235,fz,-336.63
f,25253,fz,-366.24
f,25273,fz,-366.24
f,25289,fz,-366.24
f,25307,fz,-357.15
f,25327,fz,-316.44
f,25343,fz,-336.63
f,25361,fz,-307.35
f,25381,fz,-307.35
f,25397,fz,-307.35
f,25419,fz,-357.15
f,25427,fz,-316.44
f,25451,fz,-336.63
f,25469,fz,-366.24
f,25489,fz,-366.24
f,25505,fz,-366.24
f,25523,fz,-357.15
f,25543,fz,-316.44
f,25559,fz,-336.63
f,25577,fz,-307.35
f,25597,fz,-307.35
f,25613,fz,-307.35
f,25635,fz,-357.15
f,25643,fz,-316.44
f,25667,fz,-336.63
f,25685,fz,-366.24
f,25705,fz,-366.24
f,25721,fz,-366.24
f,25739,fz,-357.15
f,25759,fz,-316.44
f,25775,fz,-336.63
f,25793,fz,-307.35
f,25813,fz,-307.35
f,25829,fz,-307.35
f,25851,fz,-357.15
f,25859,fz,-316.44
f,25883,fz,-336.63
f,25901,fz,-366.24
f,25921,fz,-366.24
f,25937,fz,-366.24
f,25955,fz,-357.15
f,25975,fz,-316.44
f,25991,fz,-336.63
f,26009,fz,-307.35
f,26029,fz,-307.35
f,26045,fz,-307.35
f,26067,fz,-357.15
f,26075,fz,-316.44
f,26099,fz,-336.63
f,26117,fz,-366.24
f,26137,fz,-366.24
f,26153,fz,-366.24
f,26171,fz,-357.15
f,26191,fz,-316.44
f,26207,fz,-336.63
f,26225,fz,-307.35
f,26245,fz,-307.35
f,26261,fz,-307.35
f,26283,fz,-357.15
f,26291,fz,-316.44
f,26315,fz,-336.63
f,26333,fz,-366.24
f,26353,fz,-366.24
f,26369,fz,-366.24
f,26387,fz,-357.15
f,26407,fz,-316.44
f,26423,fz,-336.63
f,26441,fz,-307.35
f,26461,fz,-307.35
f,26477,fz,-307.35
f,26499,fz,-357.15
f,26507,fz,-316.44
f,26531,fz,-336.63
f,26549,fz,-366.24
f,26569,fz,-366.24
f,26585,fz,-366.24
f,26603,fz,-357.15
f,26623,fz,-316.44
f,26639,fz,-336.63
f,26657,fz,-307.35
f,26677,fz,-307.35
f,26693,fz,-307.35
f,26715,fz,-437.57
f,26723,fz,-396.85
f,26747,fz,-417.38
f,26765,fz,-446.65
f,26785,fz,-446.65
f,26801,fz,-446.65
f,26819,fz,-437.57
f,26839,fz,-396.85
f,26855,fz,-417.38
f,26873,fz,-387.77
f,26893,fz,-387.77
f,26909,fz,-387.77
f,26931,fz,-437.57
f,26939,fz,-396.85
f,26963,fz,-417.38
f,26981,fz,-446.65
f,27001,fz,-446.65
f,27017,fz,-446.65
f,27035,fz,-437.57
f,27055,fz,-396.85
f,27071,fz,-417.38
f,27089,fz,-387.77
f,27109,fz,-387.77
f,27125,fz,-387.77
f,27147,fz,-437.57
f,27155,fz,-396.85
f,27179,fz,-417.38
f,27197,fz,-446.65
f,27217,fz,-446.65
f,27233,fz,-446.65
f,27251,fz,-437.57
f,27271,fz,-396.85
f,27287,fz,-417.38
f,27305,fz,-387.77
f,27325,fz,-387.77
f,27341,fz,-387.77
f,27363,fz,-437.57
f,27371,fz,-396.85
f,27395,fz,-417.38
f,27413,fz,-446.65
f,27433,fz,-446.65
f,27449,fz,-446.65
f,27467,fz,-437.57
f,27487,fz,-396.85

f,27503,fz,-417.38
f,27521,fz,-387.77
f,27541,fz,-387.77
f,27557,fz,-387.77
f,27579,fz,-437.57
f,27587,fz,-396.85
f,27611,fz,-417.38
f,27629,fz,-446.65
f,27649,fz,-446.65
f,27665,fz,-446.65
f,27683,fz,-437.57
f,27703,fz,-396.85
f,27719,fz,-417.38
f,27737,fz,-387.77
f,27757,fz,-387.77
f,27773,fz,-387.77
f,27795,fz,-437.57
f,27803,fz,-396.85
f,27827,fz,-417.38
f,27845,fz,-446.65
f,27865,fz,-446.65
f,27881,fz,-446.65
f,27899,fz,-437.57
f,27919,fz,-396.85
f,27935,fz,-417.38
f,27953,fz,-387.77
f,27973,fz,-387.77
f,27989,fz,-387.77
f,28011,fz,-437.57
f,28019,fz,-396.85
f,28043,fz,-417.38
f,28061,fz,-446.65
f,28081,fz,-446.65
f,28097,fz,-446.65
f,28115,fz,-437.57
f,28135,fz,-396.85
f,28151,fz,-417.38
f,28169,fz,-387.77
f,28189,fz,-387.77
f,28205,fz,-387.77
f,28227,fz,-437.57
f,28235,fz,-396.85
f,28259,fz,-417.38
f,28277,fz,-446.65
f,28297,fz,-446.65
f,28313,fz,-446.65
f,28331,fz,-437.57
f,28351,fz,-396.85
f,28367,fz,-417.38
f,28385,fz,-387.77
f,28405,fz,-387.77
f,28421,fz,-387.77
f,28443,fz,-517.98
f,28451,fz,-477.61
f,28475,fz,-497.79
f,28493,fz,-527.07
f,28513,fz,-527.07
f,28529,fz,-527.07
f,28547,fz,-517.98
f,28567,fz,-477.61
f,28583,fz,-497.79
f,28601,fz,-468.52
f,28621,fz,-468.52
f,28637,fz,-468.52
f,28659,fz,-517.98
f,28667,fz,-477.61
f,28691,fz,-497.79
f,28709,fz,-527.07
f,28729,fz,-527.07
f,28745,fz,-527.07
f,28763,fz,-517.98
f,28783,fz,-477.61
f,28799,fz,-497.79
f,28817,fz,-468.52
f,28837,fz,-468.52
f,28853,fz,-468.52
f,28875,fz,-517.98
f,28883,fz,-477.61
f,28907,fz,-497.79
f,28925,fz,-527.07
f,28945,fz,-527.07
f,28961,fz,-527.07
f,28979,fz,-517.98
f,28999,fz,-477.61
f,29015,fz,-497.79
f,29033,fz,-468.52
f,29053,fz,-468.52
f,29069,fz,-468.52
f,29091,fz,-517.98
f,29099,fz,-477.61
f,29123,fz,-497.79
f,29141,fz,-527.07
f,29161,fz,-527.07
f,29177,fz,-527.07
f,29195,fz,-517.98
f,29215,fz,-477.61
f,29231,fz,-497.79
f,29249,fz,-468.52
f,29269,fz,-468.52
f,29285,fz,-468.52
f,29307,fz,-517.98
f,29315,fz,-477.61
f,29339,fz,-497.79
f,29357,fz,-527.07
f,29377,fz,-527.07
f,29393,fz,-527.07
f,29411,fz,-517.98
f,29431,fz,-477.61
f,29447,fz,-497.79
f,29465,fz,-468.52
f,29485,fz,-468.52
f,29501,fz,-468.52
f,29523,fz,-517.98
f,29531,fz,-477.61
f,29555,fz,-497.79
f,29573,fz,-527.07
f,29593,fz,-527.07
f,29609,fz,-527.07
f,29627,fz,-517.98
f,29647,fz,-477.61
f,29663,fz,-497.79
f,29681,fz,-468.52
f,29701,fz,-468.52
f,29717,fz,-468.52
f,29739,fz,-517.98
f,29747,fz,-477.61
f,29771,fz,-497.79
f,29789,fz,-527.07
f,29809,fz,-527.07
f,29825,fz,-527.07
f,29843,fz,-517.98
f,29863,fz,-477.61
f,29879,fz,-497.79
f,29897,fz,-468.52
f,29917,fz,-468.52
f,29933,fz,-468.52
f,29955,fz,-517.98
f,29963,fz,-477.61
f,29987,fz,-497.79
f,30005,fz,-527.07
f,30025,fz,-527.07
f,30041,fz,-527.07
f,30059,fz,-517.98
f,30079,fz,-477.61
f,30095,fz,-497.79
f,30113,fz,-468.52
f,30133,fz,-468.52
f,30149,fz,-468.52
f,30171,fz,-598.73
f,30179,fz,-558.02
f,30203,fz,-578.21
f,30221,fz,-607.82
f,30241,fz,-607.82
f,30257,fz,-607.82
f,30275,fz,-598.73
f,30295,fz,-558.02
f,30311,fz,-578.21
f,30329,fz,-548.94
f,30349,fz,-548.94
f,30365,fz,-548.94
f,30387,fz,-598.73
f,30395,fz,-558.02
f,30419,fz,-578.21
f,30437,fz,-607.82
f,30457,fz,-607.82
f,30473,fz,-607.82
f,30491,fz,-598.73
f,30511,fz,-558.02
f,30527,fz,-578.21
f,30545,fz,-548.94
f,30565,fz,-548.94
f,30581,fz,-548.94
f,30603,fz,-598.73
f,30611,fz,-558.02
f,30635,fz,-578.21
f,30653,fz,-607.82
f,30673,fz,-607.82
f,30689,fz,-607.82
f,30707,fz,-598.73
f,30727,fz,-558.02
f,30743,fz,-578.21
f,30761,fz,-548.94
f,30781,fz,-548.94
f,30797,fz,-548.94
f,30819,fz,-598.73
f,30827,fz,-558.02
f,30851,fz,-578.21
f,30869,fz,-607.82
f,30889,fz,-607.82
f,30905,fz,-607.82
f,30923,fz,-598.73
f,30943,fz,-558.02
f,30959,fz,-578.21
f,30977,fz,-548.94
f,30997,fz,-548.94
f,31013,fz,-548.94
f,31035,fz,-598.73
f,31043,fz,-558.02
f,31067,fz,-578.21
f,31085,fz,-607.82
f,31105,fz,-607.82
f,31121,fz,-607.82
f,31139,fz,-598.73
f,31159,fz,-558.02
f,31175,fz,-578.21
f,31193,fz,-548.94
f,31213,fz,-548.94
f,31229,fz,-548.94
f,31251,fz,-598.73
f,31259,fz,-558.02
f,31283,fz,-578.21
f,31301,fz,-607.82
f,31321,fz,-607.82
f,31337,fz,-607.82
f,31355,fz,-598.73
f,31375,fz,-558.02
f,31391,fz,-578.21
f,31409,fz,-548.94
f,31429,fz,-548.94
f,31445,fz,-548.94
f,31467,fz,-598.73
f,31475,fz,-558.02
f,31499,fz,-578.21
f,31517,fz,-607.82
f,31537,fz,-607.82
f,31553,fz,-607.82
f,31571,fz,-598.73
f,31591,fz,-558.02
f,31607,fz,-578.21
f,31625,fz,-548.94
f,31645,fz,-548.94
f,31661,fz,-548.94
f,31683,fz,-598.73
f,31691,fz,-558.02
f,31715,fz,-578.21
f,31733,fz,-607.82
f,31753,fz,-607.82
f,31769,fz,-607.82
f,31787,fz,-598.73
f,31807,fz,-558.02
f,31823,fz,-578.21
f,31841,fz,-548.94
f,31861,fz,-548.94
f,31877,fz,-548.94
f,31899,fz,-679.15
f,31907,fz,-638.44
f,31931,fz,-658.96
f,31949,fz,-688.24
f,31969,fz,-688.24
f,31985,fz,-688.24
f,32003,fz,-679.15
f,32023,fz,-638.44
f,32039,fz,-658.96
f,32057,fz,-629.35
f,32077,fz,-629.35
f,32093,fz,-629.35
f,32115,fz,-679.15
f,32123,fz,-638.44
f,32147,fz,-658.96
f,32165,fz,-688.24
f,32185,fz,-688.24
f,32201,fz,-688.24
f,32219,fz,-679.15
f,32239,fz,-638.44
f,32255,fz,-658.96
f,32273,fz,-629.35
f,32293,fz,-629.35
f,32309,fz,-629.35
f,32331,fz,-679.15
f,32339,fz,-638.44
f,32363,fz,-658.96
f,32381,fz,-688.24
f,32401,fz,-688.24
f,32417,fz,-688.24
f,32435,fz,-679.15
f,32455,fz,-638.44
f,32471,fz,-658.96
f,32489,fz,-629.35
f,32509,fz,-629.35
f,32525,fz,-629.35
f,32547,fz,-679.15
f,32555,fz,-638.44
f,32579,fz,-658.96
f,32597,fz,-688.24
f,32617,fz,-688.24
f,32633,fz,-688.24
f,32651,fz,-679.15
f,32671,fz,-638.44
f,32687,fz,-658.96
f,32705,fz,-629.35
f,32725,fz,-629.35
f,32741,fz,-629.35
f,32763,fz,-679.15
f,32771,fz,-638.44
f,32795,fz,-658.96
f,32813,fz,-688.24
f,32833,fz,-688.24
f,32849,fz,-688.24
f,32867,fz,-679.15
f,32887,fz,-638.44
f,32903,fz,-658.96
f,32921,fz,-629.35
f,32941,fz,-629.35
f,32957,fz,-629.35
f,32979,fz,-679.15
f,32987,fz,-638.44
f,33011,fz,-658.96
f,33029,fz,-688.24
f,33049,fz,-688.24
f,33065,fz,-688.24
f,33083,fz,-679.15
f,33103,fz,-638.44
f,33119,fz,-658.96
f,33137,fz,-629.35
f,33157,fz,-629.35
f,33173,fz,-629.35
f,33195,fz,-679.15
f,33203,fz,-638.44
f,33227,fz,-658.96
f,33245,fz,-688.24
f,33265,fz,-688.24
f,33281,fz,-688.24
f,33299,fz,-679.15
f,33319,fz,-638.44
f,33335,fz,-658.96
f,33353,fz,-629.35
f,33373,fz,-629.35
f,33389,fz,-629.35
f,33411,fz,-679.15
f,33419,fz,-638.44
f,33443,fz,-658.96
f,33461,fz,-688.24

f,33481,fz,-688.24
f,33497,fz,-688.24
f,33515,fz,-679.15
f,33535,fz,-638.44
f,33551,fz,-658.96
f,33569,fz,-629.35
f,33589,fz,-629.35
f,33605,fz,-629.35
f,5980,fz,520.86
f,5988,fz,561.573
f,6012,fz,541.384
f,6030,fz,511.775
f,6050,fz,511.775
f,6066,fz,511.775
f,6084,fz,520.86
f,6104,fz,561.573
f,6120,fz,541.384
f,6138,fz,570.657
f,6158,fz,570.657
f,6174,fz,570.657
f,6196,fz,520.86
f,6204,fz,561.573
f,6228,fz,541.384
f,6246,fz,511.775
f,6266,fz,511.775
f,6282,fz,511.775
f,6300,fz,520.86
f,6320,fz,561.573
f,6336,fz,541.384
f,6354,fz,570.657
f,6374,fz,570.657
f,6390,fz,570.657
f,6412,fz,520.86
f,6420,fz,561.573
f,6444,fz,541.384
f,6462,fz,511.775
f,6482,fz,511.775
f,6498,fz,511.775
f,6516,fz,520.86
f,6536,fz,561.573
f,6552,fz,541.384
f,6570,fz,570.657
f,6590,fz,570.657
f,6606,fz,570.657
f,6628,fz,520.86
f,6636,fz,561.573
f,6660,fz,541.384
f,6678,fz,511.775
f,6698,fz,511.775
f,6714,fz,511.775
f,6732,fz,520.86
f,6752,fz,561.573
f,6768,fz,541.384
f,6786,fz,570.657
f,6806,fz,570.657
f,6822,fz,570.657
f,6844,fz,520.86
f,6852,fz,561.573
f,6876,fz,541.384
f,6894,fz,511.775
f,6914,fz,511.775
f,6930,fz,511.775
f,6948,fz,520.86
f,6968,fz,561.573
f,6984,fz,541.384
f,7002,fz,570.657
f,7022,fz,570.657
f,7038,fz,570.657
f,7060,fz,520.86
f,7068,fz,561.573
f,7092,fz,541.384
f,7110,fz,511.775
f,7130,fz,511.775
f,7146,fz,511.775
f,7164,fz,520.86
f,7184,fz,561.573
f,7200,fz,541.384
f,7218,fz,570.657
f,7238,fz,570.657
f,7254,fz,570.657
f,7276,fz,520.86
f,7284,fz,561.573
f,7308,fz,541.384
f,7326,fz,511.775
f,7346,fz,511.775
f,7362,fz,511.775
f,7380,fz,520.86
f,7400,fz,561.573
f,7416,fz,541.384
f,7434,fz,570.657
f,7454,fz,570.657
f,7470,fz,570.657
f,7492,fz,520.86
f,7500,fz,561.573
f,7524,fz,541.384
f,7542,fz,511.775
f,7562,fz,511.775
f,7578,fz,511.775
f,7596,fz,520.86
f,7616,fz,561.573
f,7632,fz,541.384
f,7650,fz,570.657
f,7670,fz,570.657
f,7686,fz,570.657
f,7708,fz,440.444
f,7716,fz,481.157
f,7740,fz,460.632
f,7758,fz,431.36
f,7778,fz,431.36
f,7794,fz,431.36
f,7812,fz,440.444
f,7832,fz,481.157
f,7848,fz,460.632
f,7866,fz,490.241
f,7886,fz,490.241
f,7902,fz,490.241
f,7924,fz,440.444
f,7932,fz,481.157
f,7956,fz,460.632
f,7974,fz,431.36
f,7994,fz,431.36
f,8010,fz,431.36
f,8028,fz,440.444
f,8048,fz,481.157
f,8064,fz,460.632
f,8082,fz,490.241
f,8102,fz,490.241
f,8118,fz,490.241
f,8140,fz,440.444
f,8148,fz,481.157
f,8172,fz,460.632
f,8190,fz,431.36
f,8210,fz,431.36
f,8226,fz,431.36
f,8244,fz,440.444
f,8264,fz,481.157
f,8280,fz,460.632
f,8298,fz,490.241
f,8318,fz,490.241
f,8334,fz,490.241
f,8356,fz,440.444
f,8364,fz,481.157
f,8388,fz,460.632
f,8406,fz,431.36
f,8426,fz,431.36
f,8442,fz,431.36
f,8460,fz,440.444
f,8480,fz,481.157
f,8496,fz,460.632
f,8514,fz,490.241
f,8534,fz,490.241
f,8550,fz,490.241
f,8572,fz,440.444
f,8580,fz,481.157
f,8604,fz,460.632
f,8622,fz,431.36
f,8642,fz,431.36
f,8658,fz,431.36
f,8676,fz,440.444
f,8696,fz,481.157
f,8712,fz,460.632
f,8730,fz,490.241
f,8750,fz,490.241
f,8766,fz,490.241
f,8788,fz,440.444
f,8796,fz,481.157
f,8820,fz,460.632
f,8838,fz,431.36
f,8858,fz,431.36
f,8874,fz,431.36
f,8892,fz,440.444
f,8912,fz,481.157
f,8928,fz,460.632
f,8946,fz,490.241
f,8966,fz,490.241
f,8982,fz,490.241
f,9004,fz,440.444
f,9012,fz,481.157
f,9036,fz,460.632
f,9054,fz,431.36
f,9074,fz,431.36
f,9090,fz,431.36
f,9108,fz,440.444
f,9128,fz,481.157
f,9144,fz,460.632
f,9162,fz,490.241
f,9182,fz,490.241
f,9198,fz,490.241
f,9220,fz,440.444
f,9228,fz,481.157
f,9252,fz,460.632
f,9270,fz,431.36
f,9290,fz,431.36
f,9306,fz,431.36
f,9324,fz,440.444
f,9344,fz,481.157
f,9360,fz,460.632
f,9378,fz,490.241
f,9398,fz,490.241
f,9414,fz,490.241
f,9436,fz,360.029
f,9444,fz,400.405
f,9468,fz,380.217
f,9486,fz,350.944
f,9506,fz,350.944
f,9522,fz,350.944
f,9540,fz,360.029
f,9560,fz,400.405
f,9576,fz,380.217
f,9594,fz,409.489
f,9614,fz,409.489
f,9630,fz,409.489
f,9652,fz,360.029
f,9660,fz,400.405
f,9684,fz,380.217
f,9702,fz,350.944
f,9722,fz,350.944
f,9738,fz,350.944
f,9756,fz,360.029
f,9776,fz,400.405
f,9792,fz,380.217
f,9810,fz,409.489
f,9830,fz,409.489
f,9846,fz,409.489
f,9868,fz,360.029
f,9876,fz,400.405
f,9900,fz,380.217
f,9918,fz,350.944
f,9938,fz,350.944
f,9954,fz,350.944
f,9972,fz,360.029
f,9992,fz,400.405
f,10008,fz,380.217
f,10026,fz,409.489
f,10046,fz,409.489
f,10062,fz,409.489
f,10084,fz,360.029
f,10092,fz,400.405
f,10116,fz,380.217
f,10134,fz,350.944
f,10154,fz,350.944
f,10170,fz,350.944
f,10188,fz,360.029
f,10208,fz,400.405
f,10224,fz,380.217
f,10242,fz,409.489
f,10262,fz,409.489
f,10278,fz,409.489
f,10300,fz,360.029
f,10308,fz,400.405
f,10332,fz,380.217
f,10350,fz,350.944
f,10370,fz,350.944
f,10386,fz,350.944
f,10404,fz,360.029
f,10424,fz,400.405
f,10440,fz,380.217
f,10458,fz,409.489
f,10478,fz,409.489
f,10494,fz,409.489
f,10516,fz,360.029
f,10524,fz,400.405
f,10548,fz,380.217
f,10566,fz,350.944
f,10586,fz,350.944
f,10602,fz,350.944
f,10620,fz,360.029
f,10640,fz,400.405
f,10656,fz,380.217
f,10674,fz,409.489
f,10694,fz,409.489
f,10710,fz,409.489
f,10732,fz,360.029
f,10740,fz,400.405
f,10764,fz,380.217
f,10782,fz,350.944
f,10802,fz,350.944
f,10818,fz,350.944
f,10836,fz,360.029
f,10856,fz,400.405
f,10872,fz,380.217
f,10890,fz,409.489
f,10910,fz,409.489
f,10926,fz,409.489
f,10948,fz,360.029
f,10956,fz,400.405
f,10980,fz,380.217
f,10998,fz,350.944
f,11018,fz,350.944
f,11034,fz,350.944
f,11052,fz,360.029
f,11072,fz,400.405
f,11088,fz,380.217
f,11106,fz,409.489
f,11126,fz,409.489
f,11142,fz,409.489
f,11164,fz,279.276
f,11172,fz,319.989
f,11196,fz,299.801
f,11214,fz,270.192
f,11234,fz,270.192
f,11250,fz,270.192
f,11268,fz,279.276
f,11288,fz,319.989
f,11304,fz,299.801
f,11322,fz,329.074
f,11342,fz,329.074
f,11358,fz,329.074
f,11380,fz,279.276
f,11388,fz,319.989
f,11412,fz,299.801
f,11430,fz,270.192
f,11450,fz,270.192
f,11466,fz,270.192
f,11484,fz,279.276
f,11504,fz,319.989
f,11520,fz,299.801
f,11538,fz,329.074
f,11558,fz,329.074
f,11574,fz,329.074
f,11596,fz,279.276
f,11604,fz,319.989
f,11628,fz,299.801
f,11646,fz,270.192
f,11666,fz,270.192
f,11682,fz,270.192
f,11700,fz,279.276
f,11720,fz,319.989
f,11736,fz,299.801
f,11754,fz,329.074
f,11774,fz,329.074
f,11790,fz,329.074

f,11812,fr,279.276
f,11820,fr,319.989
f,11844,fr,299.801
f,11862,fr,270.192
f,11882,fr,270.192
f,11898,fr,270.192
f,11916,fr,279.276
f,11936,fr,319.989
f,11952,fr,299.801
f,11970,fr,329.074
f,11990,fr,329.074
f,12006,fr,329.074
f,12028,fr,279.276
f,12036,fr,319.989
f,12060,fr,299.801
f,12078,fr,270.192
f,12098,fr,270.192
f,12114,fr,270.192
f,12132,fr,279.276
f,12152,fr,319.989
f,12168,fr,299.801
f,12186,fr,329.074
f,12206,fr,329.074
f,12222,fr,329.074
f,12244,fr,279.276
f,12252,fr,319.989
f,12276,fr,299.801
f,12294,fr,270.192
f,12314,fr,270.192
f,12330,fr,270.192
f,12348,fr,279.276
f,12368,fr,319.989
f,12384,fr,299.801
f,12402,fr,329.074
f,12422,fr,329.074
f,12438,fr,329.074
f,12460,fr,279.276
f,12468,fr,319.989
f,12492,fr,299.801
f,12510,fr,270.192
f,12530,fr,270.192
f,12546,fr,270.192
f,12564,fr,279.276
f,12584,fr,319.989
f,12600,fr,299.801
f,12618,fr,329.074
f,12638,fr,329.074
f,12654,fr,329.074
f,12676,fr,279.276
f,12684,fr,319.989
f,12708,fr,299.801
f,12726,fr,270.192
f,12746,fr,270.192
f,12762,fr,270.192
f,12780,fr,279.276
f,12800,fr,319.989
f,12816,fr,299.801
f,12834,fr,329.074
f,12854,fr,329.074
f,12870,fr,329.074
f,12892,fr,198.861
f,12900,fr,239.573
f,12924,fr,219.049
f,12942,fr,189.776
f,12962,fr,189.776
f,12978,fr,189.776
f,12996,fr,198.861
f,13016,fr,239.573
f,13032,fr,219.049
f,13050,fr,248.658
f,13070,fr,248.658
f,13086,fr,248.658
f,13108,fr,198.861
f,13116,fr,239.573
f,13140,fr,219.049
f,13158,fr,189.776
f,13178,fr,189.776
f,13194,fr,189.776
f,13212,fr,198.861
f,13232,fr,239.573
f,13248,fr,219.049
f,13266,fr,248.658
f,13286,fr,248.658
f,13302,fr,248.658
f,13324,fr,198.861
f,13332,fr,239.573
f,13356,fr,219.049
f,13374,fr,189.776
f,13394,fr,189.776
f,13410,fr,189.776
f,13428,fr,198.861
f,13448,fr,239.573
f,13464,fr,219.049
f,13482,fr,248.658
f,13502,fr,248.658
f,13518,fr,248.658
f,13540,fr,198.861
f,13548,fr,239.573
f,13572,fr,219.049
f,13590,fr,189.776
f,13610,fr,189.776
f,13626,fr,189.776
f,13644,fr,198.861
f,13664,fr,239.573
f,13680,fr,219.049
f,13698,fr,248.658
f,13718,fr,248.658
f,13734,fr,248.658
f,13756,fr,198.861
f,13764,fr,239.573
f,13788,fr,219.049
f,13806,fr,189.776
f,13826,fr,189.776
f,13842,fr,189.776
f,13860,fr,198.861
f,13880,fr,239.573
f,13896,fr,219.049
f,13914,fr,248.658
f,13934,fr,248.658
f,13950,fr,248.658
f,13972,fr,198.861
f,13980,fr,239.573
f,14004,fr,219.049
f,14022,fr,189.776
f,14042,fr,189.776
f,14058,fr,189.776
f,14076,fr,198.861
f,14096,fr,239.573
f,14112,fr,219.049
f,14130,fr,248.658
f,14150,fr,248.658
f,14166,fr,248.658
f,14188,fr,198.861
f,14196,fr,239.573
f,14220,fr,219.049
f,14238,fr,189.776
f,14258,fr,189.776
f,14274,fr,189.776
f,14292,fr,198.861
f,14312,fr,239.573
f,14328,fr,219.049
f,14346,fr,248.658
f,14366,fr,248.658
f,14382,fr,248.658
f,14404,fr,198.861
f,14412,fr,239.573
f,14436,fr,219.049
f,14454,fr,189.776
f,14474,fr,189.776
f,14490,fr,189.776
f,14508,fr,198.861
f,14528,fr,239.573
f,14544,fr,219.049
f,14562,fr,248.658
f,14582,fr,248.658
f,14598,fr,248.658
f,14620,fr,118.445
f,14628,fr,159.158
f,14652,fr,138.633
f,14670,fr,109.36
f,14690,fr,109.36
f,14706,fr,109.36
f,14724,fr,118.445
f,14744,fr,159.158
f,14760,fr,138.633
f,14778,fr,168.242
f,14798,fr,168.242
f,14814,fr,168.242
f,14836,fr,118.445
f,14844,fr,159.158
f,14868,fr,138.633
f,14886,fr,109.36
f,14906,fr,109.36
f,14922,fr,109.36
f,14940,fr,118.445
f,14960,fr,159.158
f,14976,fr,138.633
f,14994,fr,168.242
f,15014,fr,168.242
f,15030,fr,168.242
f,15052,fr,118.445
f,15060,fr,159.158
f,15084,fr,138.633
f,15102,fr,109.36
f,15122,fr,109.36
f,15138,fr,109.36
f,15156,fr,118.445
f,15176,fr,159.158
f,15192,fr,138.633
f,15210,fr,168.242
f,15230,fr,168.242
f,15246,fr,168.242
f,15268,fr,118.445
f,15276,fr,159.158
f,15300,fr,138.633
f,15318,fr,109.36
f,15338,fr,109.36
f,15354,fr,109.36
f,15372,fr,118.445
f,15392,fr,159.158
f,15408,fr,138.633
f,15426,fr,168.242
f,15446,fr,168.242
f,15462,fr,168.242
f,15484,fr,118.445
f,15492,fr,159.158
f,15516,fr,138.633
f,15534,fr,109.36
f,15554,fr,109.36
f,15570,fr,109.36
f,15588,fr,118.445
f,15608,fr,159.158
f,15624,fr,138.633
f,15642,fr,168.242
f,15662,fr,168.242
f,15678,fr,168.242
f,15700,fr,118.445
f,15708,fr,159.158
f,15732,fr,138.633
f,15750,fr,109.36
f,15770,fr,109.36
f,15786,fr,109.36
f,15804,fr,118.445
f,15824,fr,159.158
f,15840,fr,138.633
f,15858,fr,168.242
f,15878,fr,168.242
f,15894,fr,168.242
f,15916,fr,118.445
f,15924,fr,159.158
f,15948,fr,138.633
f,15966,fr,109.36
f,15986,fr,109.36
f,16002,fr,109.36
f,16020,fr,118.445
f,16040,fr,159.158
f,16056,fr,138.633
f,16074,fr,168.242
f,16094,fr,168.242
f,16110,fr,168.242
f,16132,fr,118.445
f,16140,fr,159.158
f,16164,fr,138.633
f,16182,fr,109.36
f,16202,fr,109.36
f,16218,fr,109.36
f,16236,fr,118.445
f,16256,fr,159.158
f,16272,fr,138.633
f,16290,fr,168.242
f,16310,fr,168.242
f,16326,fr,168.242
f,16348,fr,37.6928
f,16356,fr,78.4054
f,16380,fr,58.2173
f,16398,fr,28.9447
f,16418,fr,28.9447
f,16434,fr,28.9447
f,16452,fr,37.6928
f,16472,fr,78.4054
f,16488,fr,58.2173
f,16506,fr,87.49
f,16526,fr,87.49
f,16542,fr,87.49
f,16564,fr,37.6928
f,16572,fr,78.4054
f,16596,fr,58.2173
f,16614,fr,28.9447
f,16634,fr,28.9447
f,16650,fr,28.9447
f,16668,fr,37.6928
f,16688,fr,78.4054
f,16704,fr,58.2173
f,16722,fr,87.49
f,16742,fr,87.49
f,16758,fr,87.49
f,16780,fr,37.6928
f,16788,fr,78.4054
f,16812,fr,58.2173
f,16830,fr,28.9447
f,16850,fr,28.9447
f,16866,fr,28.9447
f,16884,fr,37.6928
f,16904,fr,78.4054
f,16920,fr,58.2173
f,16938,fr,87.49
f,16958,fr,87.49
f,16974,fr,87.49
f,16996,fr,37.6928
f,17004,fr,78.4054
f,17028,fr,58.2173
f,17046,fr,28.9447
f,17066,fr,28.9447
f,17082,fr,28.9447
f,17100,fr,37.6928
f,17120,fr,78.4054
f,17136,fr,58.2173
f,17154,fr,87.49
f,17174,fr,87.49
f,17190,fr,87.49
f,17212,fr,37.6928
f,17220,fr,78.4054
f,17244,fr,58.2173
f,17262,fr,28.9447
f,17282,fr,28.9447
f,17298,fr,28.9447
f,17316,fr,37.6928
f,17336,fr,78.4054
f,17352,fr,58.2173
f,17370,fr,87.49
f,17390,fr,87.49
f,17406,fr,87.49
f,17428,fr,37.6928
f,17436,fr,78.4054
f,17460,fr,58.2173
f,17478,fr,28.9447
f,17498,fr,28.9447
f,17514,fr,28.9447
f,17532,fr,37.6928
f,17552,fr,78.4054
f,17568,fr,58.2173
f,17586,fr,87.49
f,17606,fr,87.49
f,17622,fr,87.49
f,17644,fr,37.6928
f,17652,fr,78.4054
f,17676,fr,58.2173
f,17694,fr,28.9447
f,17714,fr,28.9447
f,17730,fr,28.9447
f,17748,fr,37.6928
f,17768,fr,78.4054

f,17784,fz,58.2173
f,17802,fz,87.49
f,17822,fz,87.49
f,17838,fz,87.49
f,17860,fz,37.6928
f,17868,fz,78.4054
f,17892,fz,58.2173
f,17910,fz,28.9447
f,17930,fz,28.9447
f,17946,fz,28.9447
f,17964,fz,37.6928
f,17984,fz,78.4054
f,18000,fz,58.2173
f,18018,fz,87.49
f,18038,fz,87.49
f,18054,fz,87.49
f,18076,fz,-42.723
f,18084,fz,-2.0103
f,18108,fz,-22.198
f,18126,fz,-51.808
f,18146,fz,-51.808
f,18162,fz,-51.808
f,18180,fz,-42.723
f,18200,fz,-2.0103
f,18216,fz,-22.198
f,18234,fz,7.07428
f,18254,fz,7.07428
f,18270,fz,7.07428
f,18292,fz,-42.723
f,18300,fz,-2.0103
f,18324,fz,-22.198
f,18342,fz,-51.808
f,18362,fz,-51.808
f,18378,fz,-51.808
f,18396,fz,-42.723
f,18416,fz,-2.0103
f,18432,fz,-22.198
f,18450,fz,7.07428
f,18470,fz,7.07428
f,18486,fz,7.07428
f,18508,fz,-42.723
f,18516,fz,-2.0103
f,18540,fz,-22.198
f,18558,fz,-51.808
f,18578,fz,-51.808
f,18594,fz,-51.808
f,18612,fz,-42.723
f,18632,fz,-2.0103
f,18648,fz,-22.198
f,18666,fz,7.07428
f,18686,fz,7.07428
f,18702,fz,7.07428
f,18724,fz,-42.723
f,18732,fz,-2.0103
f,18756,fz,-22.198
f,18774,fz,-51.808
f,18794,fz,-51.808
f,18810,fz,-51.808
f,18828,fz,-42.723
f,18848,fz,-2.0103
f,18864,fz,-22.198
f,18882,fz,7.07428
f,18902,fz,7.07428
f,18918,fz,7.07428
f,18940,fz,-42.723
f,18948,fz,-2.0103
f,18972,fz,-22.198
f,18990,fz,-51.808
f,19010,fz,-51.808
f,19026,fz,-51.808
f,19044,fz,-42.723
f,19064,fz,-2.0103
f,19080,fz,-22.198
f,19098,fz,7.07428
f,19118,fz,7.07428
f,19134,fz,7.07428
f,19156,fz,-42.723
f,19164,fz,-2.0103
f,19188,fz,-22.198
f,19206,fz,-51.808
f,19226,fz,-51.808
f,19242,fz,-51.808
f,19260,fz,-42.723
f,19280,fz,-2.0103
f,19296,fz,-22.198
f,19314,fz,7.07428
f,19334,fz,7.07428
f,19350,fz,7.07428
f,19372,fz,-42.723
f,19380,fz,-2.0103
f,19404,fz,-22.198
f,19422,fz,-51.808
f,19442,fz,-51.808
f,19458,fz,-51.808
f,19476,fz,-42.723
f,19496,fz,-2.0103
f,19512,fz,-22.198
f,19530,fz,7.07428
f,19550,fz,7.07428
f,19566,fz,7.07428
f,19588,fz,-42.723
f,19596,fz,-2.0103
f,19620,fz,-22.198
f,19638,fz,-51.808
f,19658,fz,-51.808
f,19674,fz,-51.808
f,19692,fz,-42.723
f,19712,fz,-2.0103
f,19728,fz,-22.198
f,19746,fz,7.07428
f,19766,fz,7.07428
f,19782,fz,7.07428
f,19804,fz,-123.14
f,19812,fz,-82.426
f,19836,fz,-102.95
f,19854,fz,-132.22
f,19874,fz,-132.22
f,19890,fz,-132.22
f,19908,fz,-123.14
f,19928,fz,-82.426
f,19944,fz,-102.95
f,19962,fz,-73.341
f,19982,fz,-73.341
f,19998,fz,-73.341
f,20020,fz,-123.14
f,20028,fz,-82.426
f,20052,fz,-102.95
f,20070,fz,-132.22
f,20090,fz,-132.22
f,20106,fz,-132.22
f,20124,fz,-123.14
f,20144,fz,-82.426
f,20160,fz,-102.95
f,20178,fz,-73.341
f,20198,fz,-73.341
f,20214,fz,-73.341
f,20236,fz,-123.14
f,20244,fz,-82.426
f,20268,fz,-102.95
f,20286,fz,-132.22
f,20306,fz,-132.22
f,20322,fz,-132.22
f,20340,fz,-123.14
f,20360,fz,-82.426
f,20376,fz,-102.95
f,20394,fz,-73.341
f,20414,fz,-73.341
f,20430,fz,-73.341
f,20452,fz,-123.14
f,20460,fz,-82.426
f,20484,fz,-102.95
f,20502,fz,-132.22
f,20522,fz,-132.22
f,20538,fz,-132.22
f,20556,fz,-123.14
f,20576,fz,-82.426
f,20592,fz,-102.95
f,20610,fz,-73.341
f,20630,fz,-73.341
f,20646,fz,-73.341
f,20668,fz,-123.14
f,20676,fz,-82.426
f,20700,fz,-102.95
f,20718,fz,-132.22
f,20738,fz,-132.22
f,20754,fz,-132.22
f,20772,fz,-123.14
f,20792,fz,-82.426
f,20808,fz,-102.95
f,20826,fz,-73.341
f,20846,fz,-73.341
f,20862,fz,-73.341
f,20884,fz,-123.14
f,20892,fz,-82.426
f,20916,fz,-102.95
f,20934,fz,-132.22
f,20954,fz,-132.22
f,20970,fz,-132.22
f,20988,fz,-123.14
f,21008,fz,-82.426
f,21024,fz,-102.95
f,21042,fz,-73.341
f,21062,fz,-73.341
f,21078,fz,-73.341
f,21100,fz,-123.14
f,21108,fz,-82.426
f,21132,fz,-102.95
f,21150,fz,-132.22
f,21170,fz,-132.22
f,21186,fz,-132.22
f,21204,fz,-123.14
f,21224,fz,-82.426
f,21240,fz,-102.95
f,21258,fz,-73.341
f,21278,fz,-73.341
f,21294,fz,-73.341
f,21316,fz,-123.14
f,21324,fz,-82.426
f,21348,fz,-102.95
f,21366,fz,-132.22
f,21386,fz,-132.22
f,21402,fz,-132.22
f,21420,fz,-123.14
f,21440,fz,-82.426
f,21456,fz,-102.95
f,21474,fz,-73.341
f,21494,fz,-73.341
f,21510,fz,-73.341
f,21532,fz,-203.55
f,21540,fz,-162.84
f,21564,fz,-183.37
f,21582,fz,-212.64
f,21602,fz,-212.64
f,21618,fz,-212.64
f,21636,fz,-203.55
f,21656,fz,-162.84
f,21672,fz,-183.37
f,21690,fz,-154.09
f,21710,fz,-154.09
f,21726,fz,-154.09
f,21748,fz,-203.55
f,21756,fz,-162.84
f,21780,fz,-183.37
f,21798,fz,-212.64
f,21818,fz,-212.64
f,21834,fz,-212.64
f,21852,fz,-203.55
f,21872,fz,-162.84
f,21888,fz,-183.37
f,21906,fz,-154.09
f,21926,fz,-154.09
f,21942,fz,-154.09
f,21964,fz,-203.55
f,21972,fz,-162.84
f,21996,fz,-183.37
f,22014,fz,-212.64
f,22034,fz,-212.64
f,22050,fz,-212.64
f,22068,fz,-203.55
f,22088,fz,-162.84
f,22104,fz,-183.37
f,22122,fz,-154.09
f,22142,fz,-154.09
f,22158,fz,-154.09
f,22180,fz,-203.55
f,22188,fz,-162.84
f,22212,fz,-183.37
f,22230,fz,-212.64
f,22250,fz,-212.64
f,22266,fz,-212.64
f,22284,fz,-203.55
f,22304,fz,-162.84
f,22320,fz,-183.37
f,22338,fz,-154.09
f,22358,fz,-154.09
f,22374,fz,-154.09
f,22396,fz,-203.55
f,22404,fz,-162.84
f,22428,fz,-183.37
f,22446,fz,-212.64
f,22466,fz,-212.64
f,22482,fz,-212.64
f,22500,fz,-203.55
f,22520,fz,-162.84
f,22536,fz,-183.37
f,22554,fz,-154.09
f,22574,fz,-154.09
f,22590,fz,-154.09
f,22612,fz,-203.55
f,22620,fz,-162.84
f,22644,fz,-183.37
f,22662,fz,-212.64
f,22682,fz,-212.64
f,22698,fz,-212.64
f,22716,fz,-203.55
f,22736,fz,-162.84
f,22752,fz,-183.37
f,22770,fz,-154.09
f,22790,fz,-154.09
f,22806,fz,-154.09
f,22828,fz,-203.55
f,22836,fz,-162.84
f,22860,fz,-183.37
f,22878,fz,-212.64
f,22898,fz,-212.64
f,22914,fz,-212.64
f,22932,fz,-203.55
f,22952,fz,-162.84
f,22968,fz,-183.37
f,22986,fz,-154.09
f,23006,fz,-154.09
f,23022,fz,-154.09
f,23044,fz,-203.55
f,23052,fz,-162.84
f,23076,fz,-183.37
f,23094,fz,-212.64
f,23114,fz,-212.64
f,23130,fz,-212.64
f,23148,fz,-203.55
f,23168,fz,-162.84
f,23184,fz,-183.37
f,23202,fz,-154.09
f,23222,fz,-154.09
f,23238,fz,-154.09
f,23260,fz,-284.31
f,23268,fz,-243.59
f,23292,fz,-263.78
f,23310,fz,-293.39
f,23330,fz,-293.39
f,23346,fz,-293.39
f,23364,fz,-284.31
f,23384,fz,-243.59
f,23400,fz,-263.78
f,23418,fz,-234.51
f,23438,fz,-234.51
f,23454,fz,-234.51
f,23476,fz,-284.31
f,23484,fz,-243.59
f,23508,fz,-263.78
f,23526,fz,-293.39
f,23546,fz,-293.39
f,23562,fz,-293.39
f,23580,fz,-284.31
f,23600,fz,-243.59
f,23616,fz,-263.78
f,23634,fz,-234.51
f,23654,fz,-234.51
f,23670,fz,-234.51
f,23692,fz,-284.31
f,23700,fz,-243.59
f,23724,fz,-263.78
f,23742,fz,-293.39

f,23762,fz,-293.39
f,23778,fz,-293.39
f,23796,fz,-284.31
f,23816,fz,-243.59
f,23832,fz,-263.78
f,23850,fz,-234.51
f,23870,fz,-234.51
f,23886,fz,-234.51
f,23908,fz,-284.31
f,23916,fz,-243.59
f,23940,fz,-263.78
f,23958,fz,-293.39
f,23978,fz,-293.39
f,23994,fz,-293.39
f,24012,fz,-284.31
f,24032,fz,-243.59
f,24048,fz,-263.78
f,24066,fz,-234.51
f,24086,fz,-234.51
f,24102,fz,-234.51
f,24124,fz,-284.31
f,24132,fz,-243.59
f,24156,fz,-263.78
f,24174,fz,-293.39
f,24194,fz,-293.39
f,24210,fz,-293.39
f,24228,fz,-284.31
f,24248,fz,-243.59
f,24264,fz,-263.78
f,24282,fz,-234.51
f,24302,fz,-234.51
f,24318,fz,-234.51
f,24340,fz,-284.31
f,24348,fz,-243.59
f,24372,fz,-263.78
f,24390,fz,-293.39
f,24410,fz,-293.39
f,24426,fz,-293.39
f,24444,fz,-284.31
f,24464,fz,-243.59
f,24480,fz,-263.78
f,24498,fz,-234.51
f,24518,fz,-234.51
f,24534,fz,-234.51
f,24556,fz,-284.31
f,24564,fz,-243.59
f,24588,fz,-263.78
f,24606,fz,-293.39
f,24626,fz,-293.39
f,24642,fz,-293.39
f,24660,fz,-284.31
f,24680,fz,-243.59
f,24696,fz,-263.78
f,24714,fz,-234.51
f,24734,fz,-234.51
f,24750,fz,-234.51
f,24772,fz,-284.31
f,24780,fz,-243.59
f,24804,fz,-263.78
f,24822,fz,-293.39
f,24842,fz,-293.39
f,24858,fz,-293.39
f,24876,fz,-284.31
f,24896,fz,-243.59
f,24912,fz,-263.78
f,24930,fz,-234.51
f,24950,fz,-234.51
f,24966,fz,-234.51
f,24988,fz,-364.72
f,24996,fz,-324.01
f,25020,fz,-344.2
f,25038,fz,-373.81
f,25058,fz,-373.81
f,25074,fz,-373.81
f,25092,fz,-364.72
f,25112,fz,-324.01
f,25128,fz,-344.2
f,25146,fz,-314.93
f,25166,fz,-314.93
f,25182,fz,-314.93
f,25204,fz,-364.72
f,25212,fz,-324.01
f,25236,fz,-344.2
f,25254,fz,-373.81
f,25274,fz,-373.81
f,25290,fz,-373.81
f,25308,fz,-364.72
f,25328,fz,-324.01
f,25344,fz,-344.2
f,25362,fz,-314.93
f,25382,fz,-314.93
f,25398,fz,-314.93
f,25420,fz,-364.72
f,25428,fz,-324.01
f,25452,fz,-344.2
f,25470,fz,-373.81
f,25490,fz,-373.81
f,25506,fz,-373.81
f,25524,fz,-364.72
f,25544,fz,-324.01
f,25560,fz,-344.2
f,25578,fz,-314.93
f,25598,fz,-314.93
f,25614,fz,-314.93
f,25636,fz,-364.72
f,25644,fz,-324.01
f,25668,fz,-344.2
f,25686,fz,-373.81
f,25706,fz,-373.81
f,25722,fz,-373.81
f,25740,fz,-364.72
f,25760,fz,-324.01
f,25776,fz,-344.2
f,25794,fz,-314.93
f,25814,fz,-314.93
f,25830,fz,-314.93
f,25852,fz,-364.72
f,25860,fz,-324.01
f,25884,fz,-344.2
f,25902,fz,-373.81
f,25922,fz,-373.81
f,25938,fz,-373.81
f,25956,fz,-364.72
f,25976,fz,-324.01
f,25992,fz,-344.2
f,26010,fz,-314.93
f,26030,fz,-314.93
f,26046,fz,-314.93
f,26068,fz,-364.72
f,26076,fz,-324.01
f,26100,fz,-344.2
f,26118,fz,-373.81
f,26138,fz,-373.81
f,26154,fz,-373.81
f,26172,fz,-364.72
f,26192,fz,-324.01
f,26208,fz,-344.2
f,26226,fz,-314.93
f,26246,fz,-314.93
f,26262,fz,-314.93
f,26284,fz,-364.72
f,26292,fz,-324.01
f,26316,fz,-344.2
f,26334,fz,-373.81
f,26354,fz,-373.81
f,26370,fz,-373.81
f,26388,fz,-364.72
f,26408,fz,-324.01
f,26424,fz,-344.2
f,26442,fz,-314.93
f,26462,fz,-314.93
f,26478,fz,-314.93
f,26500,fz,-364.72
f,26508,fz,-324.01
f,26532,fz,-344.2
f,26550,fz,-373.81
f,26570,fz,-373.81
f,26586,fz,-373.81
f,26604,fz,-364.72
f,26624,fz,-324.01
f,26640,fz,-344.2
f,26658,fz,-314.93
f,26678,fz,-314.93
f,26694,fz,-314.93
f,26716,fz,-445.14
f,26724,fz,-404.43
f,26748,fz,-424.95
f,26766,fz,-454.22
f,26786,fz,-454.22
f,26802,fz,-454.22
f,26820,fz,-445.14
f,26840,fz,-404.43
f,26856,fz,-424.95
f,26874,fz,-395.34
f,26894,fz,-395.34
f,26910,fz,-395.34
f,26932,fz,-445.14
f,26940,fz,-404.43
f,26964,fz,-424.95
f,26982,fz,-454.22
f,27002,fz,-454.22
f,27018,fz,-454.22
f,27036,fz,-445.14
f,27056,fz,-404.43
f,27072,fz,-424.95
f,27090,fz,-395.34
f,27110,fz,-395.34
f,27126,fz,-395.34
f,27148,fz,-445.14
f,27156,fz,-404.43
f,27180,fz,-424.95
f,27198,fz,-454.22
f,27218,fz,-454.22
f,27234,fz,-454.22
f,27252,fz,-445.14
f,27272,fz,-404.43
f,27288,fz,-424.95
f,27306,fz,-395.34
f,27326,fz,-395.34
f,27342,fz,-395.34
f,27364,fz,-445.14
f,27372,fz,-404.43
f,27396,fz,-424.95
f,27414,fz,-454.22
f,27434,fz,-454.22
f,27450,fz,-454.22
f,27468,fz,-445.14
f,27488,fz,-404.43
f,27504,fz,-424.95
f,27522,fz,-395.34
f,27542,fz,-395.34
f,27558,fz,-395.34
f,27580,fz,-445.14
f,27588,fz,-404.43
f,27612,fz,-424.95
f,27630,fz,-454.22
f,27650,fz,-454.22
f,27666,fz,-454.22
f,27684,fz,-445.14
f,27704,fz,-404.43
f,27720,fz,-424.95
f,27738,fz,-395.34
f,27758,fz,-395.34
f,27774,fz,-395.34
f,27796,fz,-445.14
f,27804,fz,-404.43
f,27828,fz,-424.95
f,27846,fz,-454.22
f,27866,fz,-454.22
f,27882,fz,-454.22
f,27900,fz,-445.14
f,27920,fz,-404.43
f,27936,fz,-424.95
f,27954,fz,-395.34
f,27974,fz,-395.34
f,27990,fz,-395.34
f,28012,fz,-445.14
f,28020,fz,-404.43
f,28044,fz,-424.95
f,28062,fz,-454.22
f,28082,fz,-454.22
f,28098,fz,-454.22
f,28116,fz,-445.14
f,28136,fz,-404.43
f,28152,fz,-424.95
f,28170,fz,-395.34
f,28190,fz,-395.34
f,28206,fz,-395.34
f,28228,fz,-445.14
f,28236,fz,-404.43
f,28260,fz,-424.95
f,28278,fz,-454.22
f,28298,fz,-454.22
f,28314,fz,-454.22
f,28332,fz,-445.14
f,28352,fz,-404.43
f,28368,fz,-424.95
f,28386,fz,-395.34
f,28406,fz,-395.34
f,28422,fz,-395.34
f,28444,fz,-525.55
f,28452,fz,-485.18
f,28476,fz,-505.37
f,28494,fz,-534.64
f,28514,fz,-534.64
f,28530,fz,-534.64
f,28548,fz,-525.55
f,28568,fz,-485.18
f,28584,fz,-505.37
f,28602,fz,-476.09
f,28622,fz,-476.09
f,28638,fz,-476.09
f,28660,fz,-525.55
f,28668,fz,-485.18
f,28692,fz,-505.37
f,28710,fz,-534.64
f,28730,fz,-534.64
f,28746,fz,-534.64
f,28764,fz,-525.55
f,28784,fz,-485.18
f,28800,fz,-505.37
f,28818,fz,-476.09
f,28838,fz,-476.09
f,28854,fz,-476.09
f,28876,fz,-525.55
f,28884,fz,-485.18
f,28908,fz,-505.37
f,28926,fz,-534.64
f,28946,fz,-534.64
f,28962,fz,-534.64
f,28980,fz,-525.55
f,29000,fz,-485.18
f,29016,fz,-505.37
f,29034,fz,-476.09
f,29054,fz,-476.09
f,29070,fz,-476.09
f,29092,fz,-525.55
f,29100,fz,-485.18
f,29124,fz,-505.37
f,29142,fz,-534.64
f,29162,fz,-534.64
f,29178,fz,-534.64
f,29196,fz,-525.55
f,29216,fz,-485.18
f,29232,fz,-505.37
f,29250,fz,-476.09
f,29270,fz,-476.09
f,29286,fz,-476.09
f,29308,fz,-525.55
f,29316,fz,-485.18
f,29340,fz,-505.37
f,29358,fz,-534.64
f,29378,fz,-534.64
f,29394,fz,-534.64
f,29412,fz,-525.55
f,29432,fz,-485.18
f,29448,fz,-505.37
f,29466,fz,-476.09
f,29486,fz,-476.09
f,29502,fz,-476.09
f,29524,fz,-525.55
f,29532,fz,-485.18
f,29556,fz,-505.37
f,29574,fz,-534.64
f,29594,fz,-534.64
f,29610,fz,-534.64
f,29628,fz,-525.55
f,29648,fz,-485.18
f,29664,fz,-505.37
f,29682,fz,-476.09
f,29702,fz,-476.09
f,29718,fz,-476.09

f,29740,fz,-525.55
f,29748,fz,-485.18
f,29772,fz,-505.37
f,29790,fz,-534.64
f,29810,fz,-534.64
f,29826,fz,-534.64
f,29844,fz,-525.55
f,29864,fz,-485.18
f,29880,fz,-505.37
f,29898,fz,-476.09
f,29918,fz,-476.09
f,29934,fz,-476.09
f,29956,fz,-525.55
f,29964,fz,-485.18
f,29988,fz,-505.37
f,30006,fz,-534.64
f,30026,fz,-534.64
f,30042,fz,-534.64
f,30060,fz,-525.55
f,30080,fz,-485.18
f,30096,fz,-505.37
f,30114,fz,-476.09
f,30134,fz,-476.09
f,30150,fz,-476.09
f,30172,fz,-606.31
f,30180,fz,-565.59
f,30204,fz,-585.78
f,30222,fz,-615.39
f,30242,fz,-615.39
f,30258,fz,-615.39
f,30276,fz,-606.31
f,30296,fz,-565.59
f,30312,fz,-585.78
f,30330,fz,-556.51
f,30350,fz,-556.51
f,30366,fz,-556.51
f,30388,fz,-606.31
f,30396,fz,-565.59
f,30420,fz,-585.78
f,30438,fz,-615.39
f,30458,fz,-615.39
f,30474,fz,-615.39
f,30492,fz,-606.31
f,30512,fz,-565.59
f,30528,fz,-585.78
f,30546,fz,-556.51
f,30566,fz,-556.51
f,30582,fz,-556.51
f,30604,fz,-606.31
f,30612,fz,-565.59
f,30636,fz,-585.78
f,30654,fz,-615.39
f,30674,fz,-615.39
f,30690,fz,-615.39
f,30708,fz,-606.31
f,30728,fz,-565.59
f,30744,fz,-585.78
f,30762,fz,-556.51
f,30782,fz,-556.51
f,30798,fz,-556.51
f,30820,fz,-606.31
f,30828,fz,-565.59
f,30852,fz,-585.78
f,30870,fz,-615.39
f,30890,fz,-615.39
f,30906,fz,-615.39
f,30924,fz,-606.31
f,30944,fz,-565.59
f,30960,fz,-585.78
f,30978,fz,-556.51
f,30998,fz,-556.51
f,31014,fz,-556.51
f,31036,fz,-606.31
f,31044,fz,-565.59
f,31068,fz,-585.78
f,31086,fz,-615.39
f,31106,fz,-615.39
f,31122,fz,-615.39
f,31140,fz,-606.31
f,31160,fz,-565.59
f,31176,fz,-585.78
f,31194,fz,-556.51
f,31214,fz,-556.51
f,31230,fz,-556.51
f,31252,fz,-606.31
f,31260,fz,-565.59
f,31284,fz,-585.78
f,31302,fz,-615.39
f,31322,fz,-615.39
f,31338,fz,-615.39
f,31356,fz,-606.31
f,31376,fz,-565.59
f,31392,fz,-585.78
f,31410,fz,-556.51
f,31430,fz,-556.51
f,31446,fz,-556.51
f,31468,fz,-606.31
f,31476,fz,-565.59
f,31500,fz,-585.78
f,31518,fz,-615.39
f,31538,fz,-615.39
f,31554,fz,-615.39
f,31572,fz,-606.31
f,31592,fz,-565.59
f,31608,fz,-585.78
f,31626,fz,-556.51
f,31646,fz,-556.51
f,31662,fz,-556.51
f,31684,fz,-606.31
f,31692,fz,-565.59
f,31716,fz,-585.78
f,31734,fz,-615.39
f,31754,fz,-615.39
f,31770,fz,-615.39
f,31788,fz,-606.31
f,31808,fz,-565.59
f,31824,fz,-585.78
f,31842,fz,-556.51
f,31862,fz,-556.51
f,31878,fz,-556.51
f,31900,fz,-686.72
f,31908,fz,-646.01
f,31932,fz,-666.53
f,31950,fz,-695.81
f,31970,fz,-695.81
f,31986,fz,-695.81
f,32004,fz,-686.72
f,32024,fz,-646.01
f,32040,fz,-666.53
f,32058,fz,-636.92
f,32078,fz,-636.92
f,32094,fz,-636.92
f,32116,fz,-686.72
f,32124,fz,-646.01
f,32148,fz,-666.53
f,32166,fz,-695.81
f,32186,fz,-695.81
f,32202,fz,-695.81
f,32220,fz,-686.72
f,32240,fz,-646.01
f,32256,fz,-666.53
f,32274,fz,-636.92
f,32294,fz,-636.92
f,32310,fz,-636.92
f,32332,fz,-686.72
f,32340,fz,-646.01
f,32364,fz,-666.53
f,32382,fz,-695.81
f,32402,fz,-695.81
f,32418,fz,-695.81
f,32436,fz,-686.72
f,32456,fz,-646.01
f,32472,fz,-666.53
f,32490,fz,-636.92
f,32510,fz,-636.92
f,32526,fz,-636.92
f,32548,fz,-686.72
f,32556,fz,-646.01
f,32580,fz,-666.53
f,32598,fz,-695.81
f,32618,fz,-695.81
f,32634,fz,-695.81
f,32652,fz,-686.72
f,32672,fz,-646.01
f,32688,fz,-666.53
f,32706,fz,-636.92
f,32726,fz,-636.92
f,32742,fz,-636.92
f,32764,fz,-686.72
f,32772,fz,-646.01
f,32796,fz,-666.53
f,32814,fz,-695.81
f,32834,fz,-695.81
f,32850,fz,-695.81
f,32868,fz,-686.72
f,32888,fz,-646.01
f,32904,fz,-666.53
f,32922,fz,-636.92
f,32942,fz,-636.92
f,32958,fz,-636.92
f,32980,fz,-686.72
f,32988,fz,-646.01
f,33012,fz,-666.53
f,33030,fz,-695.81
f,33050,fz,-695.81
f,33066,fz,-695.81
f,33084,fz,-686.72
f,33104,fz,-646.01
f,33120,fz,-666.53
f,33138,fz,-636.92
f,33158,fz,-636.92
f,33174,fz,-636.92
f,33196,fz,-686.72
f,33204,fz,-646.01
f,33228,fz,-666.53
f,33246,fz,-695.81
f,33266,fz,-695.81
f,33282,fz,-695.81
f,33300,fz,-686.72
f,33320,fz,-646.01
f,33336,fz,-666.53
f,33354,fz,-636.92
f,33374,fz,-636.92
f,33390,fz,-636.92
f,33412,fz,-686.72
f,33420,fz,-646.01
f,33444,fz,-666.53
f,33462,fz,-695.81
f,33482,fz,-695.81
f,33498,fz,-695.81
f,33516,fz,-686.72
f,33536,fz,-646.01
f,33552,fz,-666.53
f,33570,fz,-636.92
f,33590,fz,-636.92
f,33606,fz,-636.92
f,5981,fz,522.259
f,5989,fz,562.972
f,6013,fz,542.784
f,6031,fz,513.174
f,6051,fz,513.174
f,6067,fz,513.174
f,6085,fz,522.259
f,6105,fz,562.972
f,6121,fz,542.784
f,6139,fz,572.056
f,6159,fz,572.056
f,6175,fz,572.056
f,6197,fz,522.259
f,6205,fz,562.972
f,6229,fz,542.784
f,6247,fz,513.174
f,6267,fz,513.174
f,6283,fz,513.174
f,6301,fz,522.259
f,6321,fz,562.972
f,6337,fz,542.784
f,6355,fz,572.056
f,6375,fz,572.056
f,6391,fz,572.056
f,6413,fz,522.259
f,6421,fz,562.972
f,6445,fz,542.784
f,6463,fz,513.174
f,6483,fz,513.174
f,6499,fz,513.174
f,6517,fz,522.259
f,6537,fz,562.972
f,6553,fz,542.784
f,6571,fz,572.056
f,6591,fz,572.056
f,6607,fz,572.056
f,6629,fz,522.259
f,6637,fz,562.972
f,6661,fz,542.784
f,6679,fz,513.174
f,6699,fz,513.174
f,6715,fz,513.174
f,6733,fz,522.259
f,6753,fz,562.972
f,6769,fz,542.784
f,6787,fz,572.056
f,6807,fz,572.056
f,6823,fz,572.056
f,6845,fz,522.259
f,6853,fz,562.972
f,6877,fz,542.784
f,6895,fz,513.174
f,6915,fz,513.174
f,6931,fz,513.174
f,6949,fz,522.259
f,6969,fz,562.972
f,6985,fz,542.784
f,7003,fz,572.056
f,7023,fz,572.056
f,7039,fz,572.056
f,7061,fz,522.259
f,7069,fz,562.972
f,7093,fz,542.784
f,7111,fz,513.174
f,7131,fz,513.174
f,7147,fz,513.174
f,7165,fz,522.259
f,7185,fz,562.972
f,7201,fz,542.784
f,7219,fz,572.056
f,7239,fz,572.056
f,7255,fz,572.056
f,7277,fz,522.259
f,7285,fz,562.972
f,7309,fz,542.784
f,7327,fz,513.174
f,7347,fz,513.174
f,7363,fz,513.174
f,7381,fz,522.259
f,7401,fz,562.972
f,7417,fz,542.784
f,7435,fz,572.056
f,7455,fz,572.056
f,7471,fz,572.056
f,7493,fz,522.259
f,7501,fz,562.972
f,7525,fz,542.784
f,7543,fz,513.174
f,7563,fz,513.174
f,7579,fz,513.174
f,7597,fz,522.259
f,7617,fz,562.972
f,7633,fz,542.784
f,7651,fz,572.056
f,7671,fz,572.056
f,7687,fz,572.056
f,7709,fz,441.843
f,7717,fz,482.556
f,7741,fz,462.031
f,7759,fz,432.759
f,7779,fz,432.759
f,7795,fz,432.759
f,7813,fz,441.843
f,7833,fz,482.556
f,7849,fz,462.031
f,7867,fz,491.641
f,7887,fz,491.641
f,7903,fz,491.641
f,7925,fz,441.843
f,7933,fz,482.556
f,7957,fz,462.031
f,7975,fz,432.759
f,7995,fz,432.759
f,8011,fz,432.759
f,8029,fz,441.843
f,8049,fz,482.556

f,8065,fz,462.031
f,8083,fz,491.641
f,8103,fz,491.641
f,8119,fz,491.641
f,8141,fz,441.843
f,8149,fz,482.556
f,8173,fz,462.031
f,8191,fz,432.759
f,8211,fz,432.759
f,8227,fz,432.759
f,8245,fz,441.843
f,8265,fz,482.556
f,8281,fz,462.031
f,8299,fz,491.641
f,8319,fz,491.641
f,8335,fz,491.641
f,8357,fz,441.843
f,8365,fz,482.556
f,8389,fz,462.031
f,8407,fz,432.759
f,8427,fz,432.759
f,8443,fz,432.759
f,8461,fz,441.843
f,8481,fz,482.556
f,8497,fz,462.031
f,8515,fz,491.641
f,8535,fz,491.641
f,8551,fz,491.641
f,8573,fz,441.843
f,8581,fz,482.556
f,8605,fz,462.031
f,8623,fz,432.759
f,8643,fz,432.759
f,8659,fz,432.759
f,8677,fz,441.843
f,8697,fz,482.556
f,8713,fz,462.031
f,8731,fz,491.641
f,8751,fz,491.641
f,8767,fz,491.641
f,8789,fz,441.843
f,8797,fz,482.556
f,8821,fz,462.031
f,8839,fz,432.759
f,8859,fz,432.759
f,8875,fz,432.759
f,8893,fz,441.843
f,8913,fz,482.556
f,8929,fz,462.031
f,8947,fz,491.641
f,8967,fz,491.641
f,8983,fz,491.641
f,9005,fz,441.843
f,9013,fz,482.556
f,9037,fz,462.031
f,9055,fz,432.759
f,9075,fz,432.759
f,9091,fz,432.759
f,9109,fz,441.843
f,9129,fz,482.556
f,9145,fz,462.031
f,9163,fz,491.641
f,9183,fz,491.641
f,9199,fz,491.641
f,9221,fz,441.843
f,9229,fz,482.556
f,9253,fz,462.031
f,9271,fz,432.759
f,9291,fz,432.759
f,9307,fz,432.759
f,9325,fz,441.843
f,9345,fz,482.556
f,9361,fz,462.031
f,9379,fz,491.641
f,9399,fz,491.641
f,9415,fz,491.641
f,9437,fz,361.428
f,9445,fz,401.804
f,9469,fz,381.616
f,9487,fz,352.343
f,9507,fz,352.343
f,9523,fz,352.343
f,9541,fz,361.428
f,9561,fz,401.804
f,9577,fz,381.616
f,9595,fz,410.888
f,9615,fz,410.888
f,9631,fz,410.888
f,9653,fz,361.428
f,9661,fz,401.804
f,9685,fz,381.616
f,9703,fz,352.343
f,9723,fz,352.343
f,9739,fz,352.343
f,9757,fz,361.428
f,9777,fz,401.804
f,9793,fz,381.616
f,9811,fz,410.888
f,9831,fz,410.888
f,9847,fz,410.888
f,9869,fz,361.428
f,9877,fz,401.804
f,9901,fz,381.616
f,9919,fz,352.343
f,9939,fz,352.343
f,9955,fz,352.343
f,9973,fz,361.428
f,9993,fz,401.804
f,10009,fz,381.616
f,10027,fz,410.888
f,10047,fz,410.888
f,10063,fz,410.888
f,10085,fz,361.428
f,10093,fz,401.804
f,10117,fz,381.616
f,10135,fz,352.343
f,10155,fz,352.343
f,10171,fz,352.343
f,10189,fz,361.428
f,10209,fz,401.804
f,10225,fz,381.616
f,10243,fz,410.888
f,10263,fz,410.888
f,10279,fz,410.888
f,10301,fz,361.428
f,10309,fz,401.804
f,10333,fz,381.616
f,10351,fz,352.343
f,10371,fz,352.343
f,10387,fz,352.343
f,10405,fz,361.428
f,10425,fz,401.804
f,10441,fz,381.616
f,10459,fz,410.888
f,10479,fz,410.888
f,10495,fz,410.888
f,10517,fz,361.428
f,10525,fz,401.804
f,10549,fz,381.616
f,10567,fz,352.343
f,10587,fz,352.343
f,10603,fz,352.343
f,10621,fz,361.428
f,10641,fz,401.804
f,10657,fz,381.616
f,10675,fz,410.888
f,10695,fz,410.888
f,10711,fz,410.888
f,10733,fz,361.428
f,10741,fz,401.804
f,10765,fz,381.616
f,10783,fz,352.343
f,10803,fz,352.343
f,10819,fz,352.343
f,10837,fz,361.428
f,10857,fz,401.804
f,10873,fz,381.616
f,10891,fz,410.888
f,10911,fz,410.888
f,10927,fz,410.888
f,10949,fz,361.428
f,10957,fz,401.804
f,10981,fz,381.616
f,10999,fz,352.343
f,11019,fz,352.343
f,11035,fz,352.343
f,11053,fz,361.428
f,11073,fz,401.804
f,11089,fz,381.616
f,11107,fz,410.888
f,11127,fz,410.888
f,11143,fz,410.888
f,11165,fz,280.675
f,11173,fz,321.388
f,11197,fz,301.2
f,11215,fz,271.591
f,11235,fz,271.591
f,11251,fz,271.591
f,11269,fz,280.675
f,11289,fz,321.388
f,11305,fz,301.2
f,11323,fz,330.473
f,11343,fz,330.473
f,11359,fz,330.473
f,11381,fz,280.675
f,11389,fz,321.388
f,11413,fz,301.2
f,11431,fz,271.591
f,11451,fz,271.591
f,11467,fz,271.591
f,11485,fz,280.675
f,11505,fz,321.388
f,11521,fz,301.2
f,11539,fz,330.473
f,11559,fz,330.473
f,11575,fz,330.473
f,11597,fz,280.675
f,11605,fz,321.388
f,11629,fz,301.2
f,11647,fz,271.591
f,11667,fz,271.591
f,11683,fz,271.591
f,11701,fz,280.675
f,11721,fz,321.388
f,11737,fz,301.2
f,11755,fz,330.473
f,11775,fz,330.473
f,11791,fz,330.473
f,11813,fz,280.675
f,11821,fz,321.388
f,11845,fz,301.2
f,11863,fz,271.591
f,11883,fz,271.591
f,11899,fz,271.591
f,11917,fz,280.675
f,11937,fz,321.388
f,11953,fz,301.2
f,11971,fz,330.473
f,11991,fz,330.473
f,12007,fz,330.473
f,12029,fz,280.675
f,12037,fz,321.388
f,12061,fz,301.2
f,12079,fz,271.591
f,12099,fz,271.591
f,12115,fz,271.591
f,12133,fz,280.675
f,12153,fz,321.388
f,12169,fz,301.2
f,12187,fz,330.473
f,12207,fz,330.473
f,12223,fz,330.473
f,12245,fz,280.675
f,12253,fz,321.388
f,12277,fz,301.2
f,12295,fz,271.591
f,12315,fz,271.591
f,12331,fz,271.591
f,12349,fz,280.675
f,12369,fz,321.388
f,12385,fz,301.2
f,12403,fz,330.473
f,12423,fz,330.473
f,12439,fz,330.473
f,12461,fz,280.675
f,12469,fz,321.388
f,12493,fz,301.2
f,12511,fz,271.591
f,12531,fz,271.591
f,12547,fz,271.591
f,12565,fz,280.675
f,12585,fz,321.388
f,12601,fz,301.2
f,12619,fz,330.473
f,12639,fz,330.473
f,12655,fz,330.473
f,12677,fz,280.675
f,12685,fz,321.388
f,12709,fz,301.2
f,12727,fz,271.591
f,12747,fz,271.591
f,12763,fz,271.591
f,12781,fz,280.675
f,12801,fz,321.388
f,12817,fz,301.2
f,12835,fz,330.473
f,12855,fz,330.473
f,12871,fz,330.473
f,12893,fz,200.26
f,12901,fz,240.972
f,12925,fz,220.448
f,12943,fz,191.175
f,12963,fz,191.175
f,12979,fz,191.175
f,12997,fz,200.26
f,13017,fz,240.972
f,13033,fz,220.448
f,13051,fz,250.057
f,13071,fz,250.057
f,13087,fz,250.057
f,13109,fz,200.26
f,13117,fz,240.972
f,13141,fz,220.448
f,13159,fz,191.175
f,13179,fz,191.175
f,13195,fz,191.175
f,13213,fz,200.26
f,13233,fz,240.972
f,13249,fz,220.448
f,13267,fz,250.057
f,13287,fz,250.057
f,13303,fz,250.057
f,13325,fz,200.26
f,13333,fz,240.972
f,13357,fz,220.448
f,13375,fz,191.175
f,13395,fz,191.175
f,13411,fz,191.175
f,13429,fz,200.26
f,13449,fz,240.972
f,13465,fz,220.448
f,13483,fz,250.057
f,13503,fz,250.057
f,13519,fz,250.057
f,13541,fz,200.26
f,13549,fz,240.972
f,13573,fz,220.448
f,13591,fz,191.175
f,13611,fz,191.175
f,13627,fz,191.175
f,13645,fz,200.26
f,13665,fz,240.972
f,13681,fz,220.448
f,13699,fz,250.057
f,13719,fz,250.057
f,13735,fz,250.057
f,13757,fz,200.26
f,13765,fz,240.972
f,13789,fz,220.448
f,13807,fz,191.175
f,13827,fz,191.175
f,13843,fz,191.175
f,13861,fz,200.26
f,13881,fz,240.972
f,13897,fz,220.448
f,13915,fz,250.057
f,13935,fz,250.057
f,13951,fz,250.057
f,13973,fz,200.26
f,13981,fz,240.972
f,14005,fz,220.448
f,14023,fz,191.175

f,14043,fz,191.175
f,14059,fz,191.175
f,14077,fz,200.26
f,14097,fz,240.972
f,14113,fz,220.448
f,14131,fz,250.057
f,14151,fz,250.057
f,14167,fz,250.057
f,14189,fz,200.26
f,14197,fz,240.972
f,14221,fz,220.448
f,14239,fz,191.175
f,14259,fz,191.175
f,14275,fz,191.175
f,14293,fz,200.26
f,14313,fz,240.972
f,14329,fz,220.448
f,14347,fz,250.057
f,14367,fz,250.057
f,14383,fz,250.057
f,14405,fz,200.26
f,14413,fz,240.972
f,14437,fz,220.448
f,14455,fz,191.175
f,14475,fz,191.175
f,14491,fz,191.175
f,14509,fz,200.26
f,14529,fz,240.972
f,14545,fz,220.448
f,14563,fz,250.057
f,14583,fz,250.057
f,14599,fz,250.057
f,14621,fz,119.844
f,14629,fz,160.557
f,14653,fz,140.032
f,14671,fz,110.759
f,14691,fz,110.759
f,14707,fz,110.759
f,14725,fz,119.844
f,14745,fz,160.557
f,14761,fz,140.032
f,14779,fz,169.641
f,14799,fz,169.641
f,14815,fz,169.641
f,14837,fz,119.844
f,14845,fz,160.557
f,14869,fz,140.032
f,14887,fz,110.759
f,14907,fz,110.759
f,14923,fz,110.759
f,14941,fz,119.844
f,14961,fz,160.557
f,14977,fz,140.032
f,14995,fz,169.641
f,15015,fz,169.641
f,15031,fz,169.641
f,15053,fz,119.844
f,15061,fz,160.557
f,15085,fz,140.032
f,15103,fz,110.759
f,15123,fz,110.759
f,15139,fz,110.759
f,15157,fz,119.844
f,15177,fz,160.557
f,15193,fz,140.032
f,15211,fz,169.641
f,15231,fz,169.641
f,15247,fz,169.641
f,15269,fz,119.844
f,15277,fz,160.557
f,15301,fz,140.032
f,15319,fz,110.759
f,15339,fz,110.759
f,15355,fz,110.759
f,15373,fz,119.844
f,15393,fz,160.557
f,15409,fz,140.032
f,15427,fz,169.641
f,15447,fz,169.641
f,15463,fz,169.641
f,15485,fz,119.844
f,15493,fz,160.557
f,15517,fz,140.032
f,15535,fz,110.759
f,15555,fz,110.759
f,15571,fz,110.759
f,15589,fz,119.844
f,15609,fz,160.557
f,15625,fz,140.032
f,15643,fz,169.641
f,15663,fz,169.641
f,15679,fz,169.641
f,15701,fz,119.844
f,15709,fz,160.557
f,15733,fz,140.032
f,15751,fz,110.759
f,15771,fz,110.759
f,15787,fz,110.759
f,15805,fz,119.844
f,15825,fz,160.557
f,15841,fz,140.032
f,15859,fz,169.641
f,15879,fz,169.641
f,15895,fz,169.641
f,15917,fz,119.844
f,15925,fz,160.557
f,15949,fz,140.032
f,15967,fz,110.759
f,15987,fz,110.759
f,16003,fz,110.759
f,16021,fz,119.844
f,16041,fz,160.557
f,16057,fz,140.032
f,16075,fz,169.641
f,16095,fz,169.641
f,16111,fz,169.641
f,16133,fz,119.844
f,16141,fz,160.557
f,16165,fz,140.032
f,16183,fz,110.759
f,16203,fz,110.759
f,16219,fz,110.759
f,16237,fz,119.844
f,16257,fz,160.557
f,16273,fz,140.032
f,16291,fz,169.641
f,16311,fz,169.641
f,16327,fz,169.641
f,16349,fz,39.0919
f,16357,fz,79.8044
f,16381,fz,59.6164
f,16399,fz,30.3437
f,16419,fz,30.3437
f,16435,fz,30.3437
f,16453,fz,39.0919
f,16473,fz,79.8044
f,16489,fz,59.6164
f,16507,fz,88.889
f,16527,fz,88.889
f,16543,fz,88.889
f,16565,fz,39.0919
f,16573,fz,79.8044
f,16597,fz,59.6164
f,16615,fz,30.3437
f,16635,fz,30.3437
f,16651,fz,30.3437
f,16669,fz,39.0919
f,16689,fz,79.8044
f,16705,fz,59.6164
f,16723,fz,88.889
f,16743,fz,88.889
f,16759,fz,88.889
f,16781,fz,39.0919
f,16789,fz,79.8044
f,16813,fz,59.6164
f,16831,fz,30.3437
f,16851,fz,30.3437
f,16867,fz,30.3437
f,16885,fz,39.0919
f,16905,fz,79.8044
f,16921,fz,59.6164
f,16939,fz,88.889
f,16959,fz,88.889
f,16975,fz,88.889
f,16997,fz,39.0919
f,17005,fz,79.8044
f,17029,fz,59.6164
f,17047,fz,30.3437
f,17067,fz,30.3437
f,17083,fz,30.3437
f,17101,fz,39.0919
f,17121,fz,79.8044
f,17137,fz,59.6164
f,17155,fz,88.889
f,17175,fz,88.889
f,17191,fz,88.889
f,17213,fz,39.0919
f,17221,fz,79.8044
f,17245,fz,59.6164
f,17263,fz,30.3437
f,17283,fz,30.3437
f,17299,fz,30.3437
f,17317,fz,39.0919
f,17337,fz,79.8044
f,17353,fz,59.6164
f,17371,fz,88.889
f,17391,fz,88.889
f,17407,fz,88.889
f,17429,fz,39.0919
f,17437,fz,79.8044
f,17461,fz,59.6164
f,17479,fz,30.3437
f,17499,fz,30.3437
f,17515,fz,30.3437
f,17533,fz,39.0919
f,17553,fz,79.8044
f,17569,fz,59.6164
f,17587,fz,88.889
f,17607,fz,88.889
f,17623,fz,88.889
f,17645,fz,39.0919
f,17653,fz,79.8044
f,17677,fz,59.6164
f,17695,fz,30.3437
f,17715,fz,30.3437
f,17731,fz,30.3437
f,17749,fz,39.0919
f,17769,fz,79.8044
f,17785,fz,59.6164
f,17803,fz,88.889
f,17823,fz,88.889
f,17839,fz,88.889
f,17861,fz,39.0919
f,17869,fz,79.8044
f,17893,fz,59.6164
f,17911,fz,30.3437
f,17931,fz,30.3437
f,17947,fz,30.3437
f,17965,fz,39.0919
f,17985,fz,79.8044
f,18001,fz,59.6164
f,18019,fz,88.889
f,18039,fz,88.889
f,18055,fz,88.889
f,18077,fz,-41.324
f,18085,fz,-0.6113
f,18109,fz,-20.799
f,18127,fz,-50.408
f,18147,fz,-50.408
f,18163,fz,-50.408
f,18181,fz,-41.324
f,18201,fz,-0.6113
f,18217,fz,-20.799
f,18235,fz,8.47334
f,18255,fz,8.47334
f,18271,fz,8.47334
f,18293,fz,-41.324
f,18301,fz,-0.6113
f,18325,fz,-20.799
f,18343,fz,-50.408
f,18363,fz,-50.408
f,18379,fz,-50.408
f,18397,fz,-41.324
f,18417,fz,-0.6113
f,18433,fz,-20.799
f,18451,fz,8.47334
f,18471,fz,8.47334
f,18487,fz,8.47334
f,18509,fz,-41.324
f,18517,fz,-0.6113
f,18541,fz,-20.799
f,18559,fz,-50.408
f,18579,fz,-50.408
f,18595,fz,-50.408
f,18613,fz,-41.324
f,18633,fz,-0.6113
f,18649,fz,-20.799
f,18667,fz,8.47334
f,18687,fz,8.47334
f,18703,fz,8.47334
f,18725,fz,-41.324
f,18733,fz,-0.6113
f,18757,fz,-20.799
f,18775,fz,-50.408
f,18795,fz,-50.408
f,18811,fz,-50.408
f,18829,fz,-41.324
f,18849,fz,-0.6113
f,18865,fz,-20.799
f,18883,fz,8.47334
f,18903,fz,8.47334
f,18919,fz,8.47334
f,18941,fz,-41.324
f,18949,fz,-0.6113
f,18973,fz,-20.799
f,18991,fz,-50.408
f,19011,fz,-50.408
f,19027,fz,-50.408
f,19045,fz,-41.324
f,19065,fz,-0.6113
f,19081,fz,-20.799
f,19099,fz,8.47334
f,19119,fz,8.47334
f,19135,fz,8.47334
f,19157,fz,-41.324
f,19165,fz,-0.6113
f,19189,fz,-20.799
f,19207,fz,-50.408
f,19227,fz,-50.408
f,19243,fz,-50.408
f,19261,fz,-41.324
f,19281,fz,-0.6113
f,19297,fz,-20.799
f,19315,fz,8.47334
f,19335,fz,8.47334
f,19351,fz,8.47334
f,19373,fz,-41.324
f,19381,fz,-0.6113
f,19405,fz,-20.799
f,19423,fz,-50.408
f,19443,fz,-50.408
f,19459,fz,-50.408
f,19477,fz,-41.324
f,19497,fz,-0.6113
f,19513,fz,-20.799
f,19531,fz,8.47334
f,19551,fz,8.47334
f,19567,fz,8.47334
f,19589,fz,-41.324
f,19597,fz,-0.6113
f,19621,fz,-20.799
f,19639,fz,-50.408
f,19659,fz,-50.408
f,19675,fz,-50.408
f,19693,fz,-41.324
f,19713,fz,-0.6113
f,19729,fz,-20.799
f,19747,fz,8.47334
f,19767,fz,8.47334
f,19783,fz,8.47334
f,19805,fz,-121.74
f,19813,fz,-81.027
f,19837,fz,-101.55
f,19855,fz,-130.82
f,19875,fz,-130.82
f,19891,fz,-130.82
f,19909,fz,-121.74
f,19929,fz,-81.027
f,19945,fz,-101.55
f,19963,fz,-71.942
f,19983,fz,-71.942
f,19999,fz,-71.942

f.20021,fz,-121.74
f.20029,fz,-81.027
f.20053,fz,-101.55
f.20071,fz,-130.82
f.20091,fz,-130.82
f.20107,fz,-130.82
f.20125,fz,-121.74
f.20145,fz,-81.027
f.20161,fz,-101.55
f.20179,fz,-71.942
f.20199,fz,-71.942
f.20215,fz,-71.942
f.20237,fz,-121.74
f.20245,fz,-81.027
f.20269,fz,-101.55
f.20287,fz,-130.82
f.20307,fz,-130.82
f.20323,fz,-130.82
f.20341,fz,-121.74
f.20361,fz,-81.027
f.20377,fz,-101.55
f.20395,fz,-71.942
f.20415,fz,-71.942
f.20431,fz,-71.942
f.20453,fz,-121.74
f.20461,fz,-81.027
f.20485,fz,-101.55
f.20503,fz,-130.82
f.20523,fz,-130.82
f.20539,fz,-130.82
f.20557,fz,-121.74
f.20577,fz,-81.027
f.20593,fz,-101.55
f.20611,fz,-71.942
f.20631,fz,-71.942
f.20647,fz,-71.942
f.20669,fz,-121.74
f.20677,fz,-81.027
f.20701,fz,-101.55
f.20719,fz,-130.82
f.20739,fz,-130.82
f.20755,fz,-130.82
f.20773,fz,-121.74
f.20793,fz,-81.027
f.20809,fz,-101.55
f.20827,fz,-71.942
f.20847,fz,-71.942
f.20863,fz,-71.942
f.20885,fz,-121.74
f.20893,fz,-81.027
f.20917,fz,-101.55
f.20935,fz,-130.82
f.20955,fz,-130.82
f.20971,fz,-130.82
f.20989,fz,-121.74
f.21009,fz,-81.027
f.21025,fz,-101.55
f.21043,fz,-71.942
f.21063,fz,-71.942
f.21079,fz,-71.942
f.21101,fz,-121.74
f.21109,fz,-81.027
f.21133,fz,-101.55
f.21151,fz,-130.82
f.21171,fz,-130.82
f.21187,fz,-130.82
f.21205,fz,-121.74
f.21225,fz,-81.027
f.21241,fz,-101.55
f.21259,fz,-71.942
f.21279,fz,-71.942
f.21295,fz,-71.942
f.21317,fz,-121.74
f.21325,fz,-81.027
f.21349,fz,-101.55
f.21367,fz,-130.82
f.21387,fz,-130.82
f.21403,fz,-130.82
f.21421,fz,-121.74
f.21441,fz,-81.027
f.21457,fz,-101.55
f.21475,fz,-71.942
f.21495,fz,-71.942
f.21511,fz,-71.942
f.21533,fz,-202.16
f.21541,fz,-161.44
f.21565,fz,-181.97
f.21583,fz,-211.24
f.21603,fz,-211.24
f.21619,fz,-211.24
f.21637,fz,-202.16
f.21657,fz,-161.44
f.21673,fz,-181.97
f.21691,fz,-152.69
f.21711,fz,-152.69
f.21727,fz,-152.69
f.21749,fz,-202.16
f.21757,fz,-161.44
f.21781,fz,-181.97
f.21799,fz,-211.24
f.21819,fz,-211.24
f.21835,fz,-211.24
f.21853,fz,-202.16
f.21873,fz,-161.44
f.21889,fz,-181.97
f.21907,fz,-152.69
f.21927,fz,-152.69
f.21943,fz,-152.69
f.21965,fz,-202.16
f.21973,fz,-161.44
f.21997,fz,-181.97
f.22015,fz,-211.24
f.22035,fz,-211.24
f.22051,fz,-211.24
f.22069,fz,-202.16
f.22089,fz,-161.44
f.22105,fz,-181.97
f.22123,fz,-152.69
f.22143,fz,-152.69
f.22159,fz,-152.69
f.22181,fz,-202.16
f.22189,fz,-161.44
f.22213,fz,-181.97
f.22231,fz,-211.24
f.22251,fz,-211.24
f.22267,fz,-211.24
f.22285,fz,-202.16
f.22305,fz,-161.44
f.22321,fz,-181.97
f.22339,fz,-152.69
f.22359,fz,-152.69
f.22375,fz,-152.69
f.22397,fz,-202.16
f.22405,fz,-161.44
f.22429,fz,-181.97
f.22447,fz,-211.24
f.22467,fz,-211.24
f.22483,fz,-211.24
f.22501,fz,-202.16
f.22521,fz,-161.44
f.22537,fz,-181.97
f.22555,fz,-152.69
f.22575,fz,-152.69
f.22591,fz,-152.69
f.22613,fz,-202.16
f.22621,fz,-161.44
f.22645,fz,-181.97
f.22663,fz,-211.24
f.22683,fz,-211.24
f.22699,fz,-211.24
f.22717,fz,-202.16
f.22737,fz,-161.44
f.22753,fz,-181.97
f.22771,fz,-152.69
f.22791,fz,-152.69
f.22807,fz,-152.69
f.22829,fz,-202.16
f.22837,fz,-161.44
f.22861,fz,-181.97
f.22879,fz,-211.24
f.22899,fz,-211.24
f.22915,fz,-211.24
f.22933,fz,-202.16
f.22953,fz,-161.44
f.22969,fz,-181.97
f.22987,fz,-152.69
f.23007,fz,-152.69
f.23023,fz,-152.69
f.23045,fz,-202.16
f.23053,fz,-161.44
f.23077,fz,-181.97
f.23095,fz,-211.24
f.23115,fz,-211.24
f.23131,fz,-211.24
f.23149,fz,-202.16
f.23169,fz,-161.44
f.23185,fz,-181.97
f.23203,fz,-152.69
f.23223,fz,-152.69
f.23239,fz,-152.69
f.23261,fz,-282.91
f.23269,fz,-242.19
f.23293,fz,-262.38
f.23311,fz,-291.99
f.23331,fz,-291.99
f.23347,fz,-291.99
f.23365,fz,-282.91
f.23385,fz,-242.19
f.23401,fz,-262.38
f.23419,fz,-233.11
f.23439,fz,-233.11
f.23455,fz,-233.11
f.23477,fz,-282.91
f.23485,fz,-242.19
f.23509,fz,-262.38
f.23527,fz,-291.99
f.23547,fz,-291.99
f.23563,fz,-291.99
f.23581,fz,-282.91
f.23601,fz,-242.19
f.23617,fz,-262.38
f.23635,fz,-233.11
f.23655,fz,-233.11
f.23671,fz,-233.11
f.23693,fz,-282.91
f.23701,fz,-242.19
f.23725,fz,-262.38
f.23743,fz,-291.99
f.23763,fz,-291.99
f.23779,fz,-291.99
f.23797,fz,-282.91
f.23817,fz,-242.19
f.23833,fz,-262.38
f.23851,fz,-233.11
f.23871,fz,-233.11
f.23887,fz,-233.11
f.23909,fz,-282.91
f.23917,fz,-242.19
f.23941,fz,-262.38
f.23959,fz,-291.99
f.23979,fz,-291.99
f.23995,fz,-291.99
f.24013,fz,-282.91
f.24033,fz,-242.19
f.24049,fz,-262.38
f.24067,fz,-233.11
f.24087,fz,-233.11
f.24103,fz,-233.11
f.24125,fz,-282.91
f.24133,fz,-242.19
f.24157,fz,-262.38
f.24175,fz,-291.99
f.24195,fz,-291.99
f.24211,fz,-291.99
f.24229,fz,-282.91
f.24249,fz,-242.19
f.24265,fz,-262.38
f.24283,fz,-233.11
f.24303,fz,-233.11
f.24319,fz,-233.11
f.24341,fz,-282.91
f.24349,fz,-242.19
f.24373,fz,-262.38
f.24391,fz,-291.99
f.24411,fz,-291.99
f.24427,fz,-291.99
f.24445,fz,-282.91
f.24465,fz,-242.19
f.24481,fz,-262.38
f.24499,fz,-233.11
f.24519,fz,-233.11
f.24535,fz,-233.11
f.24557,fz,-282.91
f.24565,fz,-242.19
f.24589,fz,-262.38
f.24607,fz,-291.99
f.24627,fz,-291.99
f.24643,fz,-291.99
f.24661,fz,-282.91
f.24681,fz,-242.19
f.24697,fz,-262.38
f.24715,fz,-233.11
f.24735,fz,-233.11
f.24751,fz,-233.11
f.24773,fz,-282.91
f.24781,fz,-242.19
f.24805,fz,-262.38
f.24823,fz,-291.99
f.24843,fz,-291.99
f.24859,fz,-291.99
f.24877,fz,-282.91
f.24897,fz,-242.19
f.24913,fz,-262.38
f.24931,fz,-233.11
f.24951,fz,-233.11
f.24967,fz,-233.11
f.24989,fz,-363.32
f.24997,fz,-322.61
f.25021,fz,-342.8
f.25039,fz,-372.41
f.25059,fz,-372.41
f.25075,fz,-372.41
f.25093,fz,-363.32
f.25113,fz,-322.61
f.25129,fz,-342.8
f.25147,fz,-313.53
f.25167,fz,-313.53
f.25183,fz,-313.53
f.25205,fz,-363.32
f.25213,fz,-322.61
f.25237,fz,-342.8
f.25255,fz,-372.41
f.25275,fz,-372.41
f.25291,fz,-372.41
f.25309,fz,-363.32
f.25329,fz,-322.61
f.25345,fz,-342.8
f.25363,fz,-313.53
f.25383,fz,-313.53
f.25399,fz,-313.53
f.25421,fz,-363.32
f.25429,fz,-322.61
f.25453,fz,-342.8
f.25471,fz,-372.41
f.25491,fz,-372.41
f.25507,fz,-372.41
f.25525,fz,-363.32
f.25545,fz,-322.61
f.25561,fz,-342.8
f.25579,fz,-313.53
f.25599,fz,-313.53
f.25615,fz,-313.53
f.25637,fz,-363.32
f.25645,fz,-322.61
f.25669,fz,-342.8
f.25687,fz,-372.41
f.25707,fz,-372.41
f.25723,fz,-372.41
f.25741,fz,-363.32
f.25761,fz,-322.61
f.25777,fz,-342.8
f.25795,fz,-313.53
f.25815,fz,-313.53
f.25831,fz,-313.53
f.25853,fz,-363.32
f.25861,fz,-322.61
f.25885,fz,-342.8
f.25903,fz,-372.41
f.25923,fz,-372.41
f.25939,fz,-372.41
f.25957,fz,-363.32
f.25977,fz,-322.61

f,25993,fz,-342.8
f,26011,fz,-313.53
f,26031,fz,-313.53
f,26047,fz,-313.53
f,26069,fz,-363.32
f,26077,fz,-322.61
f,26101,fz,-342.8
f,26119,fz,-372.41
f,26139,fz,-372.41
f,26155,fz,-372.41
f,26173,fz,-363.32
f,26193,fz,-322.61
f,26209,fz,-342.8
f,26227,fz,-313.53
f,26247,fz,-313.53
f,26263,fz,-313.53
f,26285,fz,-363.32
f,26293,fz,-322.61
f,26317,fz,-342.8
f,26335,fz,-372.41
f,26355,fz,-372.41
f,26371,fz,-372.41
f,26389,fz,-363.32
f,26409,fz,-322.61
f,26425,fz,-342.8
f,26443,fz,-313.53
f,26463,fz,-313.53
f,26479,fz,-313.53
f,26501,fz,-363.32
f,26509,fz,-322.61
f,26533,fz,-342.8
f,26551,fz,-372.41
f,26571,fz,-372.41
f,26587,fz,-372.41
f,26605,fz,-363.32
f,26625,fz,-322.61
f,26641,fz,-342.8
f,26659,fz,-313.53
f,26679,fz,-313.53
f,26695,fz,-313.53
f,26717,fz,-443.74
f,26725,fz,-403.03
f,26749,fz,-423.55
f,26767,fz,-452.82
f,26787,fz,-452.82
f,26803,fz,-452.82
f,26821,fz,-443.74
f,26841,fz,-403.03
f,26857,fz,-423.55
f,26875,fz,-393.94
f,26895,fz,-393.94
f,26911,fz,-393.94
f,26933,fz,-443.74
f,26941,fz,-403.03
f,26965,fz,-423.55
f,26983,fz,-452.82
f,27003,fz,-452.82
f,27019,fz,-452.82
f,27037,fz,-443.74
f,27057,fz,-403.03
f,27073,fz,-423.55
f,27091,fz,-393.94
f,27111,fz,-393.94
f,27127,fz,-393.94
f,27149,fz,-443.74
f,27157,fz,-403.03
f,27181,fz,-423.55
f,27199,fz,-452.82
f,27219,fz,-452.82
f,27235,fz,-452.82
f,27253,fz,-443.74
f,27273,fz,-403.03
f,27289,fz,-423.55
f,27307,fz,-393.94
f,27327,fz,-393.94
f,27343,fz,-393.94
f,27365,fz,-443.74
f,27373,fz,-403.03
f,27397,fz,-423.55
f,27415,fz,-452.82
f,27435,fz,-452.82
f,27451,fz,-452.82
f,27469,fz,-443.74
f,27489,fz,-403.03
f,27505,fz,-423.55
f,27523,fz,-393.94
f,27543,fz,-393.94
f,27559,fz,-393.94
f,27581,fz,-443.74
f,27589,fz,-403.03
f,27613,fz,-423.55
f,27631,fz,-452.82
f,27651,fz,-452.82
f,27667,fz,-452.82
f,27685,fz,-443.74
f,27705,fz,-403.03
f,27721,fz,-423.55
f,27739,fz,-393.94
f,27759,fz,-393.94
f,27775,fz,-393.94
f,27797,fz,-443.74
f,27805,fz,-403.03
f,27829,fz,-423.55
f,27847,fz,-452.82
f,27867,fz,-452.82
f,27883,fz,-452.82
f,27901,fz,-443.74
f,27921,fz,-403.03
f,27937,fz,-423.55
f,27955,fz,-393.94
f,27975,fz,-393.94
f,27991,fz,-393.94
f,28013,fz,-443.74
f,28021,fz,-403.03
f,28045,fz,-423.55
f,28063,fz,-452.82
f,28083,fz,-452.82
f,28099,fz,-452.82
f,28117,fz,-443.74
f,28137,fz,-403.03
f,28153,fz,-423.55
f,28171,fz,-393.94
f,28191,fz,-393.94
f,28207,fz,-393.94
f,28229,fz,-443.74
f,28237,fz,-403.03
f,28261,fz,-423.55
f,28279,fz,-452.82
f,28299,fz,-452.82
f,28315,fz,-452.82
f,28333,fz,-443.74
f,28353,fz,-403.03
f,28369,fz,-423.55
f,28387,fz,-393.94
f,28407,fz,-393.94
f,28423,fz,-393.94
f,28445,fz,-524.15
f,28453,fz,-483.78
f,28477,fz,-503.97
f,28495,fz,-533.24
f,28515,fz,-533.24
f,28531,fz,-533.24
f,28549,fz,-524.15
f,28569,fz,-483.78
f,28585,fz,-503.97
f,28603,fz,-474.69
f,28623,fz,-474.69
f,28639,fz,-474.69
f,28661,fz,-524.15
f,28669,fz,-483.78
f,28693,fz,-503.97
f,28711,fz,-533.24
f,28731,fz,-533.24
f,28747,fz,-533.24
f,28765,fz,-524.15
f,28785,fz,-483.78
f,28801,fz,-503.97
f,28819,fz,-474.69
f,28839,fz,-474.69
f,28855,fz,-474.69
f,28877,fz,-524.15
f,28885,fz,-483.78
f,28909,fz,-503.97
f,28927,fz,-533.24
f,28947,fz,-533.24
f,28963,fz,-533.24
f,28981,fz,-524.15
f,29001,fz,-483.78
f,29017,fz,-503.97
f,29035,fz,-474.69
f,29055,fz,-474.69
f,29071,fz,-474.69
f,29093,fz,-524.15
f,29101,fz,-483.78
f,29125,fz,-503.97
f,29143,fz,-533.24
f,29163,fz,-533.24
f,29179,fz,-533.24
f,29197,fz,-524.15
f,29217,fz,-483.78
f,29233,fz,-503.97
f,29251,fz,-474.69
f,29271,fz,-474.69
f,29287,fz,-474.69
f,29309,fz,-524.15
f,29317,fz,-483.78
f,29341,fz,-503.97
f,29359,fz,-533.24
f,29379,fz,-533.24
f,29395,fz,-533.24
f,29413,fz,-524.15
f,29433,fz,-483.78
f,29449,fz,-503.97
f,29467,fz,-474.69
f,29487,fz,-474.69
f,29503,fz,-474.69
f,29525,fz,-524.15
f,29533,fz,-483.78
f,29557,fz,-503.97
f,29575,fz,-533.24
f,29595,fz,-533.24
f,29611,fz,-533.24
f,29629,fz,-524.15
f,29649,fz,-483.78
f,29665,fz,-503.97
f,29683,fz,-474.69
f,29703,fz,-474.69
f,29719,fz,-474.69
f,29741,fz,-524.15
f,29749,fz,-483.78
f,29773,fz,-503.97
f,29791,fz,-533.24
f,29811,fz,-533.24
f,29827,fz,-533.24
f,29845,fz,-524.15
f,29865,fz,-483.78
f,29881,fz,-503.97
f,29899,fz,-474.69
f,29919,fz,-474.69
f,29935,fz,-474.69
f,29957,fz,-524.15
f,29965,fz,-483.78
f,29989,fz,-503.97
f,30007,fz,-533.24
f,30027,fz,-533.24
f,30043,fz,-533.24
f,30061,fz,-524.15
f,30081,fz,-483.78
f,30097,fz,-503.97
f,30115,fz,-474.69
f,30135,fz,-474.69
f,30151,fz,-474.69
f,30173,fz,-604.91
f,30181,fz,-564.19
f,30205,fz,-584.38
f,30223,fz,-613.99
f,30243,fz,-613.99
f,30259,fz,-613.99
f,30277,fz,-604.91
f,30297,fz,-564.19
f,30313,fz,-584.38
f,30331,fz,-555.11
f,30351,fz,-555.11
f,30367,fz,-555.11
f,30389,fz,-604.91
f,30397,fz,-564.19
f,30421,fz,-584.38
f,30439,fz,-613.99
f,30459,fz,-613.99
f,30475,fz,-613.99
f,30493,fz,-604.91
f,30513,fz,-564.19
f,30529,fz,-584.38
f,30547,fz,-555.11
f,30567,fz,-555.11
f,30583,fz,-555.11
f,30605,fz,-604.91
f,30613,fz,-564.19
f,30637,fz,-584.38
f,30655,fz,-613.99
f,30675,fz,-613.99
f,30691,fz,-613.99
f,30709,fz,-604.91
f,30729,fz,-564.19
f,30745,fz,-584.38
f,30763,fz,-555.11
f,30783,fz,-555.11
f,30799,fz,-555.11
f,30821,fz,-604.91
f,30829,fz,-564.19
f,30853,fz,-584.38
f,30871,fz,-613.99
f,30891,fz,-613.99
f,30907,fz,-613.99
f,30925,fz,-604.91
f,30945,fz,-564.19
f,30961,fz,-584.38
f,30979,fz,-555.11
f,30999,fz,-555.11
f,31015,fz,-555.11
f,31037,fz,-604.91
f,31045,fz,-564.19
f,31069,fz,-584.38
f,31087,fz,-613.99
f,31107,fz,-613.99
f,31123,fz,-613.99
f,31141,fz,-604.91
f,31161,fz,-564.19
f,31177,fz,-584.38
f,31195,fz,-555.11
f,31215,fz,-555.11
f,31231,fz,-555.11
f,31253,fz,-604.91
f,31261,fz,-564.19
f,31285,fz,-584.38
f,31303,fz,-613.99
f,31323,fz,-613.99
f,31339,fz,-613.99
f,31357,fz,-604.91
f,31377,fz,-564.19
f,31393,fz,-584.38
f,31411,fz,-555.11
f,31431,fz,-555.11
f,31447,fz,-555.11
f,31469,fz,-604.91
f,31477,fz,-564.19
f,31501,fz,-584.38
f,31519,fz,-613.99
f,31539,fz,-613.99
f,31555,fz,-613.99
f,31573,fz,-604.91
f,31593,fz,-564.19
f,31609,fz,-584.38
f,31627,fz,-555.11
f,31647,fz,-555.11
f,31663,fz,-555.11
f,31685,fz,-604.91
f,31693,fz,-564.19
f,31717,fz,-584.38
f,31735,fz,-613.99
f,31755,fz,-613.99
f,31771,fz,-613.99
f,31789,fz,-604.91
f,31809,fz,-564.19
f,31825,fz,-584.38
f,31843,fz,-555.11
f,31863,fz,-555.11
f,31879,fz,-555.11
f,31901,fz,-685.32
f,31909,fz,-644.61
f,31933,fz,-665.13
f,31951,fz,-694.41

f,31971,fz,-694.41
f,31987,fz,-694.41
f,32005,fz,-685.32
f,32025,fz,-644.61
f,32041,fz,-665.13
f,32059,fz,-635.53
f,32079,fz,-635.53
f,32095,fz,-635.53
f,32117,fz,-685.32
f,32125,fz,-644.61
f,32149,fz,-665.13
f,32167,fz,-694.41
f,32187,fz,-694.41
f,32203,fz,-694.41
f,32221,fz,-685.32
f,32241,fz,-644.61
f,32257,fz,-665.13
f,32275,fz,-635.53
f,32295,fz,-635.53
f,32311,fz,-635.53
f,32333,fz,-685.32
f,32341,fz,-644.61
f,32365,fz,-665.13
f,32383,fz,-694.41
f,32403,fz,-694.41
f,32419,fz,-694.41
f,32437,fz,-685.32
f,32457,fz,-644.61
f,32473,fz,-665.13
f,32491,fz,-635.53
f,32511,fz,-635.53
f,32527,fz,-635.53
f,32549,fz,-685.32
f,32557,fz,-644.61
f,32581,fz,-665.13
f,32599,fz,-694.41
f,32619,fz,-694.41
f,32635,fz,-694.41
f,32653,fz,-685.32
f,32673,fz,-644.61
f,32689,fz,-665.13
f,32707,fz,-635.53
f,32727,fz,-635.53
f,32743,fz,-635.53
f,32765,fz,-685.32
f,32773,fz,-644.61
f,32797,fz,-665.13
f,32815,fz,-694.41
f,32835,fz,-694.41
f,32851,fz,-694.41
f,32869,fz,-685.32
f,32889,fz,-644.61
f,32905,fz,-665.13
f,32923,fz,-635.53
f,32943,fz,-635.53
f,32959,fz,-635.53
f,32981,fz,-685.32
f,32989,fz,-644.61
f,33013,fz,-665.13
f,33031,fz,-694.41
f,33051,fz,-694.41
f,33067,fz,-694.41
f,33085,fz,-685.32
f,33105,fz,-644.61
f,33121,fz,-665.13
f,33139,fz,-635.53
f,33159,fz,-635.53
f,33175,fz,-635.53
f,33197,fz,-685.32
f,33205,fz,-644.61
f,33229,fz,-665.13
f,33247,fz,-694.41
f,33267,fz,-694.41
f,33283,fz,-694.41
f,33301,fz,-685.32
f,33321,fz,-644.61
f,33337,fz,-665.13
f,33355,fz,-635.53
f,33375,fz,-635.53
f,33391,fz,-635.53
f,33413,fz,-685.32
f,33421,fz,-644.61
f,33445,fz,-665.13
f,33463,fz,-694.41
f,33483,fz,-694.41
f,33499,fz,-694.41
f,33517,fz,-685.32
f,33537,fz,-644.61
f,33553,fz,-665.13
f,33571,fz,-635.53
f,33591,fz,-635.53
f,33607,fz,-635.53
f,5982,fz,530.316
f,5990,fz,571.028
f,6014,fz,550.84
f,6032,fz,521.231
f,6052,fz,521.231
f,6068,fz,521.231
f,6086,fz,530.316
f,6106,fz,571.028
f,6122,fz,550.84
f,6140,fz,580.113
f,6160,fz,580.113
f,6176,fz,580.113
f,6198,fz,530.316
f,6206,fz,571.028
f,6230,fz,550.84
f,6248,fz,521.231
f,6268,fz,521.231
f,6284,fz,521.231
f,6302,fz,530.316
f,6322,fz,571.028
f,6338,fz,550.84
f,6356,fz,580.113
f,6376,fz,580.113
f,6392,fz,580.113
f,6414,fz,530.316
f,6422,fz,571.028
f,6446,fz,550.84
f,6464,fz,521.231
f,6484,fz,521.231
f,6500,fz,521.231
f,6518,fz,530.316
f,6538,fz,571.028
f,6554,fz,550.84
f,6572,fz,580.113
f,6592,fz,580.113
f,6608,fz,580.113
f,6630,fz,530.316
f,6638,fz,571.028
f,6662,fz,550.84
f,6680,fz,521.231
f,6700,fz,521.231
f,6716,fz,521.231
f,6734,fz,530.316
f,6754,fz,571.028
f,6770,fz,550.84
f,6788,fz,580.113
f,6808,fz,580.113
f,6824,fz,580.113
f,6846,fz,530.316
f,6854,fz,571.028
f,6878,fz,550.84
f,6896,fz,521.231
f,6916,fz,521.231
f,6932,fz,521.231
f,6950,fz,530.316
f,6970,fz,571.028
f,6986,fz,550.84
f,7004,fz,580.113
f,7024,fz,580.113
f,7040,fz,580.113
f,7062,fz,530.316
f,7070,fz,571.028
f,7094,fz,550.84
f,7112,fz,521.231
f,7132,fz,521.231
f,7148,fz,521.231
f,7166,fz,530.316
f,7186,fz,571.028
f,7202,fz,550.84
f,7220,fz,580.113
f,7240,fz,580.113
f,7256,fz,580.113
f,7278,fz,530.316
f,7286,fz,571.028
f,7310,fz,550.84
f,7328,fz,521.231
f,7348,fz,521.231
f,7364,fz,521.231
f,7382,fz,530.316
f,7402,fz,571.028
f,7418,fz,550.84
f,7436,fz,580.113
f,7456,fz,580.113
f,7472,fz,580.113
f,7494,fz,530.316
f,7502,fz,571.028
f,7526,fz,550.84
f,7544,fz,521.231
f,7564,fz,521.231
f,7580,fz,521.231
f,7598,fz,530.316
f,7618,fz,571.028
f,7634,fz,550.84
f,7652,fz,580.113
f,7672,fz,580.113
f,7688,fz,580.113
f,7710,fz,449.9
f,7718,fz,490.613
f,7742,fz,470.088
f,7760,fz,440.816
f,7780,fz,440.816
f,7796,fz,440.816
f,7814,fz,449.9
f,7834,fz,490.613
f,7850,fz,470.088
f,7868,fz,499.697
f,7888,fz,499.697
f,7904,fz,499.697
f,7926,fz,449.9
f,7934,fz,490.613
f,7958,fz,470.088
f,7976,fz,440.816
f,7996,fz,440.816
f,8012,fz,440.816
f,8030,fz,449.9
f,8050,fz,490.613
f,8066,fz,470.088
f,8084,fz,499.697
f,8104,fz,499.697
f,8120,fz,499.697
f,8142,fz,449.9
f,8150,fz,490.613
f,8174,fz,470.088
f,8192,fz,440.816
f,8212,fz,440.816
f,8228,fz,440.816
f,8246,fz,449.9
f,8266,fz,490.613
f,8282,fz,470.088
f,8300,fz,499.697
f,8320,fz,499.697
f,8336,fz,499.697
f,8358,fz,449.9
f,8366,fz,490.613
f,8390,fz,470.088
f,8408,fz,440.816
f,8428,fz,440.816
f,8444,fz,440.816
f,8462,fz,449.9
f,8482,fz,490.613
f,8498,fz,470.088
f,8516,fz,499.697
f,8536,fz,499.697
f,8552,fz,499.697
f,8574,fz,449.9
f,8582,fz,490.613
f,8606,fz,470.088
f,8624,fz,440.816
f,8644,fz,440.816
f,8660,fz,440.816
f,8678,fz,449.9
f,8698,fz,490.613
f,8714,fz,470.088
f,8732,fz,499.697
f,8752,fz,499.697
f,8768,fz,499.697
f,8790,fz,449.9
f,8798,fz,490.613
f,8822,fz,470.088
f,8840,fz,440.816
f,8860,fz,440.816
f,8876,fz,440.816
f,8894,fz,449.9
f,8914,fz,490.613
f,8930,fz,470.088
f,8948,fz,499.697
f,8968,fz,499.697
f,8984,fz,499.697
f,9006,fz,449.9
f,9014,fz,490.613
f,9038,fz,470.088
f,9056,fz,440.816
f,9076,fz,440.816
f,9092,fz,440.816
f,9110,fz,449.9
f,9130,fz,490.613
f,9146,fz,470.088
f,9164,fz,499.697
f,9184,fz,499.697
f,9200,fz,499.697
f,9222,fz,449.9
f,9230,fz,490.613
f,9254,fz,470.088
f,9272,fz,440.816
f,9292,fz,440.816
f,9308,fz,440.816
f,9326,fz,449.9
f,9346,fz,490.613
f,9362,fz,470.088
f,9380,fz,499.697
f,9400,fz,499.697
f,9416,fz,499.697
f,9438,fz,369.484
f,9446,fz,409.861
f,9470,fz,389.673
f,9488,fz,360.4
f,9508,fz,360.4
f,9524,fz,360.4
f,9542,fz,369.484
f,9562,fz,409.861
f,9578,fz,389.673
f,9596,fz,418.945
f,9616,fz,418.945
f,9632,fz,418.945
f,9654,fz,369.484
f,9662,fz,409.861
f,9686,fz,389.673
f,9704,fz,360.4
f,9724,fz,360.4
f,9740,fz,360.4
f,9758,fz,369.484
f,9778,fz,409.861
f,9794,fz,389.673
f,9812,fz,418.945
f,9832,fz,418.945
f,9848,fz,418.945
f,9870,fz,369.484
f,9878,fz,409.861
f,9902,fz,389.673
f,9920,fz,360.4
f,9940,fz,360.4
f,9956,fz,360.4
f,9974,fz,369.484
f,9994,fz,409.861
f,10010,fz,389.673
f,10028,fz,418.945
f,10048,fz,418.945
f,10064,fz,418.945
f,10086,fz,369.484
f,10094,fz,409.861
f,10118,fz,389.673
f,10136,fz,360.4
f,10156,fz,360.4
f,10172,fz,360.4
f,10190,fz,369.484
f,10210,fz,409.861
f,10226,fz,389.673
f,10244,fz,418.945
f,10264,fz,418.945
f,10280,fz,418.945

f,10302,fr,369.484
f,10310,fr,409.861
f,10334,fr,389.673
f,10352,fr,360.4
f,10372,fr,360.4
f,10388,fr,360.4
f,10406,fr,369.484
f,10426,fr,409.861
f,10442,fr,389.673
f,10460,fr,418.945
f,10480,fr,418.945
f,10496,fr,418.945
f,10518,fr,369.484
f,10526,fr,409.861
f,10550,fr,389.673
f,10568,fr,360.4
f,10588,fr,360.4
f,10604,fr,360.4
f,10622,fr,369.484
f,10642,fr,409.861
f,10658,fr,389.673
f,10676,fr,418.945
f,10696,fr,418.945
f,10712,fr,418.945
f,10734,fr,369.484
f,10742,fr,409.861
f,10766,fr,389.673
f,10784,fr,360.4
f,10804,fr,360.4
f,10820,fr,360.4
f,10838,fr,369.484
f,10858,fr,409.861
f,10874,fr,389.673
f,10892,fr,418.945
f,10912,fr,418.945
f,10928,fr,418.945
f,10950,fr,369.484
f,10958,fr,409.861
f,10982,fr,389.673
f,11000,fr,360.4
f,11020,fr,360.4
f,11036,fr,360.4
f,11054,fr,369.484
f,11074,fr,409.861
f,11090,fr,389.673
f,11108,fr,418.945
f,11128,fr,418.945
f,11144,fr,418.945
f,11166,fr,288.732
f,11174,fr,329.445
f,11198,fr,309.257
f,11216,fr,279.648
f,11236,fr,279.648
f,11252,fr,279.648
f,11270,fr,288.732
f,11290,fr,329.445
f,11306,fr,309.257
f,11324,fr,338.529
f,11344,fr,338.529
f,11360,fr,338.529
f,11382,fr,288.732
f,11390,fr,329.445
f,11414,fr,309.257
f,11432,fr,279.648
f,11452,fr,279.648
f,11468,fr,279.648
f,11486,fr,288.732
f,11506,fr,329.445
f,11522,fr,309.257
f,11540,fr,338.529
f,11560,fr,338.529
f,11576,fr,338.529
f,11598,fr,288.732
f,11606,fr,329.445
f,11630,fr,309.257
f,11648,fr,279.648
f,11668,fr,279.648
f,11684,fr,279.648
f,11702,fr,288.732
f,11722,fr,329.445
f,11738,fr,309.257
f,11756,fr,338.529
f,11776,fr,338.529
f,11792,fr,338.529
f,11814,fr,288.732
f,11822,fr,329.445
f,11846,fr,309.257
f,11864,fr,279.648
f,11884,fr,279.648
f,11900,fr,279.648
f,11918,fr,288.732
f,11938,fr,329.445
f,11954,fr,309.257
f,11972,fr,338.529
f,11992,fr,338.529
f,12008,fr,338.529
f,12030,fr,288.732
f,12038,fr,329.445
f,12062,fr,309.257
f,12080,fr,279.648
f,12100,fr,279.648
f,12116,fr,279.648
f,12134,fr,288.732
f,12154,fr,329.445
f,12170,fr,309.257
f,12188,fr,338.529
f,12208,fr,338.529
f,12224,fr,338.529
f,12246,fr,288.732
f,12254,fr,329.445
f,12278,fr,309.257
f,12296,fr,279.648
f,12316,fr,279.648
f,12332,fr,279.648
f,12350,fr,288.732
f,12370,fr,329.445
f,12386,fr,309.257
f,12404,fr,338.529
f,12424,fr,338.529
f,12440,fr,338.529
f,12462,fr,288.732
f,12470,fr,329.445
f,12494,fr,309.257
f,12512,fr,279.648
f,12532,fr,279.648
f,12548,fr,279.648
f,12566,fr,288.732
f,12586,fr,329.445
f,12602,fr,309.257
f,12620,fr,338.529
f,12640,fr,338.529
f,12656,fr,338.529
f,12678,fr,288.732
f,12686,fr,329.445
f,12710,fr,309.257
f,12728,fr,279.648
f,12748,fr,279.648
f,12764,fr,279.648
f,12782,fr,288.732
f,12802,fr,329.445
f,12818,fr,309.257
f,12836,fr,338.529
f,12856,fr,338.529
f,12872,fr,338.529
f,12894,fr,208.317
f,12902,fr,249.029
f,12926,fr,228.505
f,12944,fr,199.232
f,12964,fr,199.232
f,12980,fr,199.232
f,12998,fr,208.317
f,13018,fr,249.029
f,13034,fr,228.505
f,13052,fr,258.114
f,13072,fr,258.114
f,13088,fr,258.114
f,13110,fr,208.317
f,13118,fr,249.029
f,13142,fr,228.505
f,13160,fr,199.232
f,13180,fr,199.232
f,13196,fr,199.232
f,13214,fr,208.317
f,13234,fr,249.029
f,13250,fr,228.505
f,13268,fr,258.114
f,13288,fr,258.114
f,13304,fr,258.114
f,13326,fr,208.317
f,13334,fr,249.029
f,13358,fr,228.505
f,13376,fr,199.232
f,13396,fr,199.232
f,13412,fr,199.232
f,13430,fr,208.317
f,13450,fr,249.029
f,13466,fr,228.505
f,13484,fr,258.114
f,13504,fr,258.114
f,13520,fr,258.114
f,13542,fr,208.317
f,13550,fr,249.029
f,13574,fr,228.505
f,13592,fr,199.232
f,13612,fr,199.232
f,13628,fr,199.232
f,13646,fr,208.317
f,13666,fr,249.029
f,13682,fr,228.505
f,13700,fr,258.114
f,13720,fr,258.114
f,13736,fr,258.114
f,13758,fr,208.317
f,13766,fr,249.029
f,13790,fr,228.505
f,13808,fr,199.232
f,13828,fr,199.232
f,13844,fr,199.232
f,13862,fr,208.317
f,13882,fr,249.029
f,13898,fr,228.505
f,13916,fr,258.114
f,13936,fr,258.114
f,13952,fr,258.114
f,13974,fr,208.317
f,13982,fr,249.029
f,14006,fr,228.505
f,14024,fr,199.232
f,14044,fr,199.232
f,14060,fr,199.232
f,14078,fr,208.317
f,14098,fr,249.029
f,14114,fr,228.505
f,14132,fr,258.114
f,14152,fr,258.114
f,14168,fr,258.114
f,14190,fr,208.317
f,14198,fr,249.029
f,14222,fr,228.505
f,14240,fr,199.232
f,14260,fr,199.232
f,14276,fr,199.232
f,14294,fr,208.317
f,14314,fr,249.029
f,14330,fr,228.505
f,14348,fr,258.114
f,14368,fr,258.114
f,14384,fr,258.114
f,14406,fr,208.317
f,14414,fr,249.029
f,14438,fr,228.505
f,14456,fr,199.232
f,14476,fr,199.232
f,14492,fr,199.232
f,14510,fr,208.317
f,14530,fr,249.029
f,14546,fr,228.505
f,14564,fr,258.114
f,14584,fr,258.114
f,14600,fr,258.114
f,14622,fr,127.901
f,14630,fr,168.613
f,14654,fr,148.089
f,14672,fr,118.816
f,14692,fr,118.816
f,14708,fr,118.816
f,14726,fr,127.901
f,14746,fr,168.613
f,14762,fr,148.089
f,14780,fr,177.698
f,14800,fr,177.698
f,14816,fr,177.698
f,14838,fr,127.901
f,14846,fr,168.613
f,14870,fr,148.089
f,14888,fr,118.816
f,14908,fr,118.816
f,14924,fr,118.816
f,14942,fr,127.901
f,14962,fr,168.613
f,14978,fr,148.089
f,14996,fr,177.698
f,15016,fr,177.698
f,15032,fr,177.698
f,15054,fr,127.901
f,15062,fr,168.613
f,15086,fr,148.089
f,15104,fr,118.816
f,15124,fr,118.816
f,15140,fr,118.816
f,15158,fr,127.901
f,15178,fr,168.613
f,15194,fr,148.089
f,15212,fr,177.698
f,15232,fr,177.698
f,15248,fr,177.698
f,15270,fr,127.901
f,15278,fr,168.613
f,15302,fr,148.089
f,15320,fr,118.816
f,15340,fr,118.816
f,15356,fr,118.816
f,15374,fr,127.901
f,15394,fr,168.613
f,15410,fr,148.089
f,15428,fr,177.698
f,15448,fr,177.698
f,15464,fr,177.698
f,15486,fr,127.901
f,15494,fr,168.613
f,15518,fr,148.089
f,15536,fr,118.816
f,15556,fr,118.816
f,15572,fr,118.816
f,15590,fr,127.901
f,15610,fr,168.613
f,15626,fr,148.089
f,15644,fr,177.698
f,15664,fr,177.698
f,15680,fr,177.698
f,15702,fr,127.901
f,15710,fr,168.613
f,15734,fr,148.089
f,15752,fr,118.816
f,15772,fr,118.816
f,15788,fr,118.816
f,15806,fr,127.901
f,15826,fr,168.613
f,15842,fr,148.089
f,15860,fr,177.698
f,15880,fr,177.698
f,15896,fr,177.698
f,15918,fr,127.901
f,15926,fr,168.613
f,15950,fr,148.089
f,15968,fr,118.816
f,15988,fr,118.816
f,16004,fr,118.816
f,16022,fr,127.901
f,16042,fr,168.613
f,16058,fr,148.089
f,16076,fr,177.698
f,16096,fr,177.698
f,16112,fr,177.698
f,16134,fr,127.901
f,16142,fr,168.613
f,16166,fr,148.089
f,16184,fr,118.816
f,16204,fr,118.816
f,16220,fr,118.816
f,16238,fr,127.901
f,16258,fr,168.613

f,16274,fz,148.089
f,16292,fz,177.698
f,16312,fz,177.698
f,16328,fz,177.698
f,16350,fz,47.1487
f,16358,fz,87.8613
f,16382,fz,67.6732
f,16400,fz,38.4006
f,16420,fz,38.4006
f,16436,fz,38.4006
f,16454,fz,47.1487
f,16474,fz,87.8613
f,16490,fz,67.6732
f,16508,fz,96.9459
f,16528,fz,96.9459
f,16544,fz,96.9459
f,16566,fz,47.1487
f,16574,fz,87.8613
f,16598,fz,67.6732
f,16616,fz,38.4006
f,16636,fz,38.4006
f,16652,fz,38.4006
f,16670,fz,47.1487
f,16690,fz,87.8613
f,16706,fz,67.6732
f,16724,fz,96.9459
f,16744,fz,96.9459
f,16760,fz,96.9459
f,16782,fz,47.1487
f,16790,fz,87.8613
f,16814,fz,67.6732
f,16832,fz,38.4006
f,16852,fz,38.4006
f,16868,fz,38.4006
f,16886,fz,47.1487
f,16906,fz,87.8613
f,16922,fz,67.6732
f,16940,fz,96.9459
f,16960,fz,96.9459
f,16976,fz,96.9459
f,16998,fz,47.1487
f,17006,fz,87.8613
f,17030,fz,67.6732
f,17048,fz,38.4006
f,17068,fz,38.4006
f,17084,fz,38.4006
f,17102,fz,47.1487
f,17122,fz,87.8613
f,17138,fz,67.6732
f,17156,fz,96.9459
f,17176,fz,96.9459
f,17192,fz,96.9459
f,17214,fz,47.1487
f,17222,fz,87.8613
f,17246,fz,67.6732
f,17264,fz,38.4006
f,17284,fz,38.4006
f,17300,fz,38.4006
f,17318,fz,47.1487
f,17338,fz,87.8613
f,17354,fz,67.6732
f,17372,fz,96.9459
f,17392,fz,96.9459
f,17408,fz,96.9459
f,17430,fz,47.1487
f,17438,fz,87.8613
f,17462,fz,67.6732
f,17480,fz,38.4006
f,17500,fz,38.4006
f,17516,fz,38.4006
f,17534,fz,47.1487
f,17554,fz,87.8613
f,17570,fz,67.6732
f,17588,fz,96.9459
f,17608,fz,96.9459
f,17624,fz,96.9459
f,17646,fz,47.1487
f,17654,fz,87.8613
f,17678,fz,67.6732
f,17696,fz,38.4006
f,17716,fz,38.4006
f,17732,fz,38.4006
f,17750,fz,47.1487
f,17770,fz,87.8613
f,17786,fz,67.6732
f,17804,fz,96.9459
f,17824,fz,96.9459
f,17840,fz,96.9459
f,17862,fz,47.1487
f,17870,fz,87.8613
f,17894,fz,67.6732
f,17912,fz,38.4006
f,17932,fz,38.4006
f,17948,fz,38.4006
f,17966,fz,47.1487
f,17986,fz,87.8613
f,18002,fz,67.6732
f,18020,fz,96.9459
f,18040,fz,96.9459
f,18056,fz,96.9459
f,18078,fz,-33.267
f,18086,fz,7.44556
f,18110,fz,-12.742
f,18128,fz,-42.352
f,18148,fz,-42.352
f,18164,fz,-42.352
f,18182,fz,-33.267
f,18202,fz,7.44556
f,18218,fz,-12.742
f,18236,fz,16.5302
f,18256,fz,16.5302
f,18272,fz,16.5302
f,18294,fz,-33.267
f,18302,fz,7.44556
f,18326,fz,-12.742
f,18344,fz,-42.352
f,18364,fz,-42.352
f,18380,fz,-42.352
f,18398,fz,-33.267
f,18418,fz,7.44556
f,18434,fz,-12.742
f,18452,fz,16.5302
f,18472,fz,16.5302
f,18488,fz,16.5302
f,18510,fz,-33.267
f,18518,fz,7.44556
f,18542,fz,-12.742
f,18560,fz,-42.352
f,18580,fz,-42.352
f,18596,fz,-42.352
f,18614,fz,-33.267
f,18634,fz,7.44556
f,18650,fz,-12.742
f,18668,fz,16.5302
f,18688,fz,16.5302
f,18704,fz,16.5302
f,18726,fz,-33.267
f,18734,fz,7.44556
f,18758,fz,-12.742
f,18776,fz,-42.352
f,18796,fz,-42.352
f,18812,fz,-42.352
f,18830,fz,-33.267
f,18850,fz,7.44556
f,18866,fz,-12.742
f,18884,fz,16.5302
f,18904,fz,16.5302
f,18920,fz,16.5302
f,18942,fz,-33.267
f,18950,fz,7.44556
f,18974,fz,-12.742
f,18992,fz,-42.352
f,19012,fz,-42.352
f,19028,fz,-42.352
f,19046,fz,-33.267
f,19066,fz,7.44556
f,19082,fz,-12.742
f,19100,fz,16.5302
f,19120,fz,16.5302
f,19136,fz,16.5302
f,19158,fz,-33.267
f,19166,fz,7.44556
f,19190,fz,-12.742
f,19208,fz,-42.352
f,19228,fz,-42.352
f,19244,fz,-42.352
f,19262,fz,-33.267
f,19282,fz,7.44556
f,19298,fz,-12.742
f,19316,fz,16.5302
f,19336,fz,16.5302
f,19352,fz,16.5302
f,19374,fz,-33.267
f,19382,fz,7.44556
f,19406,fz,-12.742
f,19424,fz,-42.352
f,19444,fz,-42.352
f,19460,fz,-42.352
f,19478,fz,-33.267
f,19498,fz,7.44556
f,19514,fz,-12.742
f,19532,fz,16.5302
f,19552,fz,16.5302
f,19568,fz,16.5302
f,19590,fz,-33.267
f,19598,fz,7.44556
f,19622,fz,-12.742
f,19640,fz,-42.352
f,19660,fz,-42.352
f,19676,fz,-42.352
f,19694,fz,-33.267
f,19714,fz,7.44556
f,19730,fz,-12.742
f,19748,fz,16.5302
f,19768,fz,16.5302
f,19784,fz,16.5302
f,19806,fz,-113.68
f,19814,fz,-72.97
f,19838,fz,-93.495
f,19856,fz,-122.77
f,19876,fz,-122.77
f,19892,fz,-122.77
f,19910,fz,-113.68
f,19930,fz,-72.97
f,19946,fz,-93.495
f,19964,fz,-63.886
f,19984,fz,-63.886
f,20000,fz,-63.886
f,20022,fz,-113.68
f,20030,fz,-72.97
f,20054,fz,-93.495
f,20072,fz,-122.77
f,20092,fz,-122.77
f,20108,fz,-122.77
f,20126,fz,-113.68
f,20146,fz,-72.97
f,20162,fz,-93.495
f,20180,fz,-63.886
f,20200,fz,-63.886
f,20216,fz,-63.886
f,20238,fz,-113.68
f,20246,fz,-72.97
f,20270,fz,-93.495
f,20288,fz,-122.77
f,20308,fz,-122.77
f,20324,fz,-122.77
f,20342,fz,-113.68
f,20362,fz,-72.97
f,20378,fz,-93.495
f,20396,fz,-63.886
f,20416,fz,-63.886
f,20432,fz,-63.886
f,20454,fz,-113.68
f,20462,fz,-72.97
f,20486,fz,-93.495
f,20504,fz,-122.77
f,20524,fz,-122.77
f,20540,fz,-122.77
f,20558,fz,-113.68
f,20578,fz,-72.97
f,20594,fz,-93.495
f,20612,fz,-63.886
f,20632,fz,-63.886
f,20648,fz,-63.886
f,20670,fz,-113.68
f,20678,fz,-72.97
f,20702,fz,-93.495
f,20720,fz,-122.77
f,20740,fz,-122.77
f,20756,fz,-122.77
f,20774,fz,-113.68
f,20794,fz,-72.97
f,20810,fz,-93.495
f,20828,fz,-63.886
f,20848,fz,-63.886
f,20864,fz,-63.886
f,20886,fz,-113.68
f,20894,fz,-72.97
f,20918,fz,-93.495
f,20936,fz,-122.77
f,20956,fz,-122.77
f,20972,fz,-122.77
f,20990,fz,-113.68
f,21010,fz,-72.97
f,21026,fz,-93.495
f,21044,fz,-63.886
f,21064,fz,-63.886
f,21080,fz,-63.886
f,21102,fz,-113.68
f,21110,fz,-72.97
f,21134,fz,-93.495
f,21152,fz,-122.77
f,21172,fz,-122.77
f,21188,fz,-122.77
f,21206,fz,-113.68
f,21226,fz,-72.97
f,21242,fz,-93.495
f,21260,fz,-63.886
f,21280,fz,-63.886
f,21296,fz,-63.886
f,21318,fz,-113.68
f,21326,fz,-72.97
f,21350,fz,-93.495
f,21368,fz,-122.77
f,21388,fz,-122.77
f,21404,fz,-122.77
f,21422,fz,-113.68
f,21442,fz,-72.97
f,21458,fz,-93.495
f,21476,fz,-63.886
f,21496,fz,-63.886
f,21512,fz,-63.886
f,21534,fz,-194.1
f,21542,fz,-153.39
f,21566,fz,-173.91
f,21584,fz,-203.18
f,21604,fz,-203.18
f,21620,fz,-203.18
f,21638,fz,-194.1
f,21658,fz,-153.39
f,21674,fz,-173.91
f,21692,fz,-144.64
f,21712,fz,-144.64
f,21728,fz,-144.64
f,21750,fz,-194.1
f,21758,fz,-153.39
f,21782,fz,-173.91
f,21800,fz,-203.18
f,21820,fz,-203.18
f,21836,fz,-203.18
f,21854,fz,-194.1
f,21874,fz,-153.39
f,21890,fz,-173.91
f,21908,fz,-144.64
f,21928,fz,-144.64
f,21944,fz,-144.64
f,21966,fz,-194.1
f,21974,fz,-153.39
f,21998,fz,-173.91
f,22016,fz,-203.18
f,22036,fz,-203.18
f,22052,fz,-203.18
f,22070,fz,-194.1
f,22090,fz,-153.39
f,22106,fz,-173.91
f,22124,fz,-144.64
f,22144,fz,-144.64
f,22160,fz,-144.64
f,22182,fz,-194.1
f,22190,fz,-153.39
f,22214,fz,-173.91
f,22232,fz,-203.18

f,22252,fz,-203.18
f,22268,fz,-203.18
f,22286,fz,-194.1
f,22306,fz,-153.39
f,22322,fz,-173.91
f,22340,fz,-144.64
f,22360,fz,-144.64
f,22376,fz,-144.64
f,22398,fz,-194.1
f,22406,fz,-153.39
f,22430,fz,-173.91
f,22448,fz,-203.18
f,22468,fz,-203.18
f,22484,fz,-203.18
f,22502,fz,-194.1
f,22522,fz,-153.39
f,22538,fz,-173.91
f,22556,fz,-144.64
f,22576,fz,-144.64
f,22592,fz,-144.64
f,22614,fz,-194.1
f,22622,fz,-153.39
f,22646,fz,-173.91
f,22664,fz,-203.18
f,22684,fz,-203.18
f,22700,fz,-203.18
f,22718,fz,-194.1
f,22738,fz,-153.39
f,22754,fz,-173.91
f,22772,fz,-144.64
f,22792,fz,-144.64
f,22808,fz,-144.64
f,22830,fz,-194.1
f,22838,fz,-153.39
f,22862,fz,-173.91
f,22880,fz,-203.18
f,22900,fz,-203.18
f,22916,fz,-203.18
f,22934,fz,-194.1
f,22954,fz,-153.39
f,22970,fz,-173.91
f,22988,fz,-144.64
f,23008,fz,-144.64
f,23024,fz,-144.64
f,23046,fz,-194.1
f,23054,fz,-153.39
f,23078,fz,-173.91
f,23096,fz,-203.18
f,23116,fz,-203.18
f,23132,fz,-203.18
f,23150,fz,-194.1
f,23170,fz,-153.39
f,23186,fz,-173.91
f,23204,fz,-144.64
f,23224,fz,-144.64
f,23240,fz,-144.64
f,23262,fz,-274.85
f,23270,fz,-234.14
f,23294,fz,-254.33
f,23312,fz,-283.94
f,23332,fz,-283.94
f,23348,fz,-283.94
f,23366,fz,-274.85
f,23386,fz,-234.14
f,23402,fz,-254.33
f,23420,fz,-225.05
f,23440,fz,-225.05
f,23456,fz,-225.05
f,23478,fz,-274.85
f,23486,fz,-234.14
f,23510,fz,-254.33
f,23528,fz,-283.94
f,23548,fz,-283.94
f,23564,fz,-283.94
f,23582,fz,-274.85
f,23602,fz,-234.14
f,23618,fz,-254.33
f,23636,fz,-225.05
f,23656,fz,-225.05
f,23672,fz,-225.05
f,23694,fz,-274.85
f,23702,fz,-234.14
f,23726,fz,-254.33
f,23744,fz,-283.94
f,23764,fz,-283.94
f,23780,fz,-283.94
f,23798,fz,-274.85
f,23818,fz,-234.14
f,23834,fz,-254.33
f,23852,fz,-225.05
f,23872,fz,-225.05
f,23888,fz,-225.05
f,23910,fz,-274.85
f,23918,fz,-234.14
f,23942,fz,-254.33
f,23960,fz,-283.94
f,23980,fz,-283.94
f,23996,fz,-283.94
f,24014,fz,-274.85
f,24034,fz,-234.14
f,24050,fz,-254.33
f,24068,fz,-225.05
f,24088,fz,-225.05
f,24104,fz,-225.05
f,24126,fz,-274.85
f,24134,fz,-234.14
f,24158,fz,-254.33
f,24176,fz,-283.94
f,24196,fz,-283.94
f,24212,fz,-283.94
f,24230,fz,-274.85
f,24250,fz,-234.14
f,24266,fz,-254.33
f,24284,fz,-225.05
f,24304,fz,-225.05
f,24320,fz,-225.05
f,24342,fz,-274.85
f,24350,fz,-234.14
f,24374,fz,-254.33
f,24392,fz,-283.94
f,24412,fz,-283.94
f,24428,fz,-283.94
f,24446,fz,-274.85
f,24466,fz,-234.14
f,24482,fz,-254.33
f,24500,fz,-225.05
f,24520,fz,-225.05
f,24536,fz,-225.05
f,24558,fz,-274.85
f,24566,fz,-234.14
f,24590,fz,-254.33
f,24608,fz,-283.94
f,24628,fz,-283.94
f,24644,fz,-283.94
f,24662,fz,-274.85
f,24682,fz,-234.14
f,24698,fz,-254.33
f,24716,fz,-225.05
f,24736,fz,-225.05
f,24752,fz,-225.05
f,24774,fz,-274.85
f,24782,fz,-234.14
f,24806,fz,-254.33
f,24824,fz,-283.94
f,24844,fz,-283.94
f,24860,fz,-283.94
f,24878,fz,-274.85
f,24898,fz,-234.14
f,24914,fz,-254.33
f,24932,fz,-225.05
f,24952,fz,-225.05
f,24968,fz,-225.05
f,24990,fz,-355.27
f,24998,fz,-314.55
f,25022,fz,-334.74
f,25040,fz,-364.35
f,25060,fz,-364.35
f,25076,fz,-364.35
f,25094,fz,-355.27
f,25114,fz,-314.55
f,25130,fz,-334.74
f,25148,fz,-305.47
f,25168,fz,-305.47
f,25184,fz,-305.47
f,25206,fz,-355.27
f,25214,fz,-314.55
f,25238,fz,-334.74
f,25256,fz,-364.35
f,25276,fz,-364.35
f,25292,fz,-364.35
f,25310,fz,-355.27
f,25330,fz,-314.55
f,25346,fz,-334.74
f,25364,fz,-305.47
f,25384,fz,-305.47
f,25400,fz,-305.47
f,25422,fz,-355.27
f,25430,fz,-314.55
f,25454,fz,-334.74
f,25472,fz,-364.35
f,25492,fz,-364.35
f,25508,fz,-364.35
f,25526,fz,-355.27
f,25546,fz,-314.55
f,25562,fz,-334.74
f,25580,fz,-305.47
f,25600,fz,-305.47
f,25616,fz,-305.47
f,25638,fz,-355.27
f,25646,fz,-314.55
f,25670,fz,-334.74
f,25688,fz,-364.35
f,25708,fz,-364.35
f,25724,fz,-364.35
f,25742,fz,-355.27
f,25762,fz,-314.55
f,25778,fz,-334.74
f,25796,fz,-305.47
f,25816,fz,-305.47
f,25832,fz,-305.47
f,25854,fz,-355.27
f,25862,fz,-314.55
f,25886,fz,-334.74
f,25904,fz,-364.35
f,25924,fz,-364.35
f,25940,fz,-364.35
f,25958,fz,-355.27
f,25978,fz,-314.55
f,25994,fz,-334.74
f,26012,fz,-305.47
f,26032,fz,-305.47
f,26048,fz,-305.47
f,26070,fz,-355.27
f,26078,fz,-314.55
f,26102,fz,-334.74
f,26120,fz,-364.35
f,26140,fz,-364.35
f,26156,fz,-364.35
f,26174,fz,-355.27
f,26194,fz,-314.55
f,26210,fz,-334.74
f,26228,fz,-305.47
f,26248,fz,-305.47
f,26264,fz,-305.47
f,26286,fz,-355.27
f,26294,fz,-314.55
f,26318,fz,-334.74
f,26336,fz,-364.35
f,26356,fz,-364.35
f,26372,fz,-364.35
f,26390,fz,-355.27
f,26410,fz,-314.55
f,26426,fz,-334.74
f,26444,fz,-305.47
f,26464,fz,-305.47
f,26480,fz,-305.47
f,26502,fz,-355.27
f,26510,fz,-314.55
f,26534,fz,-334.74
f,26552,fz,-364.35
f,26572,fz,-364.35
f,26588,fz,-364.35
f,26606,fz,-355.27
f,26626,fz,-314.55
f,26642,fz,-334.74
f,26660,fz,-305.47
f,26680,fz,-305.47
f,26696,fz,-305.47
f,26718,fz,-435.68
f,26726,fz,-394.97
f,26750,fz,-415.49
f,26768,fz,-444.77
f,26788,fz,-444.77
f,26804,fz,-444.77
f,26822,fz,-435.68
f,26842,fz,-394.97
f,26858,fz,-415.49
f,26876,fz,-385.88
f,26896,fz,-385.88
f,26912,fz,-385.88
f,26934,fz,-435.68
f,26942,fz,-394.97
f,26966,fz,-415.49
f,26984,fz,-444.77
f,27004,fz,-444.77
f,27020,fz,-444.77
f,27038,fz,-435.68
f,27058,fz,-394.97
f,27074,fz,-415.49
f,27092,fz,-385.88
f,27112,fz,-385.88
f,27128,fz,-385.88
f,27150,fz,-435.68
f,27158,fz,-394.97
f,27182,fz,-415.49
f,27200,fz,-444.77
f,27220,fz,-444.77
f,27236,fz,-444.77
f,27254,fz,-435.68
f,27274,fz,-394.97
f,27290,fz,-415.49
f,27308,fz,-385.88
f,27328,fz,-385.88
f,27344,fz,-385.88
f,27366,fz,-435.68
f,27374,fz,-394.97
f,27398,fz,-415.49
f,27416,fz,-444.77
f,27436,fz,-444.77
f,27452,fz,-444.77
f,27470,fz,-435.68
f,27490,fz,-394.97
f,27506,fz,-415.49
f,27524,fz,-385.88
f,27544,fz,-385.88
f,27560,fz,-385.88
f,27582,fz,-435.68
f,27590,fz,-394.97
f,27614,fz,-415.49
f,27632,fz,-444.77
f,27652,fz,-444.77
f,27668,fz,-444.77
f,27686,fz,-435.68
f,27706,fz,-394.97
f,27722,fz,-415.49
f,27740,fz,-385.88
f,27760,fz,-385.88
f,27776,fz,-385.88
f,27798,fz,-435.68
f,27806,fz,-394.97
f,27830,fz,-415.49
f,27848,fz,-444.77
f,27868,fz,-444.77
f,27884,fz,-444.77
f,27902,fz,-435.68
f,27922,fz,-394.97
f,27938,fz,-415.49
f,27956,fz,-385.88
f,27976,fz,-385.88
f,27992,fz,-385.88
f,28014,fz,-435.68
f,28022,fz,-394.97
f,28046,fz,-415.49
f,28064,fz,-444.77
f,28084,fz,-444.77
f,28100,fz,-444.77
f,28118,fz,-435.68
f,28138,fz,-394.97
f,28154,fz,-415.49
f,28172,fz,-385.88
f,28192,fz,-385.88
f,28208,fz,-385.88

f,28230,fz,-435.68
f,28238,fz,-394.97
f,28262,fz,-415.49
f,28280,fz,-444.77
f,28300,fz,-444.77
f,28316,fz,-444.77
f,28334,fz,-435.68
f,28354,fz,-394.97
f,28370,fz,-415.49
f,28388,fz,-385.88
f,28408,fz,-385.88
f,28424,fz,-385.88
f,28446,fz,-516.1
f,28454,fz,-475.72
f,28478,fz,-495.91
f,28496,fz,-525.18
f,28516,fz,-525.18
f,28532,fz,-525.18
f,28550,fz,-516.1
f,28570,fz,-475.72
f,28586,fz,-495.91
f,28604,fz,-466.64
f,28624,fz,-466.64
f,28640,fz,-466.64
f,28662,fz,-516.1
f,28670,fz,-475.72
f,28694,fz,-495.91
f,28712,fz,-525.18
f,28732,fz,-525.18
f,28748,fz,-525.18
f,28766,fz,-516.1
f,28786,fz,-475.72
f,28802,fz,-495.91
f,28820,fz,-466.64
f,28840,fz,-466.64
f,28856,fz,-466.64
f,28878,fz,-516.1
f,28886,fz,-475.72
f,28910,fz,-495.91
f,28928,fz,-525.18
f,28948,fz,-525.18
f,28964,fz,-525.18
f,28982,fz,-516.1
f,29002,fz,-475.72
f,29018,fz,-495.91
f,29036,fz,-466.64
f,29056,fz,-466.64
f,29072,fz,-466.64
f,29094,fz,-516.1
f,29102,fz,-475.72
f,29126,fz,-495.91
f,29144,fz,-525.18
f,29164,fz,-525.18
f,29180,fz,-525.18
f,29198,fz,-516.1
f,29218,fz,-475.72
f,29234,fz,-495.91
f,29252,fz,-466.64
f,29272,fz,-466.64
f,29288,fz,-466.64
f,29310,fz,-516.1
f,29318,fz,-475.72
f,29342,fz,-495.91
f,29360,fz,-525.18
f,29380,fz,-525.18
f,29396,fz,-525.18
f,29414,fz,-516.1
f,29434,fz,-475.72
f,29450,fz,-495.91
f,29468,fz,-466.64
f,29488,fz,-466.64
f,29504,fz,-466.64
f,29526,fz,-516.1
f,29534,fz,-475.72
f,29558,fz,-495.91
f,29576,fz,-525.18
f,29596,fz,-525.18
f,29612,fz,-525.18
f,29630,fz,-516.1
f,29650,fz,-475.72
f,29666,fz,-495.91
f,29684,fz,-466.64
f,29704,fz,-466.64
f,29720,fz,-466.64
f,29742,fz,-516.1
f,29750,fz,-475.72
f,29774,fz,-495.91
f,29792,fz,-525.18
f,29812,fz,-525.18
f,29828,fz,-525.18
f,29846,fz,-516.1
f,29866,fz,-475.72
f,29882,fz,-495.91
f,29900,fz,-466.64
f,29920,fz,-466.64
f,29936,fz,-466.64
f,29958,fz,-516.1
f,29966,fz,-475.72
f,29990,fz,-495.91
f,30008,fz,-525.18
f,30028,fz,-525.18
f,30044,fz,-525.18
f,30062,fz,-516.1
f,30082,fz,-475.72
f,30098,fz,-495.91
f,30116,fz,-466.64
f,30136,fz,-466.64
f,30152,fz,-466.64
f,30174,fz,-596.85
f,30182,fz,-556.14
f,30206,fz,-576.33
f,30224,fz,-605.93
f,30244,fz,-605.93
f,30260,fz,-605.93
f,30278,fz,-596.85
f,30298,fz,-556.14
f,30314,fz,-576.33
f,30332,fz,-547.05
f,30352,fz,-547.05
f,30368,fz,-547.05
f,30390,fz,-596.85
f,30398,fz,-556.14
f,30422,fz,-576.33
f,30440,fz,-605.93
f,30460,fz,-605.93
f,30476,fz,-605.93
f,30494,fz,-596.85
f,30514,fz,-556.14
f,30530,fz,-576.33
f,30548,fz,-547.05
f,30568,fz,-547.05
f,30584,fz,-547.05
f,30606,fz,-596.85
f,30614,fz,-556.14
f,30638,fz,-576.33
f,30656,fz,-605.93
f,30676,fz,-605.93
f,30692,fz,-605.93
f,30710,fz,-596.85
f,30730,fz,-556.14
f,30746,fz,-576.33
f,30764,fz,-547.05
f,30784,fz,-547.05
f,30800,fz,-547.05
f,30822,fz,-596.85
f,30830,fz,-556.14
f,30854,fz,-576.33
f,30872,fz,-605.93
f,30892,fz,-605.93
f,30908,fz,-605.93
f,30926,fz,-596.85
f,30946,fz,-556.14
f,30962,fz,-576.33
f,30980,fz,-547.05
f,31000,fz,-547.05
f,31016,fz,-547.05
f,31038,fz,-596.85
f,31046,fz,-556.14
f,31070,fz,-576.33
f,31088,fz,-605.93
f,31108,fz,-605.93
f,31124,fz,-605.93
f,31142,fz,-596.85
f,31162,fz,-556.14
f,31178,fz,-576.33
f,31196,fz,-547.05
f,31216,fz,-547.05
f,31232,fz,-547.05
f,31254,fz,-596.85
f,31262,fz,-556.14
f,31286,fz,-576.33
f,31304,fz,-605.93
f,31324,fz,-605.93
f,31340,fz,-605.93
f,31358,fz,-596.85
f,31378,fz,-556.14
f,31394,fz,-576.33
f,31412,fz,-547.05
f,31432,fz,-547.05
f,31448,fz,-547.05
f,31470,fz,-596.85
f,31478,fz,-556.14
f,31502,fz,-576.33
f,31520,fz,-605.93
f,31540,fz,-605.93
f,31556,fz,-605.93
f,31574,fz,-596.85
f,31594,fz,-556.14
f,31610,fz,-576.33
f,31628,fz,-547.05
f,31648,fz,-547.05
f,31664,fz,-547.05
f,31686,fz,-596.85
f,31694,fz,-556.14
f,31718,fz,-576.33
f,31736,fz,-605.93
f,31756,fz,-605.93
f,31772,fz,-605.93
f,31790,fz,-596.85
f,31810,fz,-556.14
f,31826,fz,-576.33
f,31844,fz,-547.05
f,31864,fz,-547.05
f,31880,fz,-547.05
f,31902,fz,-677.27
f,31910,fz,-636.55
f,31934,fz,-657.08
f,31952,fz,-686.35
f,31972,fz,-686.35
f,31988,fz,-686.35
f,32006,fz,-677.27
f,32026,fz,-636.55
f,32042,fz,-657.08
f,32060,fz,-627.47
f,32080,fz,-627.47
f,32096,fz,-627.47
f,32118,fz,-677.27
f,32126,fz,-636.55
f,32150,fz,-657.08
f,32168,fz,-686.35
f,32188,fz,-686.35
f,32204,fz,-686.35
f,32222,fz,-677.27
f,32242,fz,-636.55
f,32258,fz,-657.08
f,32276,fz,-627.47
f,32296,fz,-627.47
f,32312,fz,-627.47
f,32334,fz,-677.27
f,32342,fz,-636.55
f,32366,fz,-657.08
f,32384,fz,-686.35
f,32404,fz,-686.35
f,32420,fz,-686.35
f,32438,fz,-677.27
f,32458,fz,-636.55
f,32474,fz,-657.08
f,32492,fz,-627.47
f,32512,fz,-627.47
f,32528,fz,-627.47
f,32550,fz,-677.27
f,32558,fz,-636.55
f,32582,fz,-657.08
f,32600,fz,-686.35
f,32620,fz,-686.35
f,32636,fz,-686.35
f,32654,fz,-677.27
f,32674,fz,-636.55
f,32690,fz,-657.08
f,32708,fz,-627.47
f,32728,fz,-627.47
f,32744,fz,-627.47
f,32766,fz,-677.27
f,32774,fz,-636.55
f,32798,fz,-657.08
f,32816,fz,-686.35
f,32836,fz,-686.35
f,32852,fz,-686.35
f,32870,fz,-677.27
f,32890,fz,-636.55
f,32906,fz,-657.08
f,32924,fz,-627.47
f,32944,fz,-627.47
f,32960,fz,-627.47
f,32982,fz,-677.27
f,32990,fz,-636.55
f,33014,fz,-657.08
f,33032,fz,-686.35
f,33052,fz,-686.35
f,33068,fz,-686.35
f,33086,fz,-677.27
f,33106,fz,-636.55
f,33122,fz,-657.08
f,33140,fz,-627.47
f,33160,fz,-627.47
f,33176,fz,-627.47
f,33198,fz,-677.27
f,33206,fz,-636.55
f,33230,fz,-657.08
f,33248,fz,-686.35
f,33268,fz,-686.35
f,33284,fz,-686.35
f,33302,fz,-677.27
f,33322,fz,-636.55
f,33338,fz,-657.08
f,33356,fz,-627.47
f,33376,fz,-627.47
f,33392,fz,-627.47
f,33414,fz,-677.27
f,33422,fz,-636.55
f,33446,fz,-657.08
f,33464,fz,-686.35
f,33484,fz,-686.35
f,33500,fz,-686.35
f,33518,fz,-677.27
f,33538,fz,-636.55
f,33554,fz,-657.08
f,33572,fz,-627.47
f,33592,fz,-627.47
f,33608,fz,-627.47
f,5983,fz,531.715
f,5991,fz,572.427
f,6015,fz,552.239
f,6033,fz,522.63
f,6053,fz,522.63
f,6069,fz,522.63
f,6087,fz,531.715
f,6107,fz,572.427
f,6123,fz,552.239
f,6141,fz,581.512
f,6161,fz,581.512
f,6177,fz,581.512
f,6199,fz,531.715
f,6207,fz,572.427
f,6231,fz,552.239
f,6249,fz,522.63
f,6269,fz,522.63
f,6285,fz,522.63
f,6303,fz,531.715
f,6323,fz,572.427
f,6339,fz,552.239
f,6357,fz,581.512
f,6377,fz,581.512
f,6393,fz,581.512
f,6415,fz,531.715
f,6423,fz,572.427
f,6447,fz,552.239
f,6465,fz,522.63
f,6485,fz,522.63
f,6501,fz,522.63
f,6519,fz,531.715
f,6539,fz,572.427

f.6555,fz.552.239
f.6573,fz.581.512
f.6593,fz.581.512
f.6609,fz.581.512
f.6631,fz.531.715
f.6639,fz.572.427
f.6663,fz.552.239
f.6681,fz.522.63
f.6701,fz.522.63
f.6717,fz.522.63
f.6735,fz.531.715
f.6755,fz.572.427
f.6771,fz.552.239
f.6789,fz.581.512
f.6809,fz.581.512
f.6825,fz.581.512
f.6847,fz.531.715
f.6855,fz.572.427
f.6879,fz.552.239
f.6897,fz.522.63
f.6917,fz.522.63
f.6933,fz.522.63
f.6951,fz.531.715
f.6971,fz.572.427
f.6987,fz.552.239
f.7005,fz.581.512
f.7025,fz.581.512
f.7041,fz.581.512
f.7063,fz.531.715
f.7071,fz.572.427
f.7095,fz.552.239
f.7113,fz.522.63
f.7133,fz.522.63
f.7149,fz.522.63
f.7167,fz.531.715
f.7187,fz.572.427
f.7203,fz.552.239
f.7221,fz.581.512
f.7241,fz.581.512
f.7257,fz.581.512
f.7279,fz.531.715
f.7287,fz.572.427
f.7311,fz.552.239
f.7329,fz.522.63
f.7349,fz.522.63
f.7365,fz.522.63
f.7383,fz.531.715
f.7403,fz.572.427
f.7419,fz.552.239
f.7437,fz.581.512
f.7457,fz.581.512
f.7473,fz.581.512
f.7495,fz.531.715
f.7503,fz.572.427
f.7527,fz.552.239
f.7545,fz.522.63
f.7565,fz.522.63
f.7581,fz.522.63
f.7599,fz.531.715
f.7619,fz.572.427
f.7635,fz.552.239
f.7653,fz.581.512
f.7673,fz.581.512
f.7689,fz.581.512
f.7711,fz.451.299
f.7719,fz.492.012
f.7743,fz.471.487
f.7761,fz.442.215
f.7781,fz.442.215
f.7797,fz.442.215
f.7815,fz.451.299
f.7835,fz.492.012
f.7851,fz.471.487
f.7869,fz.501.096
f.7889,fz.501.096
f.7905,fz.501.096
f.7927,fz.451.299
f.7935,fz.492.012
f.7959,fz.471.487
f.7977,fz.442.215
f.7997,fz.442.215
f.8013,fz.442.215
f.8031,fz.451.299
f.8051,fz.492.012
f.8067,fz.471.487
f.8085,fz.501.096
f.8105,fz.501.096
f.8121,fz.501.096
f.8143,fz.451.299
f.8151,fz.492.012
f.8175,fz.471.487
f.8193,fz.442.215
f.8213,fz.442.215
f.8229,fz.442.215
f.8247,fz.451.299
f.8267,fz.492.012
f.8283,fz.471.487
f.8301,fz.501.096
f.8321,fz.501.096
f.8337,fz.501.096
f.8359,fz.451.299
f.8367,fz.492.012
f.8391,fz.471.487
f.8409,fz.442.215
f.8429,fz.442.215
f.8445,fz.442.215
f.8463,fz.451.299
f.8483,fz.492.012
f.8499,fz.471.487
f.8517,fz.501.096
f.8537,fz.501.096
f.8553,fz.501.096
f.8575,fz.451.299
f.8583,fz.492.012
f.8607,fz.471.487
f.8625,fz.442.215
f.8645,fz.442.215
f.8661,fz.442.215
f.8679,fz.451.299
f.8699,fz.492.012
f.8715,fz.471.487
f.8733,fz.501.096
f.8753,fz.501.096
f.8769,fz.501.096
f.8791,fz.451.299
f.8799,fz.492.012
f.8823,fz.471.487
f.8841,fz.442.215
f.8861,fz.442.215
f.8877,fz.442.215
f.8895,fz.451.299
f.8915,fz.492.012
f.8931,fz.471.487
f.8949,fz.501.096
f.8969,fz.501.096
f.8985,fz.501.096
f.9007,fz.451.299
f.9015,fz.492.012
f.9039,fz.471.487
f.9057,fz.442.215
f.9077,fz.442.215
f.9093,fz.442.215
f.9111,fz.451.299
f.9131,fz.492.012
f.9147,fz.471.487
f.9165,fz.501.096
f.9185,fz.501.096
f.9201,fz.501.096
f.9223,fz.451.299
f.9231,fz.492.012
f.9255,fz.471.487
f.9273,fz.442.215
f.9293,fz.442.215
f.9309,fz.442.215
f.9327,fz.451.299
f.9347,fz.492.012
f.9363,fz.471.487
f.9381,fz.501.096
f.9401,fz.501.096
f.9417,fz.501.096
f.9439,fz.370.884
f.9447,fz.411.26
f.9471,fz.391.072
f.9489,fz.361.799
f.9509,fz.361.799
f.9525,fz.361.799
f.9543,fz.370.884
f.9563,fz.411.26
f.9579,fz.391.072
f.9597,fz.420.344
f.9617,fz.420.344
f.9633,fz.420.344
f.9655,fz.370.884
f.9663,fz.411.26
f.9687,fz.391.072
f.9705,fz.361.799
f.9725,fz.361.799
f.9741,fz.361.799
f.9759,fz.370.884
f.9779,fz.411.26
f.9795,fz.391.072
f.9813,fz.420.344
f.9833,fz.420.344
f.9849,fz.420.344
f.9871,fz.370.884
f.9879,fz.411.26
f.9903,fz.391.072
f.9921,fz.361.799
f.9941,fz.361.799
f.9957,fz.361.799
f.9975,fz.370.884
f.9995,fz.411.26
f.10011,fz.391.072
f.10029,fz.420.344
f.10049,fz.420.344
f.10065,fz.420.344
f.10087,fz.370.884
f.10095,fz.411.26
f.10119,fz.391.072
f.10137,fz.361.799
f.10157,fz.361.799
f.10173,fz.361.799
f.10191,fz.370.884
f.10211,fz.411.26
f.10227,fz.391.072
f.10245,fz.420.344
f.10265,fz.420.344
f.10281,fz.420.344
f.10303,fz.370.884
f.10311,fz.411.26
f.10335,fz.391.072
f.10353,fz.361.799
f.10373,fz.361.799
f.10389,fz.361.799
f.10407,fz.370.884
f.10427,fz.411.26
f.10443,fz.391.072
f.10461,fz.420.344
f.10481,fz.420.344
f.10497,fz.420.344
f.10519,fz.370.884
f.10527,fz.411.26
f.10551,fz.391.072
f.10569,fz.361.799
f.10589,fz.361.799
f.10605,fz.361.799
f.10623,fz.370.884
f.10643,fz.411.26
f.10659,fz.391.072
f.10677,fz.420.344
f.10697,fz.420.344
f.10713,fz.420.344
f.10735,fz.370.884
f.10743,fz.411.26
f.10767,fz.391.072
f.10785,fz.361.799
f.10805,fz.361.799
f.10821,fz.361.799
f.10839,fz.370.884
f.10859,fz.411.26
f.10875,fz.391.072
f.10893,fz.420.344
f.10913,fz.420.344
f.10929,fz.420.344
f.10951,fz.370.884
f.10959,fz.411.26
f.10983,fz.391.072
f.11001,fz.361.799
f.11021,fz.361.799
f.11037,fz.361.799
f.11055,fz.370.884
f.11075,fz.411.26
f.11091,fz.391.072
f.11109,fz.420.344
f.11129,fz.420.344
f.11145,fz.420.344
f.11167,fz.290.131
f.11175,fz.330.844
f.11199,fz.310.656
f.11217,fz.281.047
f.11237,fz.281.047
f.11253,fz.281.047
f.11271,fz.290.131
f.11291,fz.330.844
f.11307,fz.310.656
f.11325,fz.339.929
f.11345,fz.339.929
f.11361,fz.339.929
f.11383,fz.290.131
f.11391,fz.330.844
f.11415,fz.310.656
f.11433,fz.281.047
f.11453,fz.281.047
f.11469,fz.281.047
f.11487,fz.290.131
f.11507,fz.330.844
f.11523,fz.310.656
f.11541,fz.339.929
f.11561,fz.339.929
f.11577,fz.339.929
f.11599,fz.290.131
f.11607,fz.330.844
f.11631,fz.310.656
f.11649,fz.281.047
f.11669,fz.281.047
f.11685,fz.281.047
f.11703,fz.290.131
f.11723,fz.330.844
f.11739,fz.310.656
f.11757,fz.339.929
f.11777,fz.339.929
f.11793,fz.339.929
f.11815,fz.290.131
f.11823,fz.330.844
f.11847,fz.310.656
f.11865,fz.281.047
f.11885,fz.281.047
f.11901,fz.281.047
f.11919,fz.290.131
f.11939,fz.330.844
f.11955,fz.310.656
f.11973,fz.339.929
f.11993,fz.339.929
f.12009,fz.339.929
f.12031,fz.290.131
f.12039,fz.330.844
f.12063,fz.310.656
f.12081,fz.281.047
f.12101,fz.281.047
f.12117,fz.281.047
f.12135,fz.290.131
f.12155,fz.330.844
f.12171,fz.310.656
f.12189,fz.339.929
f.12209,fz.339.929
f.12225,fz.339.929
f.12247,fz.290.131
f.12255,fz.330.844
f.12279,fz.310.656
f.12297,fz.281.047
f.12317,fz.281.047
f.12333,fz.281.047
f.12351,fz.290.131
f.12371,fz.330.844
f.12387,fz.310.656
f.12405,fz.339.929
f.12425,fz.339.929
f.12441,fz.339.929
f.12463,fz.290.131
f.12471,fz.330.844
f.12495,fz.310.656
f.12513,fz.281.047

f,12533,fz,281.047
f,12549,fz,281.047
f,12567,fz,290.131
f,12587,fz,330.844
f,12603,fz,310.656
f,12621,fz,339.929
f,12641,fz,339.929
f,12657,fz,339.929
f,12679,fz,290.131
f,12687,fz,330.844
f,12711,fz,310.656
f,12729,fz,281.047
f,12749,fz,281.047
f,12765,fz,281.047
f,12783,fz,290.131
f,12803,fz,330.844
f,12819,fz,310.656
f,12837,fz,339.929
f,12857,fz,339.929
f,12873,fz,339.929
f,12895,fz,209.716
f,12903,fz,250.428
f,12927,fz,229.904
f,12945,fz,200.631
f,12965,fz,200.631
f,12981,fz,200.631
f,12999,fz,209.716
f,13019,fz,250.428
f,13035,fz,229.904
f,13053,fz,259.513
f,13073,fz,259.513
f,13089,fz,259.513
f,13111,fz,209.716
f,13119,fz,250.428
f,13143,fz,229.904
f,13161,fz,200.631
f,13181,fz,200.631
f,13197,fz,200.631
f,13215,fz,209.716
f,13235,fz,250.428
f,13251,fz,229.904
f,13269,fz,259.513
f,13289,fz,259.513
f,13305,fz,259.513
f,13327,fz,209.716
f,13335,fz,250.428
f,13359,fz,229.904
f,13377,fz,200.631
f,13397,fz,200.631
f,13413,fz,200.631
f,13431,fz,209.716
f,13451,fz,250.428
f,13467,fz,229.904
f,13485,fz,259.513
f,13505,fz,259.513
f,13521,fz,259.513
f,13543,fz,209.716
f,13551,fz,250.428
f,13575,fz,229.904
f,13593,fz,200.631
f,13613,fz,200.631
f,13629,fz,200.631
f,13647,fz,209.716
f,13667,fz,250.428
f,13683,fz,229.904
f,13701,fz,259.513
f,13721,fz,259.513
f,13737,fz,259.513
f,13759,fz,209.716
f,13767,fz,250.428
f,13791,fz,229.904
f,13809,fz,200.631
f,13829,fz,200.631
f,13845,fz,200.631
f,13863,fz,209.716
f,13883,fz,250.428
f,13899,fz,229.904
f,13917,fz,259.513
f,13937,fz,259.513
f,13953,fz,259.513
f,13975,fz,209.716
f,13983,fz,250.428
f,14007,fz,229.904
f,14025,fz,200.631
f,14045,fz,200.631
f,14061,fz,200.631
f,14079,fz,209.716
f,14099,fz,250.428
f,14115,fz,229.904
f,14133,fz,259.513
f,14153,fz,259.513
f,14169,fz,259.513
f,14191,fz,209.716
f,14199,fz,250.428
f,14223,fz,229.904
f,14241,fz,200.631
f,14261,fz,200.631
f,14277,fz,200.631
f,14295,fz,209.716
f,14315,fz,250.428
f,14331,fz,229.904
f,14349,fz,259.513
f,14369,fz,259.513
f,14385,fz,259.513
f,14407,fz,209.716
f,14415,fz,250.428
f,14439,fz,229.904
f,14457,fz,200.631
f,14477,fz,200.631
f,14493,fz,200.631
f,14511,fz,209.716
f,14531,fz,250.428
f,14547,fz,229.904
f,14565,fz,259.513
f,14585,fz,259.513
f,14601,fz,259.513
f,14623,fz,129.3
f,14631,fz,170.012
f,14655,fz,149.488
f,14673,fz,120.215
f,14693,fz,120.215
f,14709,fz,120.215
f,14727,fz,129.3
f,14747,fz,170.012
f,14763,fz,149.488
f,14781,fz,179.097
f,14801,fz,179.097
f,14817,fz,179.097
f,14839,fz,129.3
f,14847,fz,170.012
f,14871,fz,149.488
f,14889,fz,120.215
f,14909,fz,120.215
f,14925,fz,120.215
f,14943,fz,129.3
f,14963,fz,170.012
f,14979,fz,149.488
f,14997,fz,179.097
f,15017,fz,179.097
f,15033,fz,179.097
f,15055,fz,129.3
f,15063,fz,170.012
f,15087,fz,149.488
f,15105,fz,120.215
f,15125,fz,120.215
f,15141,fz,120.215
f,15159,fz,129.3
f,15179,fz,170.012
f,15195,fz,149.488
f,15213,fz,179.097
f,15233,fz,179.097
f,15249,fz,179.097
f,15271,fz,129.3
f,15279,fz,170.012
f,15303,fz,149.488
f,15321,fz,120.215
f,15341,fz,120.215
f,15357,fz,120.215
f,15375,fz,129.3
f,15395,fz,170.012
f,15411,fz,149.488
f,15429,fz,179.097
f,15449,fz,179.097
f,15465,fz,179.097
f,15487,fz,129.3
f,15495,fz,170.012
f,15519,fz,149.488
f,15537,fz,120.215
f,15557,fz,120.215
f,15573,fz,120.215
f,15591,fz,129.3
f,15611,fz,170.012
f,15627,fz,149.488
f,15645,fz,179.097
f,15665,fz,179.097
f,15681,fz,179.097
f,15703,fz,129.3
f,15711,fz,170.012
f,15735,fz,149.488
f,15753,fz,120.215
f,15773,fz,120.215
f,15789,fz,120.215
f,15807,fz,129.3
f,15827,fz,170.012
f,15843,fz,149.488
f,15861,fz,179.097
f,15881,fz,179.097
f,15897,fz,179.097
f,15919,fz,129.3
f,15927,fz,170.012
f,15951,fz,149.488
f,15969,fz,120.215
f,15989,fz,120.215
f,16005,fz,120.215
f,16023,fz,129.3
f,16043,fz,170.012
f,16059,fz,149.488
f,16077,fz,179.097
f,16097,fz,179.097
f,16113,fz,179.097
f,16135,fz,129.3
f,16143,fz,170.012
f,16167,fz,149.488
f,16185,fz,120.215
f,16205,fz,120.215
f,16221,fz,120.215
f,16239,fz,129.3
f,16259,fz,170.012
f,16275,fz,149.488
f,16293,fz,179.097
f,16313,fz,179.097
f,16329,fz,179.097
f,16351,fz,48.5478
f,16359,fz,89.2603
f,16383,fz,69.0723
f,16401,fz,39.7996
f,16421,fz,39.7996
f,16437,fz,39.7996
f,16455,fz,48.5478
f,16475,fz,89.2603
f,16491,fz,69.0723
f,16509,fz,98.3449
f,16529,fz,98.3449
f,16545,fz,98.3449
f,16567,fz,48.5478
f,16575,fz,89.2603
f,16599,fz,69.0723
f,16617,fz,39.7996
f,16637,fz,39.7996
f,16653,fz,39.7996
f,16671,fz,48.5478
f,16691,fz,89.2603
f,16707,fz,69.0723
f,16725,fz,98.3449
f,16745,fz,98.3449
f,16761,fz,98.3449
f,16783,fz,48.5478
f,16791,fz,89.2603
f,16815,fz,69.0723
f,16833,fz,39.7996
f,16853,fz,39.7996
f,16869,fz,39.7996
f,16887,fz,48.5478
f,16907,fz,89.2603
f,16923,fz,69.0723
f,16941,fz,98.3449
f,16961,fz,98.3449
f,16977,fz,98.3449
f,16999,fz,48.5478
f,17007,fz,89.2603
f,17031,fz,69.0723
f,17049,fz,39.7996
f,17069,fz,39.7996
f,17085,fz,39.7996
f,17103,fz,48.5478
f,17123,fz,89.2603
f,17139,fz,69.0723
f,17157,fz,98.3449
f,17177,fz,98.3449
f,17193,fz,98.3449
f,17215,fz,48.5478
f,17223,fz,89.2603
f,17247,fz,69.0723
f,17265,fz,39.7996
f,17285,fz,39.7996
f,17301,fz,39.7996
f,17319,fz,48.5478
f,17339,fz,89.2603
f,17355,fz,69.0723
f,17373,fz,98.3449
f,17393,fz,98.3449
f,17409,fz,98.3449
f,17431,fz,48.5478
f,17439,fz,89.2603
f,17463,fz,69.0723
f,17481,fz,39.7996
f,17501,fz,39.7996
f,17517,fz,39.7996
f,17535,fz,48.5478
f,17555,fz,89.2603
f,17571,fz,69.0723
f,17589,fz,98.3449
f,17609,fz,98.3449
f,17625,fz,98.3449
f,17647,fz,48.5478
f,17655,fz,89.2603
f,17679,fz,69.0723
f,17697,fz,39.7996
f,17717,fz,39.7996
f,17733,fz,39.7996
f,17751,fz,48.5478
f,17771,fz,89.2603
f,17787,fz,69.0723
f,17805,fz,98.3449
f,17825,fz,98.3449
f,17841,fz,98.3449
f,17863,fz,48.5478
f,17871,fz,89.2603
f,17895,fz,69.0723
f,17913,fz,39.7996
f,17933,fz,39.7996
f,17949,fz,39.7996
f,17967,fz,48.5478
f,17987,fz,89.2603
f,18003,fz,69.0723
f,18021,fz,98.3449
f,18041,fz,98.3449
f,18057,fz,98.3449
f,18079,fz,-31.868
f,18087,fz,8.84461
f,18111,fz,-11.343
f,18129,fz,-40.953
f,18149,fz,-40.953
f,18165,fz,-40.953
f,18183,fz,-31.868
f,18203,fz,8.84461
f,18219,fz,-11.343
f,18237,fz,17.9292
f,18257,fz,17.9292
f,18273,fz,17.9292
f,18295,fz,-31.868
f,18303,fz,8.84461
f,18327,fz,-11.343
f,18345,fz,-40.953
f,18365,fz,-40.953
f,18381,fz,-40.953
f,18399,fz,-31.868
f,18419,fz,8.84461
f,18435,fz,-11.343
f,18453,fz,17.9292
f,18473,fz,17.9292
f,18489,fz,17.9292

f,18511,fz,-31.868
f,18519,fz,8.84461
f,18543,fz,-11.343
f,18561,fz,-40.953
f,18581,fz,-40.953
f,18597,fz,-40.953
f,18615,fz,-31.868
f,18635,fz,8.84461
f,18651,fz,-11.343
f,18669,fz,17.9292
f,18689,fz,17.9292
f,18705,fz,17.9292
f,18727,fz,-31.868
f,18735,fz,8.84461
f,18759,fz,-11.343
f,18777,fz,-40.953
f,18797,fz,-40.953
f,18813,fz,-40.953
f,18831,fz,-31.868
f,18851,fz,8.84461
f,18867,fz,-11.343
f,18885,fz,17.9292
f,18905,fz,17.9292
f,18921,fz,17.9292
f,18943,fz,-31.868
f,18951,fz,8.84461
f,18975,fz,-11.343
f,18993,fz,-40.953
f,19013,fz,-40.953
f,19029,fz,-40.953
f,19047,fz,-31.868
f,19067,fz,8.84461
f,19083,fz,-11.343
f,19101,fz,17.9292
f,19121,fz,17.9292
f,19137,fz,17.9292
f,19159,fz,-31.868
f,19167,fz,8.84461
f,19191,fz,-11.343
f,19209,fz,-40.953
f,19229,fz,-40.953
f,19245,fz,-40.953
f,19263,fz,-31.868
f,19283,fz,8.84461
f,19299,fz,-11.343
f,19317,fz,17.9292
f,19337,fz,17.9292
f,19353,fz,17.9292
f,19375,fz,-31.868
f,19383,fz,8.84461
f,19407,fz,-11.343
f,19425,fz,-40.953
f,19445,fz,-40.953
f,19461,fz,-40.953
f,19479,fz,-31.868
f,19499,fz,8.84461
f,19515,fz,-11.343
f,19533,fz,17.9292
f,19553,fz,17.9292
f,19569,fz,17.9292
f,19591,fz,-31.868
f,19599,fz,8.84461
f,19623,fz,-11.343
f,19641,fz,-40.953
f,19661,fz,-40.953
f,19677,fz,-40.953
f,19695,fz,-31.868
f,19715,fz,8.84461
f,19731,fz,-11.343
f,19749,fz,17.9292
f,19769,fz,17.9292
f,19785,fz,17.9292
f,19807,fz,-112.28
f,19815,fz,-71.571
f,19839,fz,-92.096
f,19857,fz,-121.37
f,19877,fz,-121.37
f,19893,fz,-121.37
f,19911,fz,-112.28
f,19931,fz,-71.571
f,19947,fz,-92.096
f,19965,fz,-62.486
f,19985,fz,-62.486
f,20001,fz,-62.486
f,20023,fz,-112.28
f,20031,fz,-71.571
f,20055,fz,-92.096
f,20073,fz,-121.37
f,20093,fz,-121.37
f,20109,fz,-121.37
f,20127,fz,-112.28
f,20147,fz,-71.571
f,20163,fz,-92.096
f,20181,fz,-62.486
f,20201,fz,-62.486
f,20217,fz,-62.486
f,20239,fz,-112.28
f,20247,fz,-71.571
f,20271,fz,-92.096
f,20289,fz,-121.37
f,20309,fz,-121.37
f,20325,fz,-121.37
f,20343,fz,-112.28
f,20363,fz,-71.571
f,20379,fz,-92.096
f,20397,fz,-62.486
f,20417,fz,-62.486
f,20433,fz,-62.486
f,20455,fz,-112.28
f,20463,fz,-71.571
f,20487,fz,-92.096
f,20505,fz,-121.37
f,20525,fz,-121.37
f,20541,fz,-121.37
f,20559,fz,-112.28
f,20579,fz,-71.571
f,20595,fz,-92.096
f,20613,fz,-62.486
f,20633,fz,-62.486
f,20649,fz,-62.486
f,20671,fz,-112.28
f,20679,fz,-71.571
f,20703,fz,-92.096
f,20721,fz,-121.37
f,20741,fz,-121.37
f,20757,fz,-121.37
f,20775,fz,-112.28
f,20795,fz,-71.571
f,20811,fz,-92.096
f,20829,fz,-62.486
f,20849,fz,-62.486
f,20865,fz,-62.486
f,20887,fz,-112.28
f,20895,fz,-71.571
f,20919,fz,-92.096
f,20937,fz,-121.37
f,20957,fz,-121.37
f,20973,fz,-121.37
f,20991,fz,-112.28
f,21011,fz,-71.571
f,21027,fz,-92.096
f,21045,fz,-62.486
f,21065,fz,-62.486
f,21081,fz,-62.486
f,21103,fz,-112.28
f,21111,fz,-71.571
f,21135,fz,-92.096
f,21153,fz,-121.37
f,21173,fz,-121.37
f,21189,fz,-121.37
f,21207,fz,-112.28
f,21227,fz,-71.571
f,21243,fz,-92.096
f,21261,fz,-62.486
f,21281,fz,-62.486
f,21297,fz,-62.486
f,21319,fz,-112.28
f,21327,fz,-71.571
f,21351,fz,-92.096
f,21369,fz,-121.37
f,21389,fz,-121.37
f,21405,fz,-121.37
f,21423,fz,-112.28
f,21443,fz,-71.571
f,21459,fz,-92.096
f,21477,fz,-62.486
f,21497,fz,-62.486
f,21513,fz,-62.486
f,21535,fz,-192.7
f,21543,fz,-151.99
f,21567,fz,-172.51
f,21585,fz,-201.78
f,21605,fz,-201.78
f,21621,fz,-201.78
f,21639,fz,-192.7
f,21659,fz,-151.99
f,21675,fz,-172.51
f,21693,fz,-143.24
f,21713,fz,-143.24
f,21729,fz,-143.24
f,21751,fz,-192.7
f,21759,fz,-151.99
f,21783,fz,-172.51
f,21801,fz,-201.78
f,21821,fz,-201.78
f,21837,fz,-201.78
f,21855,fz,-192.7
f,21875,fz,-151.99
f,21891,fz,-172.51
f,21909,fz,-143.24
f,21929,fz,-143.24
f,21945,fz,-143.24
f,21967,fz,-192.7
f,21975,fz,-151.99
f,21999,fz,-172.51
f,22017,fz,-201.78
f,22037,fz,-201.78
f,22053,fz,-201.78
f,22071,fz,-192.7
f,22091,fz,-151.99
f,22107,fz,-172.51
f,22125,fz,-143.24
f,22145,fz,-143.24
f,22161,fz,-143.24
f,22183,fz,-192.7
f,22191,fz,-151.99
f,22215,fz,-172.51
f,22233,fz,-201.78
f,22253,fz,-201.78
f,22269,fz,-201.78
f,22287,fz,-192.7
f,22307,fz,-151.99
f,22323,fz,-172.51
f,22341,fz,-143.24
f,22361,fz,-143.24
f,22377,fz,-143.24
f,22399,fz,-192.7
f,22407,fz,-151.99
f,22431,fz,-172.51
f,22449,fz,-201.78
f,22469,fz,-201.78
f,22485,fz,-201.78
f,22503,fz,-192.7
f,22523,fz,-151.99
f,22539,fz,-172.51
f,22557,fz,-143.24
f,22577,fz,-143.24
f,22593,fz,-143.24
f,22615,fz,-192.7
f,22623,fz,-151.99
f,22647,fz,-172.51
f,22665,fz,-201.78
f,22685,fz,-201.78
f,22701,fz,-201.78
f,22719,fz,-192.7
f,22739,fz,-151.99
f,22755,fz,-172.51
f,22773,fz,-143.24
f,22793,fz,-143.24
f,22809,fz,-143.24
f,22831,fz,-192.7
f,22839,fz,-151.99
f,22863,fz,-172.51
f,22881,fz,-201.78
f,22901,fz,-201.78
f,22917,fz,-201.78
f,22935,fz,-192.7
f,22955,fz,-151.99
f,22971,fz,-172.51
f,22989,fz,-143.24
f,23009,fz,-143.24
f,23025,fz,-143.24
f,23047,fz,-192.7
f,23065,fz,-151.99
f,23079,fz,-172.51
f,23097,fz,-201.78
f,23117,fz,-201.78
f,23133,fz,-201.78
f,23151,fz,-192.7
f,23171,fz,-151.99
f,23187,fz,-172.51
f,23205,fz,-143.24
f,23225,fz,-143.24
f,23241,fz,-143.24
f,23263,fz,-273.45
f,23271,fz,-232.74
f,23295,fz,-252.93
f,23313,fz,-282.54
f,23333,fz,-282.54
f,23349,fz,-282.54
f,23367,fz,-273.45
f,23387,fz,-232.74
f,23403,fz,-252.93
f,23421,fz,-223.65
f,23441,fz,-223.65
f,23457,fz,-223.65
f,23479,fz,-273.45
f,23487,fz,-232.74
f,23511,fz,-252.93
f,23529,fz,-282.54
f,23549,fz,-282.54
f,23565,fz,-282.54
f,23583,fz,-273.45
f,23603,fz,-232.74
f,23619,fz,-252.93
f,23637,fz,-223.65
f,23657,fz,-223.65
f,23673,fz,-223.65
f,23695,fz,-273.45
f,23703,fz,-232.74
f,23727,fz,-252.93
f,23745,fz,-282.54
f,23765,fz,-282.54
f,23781,fz,-282.54
f,23799,fz,-273.45
f,23819,fz,-232.74
f,23835,fz,-252.93
f,23853,fz,-223.65
f,23873,fz,-223.65
f,23889,fz,-223.65
f,23911,fz,-273.45
f,23919,fz,-232.74
f,23943,fz,-252.93
f,23961,fz,-282.54
f,23981,fz,-282.54
f,23997,fz,-282.54
f,24015,fz,-273.45
f,24035,fz,-232.74
f,24051,fz,-252.93
f,24069,fz,-223.65
f,24089,fz,-223.65
f,24105,fz,-223.65
f,24127,fz,-273.45
f,24135,fz,-232.74
f,24159,fz,-252.93
f,24177,fz,-282.54
f,24197,fz,-282.54
f,24213,fz,-282.54
f,24231,fz,-273.45
f,24251,fz,-232.74
f,24267,fz,-252.93
f,24285,fz,-223.65
f,24305,fz,-223.65
f,24321,fz,-223.65
f,24343,fz,-273.45
f,24351,fz,-232.74
f,24375,fz,-252.93
f,24393,fz,-282.54
f,24413,fz,-282.54
f,24429,fz,-282.54
f,24447,fz,-273.45
f,24467,fz,-232.74

f,24483,fz,-252.93
f,24501,fz,-223.65
f,24521,fz,-223.65
f,24537,fz,-223.65
f,24559,fz,-273.45
f,24567,fz,-232.74
f,24591,fz,-252.93
f,24609,fz,-282.54
f,24629,fz,-282.54
f,24645,fz,-282.54
f,24663,fz,-273.45
f,24683,fz,-232.74
f,24699,fz,-252.93
f,24717,fz,-223.65
f,24737,fz,-223.65
f,24753,fz,-223.65
f,24775,fz,-273.45
f,24783,fz,-232.74
f,24807,fz,-252.93
f,24825,fz,-282.54
f,24845,fz,-282.54
f,24861,fz,-282.54
f,24879,fz,-273.45
f,24899,fz,-232.74
f,24915,fz,-252.93
f,24933,fz,-223.65
f,24953,fz,-223.65
f,24969,fz,-223.65
f,24991,fz,-353.87
f,24999,fz,-313.15
f,25023,fz,-333.34
f,25041,fz,-362.95
f,25061,fz,-362.95
f,25077,fz,-362.95
f,25095,fz,-353.87
f,25115,fz,-313.15
f,25131,fz,-333.34
f,25149,fz,-304.07
f,25169,fz,-304.07
f,25185,fz,-304.07
f,25207,fz,-353.87
f,25215,fz,-313.15
f,25239,fz,-333.34
f,25257,fz,-362.95
f,25277,fz,-362.95
f,25293,fz,-362.95
f,25311,fz,-353.87
f,25331,fz,-313.15
f,25347,fz,-333.34
f,25365,fz,-304.07
f,25385,fz,-304.07
f,25401,fz,-304.07
f,25423,fz,-353.87
f,25431,fz,-313.15
f,25455,fz,-333.34
f,25473,fz,-362.95
f,25493,fz,-362.95
f,25509,fz,-362.95
f,25527,fz,-353.87
f,25547,fz,-313.15
f,25563,fz,-333.34
f,25581,fz,-304.07
f,25601,fz,-304.07
f,25617,fz,-304.07
f,25639,fz,-353.87
f,25647,fz,-313.15
f,25671,fz,-333.34
f,25689,fz,-362.95
f,25709,fz,-362.95
f,25725,fz,-362.95
f,25743,fz,-353.87
f,25763,fz,-313.15
f,25779,fz,-333.34
f,25797,fz,-304.07
f,25817,fz,-304.07
f,25833,fz,-304.07
f,25855,fz,-353.87
f,25863,fz,-313.15
f,25887,fz,-333.34
f,25905,fz,-362.95
f,25925,fz,-362.95
f,25941,fz,-362.95
f,25959,fz,-353.87
f,25979,fz,-313.15
f,25995,fz,-333.34
f,26013,fz,-304.07
f,26033,fz,-304.07
f,26049,fz,-304.07
f,26071,fz,-353.87
f,26079,fz,-313.15
f,26103,fz,-333.34
f,26121,fz,-362.95
f,26141,fz,-362.95
f,26157,fz,-362.95
f,26175,fz,-353.87
f,26195,fz,-313.15
f,26211,fz,-333.34
f,26229,fz,-304.07
f,26249,fz,-304.07
f,26265,fz,-304.07
f,26287,fz,-353.87
f,26295,fz,-313.15
f,26319,fz,-333.34
f,26337,fz,-362.95
f,26357,fz,-362.95
f,26373,fz,-362.95
f,26391,fz,-353.87
f,26411,fz,-313.15
f,26427,fz,-333.34
f,26445,fz,-304.07
f,26465,fz,-304.07
f,26481,fz,-304.07
f,26503,fz,-353.87
f,26511,fz,-313.15
f,26535,fz,-333.34
f,26553,fz,-362.95
f,26573,fz,-362.95
f,26589,fz,-362.95
f,26607,fz,-353.87
f,26627,fz,-313.15
f,26643,fz,-333.34
f,26661,fz,-304.07
f,26681,fz,-304.07
f,26697,fz,-304.07
f,26719,fz,-434.28
f,26727,fz,-393.57
f,26751,fz,-414.09
f,26769,fz,-443.37
f,26789,fz,-443.37
f,26805,fz,-443.37
f,26823,fz,-434.28
f,26843,fz,-393.57
f,26859,fz,-414.09
f,26877,fz,-384.49
f,26897,fz,-384.49
f,26913,fz,-384.49
f,26935,fz,-434.28
f,26943,fz,-393.57
f,26967,fz,-414.09
f,26985,fz,-443.37
f,27005,fz,-443.37
f,27021,fz,-443.37
f,27039,fz,-434.28
f,27059,fz,-393.57
f,27075,fz,-414.09
f,27093,fz,-384.49
f,27113,fz,-384.49
f,27129,fz,-384.49
f,27151,fz,-434.28
f,27159,fz,-393.57
f,27183,fz,-414.09
f,27201,fz,-443.37
f,27221,fz,-443.37
f,27237,fz,-443.37
f,27255,fz,-434.28
f,27275,fz,-393.57
f,27291,fz,-414.09
f,27309,fz,-384.49
f,27329,fz,-384.49
f,27345,fz,-384.49
f,27367,fz,-434.28
f,27375,fz,-393.57
f,27399,fz,-414.09
f,27417,fz,-443.37
f,27437,fz,-443.37
f,27453,fz,-443.37
f,27471,fz,-434.28
f,27491,fz,-393.57
f,27507,fz,-414.09
f,27525,fz,-384.49
f,27545,fz,-384.49
f,27561,fz,-384.49
f,27583,fz,-434.28
f,27591,fz,-393.57
f,27615,fz,-414.09
f,27633,fz,-443.37
f,27653,fz,-443.37
f,27669,fz,-443.37
f,27687,fz,-434.28
f,27707,fz,-393.57
f,27723,fz,-414.09
f,27741,fz,-384.49
f,27761,fz,-384.49
f,27777,fz,-384.49
f,27799,fz,-434.28
f,27807,fz,-393.57
f,27831,fz,-414.09
f,27849,fz,-443.37
f,27869,fz,-443.37
f,27885,fz,-443.37
f,27903,fz,-434.28
f,27923,fz,-393.57
f,27939,fz,-414.09
f,27957,fz,-384.49
f,27977,fz,-384.49
f,27993,fz,-384.49
f,28015,fz,-434.28
f,28023,fz,-393.57
f,28047,fz,-414.09
f,28065,fz,-443.37
f,28085,fz,-443.37
f,28101,fz,-443.37
f,28119,fz,-434.28
f,28139,fz,-393.57
f,28155,fz,-414.09
f,28173,fz,-384.49
f,28193,fz,-384.49
f,28209,fz,-384.49
f,28231,fz,-434.28
f,28239,fz,-393.57
f,28263,fz,-414.09
f,28281,fz,-443.37
f,28301,fz,-443.37
f,28317,fz,-443.37
f,28335,fz,-434.28
f,28355,fz,-393.57
f,28371,fz,-414.09
f,28389,fz,-384.49
f,28409,fz,-384.49
f,28425,fz,-384.49
f,28447,fz,-514.7
f,28455,fz,-474.32
f,28479,fz,-494.51
f,28497,fz,-523.78
f,28517,fz,-523.78
f,28533,fz,-523.78
f,28551,fz,-514.7
f,28571,fz,-474.32
f,28587,fz,-494.51
f,28605,fz,-465.24
f,28625,fz,-465.24
f,28641,fz,-465.24
f,28663,fz,-514.7
f,28671,fz,-474.32
f,28695,fz,-494.51
f,28713,fz,-523.78
f,28733,fz,-523.78
f,28749,fz,-523.78
f,28767,fz,-514.7
f,28787,fz,-474.32
f,28803,fz,-494.51
f,28821,fz,-465.24
f,28841,fz,-465.24
f,28857,fz,-465.24
f,28879,fz,-514.7
f,28887,fz,-474.32
f,28911,fz,-494.51
f,28929,fz,-523.78
f,28949,fz,-523.78
f,28965,fz,-523.78
f,28983,fz,-514.7
f,29003,fz,-474.32
f,29019,fz,-494.51
f,29037,fz,-465.24
f,29057,fz,-465.24
f,29073,fz,-465.24
f,29095,fz,-514.7
f,29103,fz,-474.32
f,29127,fz,-494.51
f,29145,fz,-523.78
f,29165,fz,-523.78
f,29181,fz,-523.78
f,29199,fz,-514.7
f,29219,fz,-474.32
f,29235,fz,-494.51
f,29253,fz,-465.24
f,29273,fz,-465.24
f,29289,fz,-465.24
f,29311,fz,-514.7
f,29319,fz,-474.32
f,29343,fz,-494.51
f,29361,fz,-523.78
f,29381,fz,-523.78
f,29397,fz,-523.78
f,29415,fz,-514.7
f,29435,fz,-474.32
f,29451,fz,-494.51
f,29469,fz,-465.24
f,29489,fz,-465.24
f,29505,fz,-465.24
f,29527,fz,-514.7
f,29535,fz,-474.32
f,29559,fz,-494.51
f,29577,fz,-523.78
f,29597,fz,-523.78
f,29613,fz,-523.78
f,29631,fz,-514.7
f,29651,fz,-474.32
f,29667,fz,-494.51
f,29685,fz,-465.24
f,29705,fz,-465.24
f,29721,fz,-465.24
f,29743,fz,-514.7
f,29751,fz,-474.32
f,29775,fz,-494.51
f,29793,fz,-523.78
f,29813,fz,-523.78
f,29829,fz,-523.78
f,29847,fz,-514.7
f,29867,fz,-474.32
f,29883,fz,-494.51
f,29901,fz,-465.24
f,29921,fz,-465.24
f,29937,fz,-465.24
f,29959,fz,-514.7
f,29967,fz,-474.32
f,29991,fz,-494.51
f,30009,fz,-523.78
f,30029,fz,-523.78
f,30045,fz,-523.78
f,30063,fz,-514.7
f,30083,fz,-474.32
f,30099,fz,-494.51
f,30117,fz,-465.24
f,30137,fz,-465.24
f,30153,fz,-465.24
f,30175,fz,-595.45
f,30183,fz,-554.74
f,30207,fz,-574.93
f,30225,fz,-604.54
f,30245,fz,-604.54
f,30261,fz,-604.54
f,30279,fz,-595.45
f,30299,fz,-554.74
f,30315,fz,-574.93
f,30333,fz,-545.65
f,30353,fz,-545.65
f,30369,fz,-545.65
f,30391,fz,-595.45
f,30399,fz,-554.74
f,30423,fz,-574.93
f,30441,fz,-604.54

f,30461,fz,-604.54
f,30477,fz,-604.54
f,30495,fz,-595.45
f,30515,fz,-554.74
f,30531,fz,-574.93
f,30549,fz,-545.65
f,30569,fz,-545.65
f,30585,fz,-545.65
f,30607,fz,-595.45
f,30615,fz,-554.74
f,30639,fz,-574.93
f,30657,fz,-604.54
f,30677,fz,-604.54
f,30693,fz,-604.54
f,30711,fz,-595.45
f,30731,fz,-554.74
f,30747,fz,-574.93
f,30765,fz,-545.65
f,30785,fz,-545.65
f,30801,fz,-545.65
f,30823,fz,-595.45
f,30831,fz,-554.74
f,30855,fz,-574.93
f,30873,fz,-604.54
f,30893,fz,-604.54
f,30909,fz,-604.54
f,30927,fz,-595.45
f,30947,fz,-554.74
f,30963,fz,-574.93
f,30981,fz,-545.65
f,31001,fz,-545.65
f,31017,fz,-545.65
f,31039,fz,-595.45
f,31047,fz,-554.74
f,31071,fz,-574.93
f,31089,fz,-604.54
f,31109,fz,-604.54
f,31125,fz,-604.54
f,31143,fz,-595.45
f,31163,fz,-554.74
f,31179,fz,-574.93
f,31197,fz,-545.65
f,31217,fz,-545.65
f,31233,fz,-545.65
f,31255,fz,-595.45
f,31263,fz,-554.74
f,31287,fz,-574.93
f,31305,fz,-604.54
f,31325,fz,-604.54
f,31341,fz,-604.54
f,31359,fz,-595.45
f,31379,fz,-554.74
f,31395,fz,-574.93
f,31413,fz,-545.65
f,31433,fz,-545.65
f,31449,fz,-545.65
f,31471,fz,-595.45
f,31479,fz,-554.74
f,31503,fz,-574.93
f,31521,fz,-604.54
f,31541,fz,-604.54
f,31557,fz,-604.54
f,31575,fz,-595.45
f,31595,fz,-554.74
f,31611,fz,-574.93
f,31629,fz,-545.65
f,31649,fz,-545.65
f,31665,fz,-545.65
f,31687,fz,-595.45
f,31695,fz,-554.74
f,31719,fz,-574.93
f,31737,fz,-604.54
f,31757,fz,-604.54
f,31773,fz,-604.54
f,31791,fz,-595.45
f,31811,fz,-554.74
f,31827,fz,-574.93
f,31845,fz,-545.65
f,31865,fz,-545.65
f,31881,fz,-545.65
f,31903,fz,-675.87
f,31911,fz,-635.15
f,31935,fz,-655.68
f,31953,fz,-684.95
f,31973,fz,-684.95
f,31989,fz,-684.95
f,32007,fz,-675.87
f,32027,fz,-635.15
f,32043,fz,-655.68
f,32061,fz,-626.07
f,32081,fz,-626.07
f,32097,fz,-626.07
f,32119,fz,-675.87
f,32127,fz,-635.15
f,32151,fz,-655.68
f,32169,fz,-684.95
f,32189,fz,-684.95
f,32205,fz,-684.95
f,32223,fz,-675.87
f,32243,fz,-635.15
f,32259,fz,-655.68
f,32277,fz,-626.07
f,32297,fz,-626.07
f,32313,fz,-626.07
f,32335,fz,-675.87
f,32343,fz,-635.15
f,32367,fz,-655.68
f,32385,fz,-684.95
f,32405,fz,-684.95
f,32421,fz,-684.95
f,32439,fz,-675.87
f,32459,fz,-635.15
f,32475,fz,-655.68
f,32493,fz,-626.07
f,32513,fz,-626.07
f,32529,fz,-626.07
f,32551,fz,-675.87
f,32559,fz,-635.15
f,32583,fz,-655.68
f,32601,fz,-684.95
f,32621,fz,-684.95
f,32637,fz,-684.95
f,32655,fz,-675.87
f,32675,fz,-635.15
f,32691,fz,-655.68
f,32709,fz,-626.07
f,32729,fz,-626.07
f,32745,fz,-626.07
f,32767,fz,-675.87
f,32775,fz,-635.15
f,32799,fz,-655.68
f,32817,fz,-684.95
f,32837,fz,-684.95
f,32853,fz,-684.95
f,32871,fz,-675.87
f,32891,fz,-635.15
f,32907,fz,-655.68
f,32925,fz,-626.07
f,32945,fz,-626.07
f,32961,fz,-626.07
f,32983,fz,-675.87
f,32991,fz,-635.15
f,33015,fz,-655.68
f,33033,fz,-684.95
f,33053,fz,-684.95
f,33069,fz,-684.95
f,33087,fz,-675.87
f,33107,fz,-635.15
f,33123,fz,-655.68
f,33141,fz,-626.07
f,33161,fz,-626.07
f,33177,fz,-626.07
f,33199,fz,-675.87
f,33207,fz,-635.15
f,33231,fz,-655.68
f,33249,fz,-684.95
f,33269,fz,-684.95
f,33285,fz,-684.95
f,33303,fz,-675.87
f,33323,fz,-635.15
f,33339,fz,-655.68
f,33357,fz,-626.07
f,33377,fz,-626.07
f,33393,fz,-626.07
f,33415,fz,-675.87
f,33423,fz,-635.15
f,33447,fz,-655.68
f,33465,fz,-684.95
f,33485,fz,-684.95
f,33501,fz,-684.95
f,33519,fz,-675.87
f,33539,fz,-635.15
f,33555,fz,-655.68
f,33573,fz,-626.07
f,33593,fz,-626.07
f,33609,fz,-626.07
f,5984,fz,524.144
f,5992,fz,564.857
f,6016,fz,544.668
f,6034,fz,515.059
f,6054,fz,515.059
f,6070,fz,515.059
f,6088,fz,524.144
f,6108,fz,564.857
f,6124,fz,544.668
f,6142,fz,573.941
f,6162,fz,573.941
f,6178,fz,573.941
f,6200,fz,524.144
f,6208,fz,564.857
f,6232,fz,544.668
f,6250,fz,515.059
f,6270,fz,515.059
f,6286,fz,515.059
f,6304,fz,524.144
f,6324,fz,564.857
f,6340,fz,544.668
f,6358,fz,573.941
f,6378,fz,573.941
f,6394,fz,573.941
f,6416,fz,524.144
f,6424,fz,564.857
f,6448,fz,544.668
f,6466,fz,515.059
f,6486,fz,515.059
f,6502,fz,515.059
f,6520,fz,524.144
f,6540,fz,564.857
f,6556,fz,544.668
f,6574,fz,573.941
f,6594,fz,573.941
f,6610,fz,573.941
f,6632,fz,524.144
f,6640,fz,564.857
f,6664,fz,544.668
f,6682,fz,515.059
f,6702,fz,515.059
f,6718,fz,515.059
f,6736,fz,524.144
f,6756,fz,564.857
f,6772,fz,544.668
f,6790,fz,573.941
f,6810,fz,573.941
f,6826,fz,573.941
f,6848,fz,524.144
f,6856,fz,564.857
f,6880,fz,544.668
f,6898,fz,515.059
f,6918,fz,515.059
f,6934,fz,515.059
f,6952,fz,524.144
f,6972,fz,564.857
f,6988,fz,544.668
f,7006,fz,573.941
f,7026,fz,573.941
f,7042,fz,573.941
f,7064,fz,524.144
f,7072,fz,564.857
f,7096,fz,544.668
f,7114,fz,515.059
f,7134,fz,515.059
f,7150,fz,515.059
f,7168,fz,524.144
f,7188,fz,564.857
f,7204,fz,544.668
f,7222,fz,573.941
f,7242,fz,573.941
f,7258,fz,573.941
f,7280,fz,524.144
f,7288,fz,564.857
f,7312,fz,544.668
f,7330,fz,515.059
f,7350,fz,515.059
f,7366,fz,515.059
f,7384,fz,524.144
f,7404,fz,564.857
f,7420,fz,544.668
f,7438,fz,573.941
f,7458,fz,573.941
f,7474,fz,573.941
f,7496,fz,524.144
f,7504,fz,564.857
f,7528,fz,544.668
f,7546,fz,515.059
f,7566,fz,515.059
f,7582,fz,515.059
f,7600,fz,524.144
f,7620,fz,564.857
f,7636,fz,544.668
f,7654,fz,573.941
f,7674,fz,573.941
f,7690,fz,573.941
f,7712,fz,443.728
f,7720,fz,484.441
f,7744,fz,463.916
f,7762,fz,434.644
f,7782,fz,434.644
f,7798,fz,434.644
f,7816,fz,443.728
f,7836,fz,484.441
f,7852,fz,463.916
f,7870,fz,493.525
f,7890,fz,493.525
f,7906,fz,493.525
f,7928,fz,443.728
f,7936,fz,484.441
f,7960,fz,463.916
f,7978,fz,434.644
f,7998,fz,434.644
f,8014,fz,434.644
f,8032,fz,443.728
f,8052,fz,484.441
f,8068,fz,463.916
f,8086,fz,493.525
f,8106,fz,493.525
f,8122,fz,493.525
f,8144,fz,443.728
f,8152,fz,484.441
f,8176,fz,463.916
f,8194,fz,434.644
f,8214,fz,434.644
f,8230,fz,434.644
f,8248,fz,443.728
f,8268,fz,484.441
f,8284,fz,463.916
f,8302,fz,493.525
f,8322,fz,493.525
f,8338,fz,493.525
f,8360,fz,443.728
f,8368,fz,484.441
f,8392,fz,463.916
f,8410,fz,434.644
f,8430,fz,434.644
f,8446,fz,434.644
f,8464,fz,443.728
f,8484,fz,484.441
f,8500,fz,463.916
f,8518,fz,493.525
f,8538,fz,493.525
f,8554,fz,493.525
f,8576,fz,443.728
f,8584,fz,484.441
f,8608,fz,463.916
f,8626,fz,434.644
f,8646,fz,434.644
f,8662,fz,434.644
f,8680,fz,443.728
f,8700,fz,484.441
f,8716,fz,463.916
f,8734,fz,493.525
f,8754,fz,493.525
f,8770,fz,493.525

f,8792,fr,443.728
f,8800,fr,484.441
f,8824,fr,463.916
f,8842,fr,434.644
f,8862,fr,434.644
f,8878,fr,434.644
f,8896,fr,443.728
f,8916,fr,484.441
f,8932,fr,463.916
f,8950,fr,493.525
f,8970,fr,493.525
f,8986,fr,493.525
f,9008,fr,443.728
f,9016,fr,484.441
f,9040,fr,463.916
f,9058,fr,434.644
f,9078,fr,434.644
f,9094,fr,434.644
f,9112,fr,443.728
f,9132,fr,484.441
f,9148,fr,463.916
f,9166,fr,493.525
f,9186,fr,493.525
f,9202,fr,493.525
f,9224,fr,443.728
f,9232,fr,484.441
f,9256,fr,463.916
f,9274,fr,434.644
f,9294,fr,434.644
f,9310,fr,434.644
f,9328,fr,443.728
f,9348,fr,484.441
f,9364,fr,463.916
f,9382,fr,493.525
f,9402,fr,493.525
f,9418,fr,493.525
f,9440,fr,363.313
f,9448,fr,403.689
f,9472,fr,383.501
f,9490,fr,354.228
f,9510,fr,354.228
f,9526,fr,354.228
f,9544,fr,363.313
f,9564,fr,403.689
f,9580,fr,383.501
f,9598,fr,412.773
f,9618,fr,412.773
f,9634,fr,412.773
f,9656,fr,363.313
f,9664,fr,403.689
f,9688,fr,383.501
f,9706,fr,354.228
f,9726,fr,354.228
f,9742,fr,354.228
f,9760,fr,363.313
f,9780,fr,403.689
f,9796,fr,383.501
f,9814,fr,412.773
f,9834,fr,412.773
f,9850,fr,412.773
f,9872,fr,363.313
f,9880,fr,403.689
f,9904,fr,383.501
f,9922,fr,354.228
f,9942,fr,354.228
f,9958,fr,354.228
f,9976,fr,363.313
f,9996,fr,403.689
f,10012,fr,383.501
f,10030,fr,412.773
f,10050,fr,412.773
f,10066,fr,412.773
f,10088,fr,363.313
f,10096,fr,403.689
f,10120,fr,383.501
f,10138,fr,354.228
f,10158,fr,354.228
f,10174,fr,354.228
f,10192,fr,363.313
f,10212,fr,403.689
f,10228,fr,383.501
f,10246,fr,412.773
f,10266,fr,412.773
f,10282,fr,412.773
f,10304,fr,363.313
f,10312,fr,403.689
f,10336,fr,383.501
f,10354,fr,354.228
f,10374,fr,354.228
f,10390,fr,354.228
f,10408,fr,363.313
f,10428,fr,403.689
f,10444,fr,383.501
f,10462,fr,412.773
f,10482,fr,412.773
f,10498,fr,412.773
f,10520,fr,363.313
f,10528,fr,403.689
f,10552,fr,383.501
f,10570,fr,354.228
f,10590,fr,354.228
f,10606,fr,354.228
f,10624,fr,363.313
f,10644,fr,403.689
f,10660,fr,383.501
f,10678,fr,412.773
f,10698,fr,412.773
f,10714,fr,412.773
f,10736,fr,363.313
f,10744,fr,403.689
f,10768,fr,383.501
f,10786,fr,354.228
f,10806,fr,354.228
f,10822,fr,354.228
f,10840,fr,363.313
f,10860,fr,403.689
f,10876,fr,383.501
f,10894,fr,412.773
f,10914,fr,412.773
f,10930,fr,412.773
f,10952,fr,363.313
f,10960,fr,403.689
f,10984,fr,383.501
f,11002,fr,354.228
f,11022,fr,354.228
f,11038,fr,354.228
f,11056,fr,363.313
f,11076,fr,403.689
f,11092,fr,383.501
f,11110,fr,412.773
f,11130,fr,412.773
f,11146,fr,412.773
f,11168,fr,282.56
f,11176,fr,323.273
f,11200,fr,303.085
f,11218,fr,273.476
f,11238,fr,273.476
f,11254,fr,273.476
f,11272,fr,282.56
f,11292,fr,323.273
f,11308,fr,303.085
f,11326,fr,332.358
f,11346,fr,332.358
f,11362,fr,332.358
f,11384,fr,282.56
f,11392,fr,323.273
f,11416,fr,303.085
f,11434,fr,273.476
f,11454,fr,273.476
f,11470,fr,273.476
f,11488,fr,282.56
f,11508,fr,323.273
f,11524,fr,303.085
f,11542,fr,332.358
f,11562,fr,332.358
f,11578,fr,332.358
f,11600,fr,282.56
f,11608,fr,323.273
f,11632,fr,303.085
f,11650,fr,273.476
f,11670,fr,273.476
f,11686,fr,273.476
f,11704,fr,282.56
f,11724,fr,323.273
f,11740,fr,303.085
f,11758,fr,332.358
f,11778,fr,332.358
f,11794,fr,332.358
f,11816,fr,282.56
f,11824,fr,323.273
f,11848,fr,303.085
f,11866,fr,273.476
f,11886,fr,273.476
f,11902,fr,273.476
f,11920,fr,282.56
f,11940,fr,323.273
f,11956,fr,303.085
f,11974,fr,332.358
f,11994,fr,332.358
f,12010,fr,332.358
f,12032,fr,282.56
f,12040,fr,323.273
f,12064,fr,303.085
f,12082,fr,273.476
f,12102,fr,273.476
f,12118,fr,273.476
f,12136,fr,282.56
f,12156,fr,323.273
f,12172,fr,303.085
f,12190,fr,332.358
f,12210,fr,332.358
f,12226,fr,332.358
f,12248,fr,282.56
f,12256,fr,323.273
f,12280,fr,303.085
f,12298,fr,273.476
f,12318,fr,273.476
f,12334,fr,273.476
f,12352,fr,282.56
f,12372,fr,323.273
f,12388,fr,303.085
f,12406,fr,332.358
f,12426,fr,332.358
f,12442,fr,332.358
f,12464,fr,282.56
f,12472,fr,323.273
f,12496,fr,303.085
f,12514,fr,273.476
f,12534,fr,273.476
f,12550,fr,273.476
f,12568,fr,282.56
f,12588,fr,323.273
f,12604,fr,303.085
f,12622,fr,332.358
f,12642,fr,332.358
f,12658,fr,332.358
f,12680,fr,282.56
f,12688,fr,323.273
f,12712,fr,303.085
f,12730,fr,273.476
f,12750,fr,273.476
f,12766,fr,273.476
f,12784,fr,282.56
f,12804,fr,323.273
f,12820,fr,303.085
f,12838,fr,332.358
f,12858,fr,332.358
f,12874,fr,332.358
f,12896,fr,202.145
f,12904,fr,242.857
f,12928,fr,222.333
f,12946,fr,193.06
f,12966,fr,193.06
f,12982,fr,193.06
f,13000,fr,202.145
f,13020,fr,242.857
f,13036,fr,222.333
f,13054,fr,251.942
f,13074,fr,251.942
f,13090,fr,251.942
f,13112,fr,202.145
f,13120,fr,242.857
f,13144,fr,222.333
f,13162,fr,193.06
f,13182,fr,193.06
f,13198,fr,193.06
f,13216,fr,202.145
f,13236,fr,242.857
f,13252,fr,222.333
f,13270,fr,251.942
f,13290,fr,251.942
f,13306,fr,251.942
f,13328,fr,202.145
f,13336,fr,242.857
f,13360,fr,222.333
f,13378,fr,193.06
f,13398,fr,193.06
f,13414,fr,193.06
f,13432,fr,202.145
f,13452,fr,242.857
f,13468,fr,222.333
f,13486,fr,251.942
f,13506,fr,251.942
f,13522,fr,251.942
f,13544,fr,202.145
f,13552,fr,242.857
f,13576,fr,222.333
f,13594,fr,193.06
f,13614,fr,193.06
f,13630,fr,193.06
f,13648,fr,202.145
f,13668,fr,242.857
f,13684,fr,222.333
f,13702,fr,251.942
f,13722,fr,251.942
f,13738,fr,251.942
f,13760,fr,202.145
f,13768,fr,242.857
f,13792,fr,222.333
f,13810,fr,193.06
f,13830,fr,193.06
f,13846,fr,193.06
f,13864,fr,202.145
f,13884,fr,242.857
f,13900,fr,222.333
f,13918,fr,251.942
f,13938,fr,251.942
f,13954,fr,251.942
f,13976,fr,202.145
f,13984,fr,242.857
f,14008,fr,222.333
f,14026,fr,193.06
f,14046,fr,193.06
f,14062,fr,193.06
f,14080,fr,202.145
f,14100,fr,242.857
f,14116,fr,222.333
f,14134,fr,251.942
f,14154,fr,251.942
f,14170,fr,251.942
f,14192,fr,202.145
f,14200,fr,242.857
f,14224,fr,222.333
f,14242,fr,193.06
f,14262,fr,193.06
f,14278,fr,193.06
f,14296,fr,202.145
f,14316,fr,242.857
f,14332,fr,222.333
f,14350,fr,251.942
f,14370,fr,251.942
f,14386,fr,251.942
f,14408,fr,202.145
f,14416,fr,242.857
f,14440,fr,222.333
f,14458,fr,193.06
f,14478,fr,193.06
f,14494,fr,193.06
f,14512,fr,202.145
f,14532,fr,242.857
f,14548,fr,222.333
f,14566,fr,251.942
f,14586,fr,251.942
f,14602,fr,251.942
f,14624,fr,121.729
f,14632,fr,162.442
f,14656,fr,141.917
f,14674,fr,112.644
f,14694,fr,112.644
f,14710,fr,112.644
f,14728,fr,121.729
f,14748,fr,162.442

f,14764,fz,141.917
f,14782,fz,171.526
f,14802,fz,171.526
f,14818,fz,171.526
f,14840,fz,121.729
f,14848,fz,162.442
f,14872,fz,141.917
f,14890,fz,112.644
f,14910,fz,112.644
f,14926,fz,112.644
f,14944,fz,121.729
f,14964,fz,162.442
f,14980,fz,141.917
f,14998,fz,171.526
f,15018,fz,171.526
f,15034,fz,171.526
f,15056,fz,121.729
f,15054,fz,162.442
f,15088,fz,141.917
f,15106,fz,112.644
f,15126,fz,112.644
f,15142,fz,112.644
f,15160,fz,121.729
f,15180,fz,162.442
f,15196,fz,141.917
f,15214,fz,171.526
f,15234,fz,171.526
f,15250,fz,171.526
f,15272,fz,121.729
f,15280,fz,162.442
f,15304,fz,141.917
f,15322,fz,112.644
f,15342,fz,112.644
f,15358,fz,112.644
f,15376,fz,121.729
f,15396,fz,162.442
f,15412,fz,141.917
f,15430,fz,171.526
f,15450,fz,171.526
f,15466,fz,171.526
f,15488,fz,121.729
f,15496,fz,162.442
f,15520,fz,141.917
f,15538,fz,112.644
f,15558,fz,112.644
f,15574,fz,112.644
f,15592,fz,121.729
f,15612,fz,162.442
f,15628,fz,141.917
f,15646,fz,171.526
f,15666,fz,171.526
f,15682,fz,171.526
f,15704,fz,121.729
f,15712,fz,162.442
f,15736,fz,141.917
f,15754,fz,112.644
f,15774,fz,112.644
f,15790,fz,112.644
f,15808,fz,121.729
f,15828,fz,162.442
f,15844,fz,141.917
f,15862,fz,171.526
f,15882,fz,171.526
f,15898,fz,171.526
f,15920,fz,121.729
f,15928,fz,162.442
f,15952,fz,141.917
f,15970,fz,112.644
f,15990,fz,112.644
f,16006,fz,112.644
f,16024,fz,121.729
f,16044,fz,162.442
f,16060,fz,141.917
f,16078,fz,171.526
f,16098,fz,171.526
f,16114,fz,171.526
f,16136,fz,121.729
f,16144,fz,162.442
f,16168,fz,141.917
f,16186,fz,112.644
f,16206,fz,112.644
f,16222,fz,112.644
f,16240,fz,121.729
f,16260,fz,162.442
f,16276,fz,141.917
f,16294,fz,171.526
f,16314,fz,171.526
f,16330,fz,171.526
f,16352,fz,40.9768
f,16360,fz,81.6894
f,16384,fz,61.5013
f,16402,fz,32.2287
f,16422,fz,32.2287
f,16438,fz,32.2287
f,16456,fz,40.9768
f,16476,fz,81.6894
f,16492,fz,61.5013
f,16510,fz,90.774
f,16530,fz,90.774
f,16546,fz,90.774
f,16568,fz,40.9768
f,16576,fz,81.6894
f,16600,fz,61.5013
f,16618,fz,32.2287
f,16638,fz,32.2287
f,16654,fz,32.2287
f,16672,fz,40.9768
f,16692,fz,81.6894
f,16708,fz,61.5013
f,16726,fz,90.774
f,16746,fz,90.774
f,16762,fz,90.774
f,16784,fz,40.9768
f,16792,fz,81.6894
f,16816,fz,61.5013
f,16834,fz,32.2287
f,16854,fz,32.2287
f,16870,fz,32.2287
f,16888,fz,40.9768
f,16908,fz,81.6894
f,16924,fz,61.5013
f,16942,fz,90.774
f,16962,fz,90.774
f,16978,fz,90.774
f,17000,fz,40.9768
f,17008,fz,81.6894
f,17032,fz,61.5013
f,17050,fz,32.2287
f,17070,fz,32.2287
f,17086,fz,32.2287
f,17104,fz,40.9768
f,17124,fz,81.6894
f,17140,fz,61.5013
f,17158,fz,90.774
f,17178,fz,90.774
f,17194,fz,90.774
f,17216,fz,40.9768
f,17224,fz,81.6894
f,17248,fz,61.5013
f,17266,fz,32.2287
f,17286,fz,32.2287
f,17302,fz,32.2287
f,17320,fz,40.9768
f,17340,fz,81.6894
f,17356,fz,61.5013
f,17374,fz,90.774
f,17394,fz,90.774
f,17410,fz,90.774
f,17432,fz,40.9768
f,17440,fz,81.6894
f,17464,fz,61.5013
f,17482,fz,32.2287
f,17502,fz,32.2287
f,17518,fz,32.2287
f,17536,fz,40.9768
f,17556,fz,81.6894
f,17572,fz,61.5013
f,17590,fz,90.774
f,17610,fz,90.774
f,17626,fz,90.774
f,17648,fz,40.9768
f,17656,fz,81.6894
f,17680,fz,61.5013
f,17698,fz,32.2287
f,17718,fz,32.2287
f,17734,fz,32.2287
f,17752,fz,40.9768
f,17772,fz,81.6894
f,17788,fz,61.5013
f,17806,fz,90.774
f,17826,fz,90.774
f,17842,fz,90.774
f,17864,fz,40.9768
f,17872,fz,81.6894
f,17896,fz,61.5013
f,17914,fz,32.2287
f,17934,fz,32.2287
f,17950,fz,32.2287
f,17968,fz,40.9768
f,17988,fz,81.6894
f,18004,fz,61.5013
f,18022,fz,90.774
f,18042,fz,90.774
f,18058,fz,90.774
f,18080,fz,-39.439
f,18088,fz,1.27366
f,18112,fz,-18.914
f,18130,fz,-48.524
f,18150,fz,-48.524
f,18166,fz,-48.524
f,18184,fz,-39.439
f,18204,fz,1.27366
f,18220,fz,-18.914
f,18238,fz,10.3583
f,18258,fz,10.3583
f,18274,fz,10.3583
f,18296,fz,-39.439
f,18304,fz,1.27366
f,18328,fz,-18.914
f,18346,fz,-48.524
f,18366,fz,-48.524
f,18382,fz,-48.524
f,18400,fz,-39.439
f,18420,fz,1.27366
f,18436,fz,-18.914
f,18454,fz,10.3583
f,18474,fz,10.3583
f,18490,fz,10.3583
f,18512,fz,-39.439
f,18520,fz,1.27366
f,18544,fz,-18.914
f,18562,fz,-48.524
f,18582,fz,-48.524
f,18598,fz,-48.524
f,18616,fz,-39.439
f,18636,fz,1.27366
f,18652,fz,-18.914
f,18670,fz,10.3583
f,18690,fz,10.3583
f,18706,fz,10.3583
f,18728,fz,-39.439
f,18736,fz,1.27366
f,18760,fz,-18.914
f,18778,fz,-48.524
f,18798,fz,-48.524
f,18814,fz,-48.524
f,18832,fz,-39.439
f,18852,fz,1.27366
f,18868,fz,-18.914
f,18886,fz,10.3583
f,18906,fz,10.3583
f,18922,fz,10.3583
f,18944,fz,-39.439
f,18952,fz,1.27366
f,18976,fz,-18.914
f,18994,fz,-48.524
f,19014,fz,-48.524
f,19030,fz,-48.524
f,19048,fz,-39.439
f,19068,fz,1.27366
f,19084,fz,-18.914
f,19102,fz,10.3583
f,19122,fz,10.3583
f,19138,fz,10.3583
f,19160,fz,-39.439
f,19168,fz,1.27366
f,19192,fz,-18.914
f,19210,fz,-48.524
f,19230,fz,-48.524
f,19246,fz,-48.524
f,19264,fz,-39.439
f,19284,fz,1.27366
f,19300,fz,-18.914
f,19318,fz,10.3583
f,19338,fz,10.3583
f,19354,fz,10.3583
f,19376,fz,-39.439
f,19384,fz,1.27366
f,19408,fz,-18.914
f,19426,fz,-48.524
f,19446,fz,-48.524
f,19462,fz,-48.524
f,19480,fz,-39.439
f,19500,fz,1.27366
f,19516,fz,-18.914
f,19534,fz,10.3583
f,19554,fz,10.3583
f,19570,fz,10.3583
f,19592,fz,-39.439
f,19600,fz,1.27366
f,19624,fz,-18.914
f,19642,fz,-48.524
f,19662,fz,-48.524
f,19678,fz,-48.524
f,19696,fz,-39.439
f,19716,fz,1.27366
f,19732,fz,-18.914
f,19750,fz,10.3583
f,19770,fz,10.3583
f,19786,fz,10.3583
f,19808,fz,-119.85
f,19816,fz,-79.142
f,19840,fz,-99.667
f,19858,fz,-128.94
f,19878,fz,-128.94
f,19894,fz,-128.94
f,19912,fz,-119.85
f,19932,fz,-79.142
f,19948,fz,-99.667
f,19966,fz,-70.057
f,19986,fz,-70.057
f,20002,fz,-70.057
f,20024,fz,-119.85
f,20032,fz,-79.142
f,20056,fz,-99.667
f,20074,fz,-128.94
f,20094,fz,-128.94
f,20110,fz,-128.94
f,20128,fz,-119.85
f,20148,fz,-79.142
f,20164,fz,-99.667
f,20182,fz,-70.057
f,20202,fz,-70.057
f,20218,fz,-70.057
f,20240,fz,-119.85
f,20248,fz,-79.142
f,20272,fz,-99.667
f,20290,fz,-128.94
f,20310,fz,-128.94
f,20326,fz,-128.94
f,20344,fz,-119.85
f,20364,fz,-79.142
f,20380,fz,-99.667
f,20398,fz,-70.057
f,20418,fz,-70.057
f,20434,fz,-70.057
f,20456,fz,-119.85
f,20464,fz,-79.142
f,20488,fz,-99.667
f,20506,fz,-128.94
f,20526,fz,-128.94
f,20542,fz,-128.94
f,20560,fz,-119.85
f,20580,fz,-79.142
f,20596,fz,-99.667
f,20614,fz,-70.057
f,20634,fz,-70.057
f,20650,fz,-70.057
f,20672,fz,-119.85
f,20680,fz,-79.142
f,20704,fz,-99.667
f,20722,fz,-128.94

f,20742,fz,-128.94
f,20758,fz,-128.94
f,20776,fz,-119.85
f,20796,fz,-79.142
f,20812,fz,-99.667
f,20830,fz,-70.057
f,20850,fz,-70.057
f,20866,fz,-70.057
f,20888,fz,-119.85
f,20896,fz,-79.142
f,20920,fz,-99.667
f,20938,fz,-128.94
f,20958,fz,-128.94
f,20974,fz,-128.94
f,20992,fz,-119.85
f,21012,fz,-79.142
f,21028,fz,-99.667
f,21046,fz,-70.057
f,21066,fz,-70.057
f,21082,fz,-70.057
f,21104,fz,-119.85
f,21112,fz,-79.142
f,21136,fz,-99.667
f,21154,fz,-128.94
f,21174,fz,-128.94
f,21190,fz,-128.94
f,21208,fz,-119.85
f,21228,fz,-79.142
f,21244,fz,-99.667
f,21262,fz,-70.057
f,21282,fz,-70.057
f,21298,fz,-70.057
f,21320,fz,-119.85
f,21328,fz,-79.142
f,21352,fz,-99.667
f,21370,fz,-128.94
f,21390,fz,-128.94
f,21406,fz,-128.94
f,21424,fz,-119.85
f,21444,fz,-79.142
f,21460,fz,-99.667
f,21478,fz,-70.057
f,21498,fz,-70.057
f,21514,fz,-70.057
f,21536,fz,-200.27
f,21544,fz,-159.56
f,21568,fz,-180.08
f,21586,fz,-209.35
f,21606,fz,-209.35
f,21622,fz,-209.35
f,21640,fz,-200.27
f,21660,fz,-159.56
f,21676,fz,-180.08
f,21694,fz,-150.81
f,21714,fz,-150.81
f,21730,fz,-150.81
f,21752,fz,-200.27
f,21760,fz,-159.56
f,21784,fz,-180.08
f,21802,fz,-209.35
f,21822,fz,-209.35
f,21838,fz,-209.35
f,21856,fz,-200.27
f,21876,fz,-159.56
f,21892,fz,-180.08
f,21910,fz,-150.81
f,21930,fz,-150.81
f,21946,fz,-150.81
f,21968,fz,-200.27
f,21976,fz,-159.56
f,22000,fz,-180.08
f,22018,fz,-209.35
f,22038,fz,-209.35
f,22054,fz,-209.35
f,22072,fz,-200.27
f,22092,fz,-159.56
f,22108,fz,-180.08
f,22126,fz,-150.81
f,22146,fz,-150.81
f,22162,fz,-150.81
f,22184,fz,-200.27
f,22192,fz,-159.56
f,22216,fz,-180.08
f,22234,fz,-209.35
f,22254,fz,-209.35
f,22270,fz,-209.35
f,22288,fz,-200.27
f,22308,fz,-159.56
f,22324,fz,-180.08
f,22342,fz,-150.81
f,22362,fz,-150.81
f,22378,fz,-150.81
f,22400,fz,-200.27
f,22408,fz,-159.56
f,22432,fz,-180.08
f,22450,fz,-209.35
f,22470,fz,-209.35
f,22486,fz,-209.35
f,22504,fz,-200.27
f,22524,fz,-159.56
f,22540,fz,-180.08
f,22558,fz,-150.81
f,22578,fz,-150.81
f,22594,fz,-150.81
f,22616,fz,-200.27
f,22624,fz,-159.56
f,22648,fz,-180.08
f,22666,fz,-209.35
f,22686,fz,-209.35
f,22702,fz,-209.35
f,22720,fz,-200.27
f,22740,fz,-159.56
f,22756,fz,-180.08
f,22774,fz,-150.81
f,22794,fz,-150.81
f,22810,fz,-150.81
f,22832,fz,-200.27
f,22840,fz,-159.56
f,22864,fz,-180.08
f,22882,fz,-209.35
f,22902,fz,-209.35
f,22918,fz,-209.35
f,22936,fz,-200.27
f,22956,fz,-159.56
f,22972,fz,-180.08
f,22990,fz,-150.81
f,23010,fz,-150.81
f,23026,fz,-150.81
f,23048,fz,-200.27
f,23056,fz,-159.56
f,23080,fz,-180.08
f,23098,fz,-209.35
f,23118,fz,-209.35
f,23134,fz,-209.35
f,23152,fz,-200.27
f,23172,fz,-159.56
f,23188,fz,-180.08
f,23206,fz,-150.81
f,23226,fz,-150.81
f,23242,fz,-150.81
f,23264,fz,-281.02
f,23272,fz,-240.31
f,23296,fz,-260.5
f,23314,fz,-290.11
f,23334,fz,-290.11
f,23350,fz,-290.11
f,23368,fz,-281.02
f,23388,fz,-240.31
f,23404,fz,-260.5
f,23422,fz,-231.23
f,23442,fz,-231.23
f,23458,fz,-231.23
f,23480,fz,-281.02
f,23488,fz,-240.31
f,23512,fz,-260.5
f,23530,fz,-290.11
f,23550,fz,-290.11
f,23566,fz,-290.11
f,23584,fz,-281.02
f,23604,fz,-240.31
f,23620,fz,-260.5
f,23638,fz,-231.23
f,23658,fz,-231.23
f,23674,fz,-231.23
f,23696,fz,-281.02
f,23704,fz,-240.31
f,23728,fz,-260.5
f,23746,fz,-290.11
f,23766,fz,-290.11
f,23782,fz,-290.11
f,23800,fz,-281.02
f,23820,fz,-240.31
f,23836,fz,-260.5
f,23854,fz,-231.23
f,23874,fz,-231.23
f,23890,fz,-231.23
f,23912,fz,-281.02
f,23920,fz,-240.31
f,23944,fz,-260.5
f,23962,fz,-290.11
f,23982,fz,-290.11
f,23998,fz,-290.11
f,24016,fz,-281.02
f,24036,fz,-240.31
f,24052,fz,-260.5
f,24070,fz,-231.23
f,24090,fz,-231.23
f,24106,fz,-231.23
f,24128,fz,-281.02
f,24136,fz,-240.31
f,24160,fz,-260.5
f,24178,fz,-290.11
f,24198,fz,-290.11
f,24214,fz,-290.11
f,24232,fz,-281.02
f,24252,fz,-240.31
f,24268,fz,-260.5
f,24286,fz,-231.23
f,24306,fz,-231.23
f,24322,fz,-231.23
f,24344,fz,-281.02
f,24352,fz,-240.31
f,24376,fz,-260.5
f,24394,fz,-290.11
f,24414,fz,-290.11
f,24430,fz,-290.11
f,24448,fz,-281.02
f,24468,fz,-240.31
f,24484,fz,-260.5
f,24502,fz,-231.23
f,24522,fz,-231.23
f,24538,fz,-231.23
f,24560,fz,-281.02
f,24568,fz,-240.31
f,24592,fz,-260.5
f,24610,fz,-290.11
f,24630,fz,-290.11
f,24646,fz,-290.11
f,24664,fz,-281.02
f,24684,fz,-240.31
f,24700,fz,-260.5
f,24718,fz,-231.23
f,24738,fz,-231.23
f,24754,fz,-231.23
f,24776,fz,-281.02
f,24784,fz,-240.31
f,24808,fz,-260.5
f,24826,fz,-290.11
f,24846,fz,-290.11
f,24862,fz,-290.11
f,24880,fz,-281.02
f,24900,fz,-240.31
f,24916,fz,-260.5
f,24934,fz,-231.23
f,24954,fz,-231.23
f,24970,fz,-231.23
f,24992,fz,-361.44
f,25000,fz,-320.73
f,25024,fz,-340.91
f,25042,fz,-370.52
f,25062,fz,-370.52
f,25078,fz,-370.52
f,25096,fz,-361.44
f,25116,fz,-320.73
f,25132,fz,-340.91
f,25150,fz,-311.64
f,25170,fz,-311.64
f,25186,fz,-311.64
f,25208,fz,-361.44
f,25216,fz,-320.73
f,25240,fz,-340.91
f,25258,fz,-370.52
f,25278,fz,-370.52
f,25294,fz,-370.52
f,25312,fz,-361.44
f,25332,fz,-320.73
f,25348,fz,-340.91
f,25366,fz,-311.64
f,25386,fz,-311.64
f,25402,fz,-311.64
f,25424,fz,-361.44
f,25432,fz,-320.73
f,25456,fz,-340.91
f,25474,fz,-370.52
f,25494,fz,-370.52
f,25510,fz,-370.52
f,25528,fz,-361.44
f,25548,fz,-320.73
f,25564,fz,-340.91
f,25582,fz,-311.64
f,25602,fz,-311.64
f,25618,fz,-311.64
f,25640,fz,-361.44
f,25648,fz,-320.73
f,25672,fz,-340.91
f,25690,fz,-370.52
f,25710,fz,-370.52
f,25726,fz,-370.52
f,25744,fz,-361.44
f,25764,fz,-320.73
f,25780,fz,-340.91
f,25798,fz,-311.64
f,25818,fz,-311.64
f,25834,fz,-311.64
f,25856,fz,-361.44
f,25864,fz,-320.73
f,25888,fz,-340.91
f,25906,fz,-370.52
f,25926,fz,-370.52
f,25942,fz,-370.52
f,25960,fz,-361.44
f,25980,fz,-320.73
f,25996,fz,-340.91
f,26014,fz,-311.64
f,26034,fz,-311.64
f,26050,fz,-311.64
f,26072,fz,-361.44
f,26080,fz,-320.73
f,26104,fz,-340.91
f,26122,fz,-370.52
f,26142,fz,-370.52
f,26158,fz,-370.52
f,26176,fz,-361.44
f,26196,fz,-320.73
f,26212,fz,-340.91
f,26230,fz,-311.64
f,26250,fz,-311.64
f,26266,fz,-311.64
f,26288,fz,-361.44
f,26296,fz,-320.73
f,26320,fz,-340.91
f,26338,fz,-370.52
f,26358,fz,-370.52
f,26374,fz,-370.52
f,26392,fz,-361.44
f,26412,fz,-320.73
f,26428,fz,-340.91
f,26446,fz,-311.64
f,26466,fz,-311.64
f,26482,fz,-311.64
f,26504,fz,-361.44
f,26512,fz,-320.73
f,26536,fz,-340.91
f,26554,fz,-370.52
f,26574,fz,-370.52
f,26590,fz,-370.52
f,26608,fz,-361.44
f,26628,fz,-320.73
f,26644,fz,-340.91
f,26662,fz,-311.64
f,26682,fz,-311.64
f,26698,fz,-311.64

f,26720,fz,-441.85
f,26728,fz,-401.14
f,26752,fz,-421.67
f,26770,fz,-450.94
f,26790,fz,-450.94
f,26806,fz,-450.94
f,26824,fz,-441.85
f,26844,fz,-401.14
f,26860,fz,-421.67
f,26878,fz,-392.06
f,26898,fz,-392.06
f,26914,fz,-392.06
f,26936,fz,-441.85
f,26944,fz,-401.14
f,26968,fz,-421.67
f,26986,fz,-450.94
f,27006,fz,-450.94
f,27022,fz,-450.94
f,27040,fz,-441.85
f,27060,fz,-401.14
f,27076,fz,-421.67
f,27094,fz,-392.06
f,27114,fz,-392.06
f,27130,fz,-392.06
f,27152,fz,-441.85
f,27160,fz,-401.14
f,27184,fz,-421.67
f,27202,fz,-450.94
f,27222,fz,-450.94
f,27238,fz,-450.94
f,27256,fz,-441.85
f,27276,fz,-401.14
f,27292,fz,-421.67
f,27310,fz,-392.06
f,27330,fz,-392.06
f,27346,fz,-392.06
f,27368,fz,-441.85
f,27376,fz,-401.14
f,27400,fz,-421.67
f,27418,fz,-450.94
f,27438,fz,-450.94
f,27454,fz,-450.94
f,27472,fz,-441.85
f,27492,fz,-401.14
f,27508,fz,-421.67
f,27526,fz,-392.06
f,27546,fz,-392.06
f,27562,fz,-392.06
f,27584,fz,-441.85
f,27592,fz,-401.14
f,27616,fz,-421.67
f,27634,fz,-450.94
f,27654,fz,-450.94
f,27670,fz,-450.94
f,27688,fz,-441.85
f,27708,fz,-401.14
f,27724,fz,-421.67
f,27742,fz,-392.06
f,27762,fz,-392.06
f,27778,fz,-392.06
f,27800,fz,-441.85
f,27808,fz,-401.14
f,27832,fz,-421.67
f,27850,fz,-450.94
f,27870,fz,-450.94
f,27886,fz,-450.94
f,27904,fz,-441.85
f,27924,fz,-401.14
f,27940,fz,-421.67
f,27958,fz,-392.06
f,27978,fz,-392.06
f,27994,fz,-392.06
f,28016,fz,-441.85
f,28024,fz,-401.14
f,28048,fz,-421.67
f,28066,fz,-450.94
f,28086,fz,-450.94
f,28102,fz,-450.94
f,28120,fz,-441.85
f,28140,fz,-401.14
f,28156,fz,-421.67
f,28174,fz,-392.06
f,28194,fz,-392.06
f,28210,fz,-392.06
f,28232,fz,-441.85
f,28240,fz,-401.14
f,28264,fz,-421.67
f,28282,fz,-450.94
f,28302,fz,-450.94
f,28318,fz,-450.94
f,28336,fz,-441.85
f,28356,fz,-401.14
f,28372,fz,-421.67
f,28390,fz,-392.06
f,28410,fz,-392.06
f,28426,fz,-392.06
f,28448,fz,-522.27
f,28456,fz,-481.89
f,28480,fz,-502.08
f,28498,fz,-531.35
f,28518,fz,-531.35
f,28534,fz,-531.35
f,28552,fz,-522.27
f,28572,fz,-481.89
f,28588,fz,-502.08
f,28606,fz,-472.81
f,28626,fz,-472.81
f,28642,fz,-472.81
f,28664,fz,-522.27
f,28672,fz,-481.89
f,28696,fz,-502.08
f,28714,fz,-531.35
f,28734,fz,-531.35
f,28750,fz,-531.35
f,28768,fz,-522.27
f,28788,fz,-481.89
f,28804,fz,-502.08
f,28822,fz,-472.81
f,28842,fz,-472.81
f,28858,fz,-472.81
f,28880,fz,-522.27
f,28888,fz,-481.89
f,28912,fz,-502.08
f,28930,fz,-531.35
f,28950,fz,-531.35
f,28966,fz,-531.35
f,28984,fz,-522.27
f,29004,fz,-481.89
f,29020,fz,-502.08
f,29038,fz,-472.81
f,29058,fz,-472.81
f,29074,fz,-472.81
f,29096,fz,-522.27
f,29104,fz,-481.89
f,29128,fz,-502.08
f,29146,fz,-531.35
f,29166,fz,-531.35
f,29182,fz,-531.35
f,29200,fz,-522.27
f,29220,fz,-481.89
f,29236,fz,-502.08
f,29254,fz,-472.81
f,29274,fz,-472.81
f,29290,fz,-472.81
f,29312,fz,-522.27
f,29320,fz,-481.89
f,29344,fz,-502.08
f,29362,fz,-531.35
f,29382,fz,-531.35
f,29398,fz,-531.35
f,29416,fz,-522.27
f,29436,fz,-481.89
f,29452,fz,-502.08
f,29470,fz,-472.81
f,29490,fz,-472.81
f,29506,fz,-472.81
f,29528,fz,-522.27
f,29536,fz,-481.89
f,29560,fz,-502.08
f,29578,fz,-531.35
f,29598,fz,-531.35
f,29614,fz,-531.35
f,29632,fz,-522.27
f,29652,fz,-481.89
f,29668,fz,-502.08
f,29686,fz,-472.81
f,29706,fz,-472.81
f,29722,fz,-472.81
f,29744,fz,-522.27
f,29752,fz,-481.89
f,29776,fz,-502.08
f,29794,fz,-531.35
f,29814,fz,-531.35
f,29830,fz,-531.35
f,29848,fz,-522.27
f,29868,fz,-481.89
f,29884,fz,-502.08
f,29902,fz,-472.81
f,29922,fz,-472.81
f,29938,fz,-472.81
f,29960,fz,-522.27
f,29968,fz,-481.89
f,29992,fz,-502.08
f,30010,fz,-531.35
f,30030,fz,-531.35
f,30046,fz,-531.35
f,30064,fz,-522.27
f,30084,fz,-481.89
f,30100,fz,-502.08
f,30118,fz,-472.81
f,30138,fz,-472.81
f,30154,fz,-472.81
f,30176,fz,-603.02
f,30184,fz,-562.31
f,30208,fz,-582.5
f,30226,fz,-612.11
f,30246,fz,-612.11
f,30262,fz,-612.11
f,30280,fz,-603.02
f,30300,fz,-562.31
f,30316,fz,-582.5
f,30334,fz,-553.22
f,30354,fz,-553.22
f,30370,fz,-553.22
f,30392,fz,-603.02
f,30400,fz,-562.31
f,30424,fz,-582.5
f,30442,fz,-612.11
f,30462,fz,-612.11
f,30478,fz,-612.11
f,30496,fz,-603.02
f,30516,fz,-562.31
f,30532,fz,-582.5
f,30550,fz,-553.22
f,30570,fz,-553.22
f,30586,fz,-553.22
f,30608,fz,-603.02
f,30616,fz,-562.31
f,30640,fz,-582.5
f,30658,fz,-612.11
f,30678,fz,-612.11
f,30694,fz,-612.11
f,30712,fz,-603.02
f,30732,fz,-562.31
f,30748,fz,-582.5
f,30766,fz,-553.22
f,30786,fz,-553.22
f,30802,fz,-553.22
f,30824,fz,-603.02
f,30832,fz,-562.31
f,30856,fz,-582.5
f,30874,fz,-612.11
f,30894,fz,-612.11
f,30910,fz,-612.11
f,30928,fz,-603.02
f,30948,fz,-562.31
f,30964,fz,-582.5
f,30982,fz,-553.22
f,31002,fz,-553.22
f,31018,fz,-553.22
f,31040,fz,-603.02
f,31048,fz,-562.31
f,31072,fz,-582.5
f,31090,fz,-612.11
f,31110,fz,-612.11
f,31126,fz,-612.11
f,31144,fz,-603.02
f,31164,fz,-562.31
f,31180,fz,-582.5
f,31198,fz,-553.22
f,31218,fz,-553.22
f,31234,fz,-553.22
f,31256,fz,-603.02
f,31264,fz,-562.31
f,31288,fz,-582.5
f,31306,fz,-612.11
f,31326,fz,-612.11
f,31342,fz,-612.11
f,31360,fz,-603.02
f,31380,fz,-562.31
f,31396,fz,-582.5
f,31414,fz,-553.22
f,31434,fz,-553.22
f,31450,fz,-553.22
f,31472,fz,-603.02
f,31480,fz,-562.31
f,31504,fz,-582.5
f,31522,fz,-612.11
f,31542,fz,-612.11
f,31558,fz,-612.11
f,31576,fz,-603.02
f,31596,fz,-562.31
f,31612,fz,-582.5
f,31630,fz,-553.22
f,31650,fz,-553.22
f,31666,fz,-553.22
f,31688,fz,-603.02
f,31696,fz,-562.31
f,31720,fz,-582.5
f,31738,fz,-612.11
f,31758,fz,-612.11
f,31774,fz,-612.11
f,31792,fz,-603.02
f,31812,fz,-562.31
f,31828,fz,-582.5
f,31846,fz,-553.22
f,31866,fz,-553.22
f,31882,fz,-553.22
f,31904,fz,-683.44
f,31912,fz,-642.72
f,31936,fz,-663.25
f,31954,fz,-692.52
f,31974,fz,-692.52
f,31990,fz,-692.52
f,32008,fz,-683.44
f,32028,fz,-642.72
f,32044,fz,-663.25
f,32062,fz,-633.64
f,32082,fz,-633.64
f,32098,fz,-633.64
f,32120,fz,-683.44
f,32128,fz,-642.72
f,32152,fz,-663.25
f,32170,fz,-692.52
f,32190,fz,-692.52
f,32206,fz,-692.52
f,32224,fz,-683.44
f,32244,fz,-642.72
f,32260,fz,-663.25
f,32278,fz,-633.64
f,32298,fz,-633.64
f,32314,fz,-633.64
f,32336,fz,-683.44
f,32344,fz,-642.72
f,32368,fz,-663.25
f,32386,fz,-692.52
f,32406,fz,-692.52
f,32422,fz,-692.52
f,32440,fz,-683.44
f,32460,fz,-642.72
f,32476,fz,-663.25
f,32494,fz,-633.64
f,32514,fz,-633.64
f,32530,fz,-633.64
f,32552,fz,-683.44
f,32560,fz,-642.72
f,32584,fz,-663.25
f,32602,fz,-692.52
f,32622,fz,-692.52
f,32638,fz,-692.52
f,32656,fz,-683.44
f,32676,fz,-642.72

f,32692,fz,-663.25
f,32710,fz,-633.64
f,32730,fz,-633.64
f,32746,fz,-633.64
f,32768,fz,-683.44
f,32776,fz,-642.72
f,32800,fz,-663.25
f,32818,fz,-692.52
f,32838,fz,-692.52
f,32854,fz,-692.52
f,32872,fz,-683.44
f,32892,fz,-642.72
f,32908,fz,-663.25
f,32926,fz,-633.64
f,32946,fz,-633.64
f,32962,fz,-633.64
f,32984,fz,-683.44
f,32992,fz,-642.72
f,33016,fz,-663.25
f,33034,fz,-692.52
f,33054,fz,-692.52
f,33070,fz,-692.52
f,33088,fz,-683.44
f,33108,fz,-642.72
f,33124,fz,-663.25
f,33142,fz,-633.64
f,33162,fz,-633.64
f,33178,fz,-633.64
f,33200,fz,-683.44
f,33208,fz,-642.72
f,33232,fz,-663.25
f,33250,fz,-692.52
f,33270,fz,-692.52
f,33286,fz,-692.52
f,33304,fz,-683.44
f,33324,fz,-642.72
f,33340,fz,-663.25
f,33358,fz,-633.64
f,33378,fz,-633.64
f,33394,fz,-633.64
f,33416,fz,-683.44
f,33424,fz,-642.72
f,33448,fz,-663.25
f,33466,fz,-692.52
f,33486,fz,-692.52
f,33502,fz,-692.52
f,33520,fz,-683.44
f,33540,fz,-642.72
f,33556,fz,-663.25
f,33574,fz,-633.64
f,33594,fz,-633.64
f,33610,fz,-633.64
f,5985,fz,520.116
f,5993,fz,560.828
f,6017,fz,540.64
f,6035,fz,511.031
f,6055,fz,511.031
f,6071,fz,511.031
f,6089,fz,520.116
f,6109,fz,560.828
f,6125,fz,540.64
f,6143,fz,569.913
f,6163,fz,569.913
f,6179,fz,569.913
f,6201,fz,520.116
f,6209,fz,560.828
f,6233,fz,540.64
f,6251,fz,511.031
f,6271,fz,511.031
f,6287,fz,511.031
f,6305,fz,520.116
f,6325,fz,560.828
f,6341,fz,540.64
f,6359,fz,569.913
f,6379,fz,569.913
f,6395,fz,569.913
f,6417,fz,520.116
f,6425,fz,560.828
f,6449,fz,540.64
f,6467,fz,511.031
f,6487,fz,511.031
f,6503,fz,511.031
f,6521,fz,520.116
f,6541,fz,560.828
f,6557,fz,540.64
f,6575,fz,569.913
f,6595,fz,569.913
f,6611,fz,569.913
f,6633,fz,520.116
f,6641,fz,560.828
f,6665,fz,540.64
f,6683,fz,511.031
f,6703,fz,511.031
f,6719,fz,511.031
f,6737,fz,520.116
f,6757,fz,560.828
f,6773,fz,540.64
f,6791,fz,569.913
f,6811,fz,569.913
f,6827,fz,569.913
f,6849,fz,520.116
f,6857,fz,560.828
f,6881,fz,540.64
f,6899,fz,511.031
f,6919,fz,511.031
f,6935,fz,511.031
f,6953,fz,520.116
f,6973,fz,560.828
f,6989,fz,540.64
f,7007,fz,569.913
f,7027,fz,569.913
f,7043,fz,569.913
f,7065,fz,520.116
f,7073,fz,560.828
f,7097,fz,540.64
f,7115,fz,511.031
f,7135,fz,511.031
f,7151,fz,511.031
f,7169,fz,520.116
f,7189,fz,560.828
f,7205,fz,540.64
f,7223,fz,569.913
f,7243,fz,569.913
f,7259,fz,569.913
f,7281,fz,520.116
f,7289,fz,560.828
f,7313,fz,540.64
f,7331,fz,511.031
f,7351,fz,511.031
f,7367,fz,511.031
f,7385,fz,520.116
f,7405,fz,560.828
f,7421,fz,540.64
f,7439,fz,569.913
f,7459,fz,569.913
f,7475,fz,569.913
f,7497,fz,520.116
f,7505,fz,560.828
f,7529,fz,540.64
f,7547,fz,511.031
f,7567,fz,511.031
f,7583,fz,511.031
f,7601,fz,520.116
f,7621,fz,560.828
f,7637,fz,540.64
f,7655,fz,569.913
f,7675,fz,569.913
f,7691,fz,569.913
f,7713,fz,439.7
f,7721,fz,480.412
f,7745,fz,459.888
f,7763,fz,430.615
f,7783,fz,430.615
f,7799,fz,430.615
f,7817,fz,439.7
f,7837,fz,480.412
f,7853,fz,459.888
f,7871,fz,489.497
f,7891,fz,489.497
f,7907,fz,489.497
f,7929,fz,439.7
f,7937,fz,480.412
f,7961,fz,459.888
f,7979,fz,430.615
f,7999,fz,430.615
f,8015,fz,430.615
f,8033,fz,439.7
f,8053,fz,480.412
f,8069,fz,459.888
f,8087,fz,489.497
f,8107,fz,489.497
f,8123,fz,489.497
f,8145,fz,439.7
f,8153,fz,480.412
f,8177,fz,459.888
f,8195,fz,430.615
f,8215,fz,430.615
f,8231,fz,430.615
f,8249,fz,439.7
f,8269,fz,480.412
f,8285,fz,459.888
f,8303,fz,489.497
f,8323,fz,489.497
f,8339,fz,489.497
f,8361,fz,439.7
f,8369,fz,480.412
f,8393,fz,459.888
f,8411,fz,430.615
f,8431,fz,430.615
f,8447,fz,430.615
f,8465,fz,439.7
f,8485,fz,480.412
f,8501,fz,459.888
f,8519,fz,489.497
f,8539,fz,489.497
f,8555,fz,489.497
f,8577,fz,439.7
f,8585,fz,480.412
f,8609,fz,459.888
f,8627,fz,430.615
f,8647,fz,430.615
f,8663,fz,430.615
f,8681,fz,439.7
f,8701,fz,480.412
f,8717,fz,459.888
f,8735,fz,489.497
f,8755,fz,489.497
f,8771,fz,489.497
f,8793,fz,439.7
f,8801,fz,480.412
f,8825,fz,459.888
f,8843,fz,430.615
f,8863,fz,430.615
f,8879,fz,430.615
f,8897,fz,439.7
f,8917,fz,480.412
f,8933,fz,459.888
f,8951,fz,489.497
f,8971,fz,489.497
f,8987,fz,489.497
f,9009,fz,439.7
f,9017,fz,480.412
f,9041,fz,459.888
f,9059,fz,430.615
f,9079,fz,430.615
f,9095,fz,430.615
f,9113,fz,439.7
f,9133,fz,480.412
f,9149,fz,459.888
f,9167,fz,489.497
f,9187,fz,489.497
f,9203,fz,489.497
f,9225,fz,439.7
f,9233,fz,480.412
f,9257,fz,459.888
f,9275,fz,430.615
f,9295,fz,430.615
f,9311,fz,430.615
f,9329,fz,439.7
f,9349,fz,480.412
f,9365,fz,459.888
f,9383,fz,489.497
f,9403,fz,489.497
f,9419,fz,489.497
f,9441,fz,359.284
f,9449,fz,399.66
f,9473,fz,379.472
f,9491,fz,350.2
f,9511,fz,350.2
f,9527,fz,350.2
f,9545,fz,359.284
f,9565,fz,399.66
f,9581,fz,379.472
f,9599,fz,408.745
f,9619,fz,408.745
f,9635,fz,408.745
f,9657,fz,359.284
f,9665,fz,399.66
f,9689,fz,379.472
f,9707,fz,350.2
f,9727,fz,350.2
f,9743,fz,350.2
f,9761,fz,359.284
f,9781,fz,399.66
f,9797,fz,379.472
f,9815,fz,408.745
f,9835,fz,408.745
f,9851,fz,408.745
f,9873,fz,359.284
f,9881,fz,399.66
f,9905,fz,379.472
f,9923,fz,350.2
f,9943,fz,350.2
f,9959,fz,350.2
f,9977,fz,359.284
f,9997,fz,399.66
f,10013,fz,379.472
f,10031,fz,408.745
f,10051,fz,408.745
f,10067,fz,408.745
f,10089,fz,359.284
f,10097,fz,399.66
f,10121,fz,379.472
f,10139,fz,350.2
f,10159,fz,350.2
f,10175,fz,350.2
f,10193,fz,359.284
f,10213,fz,399.66
f,10229,fz,379.472
f,10247,fz,408.745
f,10267,fz,408.745
f,10283,fz,408.745
f,10305,fz,359.284
f,10313,fz,399.66
f,10337,fz,379.472
f,10355,fz,350.2
f,10375,fz,350.2
f,10391,fz,350.2
f,10409,fz,359.284
f,10429,fz,399.66
f,10445,fz,379.472
f,10463,fz,408.745
f,10483,fz,408.745
f,10499,fz,408.745
f,10521,fz,359.284
f,10529,fz,399.66
f,10553,fz,379.472
f,10571,fz,350.2
f,10591,fz,350.2
f,10607,fz,350.2
f,10625,fz,359.284
f,10645,fz,399.66
f,10661,fz,379.472
f,10679,fz,408.745
f,10699,fz,408.745
f,10715,fz,408.745
f,10737,fz,359.284
f,10745,fz,399.66
f,10769,fz,379.472
f,10787,fz,350.2
f,10807,fz,350.2
f,10823,fz,350.2
f,10841,fz,359.284
f,10861,fz,399.66
f,10877,fz,379.472
f,10895,fz,408.745
f,10915,fz,408.745
f,10931,fz,408.745
f,10953,fz,359.284
f,10961,fz,399.66
f,10985,fz,379.472
f,11003,fz,350.2

f,11023,fz,350.2
f,11039,fz,350.2
f,11057,fz,359.284
f,11077,fz,399.66
f,11093,fz,379.472
f,11111,fz,408.745
f,11131,fz,408.745
f,11147,fz,408.745
f,11169,fz,278.532
f,11177,fz,319.245
f,11201,fz,299.056
f,11219,fz,269.447
f,11239,fz,269.447
f,11255,fz,269.447
f,11273,fz,278.532
f,11293,fz,319.245
f,11309,fz,299.056
f,11327,fz,328.329
f,11347,fz,328.329
f,11363,fz,328.329
f,11385,fz,278.532
f,11393,fz,319.245
f,11417,fz,299.056
f,11435,fz,269.447
f,11455,fz,269.447
f,11471,fz,269.447
f,11489,fz,278.532
f,11509,fz,319.245
f,11525,fz,299.056
f,11543,fz,328.329
f,11563,fz,328.329
f,11579,fz,328.329
f,11601,fz,278.532
f,11609,fz,319.245
f,11633,fz,299.056
f,11651,fz,269.447
f,11671,fz,269.447
f,11687,fz,269.447
f,11705,fz,278.532
f,11725,fz,319.245
f,11741,fz,299.056
f,11759,fz,328.329
f,11779,fz,328.329
f,11795,fz,328.329
f,11817,fz,278.532
f,11825,fz,319.245
f,11849,fz,299.056
f,11867,fz,269.447
f,11887,fz,269.447
f,11903,fz,269.447
f,11921,fz,278.532
f,11941,fz,319.245
f,11957,fz,299.056
f,11975,fz,328.329
f,11995,fz,328.329
f,12011,fz,328.329
f,12033,fz,278.532
f,12041,fz,319.245
f,12065,fz,299.056
f,12083,fz,269.447
f,12103,fz,269.447
f,12119,fz,269.447
f,12137,fz,278.532
f,12157,fz,319.245
f,12173,fz,299.056
f,12191,fz,328.329
f,12211,fz,328.329
f,12227,fz,328.329
f,12249,fz,278.532
f,12257,fz,319.245
f,12281,fz,299.056
f,12299,fz,269.447
f,12319,fz,269.447
f,12335,fz,269.447
f,12353,fz,278.532
f,12373,fz,319.245
f,12389,fz,299.056
f,12407,fz,328.329
f,12427,fz,328.329
f,12443,fz,328.329
f,12465,fz,278.532
f,12473,fz,319.245
f,12497,fz,299.056
f,12515,fz,269.447
f,12535,fz,269.447
f,12551,fz,269.447
f,12569,fz,278.532
f,12589,fz,319.245
f,12605,fz,299.056
f,12623,fz,328.329
f,12643,fz,328.329
f,12659,fz,328.329
f,12681,fz,278.532
f,12689,fz,319.245
f,12713,fz,299.056
f,12731,fz,269.447
f,12751,fz,269.447
f,12767,fz,269.447
f,12785,fz,278.532
f,12805,fz,319.245
f,12821,fz,299.056
f,12839,fz,328.329
f,12859,fz,328.329
f,12875,fz,328.329
f,12897,fz,198.116
f,12905,fz,238.829
f,12929,fz,218.304
f,12947,fz,189.032
f,12967,fz,189.032
f,12983,fz,189.032
f,13001,fz,198.116
f,13021,fz,238.829
f,13037,fz,218.304
f,13055,fz,247.913
f,13075,fz,247.913
f,13091,fz,247.913
f,13113,fz,198.116
f,13121,fz,238.829
f,13145,fz,218.304
f,13163,fz,189.032
f,13183,fz,189.032
f,13199,fz,189.032
f,13217,fz,198.116
f,13237,fz,238.829
f,13253,fz,218.304
f,13271,fz,247.913
f,13291,fz,247.913
f,13307,fz,247.913
f,13329,fz,198.116
f,13337,fz,238.829
f,13361,fz,218.304
f,13379,fz,189.032
f,13399,fz,189.032
f,13415,fz,189.032
f,13433,fz,198.116
f,13453,fz,238.829
f,13469,fz,218.304
f,13487,fz,247.913
f,13507,fz,247.913
f,13523,fz,247.913
f,13545,fz,198.116
f,13553,fz,238.829
f,13577,fz,218.304
f,13595,fz,189.032
f,13615,fz,189.032
f,13631,fz,189.032
f,13649,fz,198.116
f,13669,fz,238.829
f,13685,fz,218.304
f,13703,fz,247.913
f,13723,fz,247.913
f,13739,fz,247.913
f,13761,fz,198.116
f,13769,fz,238.829
f,13793,fz,218.304
f,13811,fz,189.032
f,13831,fz,189.032
f,13847,fz,189.032
f,13865,fz,198.116
f,13885,fz,238.829
f,13901,fz,218.304
f,13919,fz,247.913
f,13939,fz,247.913
f,13955,fz,247.913
f,13977,fz,198.116
f,13985,fz,238.829
f,14009,fz,218.304
f,14027,fz,189.032
f,14047,fz,189.032
f,14063,fz,189.032
f,14081,fz,198.116
f,14101,fz,238.829
f,14117,fz,218.304
f,14135,fz,247.913
f,14155,fz,247.913
f,14171,fz,247.913
f,14193,fz,198.116
f,14201,fz,238.829
f,14225,fz,218.304
f,14243,fz,189.032
f,14263,fz,189.032
f,14279,fz,189.032
f,14297,fz,198.116
f,14317,fz,238.829
f,14333,fz,218.304
f,14351,fz,247.913
f,14371,fz,247.913
f,14387,fz,247.913
f,14409,fz,198.116
f,14417,fz,238.829
f,14441,fz,218.304
f,14459,fz,189.032
f,14479,fz,189.032
f,14495,fz,189.032
f,14513,fz,198.116
f,14533,fz,238.829
f,14549,fz,218.304
f,14567,fz,247.913
f,14587,fz,247.913
f,14603,fz,247.913
f,14625,fz,117.701
f,14633,fz,158.413
f,14657,fz,137.889
f,14675,fz,108.616
f,14695,fz,108.616
f,14711,fz,108.616
f,14729,fz,117.701
f,14749,fz,158.413
f,14765,fz,137.889
f,14783,fz,167.498
f,14803,fz,167.498
f,14819,fz,167.498
f,14841,fz,117.701
f,14849,fz,158.413
f,14873,fz,137.889
f,14891,fz,108.616
f,14911,fz,108.616
f,14927,fz,108.616
f,14945,fz,117.701
f,14965,fz,158.413
f,14981,fz,137.889
f,14999,fz,167.498
f,15019,fz,167.498
f,15035,fz,167.498
f,15057,fz,117.701
f,15065,fz,158.413
f,15089,fz,137.889
f,15107,fz,108.616
f,15127,fz,108.616
f,15143,fz,108.616
f,15161,fz,117.701
f,15181,fz,158.413
f,15197,fz,137.889
f,15215,fz,167.498
f,15235,fz,167.498
f,15251,fz,167.498
f,15273,fz,117.701
f,15281,fz,158.413
f,15305,fz,137.889
f,15323,fz,108.616
f,15343,fz,108.616
f,15359,fz,108.616
f,15377,fz,117.701
f,15397,fz,158.413
f,15413,fz,137.889
f,15431,fz,167.498
f,15451,fz,167.498
f,15467,fz,167.498
f,15489,fz,117.701
f,15497,fz,158.413
f,15521,fz,137.889
f,15539,fz,108.616
f,15559,fz,108.616
f,15575,fz,108.616
f,15593,fz,117.701
f,15613,fz,158.413
f,15629,fz,137.889
f,15647,fz,167.498
f,15667,fz,167.498
f,15683,fz,167.498
f,15705,fz,117.701
f,15713,fz,158.413
f,15737,fz,137.889
f,15755,fz,108.616
f,15775,fz,108.616
f,15791,fz,108.616
f,15809,fz,117.701
f,15829,fz,158.413
f,15845,fz,137.889
f,15863,fz,167.498
f,15883,fz,167.498
f,15899,fz,167.498
f,15921,fz,117.701
f,15929,fz,158.413
f,15953,fz,137.889
f,15971,fz,108.616
f,15991,fz,108.616
f,16007,fz,108.616
f,16025,fz,117.701
f,16045,fz,158.413
f,16061,fz,137.889
f,16079,fz,167.498
f,16099,fz,167.498
f,16115,fz,167.498
f,16137,fz,117.701
f,16145,fz,158.413
f,16169,fz,137.889
f,16187,fz,108.616
f,16207,fz,108.616
f,16223,fz,108.616
f,16241,fz,117.701
f,16261,fz,158.413
f,16277,fz,137.889
f,16295,fz,167.498
f,16315,fz,167.498
f,16331,fz,167.498
f,16353,fz,36.9484
f,16361,fz,77.6609
f,16385,fz,57.4729
f,16403,fz,28.2002
f,16423,fz,28.2002
f,16439,fz,28.2002
f,16457,fz,36.9484
f,16477,fz,77.6609
f,16493,fz,57.4729
f,16511,fz,86.7456
f,16531,fz,86.7456
f,16547,fz,86.7456
f,16569,fz,36.9484
f,16577,fz,77.6609
f,16601,fz,57.4729
f,16619,fz,28.2002
f,16639,fz,28.2002
f,16655,fz,28.2002
f,16673,fz,36.9484
f,16693,fz,77.6609
f,16709,fz,57.4729
f,16727,fz,86.7456
f,16747,fz,86.7456
f,16763,fz,86.7456
f,16785,fz,36.9484
f,16793,fz,77.6609
f,16817,fz,57.4729
f,16835,fz,28.2002
f,16855,fz,28.2002
f,16871,fz,28.2002
f,16889,fz,36.9484
f,16909,fz,77.6609
f,16925,fz,57.4729
f,16943,fz,86.7456
f,16963,fz,86.7456
f,16979,fz,86.7456

f,17001,fz,36.9484
f,17009,fz,77.6609
f,17033,fz,57.4729
f,17051,fz,28.2002
f,17071,fz,28.2002
f,17087,fz,28.2002
f,17105,fz,36.9484
f,17125,fz,77.6609
f,17141,fz,57.4729
f,17159,fz,86.7456
f,17179,fz,86.7456
f,17195,fz,86.7456
f,17217,fz,36.9484
f,17225,fz,77.6609
f,17249,fz,57.4729
f,17267,fz,28.2002
f,17287,fz,28.2002
f,17303,fz,28.2002
f,17321,fz,36.9484
f,17341,fz,77.6609
f,17357,fz,57.4729
f,17375,fz,86.7456
f,17395,fz,86.7456
f,17411,fz,86.7456
f,17433,fz,36.9484
f,17441,fz,77.6609
f,17465,fz,57.4729
f,17483,fz,28.2002
f,17503,fz,28.2002
f,17519,fz,28.2002
f,17537,fz,36.9484
f,17557,fz,77.6609
f,17573,fz,57.4729
f,17591,fz,86.7456
f,17611,fz,86.7456
f,17627,fz,86.7456
f,17649,fz,36.9484
f,17657,fz,77.6609
f,17681,fz,57.4729
f,17699,fz,28.2002
f,17719,fz,28.2002
f,17735,fz,28.2002
f,17753,fz,36.9484
f,17773,fz,77.6609
f,17789,fz,57.4729
f,17807,fz,86.7456
f,17827,fz,86.7456
f,17843,fz,86.7456
f,17865,fz,36.9484
f,17873,fz,77.6609
f,17897,fz,57.4729
f,17915,fz,28.2002
f,17935,fz,28.2002
f,17951,fz,28.2002
f,17969,fz,36.9484
f,17989,fz,77.6609
f,18005,fz,57.4729
f,18023,fz,86.7456
f,18043,fz,86.7456
f,18059,fz,86.7456
f,18081,fz,-43.467
f,18089,fz,-2.7548
f,18113,fz,-22.943
f,18131,fz,-52.552
f,18151,fz,-52.552
f,18167,fz,-52.552
f,18185,fz,-43.467
f,18205,fz,-2.7548
f,18221,fz,-22.943
f,18239,fz,6.32986
f,18259,fz,6.32986
f,18275,fz,6.32986
f,18297,fz,-43.467
f,18305,fz,-2.7548
f,18329,fz,-22.943
f,18347,fz,-52.552
f,18367,fz,-52.552
f,18383,fz,-52.552
f,18401,fz,-43.467
f,18421,fz,-2.7548
f,18437,fz,-22.943
f,18455,fz,6.32986
f,18475,fz,6.32986
f,18491,fz,6.32986
f,18513,fz,-43.467
f,18521,fz,-2.7548
f,18545,fz,-22.943
f,18563,fz,-52.552
f,18583,fz,-52.552
f,18599,fz,-52.552
f,18617,fz,-43.467
f,18637,fz,-2.7548
f,18653,fz,-22.943
f,18671,fz,6.32986
f,18691,fz,6.32986
f,18707,fz,6.32986
f,18729,fz,-43.467
f,18737,fz,-2.7548
f,18761,fz,-22.943
f,18779,fz,-52.552
f,18799,fz,-52.552
f,18815,fz,-52.552
f,18833,fz,-43.467
f,18853,fz,-2.7548
f,18869,fz,-22.943
f,18887,fz,6.32986
f,18907,fz,6.32986
f,18923,fz,6.32986
f,18945,fz,-43.467
f,18953,fz,-2.7548
f,18977,fz,-22.943
f,18995,fz,-52.552
f,19015,fz,-52.552
f,19031,fz,-52.552
f,19049,fz,-43.467
f,19069,fz,-2.7548
f,19085,fz,-22.943
f,19103,fz,6.32986
f,19123,fz,6.32986
f,19139,fz,6.32986
f,19161,fz,-43.467
f,19169,fz,-2.7548
f,19193,fz,-22.943
f,19211,fz,-52.552
f,19231,fz,-52.552
f,19247,fz,-52.552
f,19265,fz,-43.467
f,19285,fz,-2.7548
f,19301,fz,-22.943
f,19319,fz,6.32986
f,19339,fz,6.32986
f,19355,fz,6.32986
f,19377,fz,-43.467
f,19385,fz,-2.7548
f,19409,fz,-22.943
f,19427,fz,-52.552
f,19447,fz,-52.552
f,19463,fz,-52.552
f,19481,fz,-43.467
f,19501,fz,-2.7548
f,19517,fz,-22.943
f,19535,fz,6.32986
f,19555,fz,6.32986
f,19571,fz,6.32986
f,19593,fz,-43.467
f,19601,fz,-2.7548
f,19625,fz,-22.943
f,19643,fz,-52.552
f,19663,fz,-52.552
f,19679,fz,-52.552
f,19697,fz,-43.467
f,19717,fz,-2.7548
f,19733,fz,-22.943
f,19751,fz,6.32986
f,19771,fz,6.32986
f,19787,fz,6.32986
f,19809,fz,-123.88
f,19817,fz,-83.17
f,19841,fz,-103.69
f,19859,fz,-132.97
f,19879,fz,-132.97
f,19895,fz,-132.97
f,19913,fz,-123.88
f,19933,fz,-83.17
f,19949,fz,-103.69
f,19967,fz,-74.086
f,19987,fz,-74.086
f,20003,fz,-74.086
f,20025,fz,-123.88
f,20033,fz,-83.17
f,20057,fz,-103.69
f,20075,fz,-132.97
f,20095,fz,-132.97
f,20111,fz,-132.97
f,20129,fz,-123.88
f,20149,fz,-83.17
f,20165,fz,-103.69
f,20183,fz,-74.086
f,20203,fz,-74.086
f,20219,fz,-74.086
f,20241,fz,-123.88
f,20249,fz,-83.17
f,20273,fz,-103.69
f,20291,fz,-132.97
f,20311,fz,-132.97
f,20327,fz,-132.97
f,20345,fz,-123.88
f,20365,fz,-83.17
f,20381,fz,-103.69
f,20399,fz,-74.086
f,20419,fz,-74.086
f,20435,fz,-74.086
f,20457,fz,-123.88
f,20465,fz,-83.17
f,20489,fz,-103.69
f,20507,fz,-132.97
f,20527,fz,-132.97
f,20543,fz,-132.97
f,20561,fz,-123.88
f,20581,fz,-83.17
f,20597,fz,-103.69
f,20615,fz,-74.086
f,20635,fz,-74.086
f,20651,fz,-74.086
f,20673,fz,-123.88
f,20681,fz,-83.17
f,20705,fz,-103.69
f,20723,fz,-132.97
f,20743,fz,-132.97
f,20759,fz,-132.97
f,20777,fz,-123.88
f,20797,fz,-83.17
f,20813,fz,-103.69
f,20831,fz,-74.086
f,20851,fz,-74.086
f,20867,fz,-74.086
f,20889,fz,-123.88
f,20897,fz,-83.17
f,20921,fz,-103.69
f,20939,fz,-132.97
f,20959,fz,-132.97
f,20975,fz,-132.97
f,20993,fz,-123.88
f,21013,fz,-83.17
f,21029,fz,-103.69
f,21047,fz,-74.086
f,21067,fz,-74.086
f,21083,fz,-74.086
f,21105,fz,-123.88
f,21113,fz,-83.17
f,21137,fz,-103.69
f,21155,fz,-132.97
f,21175,fz,-132.97
f,21191,fz,-132.97
f,21209,fz,-123.88
f,21229,fz,-83.17
f,21245,fz,-103.69
f,21263,fz,-74.086
f,21283,fz,-74.086
f,21299,fz,-74.086
f,21321,fz,-123.88
f,21329,fz,-83.17
f,21353,fz,-103.69
f,21371,fz,-132.97
f,21391,fz,-132.97
f,21407,fz,-132.97
f,21425,fz,-123.88
f,21445,fz,-83.17
f,21461,fz,-103.69
f,21479,fz,-74.086
f,21499,fz,-74.086
f,21515,fz,-74.086
f,21537,fz,-204.3
f,21545,fz,-163.59
f,21569,fz,-184.11
f,21587,fz,-213.38
f,21607,fz,-213.38
f,21623,fz,-213.38
f,21641,fz,-204.3
f,21661,fz,-163.59
f,21677,fz,-184.11
f,21695,fz,-154.84
f,21715,fz,-154.84
f,21731,fz,-154.84
f,21753,fz,-204.3
f,21761,fz,-163.59
f,21785,fz,-184.11
f,21803,fz,-213.38
f,21823,fz,-213.38
f,21839,fz,-213.38
f,21857,fz,-204.3
f,21877,fz,-163.59
f,21893,fz,-184.11
f,21911,fz,-154.84
f,21931,fz,-154.84
f,21947,fz,-154.84
f,21969,fz,-204.3
f,21977,fz,-163.59
f,22001,fz,-184.11
f,22019,fz,-213.38
f,22039,fz,-213.38
f,22055,fz,-213.38
f,22073,fz,-204.3
f,22093,fz,-163.59
f,22109,fz,-184.11
f,22127,fz,-154.84
f,22147,fz,-154.84
f,22163,fz,-154.84
f,22185,fz,-204.3
f,22193,fz,-163.59
f,22217,fz,-184.11
f,22235,fz,-213.38
f,22255,fz,-213.38
f,22271,fz,-213.38
f,22289,fz,-204.3
f,22309,fz,-163.59
f,22325,fz,-184.11
f,22343,fz,-154.84
f,22363,fz,-154.84
f,22379,fz,-154.84
f,22401,fz,-204.3
f,22409,fz,-163.59
f,22433,fz,-184.11
f,22451,fz,-213.38
f,22471,fz,-213.38
f,22487,fz,-213.38
f,22505,fz,-204.3
f,22525,fz,-163.59
f,22541,fz,-184.11
f,22559,fz,-154.84
f,22579,fz,-154.84
f,22595,fz,-154.84
f,22617,fz,-204.3
f,22625,fz,-163.59
f,22649,fz,-184.11
f,22667,fz,-213.38
f,22687,fz,-213.38
f,22703,fz,-213.38
f,22721,fz,-204.3
f,22741,fz,-163.59
f,22757,fz,-184.11
f,22775,fz,-154.84
f,22795,fz,-154.84
f,22811,fz,-154.84
f,22833,fz,-204.3
f,22841,fz,-163.59
f,22865,fz,-184.11
f,22883,fz,-213.38
f,22903,fz,-213.38
f,22919,fz,-213.38
f,22937,fz,-204.3
f,22957,fz,-163.59

f,22973,fz,-184.11
f,22991,fz,-154.84
f,23011,fz,-154.84
f,23027,fz,-154.84
f,23049,fz,-204.3
f,23057,fz,-163.59
f,23081,fz,-184.11
f,23099,fz,-213.38
f,23119,fz,-213.38
f,23135,fz,-213.38
f,23153,fz,-204.3
f,23173,fz,-163.59
f,23189,fz,-184.11
f,23207,fz,-154.84
f,23227,fz,-154.84
f,23243,fz,-154.84
f,23265,fz,-285.05
f,23273,fz,-244.34
f,23297,fz,-264.53
f,23315,fz,-294.14
f,23335,fz,-294.14
f,23351,fz,-294.14
f,23369,fz,-285.05
f,23389,fz,-244.34
f,23405,fz,-264.53
f,23423,fz,-235.25
f,23443,fz,-235.25
f,23459,fz,-235.25
f,23481,fz,-285.05
f,23489,fz,-244.34
f,23513,fz,-264.53
f,23531,fz,-294.14
f,23551,fz,-294.14
f,23567,fz,-294.14
f,23585,fz,-285.05
f,23605,fz,-244.34
f,23621,fz,-264.53
f,23639,fz,-235.25
f,23659,fz,-235.25
f,23675,fz,-235.25
f,23697,fz,-285.05
f,23705,fz,-244.34
f,23729,fz,-264.53
f,23747,fz,-294.14
f,23767,fz,-294.14
f,23783,fz,-294.14
f,23801,fz,-285.05
f,23821,fz,-244.34
f,23837,fz,-264.53
f,23855,fz,-235.25
f,23875,fz,-235.25
f,23891,fz,-235.25
f,23913,fz,-285.05
f,23921,fz,-244.34
f,23945,fz,-264.53
f,23963,fz,-294.14
f,23983,fz,-294.14
f,23999,fz,-294.14
f,24017,fz,-285.05
f,24037,fz,-244.34
f,24053,fz,-264.53
f,24071,fz,-235.25
f,24091,fz,-235.25
f,24107,fz,-235.25
f,24129,fz,-285.05
f,24137,fz,-244.34
f,24161,fz,-264.53
f,24179,fz,-294.14
f,24199,fz,-294.14
f,24215,fz,-294.14
f,24233,fz,-285.05
f,24253,fz,-244.34
f,24269,fz,-264.53
f,24287,fz,-235.25
f,24307,fz,-235.25
f,24323,fz,-235.25
f,24345,fz,-285.05
f,24353,fz,-244.34
f,24377,fz,-264.53
f,24395,fz,-294.14
f,24415,fz,-294.14
f,24431,fz,-294.14
f,24449,fz,-285.05
f,24469,fz,-244.34
f,24485,fz,-264.53
f,24503,fz,-235.25
f,24523,fz,-235.25
f,24539,fz,-235.25
f,24561,fz,-285.05
f,24569,fz,-244.34
f,24593,fz,-264.53
f,24611,fz,-294.14
f,24631,fz,-294.14
f,24647,fz,-294.14
f,24665,fz,-285.05
f,24685,fz,-244.34
f,24701,fz,-264.53
f,24719,fz,-235.25
f,24739,fz,-235.25
f,24755,fz,-235.25
f,24777,fz,-285.05
f,24785,fz,-244.34
f,24809,fz,-264.53
f,24827,fz,-294.14
f,24847,fz,-294.14
f,24863,fz,-294.14
f,24881,fz,-285.05
f,24901,fz,-244.34
f,24917,fz,-264.53
f,24935,fz,-235.25
f,24955,fz,-235.25
f,24971,fz,-235.25
f,24993,fz,-365.47
f,25001,fz,-324.75
f,25025,fz,-344.94
f,25043,fz,-374.55
f,25063,fz,-374.55
f,25079,fz,-374.55
f,25097,fz,-365.47
f,25117,fz,-324.75
f,25133,fz,-344.94
f,25151,fz,-315.67
f,25171,fz,-315.67
f,25187,fz,-315.67
f,25209,fz,-365.47
f,25217,fz,-324.75
f,25241,fz,-344.94
f,25259,fz,-374.55
f,25279,fz,-374.55
f,25295,fz,-374.55
f,25313,fz,-365.47
f,25333,fz,-324.75
f,25349,fz,-344.94
f,25367,fz,-315.67
f,25387,fz,-315.67
f,25403,fz,-315.67
f,25425,fz,-365.47
f,25433,fz,-324.75
f,25457,fz,-344.94
f,25475,fz,-374.55
f,25495,fz,-374.55
f,25511,fz,-374.55
f,25529,fz,-365.47
f,25549,fz,-324.75
f,25565,fz,-344.94
f,25583,fz,-315.67
f,25603,fz,-315.67
f,25619,fz,-315.67
f,25641,fz,-365.47
f,25649,fz,-324.75
f,25673,fz,-344.94
f,25691,fz,-374.55
f,25711,fz,-374.55
f,25727,fz,-374.55
f,25745,fz,-365.47
f,25765,fz,-324.75
f,25781,fz,-344.94
f,25799,fz,-315.67
f,25819,fz,-315.67
f,25835,fz,-315.67
f,25857,fz,-365.47
f,25865,fz,-324.75
f,25889,fz,-344.94
f,25907,fz,-374.55
f,25927,fz,-374.55
f,25943,fz,-374.55
f,25961,fz,-365.47
f,25981,fz,-324.75
f,25997,fz,-344.94
f,26015,fz,-315.67
f,26035,fz,-315.67
f,26051,fz,-315.67
f,26073,fz,-365.47
f,26081,fz,-324.75
f,26105,fz,-344.94
f,26123,fz,-374.55
f,26143,fz,-374.55
f,26159,fz,-374.55
f,26177,fz,-365.47
f,26197,fz,-324.75
f,26213,fz,-344.94
f,26231,fz,-315.67
f,26251,fz,-315.67
f,26267,fz,-315.67
f,26289,fz,-365.47
f,26297,fz,-324.75
f,26321,fz,-344.94
f,26339,fz,-374.55
f,26359,fz,-374.55
f,26375,fz,-374.55
f,26393,fz,-365.47
f,26413,fz,-324.75
f,26429,fz,-344.94
f,26447,fz,-315.67
f,26467,fz,-315.67
f,26483,fz,-315.67
f,26505,fz,-365.47
f,26513,fz,-324.75
f,26537,fz,-344.94
f,26555,fz,-374.55
f,26575,fz,-374.55
f,26591,fz,-374.55
f,26609,fz,-365.47
f,26629,fz,-324.75
f,26645,fz,-344.94
f,26663,fz,-315.67
f,26683,fz,-315.67
f,26699,fz,-315.67
f,26721,fz,-445.88
f,26729,fz,-405.17
f,26753,fz,-425.69
f,26771,fz,-454.97
f,26791,fz,-454.97
f,26807,fz,-454.97
f,26825,fz,-445.88
f,26845,fz,-405.17
f,26861,fz,-425.69
f,26879,fz,-396.09
f,26899,fz,-396.09
f,26915,fz,-396.09
f,26937,fz,-445.88
f,26945,fz,-405.17
f,26969,fz,-425.69
f,26987,fz,-454.97
f,27007,fz,-454.97
f,27023,fz,-454.97
f,27041,fz,-445.88
f,27061,fz,-405.17
f,27077,fz,-425.69
f,27095,fz,-396.09
f,27115,fz,-396.09
f,27131,fz,-396.09
f,27153,fz,-445.88
f,27161,fz,-405.17
f,27185,fz,-425.69
f,27203,fz,-454.97
f,27223,fz,-454.97
f,27239,fz,-454.97
f,27257,fz,-445.88
f,27277,fz,-405.17
f,27293,fz,-425.69
f,27311,fz,-396.09
f,27331,fz,-396.09
f,27347,fz,-396.09
f,27369,fz,-445.88
f,27377,fz,-405.17
f,27401,fz,-425.69
f,27419,fz,-454.97
f,27439,fz,-454.97
f,27455,fz,-454.97
f,27473,fz,-445.88
f,27493,fz,-405.17
f,27509,fz,-425.69
f,27527,fz,-396.09
f,27547,fz,-396.09
f,27563,fz,-396.09
f,27585,fz,-445.88
f,27593,fz,-405.17
f,27617,fz,-425.69
f,27635,fz,-454.97
f,27655,fz,-454.97
f,27671,fz,-454.97
f,27689,fz,-445.88
f,27709,fz,-405.17
f,27725,fz,-425.69
f,27743,fz,-396.09
f,27763,fz,-396.09
f,27779,fz,-396.09
f,27801,fz,-445.88
f,27809,fz,-405.17
f,27833,fz,-425.69
f,27851,fz,-454.97
f,27871,fz,-454.97
f,27887,fz,-454.97
f,27905,fz,-445.88
f,27925,fz,-405.17
f,27941,fz,-425.69
f,27959,fz,-396.09
f,27979,fz,-396.09
f,27995,fz,-396.09
f,28017,fz,-445.88
f,28025,fz,-405.17
f,28049,fz,-425.69
f,28067,fz,-454.97
f,28087,fz,-454.97
f,28103,fz,-454.97
f,28121,fz,-445.88
f,28141,fz,-405.17
f,28157,fz,-425.69
f,28175,fz,-396.09
f,28195,fz,-396.09
f,28211,fz,-396.09
f,28233,fz,-445.88
f,28241,fz,-405.17
f,28265,fz,-425.69
f,28283,fz,-454.97
f,28303,fz,-454.97
f,28319,fz,-454.97
f,28337,fz,-445.88
f,28357,fz,-405.17
f,28373,fz,-425.69
f,28391,fz,-396.09
f,28411,fz,-396.09
f,28427,fz,-396.09
f,28449,fz,-526.3
f,28457,fz,-485.92
f,28481,fz,-506.11
f,28499,fz,-535.38
f,28519,fz,-535.38
f,28535,fz,-535.38
f,28553,fz,-526.3
f,28573,fz,-485.92
f,28589,fz,-506.11
f,28607,fz,-476.84
f,28627,fz,-476.84
f,28643,fz,-476.84
f,28665,fz,-526.3
f,28673,fz,-485.92
f,28697,fz,-506.11
f,28715,fz,-535.38
f,28735,fz,-535.38
f,28751,fz,-535.38
f,28769,fz,-526.3
f,28789,fz,-485.92
f,28805,fz,-506.11
f,28823,fz,-476.84
f,28843,fz,-476.84
f,28859,fz,-476.84
f,28881,fz,-526.3
f,28889,fz,-485.92
f,28913,fz,-506.11
f,28931,fz,-535.38

f,28951,fz,-535.38
f,28967,fz,-535.38
f,28985,fz,-526.3
f,29005,fz,-485.92
f,29021,fz,-506.11
f,29039,fz,-476.84
f,29059,fz,-476.84
f,29075,fz,-476.84
f,29097,fz,-526.3
f,29105,fz,-485.92
f,29129,fz,-506.11
f,29147,fz,-535.38
f,29167,fz,-535.38
f,29183,fz,-535.38
f,29201,fz,-526.3
f,29221,fz,-485.92
f,29237,fz,-506.11
f,29255,fz,-476.84
f,29275,fz,-476.84
f,29291,fz,-476.84
f,29313,fz,-526.3
f,29321,fz,-485.92
f,29345,fz,-506.11
f,29363,fz,-535.38
f,29383,fz,-535.38
f,29399,fz,-535.38
f,29417,fz,-526.3
f,29437,fz,-485.92
f,29453,fz,-506.11
f,29471,fz,-476.84
f,29491,fz,-476.84
f,29507,fz,-476.84
f,29529,fz,-526.3
f,29537,fz,-485.92
f,29561,fz,-506.11
f,29579,fz,-535.38
f,29599,fz,-535.38
f,29615,fz,-535.38
f,29633,fz,-526.3
f,29653,fz,-485.92
f,29669,fz,-506.11
f,29687,fz,-476.84
f,29707,fz,-476.84
f,29723,fz,-476.84
f,29745,fz,-526.3
f,29753,fz,-485.92
f,29777,fz,-506.11
f,29795,fz,-535.38
f,29815,fz,-535.38
f,29831,fz,-535.38
f,29849,fz,-526.3
f,29869,fz,-485.92
f,29885,fz,-506.11
f,29903,fz,-476.84
f,29923,fz,-476.84
f,29939,fz,-476.84
f,29961,fz,-526.3
f,29969,fz,-485.92
f,29993,fz,-506.11
f,30011,fz,-535.38
f,30031,fz,-535.38
f,30047,fz,-535.38
f,30065,fz,-526.3
f,30085,fz,-485.92
f,30101,fz,-506.11
f,30119,fz,-476.84
f,30139,fz,-476.84
f,30155,fz,-476.84
f,30177,fz,-607.05
f,30185,fz,-566.34
f,30209,fz,-586.53
f,30227,fz,-616.13
f,30247,fz,-616.13
f,30263,fz,-616.13
f,30281,fz,-607.05
f,30301,fz,-566.34
f,30317,fz,-586.53
f,30335,fz,-557.25
f,30355,fz,-557.25
f,30371,fz,-557.25
f,30393,fz,-607.05
f,30401,fz,-566.34
f,30425,fz,-586.53
f,30443,fz,-616.13
f,30463,fz,-616.13
f,30479,fz,-616.13
f,30497,fz,-607.05
f,30517,fz,-566.34
f,30533,fz,-586.53
f,30551,fz,-557.25
f,30571,fz,-557.25
f,30587,fz,-557.25
f,30609,fz,-607.05
f,30617,fz,-566.34
f,30641,fz,-586.53
f,30659,fz,-616.13
f,30679,fz,-616.13
f,30695,fz,-616.13
f,30713,fz,-607.05
f,30733,fz,-566.34
f,30749,fz,-586.53
f,30767,fz,-557.25
f,30787,fz,-557.25
f,30803,fz,-557.25
f,30825,fz,-607.05
f,30833,fz,-566.34
f,30857,fz,-586.53
f,30875,fz,-616.13
f,30895,fz,-616.13
f,30911,fz,-616.13
f,30929,fz,-607.05
f,30949,fz,-566.34
f,30965,fz,-586.53
f,30983,fz,-557.25
f,31003,fz,-557.25
f,31019,fz,-557.25
f,31041,fz,-607.05
f,31049,fz,-566.34
f,31073,fz,-586.53
f,31091,fz,-616.13
f,31111,fz,-616.13
f,31127,fz,-616.13
f,31145,fz,-607.05
f,31165,fz,-566.34
f,31181,fz,-586.53
f,31199,fz,-557.25
f,31219,fz,-557.25
f,31235,fz,-557.25
f,31257,fz,-607.05
f,31265,fz,-566.34
f,31289,fz,-586.53
f,31307,fz,-616.13
f,31327,fz,-616.13
f,31343,fz,-616.13
f,31361,fz,-607.05
f,31381,fz,-566.34
f,31397,fz,-586.53
f,31415,fz,-557.25
f,31435,fz,-557.25
f,31451,fz,-557.25
f,31473,fz,-607.05
f,31481,fz,-566.34
f,31505,fz,-586.53
f,31523,fz,-616.13
f,31543,fz,-616.13
f,31559,fz,-616.13
f,31577,fz,-607.05
f,31597,fz,-566.34
f,31613,fz,-586.53
f,31631,fz,-557.25
f,31651,fz,-557.25
f,31667,fz,-557.25
f,31689,fz,-607.05
f,31697,fz,-566.34
f,31721,fz,-586.53
f,31739,fz,-616.13
f,31759,fz,-616.13
f,31775,fz,-616.13
f,31793,fz,-607.05
f,31813,fz,-566.34
f,31829,fz,-586.53
f,31847,fz,-557.25
f,31867,fz,-557.25
f,31883,fz,-557.25
f,31905,fz,-687.47
f,31913,fz,-646.75
f,31937,fz,-667.28
f,31955,fz,-696.55
f,31975,fz,-696.55
f,31991,fz,-696.55
f,32009,fz,-687.47
f,32029,fz,-646.75
f,32045,fz,-667.28
f,32063,fz,-637.67
f,32083,fz,-637.67
f,32099,fz,-637.67
f,32121,fz,-687.47
f,32129,fz,-646.75
f,32153,fz,-667.28
f,32171,fz,-696.55
f,32191,fz,-696.55
f,32207,fz,-696.55
f,32225,fz,-687.47
f,32245,fz,-646.75
f,32261,fz,-667.28
f,32279,fz,-637.67
f,32299,fz,-637.67
f,32315,fz,-637.67
f,32337,fz,-687.47
f,32345,fz,-646.75
f,32369,fz,-667.28
f,32387,fz,-696.55
f,32407,fz,-696.55
f,32423,fz,-696.55
f,32441,fz,-687.47
f,32461,fz,-646.75
f,32477,fz,-667.28
f,32495,fz,-637.67
f,32515,fz,-637.67
f,32531,fz,-637.67
f,32553,fz,-687.47
f,32561,fz,-646.75
f,32585,fz,-667.28
f,32603,fz,-696.55
f,32623,fz,-696.55
f,32639,fz,-696.55
f,32657,fz,-687.47
f,32677,fz,-646.75
f,32693,fz,-667.28
f,32711,fz,-637.67
f,32731,fz,-637.67
f,32747,fz,-637.67
f,32769,fz,-687.47
f,32777,fz,-646.75
f,32801,fz,-667.28
f,32819,fz,-696.55
f,32839,fz,-696.55
f,32855,fz,-696.55
f,32873,fz,-687.47
f,32893,fz,-646.75
f,32909,fz,-667.28
f,32927,fz,-637.67
f,32947,fz,-637.67
f,32963,fz,-637.67
f,32985,fz,-687.47
f,32993,fz,-646.75
f,33017,fz,-667.28
f,33035,fz,-696.55
f,33055,fz,-696.55
f,33071,fz,-696.55
f,33089,fz,-687.47
f,33109,fz,-646.75
f,33125,fz,-667.28
f,33143,fz,-637.67
f,33163,fz,-637.67
f,33179,fz,-637.67
f,33201,fz,-687.47
f,33209,fz,-646.75
f,33233,fz,-667.28
f,33251,fz,-696.55
f,33271,fz,-696.55
f,33287,fz,-696.55
f,33305,fz,-687.47
f,33325,fz,-646.75
f,33341,fz,-667.28
f,33359,fz,-637.67
f,33379,fz,-637.67
f,33395,fz,-637.67
f,33417,fz,-687.47
f,33425,fz,-646.75
f,33449,fz,-667.28
f,33467,fz,-696.55
f,33487,fz,-696.55
f,33503,fz,-696.55
f,33521,fz,-687.47
f,33541,fz,-646.75
f,33557,fz,-667.28
f,33575,fz,-637.67
f,33595,fz,-637.67
f,33611,fz,-637.67
f,5972,fz,283.5
f,5973,fz,263.144
f,5974,fz,273.406
f,6026,fz,258.601
f,6044,fz,258.601
f,6045,fz,258.601
f,6080,fz,263.144
f,6098,fz,283.5
f,6099,fz,273.406
f,6134,fz,288.042
f,6152,fz,288.042
f,6153,fz,288.042
f,6188,fz,283.5
f,6189,fz,263.144
f,6190,fz,273.406
f,6242,fz,258.601
f,6260,fz,258.601
f,6261,fz,258.601
f,6296,fz,263.144
f,6314,fz,283.5
f,6315,fz,273.406
f,6350,fz,288.042
f,6368,fz,288.042
f,6369,fz,288.042
f,6404,fz,283.5
f,6405,fz,263.144
f,6406,fz,273.406
f,6458,fz,258.601
f,6476,fz,258.601
f,6477,fz,258.601
f,6512,fz,263.144
f,6530,fz,283.5
f,6531,fz,273.406
f,6566,fz,288.042
f,6584,fz,288.042
f,6585,fz,288.042
f,6620,fz,283.5
f,6621,fz,263.144
f,6622,fz,273.406
f,6674,fz,258.601
f,6692,fz,258.601
f,6693,fz,258.601
f,6728,fz,263.144
f,6746,fz,283.5
f,6747,fz,273.406
f,6782,fz,288.042
f,6800,fz,288.042
f,6801,fz,288.042
f,6836,fz,283.5
f,6837,fz,263.144
f,6838,fz,273.406
f,6890,fz,258.601
f,6908,fz,258.601
f,6909,fz,258.601
f,6944,fz,263.144
f,6962,fz,283.5
f,6963,fz,273.406
f,6998,fz,288.042
f,7016,fz,288.042
f,7017,fz,288.042
f,7052,fz,283.5
f,7053,fz,263.144
f,7054,fz,273.406
f,7106,fz,258.601
f,7124,fz,258.601
f,7125,fz,258.601
f,7160,fz,263.144
f,7178,fz,283.5
f,7179,fz,273.406
f,7214,fz,288.042
f,7232,fz,288.042
f,7233,fz,288.042

f,7268,fr,283.5
f,7269,fr,263.144
f,7270,fr,273.406
f,7322,fr,258.601
f,7340,fr,258.601
f,7341,fr,258.601
f,7376,fr,263.144
f,7394,fr,283.5
f,7395,fr,273.406
f,7430,fr,288.042
f,7448,fr,288.042
f,7449,fr,288.042
f,7484,fr,283.5
f,7485,fr,263.144
f,7486,fr,273.406
f,7538,fr,258.601
f,7556,fr,258.601
f,7557,fr,258.601
f,7592,fr,263.144
f,7610,fr,283.5
f,7611,fr,273.406
f,7646,fr,288.042
f,7664,fr,288.042
f,7665,fr,288.042
f,7700,fr,243.292
f,7701,fr,222.936
f,7702,fr,233.03
f,7754,fr,218.394
f,7772,fr,218.394
f,7773,fr,218.394
f,7808,fr,222.936
f,7826,fr,243.292
f,7827,fr,233.03
f,7862,fr,247.834
f,7880,fr,247.834
f,7881,fr,247.834
f,7916,fr,243.292
f,7917,fr,222.936
f,7918,fr,233.03
f,7970,fr,218.394
f,7988,fr,218.394
f,7989,fr,218.394
f,8024,fr,222.936
f,8042,fr,243.292
f,8043,fr,233.03
f,8078,fr,247.834
f,8096,fr,247.834
f,8097,fr,247.834
f,8132,fr,243.292
f,8133,fr,222.936
f,8134,fr,233.03
f,8186,fr,218.394
f,8204,fr,218.394
f,8205,fr,218.394
f,8240,fr,222.936
f,8258,fr,243.292
f,8259,fr,233.03
f,8294,fr,247.834
f,8312,fr,247.834
f,8313,fr,247.834
f,8348,fr,243.292
f,8349,fr,222.936
f,8350,fr,233.03
f,8402,fr,218.394
f,8420,fr,218.394
f,8421,fr,218.394
f,8456,fr,222.936
f,8474,fr,243.292
f,8475,fr,233.03
f,8510,fr,247.834
f,8528,fr,247.834
f,8529,fr,247.834
f,8564,fr,243.292
f,8565,fr,222.936
f,8566,fr,233.03
f,8618,fr,218.394
f,8636,fr,218.394
f,8637,fr,218.394
f,8672,fr,222.936
f,8690,fr,243.292
f,8691,fr,233.03
f,8726,fr,247.834
f,8744,fr,247.834
f,8745,fr,247.834
f,8780,fr,243.292
f,8781,fr,222.936
f,8782,fr,233.03
f,8834,fr,218.394
f,8852,fr,218.394
f,8853,fr,218.394
f,8888,fr,222.936
f,8906,fr,243.292
f,8907,fr,233.03
f,8942,fr,247.834
f,8960,fr,247.834
f,8961,fr,247.834
f,8996,fr,243.292
f,8997,fr,222.936
f,8998,fr,233.03
f,9050,fr,218.394
f,9068,fr,218.394
f,9069,fr,218.394
f,9104,fr,222.936
f,9122,fr,243.292
f,9123,fr,233.03
f,9158,fr,247.834
f,9176,fr,247.834
f,9177,fr,247.834
f,9212,fr,243.292
f,9213,fr,222.936
f,9214,fr,233.03
f,9266,fr,218.394
f,9284,fr,218.394
f,9285,fr,218.394
f,9320,fr,222.936
f,9338,fr,243.292
f,9339,fr,233.03
f,9374,fr,247.834
f,9392,fr,247.834
f,9393,fr,247.834
f,9428,fr,202.916
f,9429,fr,182.728
f,9430,fr,192.822
f,9482,fr,178.186
f,9500,fr,178.186
f,9501,fr,178.186
f,9536,fr,182.728
f,9554,fr,202.916
f,9555,fr,192.822
f,9590,fr,207.458
f,9608,fr,207.458
f,9609,fr,207.458
f,9644,fr,202.916
f,9645,fr,182.728
f,9646,fr,192.822
f,9698,fr,178.186
f,9716,fr,178.186
f,9717,fr,178.186
f,9752,fr,182.728
f,9770,fr,202.916
f,9771,fr,192.822
f,9806,fr,207.458
f,9824,fr,207.458
f,9825,fr,207.458
f,9860,fr,202.916
f,9861,fr,182.728
f,9862,fr,192.822
f,9914,fr,178.186
f,9932,fr,178.186
f,9933,fr,178.186
f,9968,fr,182.728
f,9986,fr,202.916
f,9987,fr,192.822
f,10022,fr,207.458
f,10040,fr,207.458
f,10041,fr,207.458
f,10076,fr,202.916
f,10077,fr,182.728
f,10078,fr,192.822
f,10130,fr,178.186
f,10148,fr,178.186
f,10149,fr,178.186
f,10184,fr,182.728
f,10202,fr,202.916
f,10203,fr,192.822
f,10238,fr,207.458
f,10256,fr,207.458
f,10257,fr,207.458
f,10292,fr,202.916
f,10293,fr,182.728
f,10294,fr,192.822
f,10346,fr,178.186
f,10364,fr,178.186
f,10365,fr,178.186
f,10400,fr,182.728
f,10418,fr,202.916
f,10419,fr,192.822
f,10454,fr,207.458
f,10472,fr,207.458
f,10473,fr,207.458
f,10508,fr,202.916
f,10509,fr,182.728
f,10510,fr,192.822
f,10562,fr,178.186
f,10580,fr,178.186
f,10581,fr,178.186
f,10616,fr,182.728
f,10634,fr,202.916
f,10635,fr,192.822
f,10670,fr,207.458
f,10688,fr,207.458
f,10689,fr,207.458
f,10724,fr,202.916
f,10725,fr,182.728
f,10726,fr,192.822
f,10778,fr,178.186
f,10796,fr,178.186
f,10797,fr,178.186
f,10832,fr,182.728
f,10850,fr,202.916
f,10851,fr,192.822
f,10886,fr,207.458
f,10904,fr,207.458
f,10905,fr,207.458
f,10940,fr,202.916
f,10941,fr,182.728
f,10942,fr,192.822
f,10994,fr,178.186
f,11012,fr,178.186
f,11013,fr,178.186
f,11048,fr,182.728
f,11066,fr,202.916
f,11067,fr,192.822
f,11102,fr,207.458
f,11120,fr,207.458
f,11121,fr,207.458
f,11156,fr,162.708
f,11157,fr,142.352
f,11158,fr,152.614
f,11210,fr,137.81
f,11228,fr,137.81
f,11229,fr,137.81
f,11264,fr,142.352
f,11282,fr,162.708
f,11283,fr,152.614
f,11318,fr,167.251
f,11336,fr,167.251
f,11337,fr,167.251
f,11372,fr,162.708
f,11373,fr,142.352
f,11374,fr,152.614
f,11426,fr,137.81
f,11444,fr,137.81
f,11445,fr,137.81
f,11480,fr,142.352
f,11498,fr,162.708
f,11499,fr,152.614
f,11534,fr,167.251
f,11552,fr,167.251
f,11553,fr,167.251
f,11588,fr,162.708
f,11589,fr,142.352
f,11590,fr,152.614
f,11642,fr,137.81
f,11660,fr,137.81
f,11661,fr,137.81
f,11696,fr,142.352
f,11714,fr,162.708
f,11715,fr,152.614
f,11750,fr,167.251
f,11768,fr,167.251
f,11769,fr,167.251
f,11804,fr,162.708
f,11805,fr,142.352
f,11806,fr,152.614
f,11858,fr,137.81
f,11876,fr,137.81
f,11877,fr,137.81
f,11912,fr,142.352
f,11930,fr,162.708
f,11931,fr,152.614
f,11966,fr,167.251
f,11984,fr,167.251
f,11985,fr,167.251
f,12020,fr,162.708
f,12021,fr,142.352
f,12022,fr,152.614
f,12074,fr,137.81
f,12092,fr,137.81
f,12093,fr,137.81
f,12128,fr,142.352
f,12146,fr,162.708
f,12147,fr,152.614
f,12182,fr,167.251
f,12200,fr,167.251
f,12201,fr,167.251
f,12236,fr,162.708
f,12237,fr,142.352
f,12238,fr,152.614
f,12290,fr,137.81
f,12308,fr,137.81
f,12309,fr,137.81
f,12344,fr,142.352
f,12362,fr,162.708
f,12363,fr,152.614
f,12398,fr,167.251
f,12416,fr,167.251
f,12417,fr,167.251
f,12452,fr,162.708
f,12453,fr,142.352
f,12454,fr,152.614
f,12506,fr,137.81
f,12524,fr,137.81
f,12525,fr,137.81
f,12560,fr,142.352
f,12578,fr,162.708
f,12579,fr,152.614
f,12614,fr,167.251
f,12632,fr,167.251
f,12633,fr,167.251
f,12668,fr,162.708
f,12669,fr,142.352
f,12670,fr,152.614
f,12722,fr,137.81
f,12740,fr,137.81
f,12741,fr,137.81
f,12776,fr,142.352
f,12794,fr,162.708
f,12795,fr,152.614
f,12830,fr,167.251
f,12848,fr,167.251
f,12849,fr,167.251
f,12884,fr,122.5
f,12885,fr,102.144
f,12886,fr,112.238
f,12938,fr,97.6018
f,12956,fr,97.6018
f,12957,fr,97.6018
f,12992,fr,102.144
f,13010,fr,122.5
f,13011,fr,112.238
f,13046,fr,127.043
f,13064,fr,127.043
f,13065,fr,127.043
f,13100,fr,122.5
f,13101,fr,102.144
f,13102,fr,112.238
f,13154,fr,97.6018
f,13172,fr,97.6018
f,13173,fr,97.6018
f,13208,fr,102.144
f,13226,fr,122.5

f,13227,fr,112.238
f,13262,fr,127.043
f,13280,fr,127.043
f,13281,fr,127.043
f,13316,fr,122.5
f,13317,fr,102.144
f,13318,fr,112.238
f,13370,fr,97.6018
f,13388,fr,97.6018
f,13389,fr,97.6018
f,13424,fr,102.144
f,13442,fr,122.5
f,13443,fr,112.238
f,13478,fr,127.043
f,13496,fr,127.043
f,13497,fr,127.043
f,13532,fr,122.5
f,13533,fr,102.144
f,13534,fr,112.238
f,13586,fr,97.6018
f,13604,fr,97.6018
f,13605,fr,97.6018
f,13640,fr,102.144
f,13658,fr,122.5
f,13659,fr,112.238
f,13694,fr,127.043
f,13712,fr,127.043
f,13713,fr,127.043
f,13748,fr,122.5
f,13749,fr,102.144
f,13750,fr,112.238
f,13802,fr,97.6018
f,13820,fr,97.6018
f,13821,fr,97.6018
f,13856,fr,102.144
f,13874,fr,122.5
f,13875,fr,112.238
f,13910,fr,127.043
f,13928,fr,127.043
f,13929,fr,127.043
f,13964,fr,122.5
f,13965,fr,102.144
f,13966,fr,112.238
f,14018,fr,97.6018
f,14036,fr,97.6018
f,14037,fr,97.6018
f,14072,fr,102.144
f,14090,fr,122.5
f,14091,fr,112.238
f,14126,fr,127.043
f,14144,fr,127.043
f,14145,fr,127.043
f,14180,fr,122.5
f,14181,fr,102.144
f,14182,fr,112.238
f,14234,fr,97.6018
f,14252,fr,97.6018
f,14253,fr,97.6018
f,14288,fr,102.144
f,14306,fr,122.5
f,14307,fr,112.238
f,14342,fr,127.043
f,14360,fr,127.043
f,14361,fr,127.043
f,14396,fr,122.5
f,14397,fr,102.144
f,14398,fr,112.238
f,14450,fr,97.6018
f,14468,fr,97.6018
f,14469,fr,97.6018
f,14504,fr,102.144
f,14522,fr,122.5
f,14523,fr,112.238
f,14558,fr,127.043
f,14576,fr,127.043
f,14577,fr,127.043
f,14612,fr,82.2925
f,14613,fr,61.9362
f,14614,fr,72.0303
f,14666,fr,57.3939
f,14684,fr,57.3939
f,14685,fr,57.3939
f,14720,fr,61.9362
f,14738,fr,82.2925
f,14739,fr,72.0303
f,14774,fr,86.8348
f,14792,fr,86.8348
f,14793,fr,86.8348
f,14828,fr,82.2925
f,14829,fr,61.9362
f,14830,fr,72.0303
f,14882,fr,57.3939
f,14900,fr,57.3939
f,14901,fr,57.3939
f,14936,fr,61.9362
f,14954,fr,82.2925
f,14955,fr,72.0303
f,14990,fr,86.8348
f,15008,fr,86.8348
f,15009,fr,86.8348
f,15044,fr,82.2925
f,15045,fr,61.9362
f,15046,fr,72.0303
f,15098,fr,57.3939
f,15116,fr,57.3939
f,15117,fr,57.3939
f,15152,fr,61.9362
f,15170,fr,82.2925
f,15171,fr,72.0303
f,15206,fr,86.8348
f,15224,fr,86.8348
f,15225,fr,86.8348
f,15260,fr,82.2925
f,15261,fr,61.9362
f,15262,fr,72.0303
f,15314,fr,57.3939
f,15332,fr,57.3939
f,15333,fr,57.3939
f,15368,fr,61.9362
f,15386,fr,82.2925
f,15387,fr,72.0303
f,15422,fr,86.8348
f,15440,fr,86.8348
f,15441,fr,86.8348
f,15476,fr,82.2925
f,15477,fr,61.9362
f,15478,fr,72.0303
f,15530,fr,57.3939
f,15548,fr,57.3939
f,15549,fr,57.3939
f,15584,fr,61.9362
f,15602,fr,82.2925
f,15603,fr,72.0303
f,15638,fr,86.8348
f,15656,fr,86.8348
f,15657,fr,86.8348
f,15692,fr,82.2925
f,15693,fr,61.9362
f,15694,fr,72.0303
f,15746,fr,57.3939
f,15764,fr,57.3939
f,15765,fr,57.3939
f,15800,fr,61.9362
f,15818,fr,82.2925
f,15819,fr,72.0303
f,15854,fr,86.8348
f,15872,fr,86.8348
f,15873,fr,86.8348
f,15908,fr,82.2925
f,15909,fr,61.9362
f,15910,fr,72.0303
f,15962,fr,57.3939
f,15980,fr,57.3939
f,15981,fr,57.3939
f,16016,fr,61.9362
f,16034,fr,82.2925
f,16035,fr,72.0303
f,16070,fr,86.8348
f,16088,fr,86.8348
f,16089,fr,86.8348
f,16124,fr,82.2925
f,16125,fr,61.9362
f,16126,fr,72.0303
f,16178,fr,57.3939
f,16196,fr,57.3939
f,16197,fr,57.3939
f,16232,fr,61.9362
f,16250,fr,82.2925
f,16251,fr,72.0303
f,16286,fr,86.8348
f,16304,fr,86.8348
f,16305,fr,86.8348
f,16340,fr,41.9164
f,16341,fr,21.5601
f,16342,fr,31.8224
f,16394,fr,17.1861
f,16412,fr,17.1861
f,16413,fr,17.1861
f,16448,fr,21.5601
f,16466,fr,41.9164
f,16467,fr,31.8224
f,16502,fr,46.4587
f,16520,fr,46.4587
f,16521,fr,46.4587
f,16556,fr,41.9164
f,16557,fr,21.5601
f,16558,fr,31.8224
f,16610,fr,17.1861
f,16628,fr,17.1861
f,16629,fr,17.1861
f,16664,fr,21.5601
f,16682,fr,41.9164
f,16683,fr,31.8224
f,16718,fr,46.4587
f,16736,fr,46.4587
f,16737,fr,46.4587
f,16772,fr,41.9164
f,16773,fr,21.5601
f,16774,fr,31.8224
f,16826,fr,17.1861
f,16844,fr,17.1861
f,16845,fr,17.1861
f,16880,fr,21.5601
f,16898,fr,41.9164
f,16899,fr,31.8224
f,16934,fr,46.4587
f,16952,fr,46.4587
f,16953,fr,46.4587
f,16988,fr,41.9164
f,16989,fr,21.5601
f,16990,fr,31.8224
f,17042,fr,17.1861
f,17060,fr,17.1861
f,17061,fr,17.1861
f,17096,fr,21.5601
f,17114,fr,41.9164
f,17115,fr,31.8224
f,17150,fr,46.4587
f,17168,fr,46.4587
f,17169,fr,46.4587
f,17204,fr,41.9164
f,17205,fr,21.5601
f,17206,fr,31.8224
f,17258,fr,17.1861
f,17276,fr,17.1861
f,17277,fr,17.1861
f,17312,fr,21.5601
f,17330,fr,41.9164
f,17331,fr,31.8224
f,17366,fr,46.4587
f,17384,fr,46.4587
f,17385,fr,46.4587
f,17420,fr,41.9164
f,17421,fr,21.5601
f,17422,fr,31.8224
f,17474,fr,17.1861
f,17492,fr,17.1861
f,17493,fr,17.1861
f,17528,fr,21.5601
f,17546,fr,41.9164
f,17547,fr,31.8224
f,17582,fr,46.4587
f,17600,fr,46.4587
f,17601,fr,46.4587
f,17636,fr,41.9164
f,17637,fr,21.5601
f,17638,fr,31.8224
f,17690,fr,17.1861
f,17708,fr,17.1861
f,17709,fr,17.1861
f,17744,fr,21.5601
f,17762,fr,41.9164
f,17763,fr,31.8224
f,17798,fr,46.4587
f,17816,fr,46.4587
f,17817,fr,46.4587
f,17852,fr,41.9164
f,17853,fr,21.5601
f,17854,fr,31.8224
f,17906,fr,17.1861
f,17924,fr,17.1861
f,17925,fr,17.1861
f,17960,fr,21.5601
f,17978,fr,41.9164
f,17979,fr,31.8224
f,18014,fr,46.4587
f,18032,fr,46.4587
f,18033,fr,46.4587
f,18068,fr,1.70857
f,18069,fr,-18.648
f,18070,fr,-8.3855
f,18122,fr,-23.19
f,18140,fr,-23.19
f,18141,fr,-23.19
f,18176,fr,-18.648
f,18194,fr,1.70857
f,18195,fr,-8.3855
f,18230,fr,6.25088
f,18248,fr,6.25088
f,18249,fr,6.25088
f,18284,fr,1.70857
f,18285,fr,-18.648
f,18286,fr,-8.3855
f,18338,fr,-23.19
f,18356,fr,-23.19
f,18357,fr,-23.19
f,18392,fr,-18.648
f,18410,fr,1.70857
f,18411,fr,-8.3855
f,18446,fr,6.25088
f,18464,fr,6.25088
f,18465,fr,6.25088
f,18500,fr,1.70857
f,18501,fr,-18.648
f,18502,fr,-8.3855
f,18554,fr,-23.19
f,18572,fr,-23.19
f,18573,fr,-23.19
f,18608,fr,-18.648
f,18626,fr,1.70857
f,18627,fr,-8.3855
f,18662,fr,6.25088
f,18680,fr,6.25088
f,18681,fr,6.25088
f,18716,fr,1.70857
f,18717,fr,-18.648
f,18718,fr,-8.3855
f,18770,fr,-23.19
f,18788,fr,-23.19
f,18789,fr,-23.19
f,18824,fr,-18.648
f,18842,fr,1.70857
f,18843,fr,-8.3855
f,18878,fr,6.25088
f,18896,fr,6.25088
f,18897,fr,6.25088
f,18932,fr,1.70857
f,18933,fr,-18.648
f,18934,fr,-8.3855
f,18986,fr,-23.19
f,19004,fr,-23.19
f,19005,fr,-23.19
f,19040,fr,-18.648
f,19058,fr,1.70857
f,19059,fr,-8.3855
f,19094,fr,6.25088
f,19112,fr,6.25088
f,19113,fr,6.25088
f,19148,fr,1.70857
f,19149,fr,-18.648
f,19150,fr,-8.3855
f,19202,fr,-23.19

f,19220,fz,-23.19
f,19221,fz,-23.19
f,19256,fz,-18.648
f,19274,fz,1.70857
f,19275,fz,-8.3855
f,19310,fz,6.25088
f,19328,fz,6.25088
f,19329,fz,6.25088
f,19364,fz,1.70857
f,19365,fz,-18.648
f,19366,fz,-8.3855
f,19418,fz,-23.19
f,19436,fz,-23.19
f,19437,fz,-23.19
f,19472,fz,-18.648
f,19490,fz,1.70857
f,19491,fz,-8.3855
f,19526,fz,6.25088
f,19544,fz,6.25088
f,19545,fz,6.25088
f,19580,fz,1.70857
f,19581,fz,-18.648
f,19582,fz,-8.3855
f,19634,fz,-23.19
f,19652,fz,-23.19
f,19653,fz,-23.19
f,19688,fz,-18.648
f,19706,fz,1.70857
f,19707,fz,-8.3855
f,19742,fz,6.25088
f,19760,fz,6.25088
f,19761,fz,6.25088
f,19796,fz,-38.499
f,19797,fz,-58.856
f,19798,fz,-48.762
f,19850,fz,-63.398
f,19868,fz,-63.398
f,19869,fz,-63.398
f,19904,fz,-58.856
f,19922,fz,-38.499
f,19923,fz,-48.762
f,19958,fz,-33.957
f,19976,fz,-33.957
f,19977,fz,-33.957
f,20012,fz,-38.499
f,20013,fz,-58.856
f,20014,fz,-48.762
f,20066,fz,-63.398
f,20084,fz,-63.398
f,20085,fz,-63.398
f,20120,fz,-58.856
f,20138,fz,-38.499
f,20139,fz,-48.762
f,20174,fz,-33.957
f,20192,fz,-33.957
f,20193,fz,-33.957
f,20228,fz,-38.499
f,20229,fz,-58.856
f,20230,fz,-48.762
f,20282,fz,-63.398
f,20300,fz,-63.398
f,20301,fz,-63.398
f,20336,fz,-58.856
f,20354,fz,-38.499
f,20355,fz,-48.762
f,20390,fz,-33.957
f,20408,fz,-33.957
f,20409,fz,-33.957
f,20444,fz,-38.499
f,20445,fz,-58.856
f,20446,fz,-48.762
f,20498,fz,-63.398
f,20516,fz,-63.398
f,20517,fz,-63.398
f,20552,fz,-58.856
f,20570,fz,-38.499
f,20571,fz,-48.762
f,20606,fz,-33.957
f,20624,fz,-33.957
f,20625,fz,-33.957
f,20660,fz,-38.499
f,20661,fz,-58.856
f,20662,fz,-48.762
f,20714,fz,-63.398
f,20732,fz,-63.398
f,20733,fz,-63.398
f,20768,fz,-58.856
f,20786,fz,-38.499
f,20787,fz,-48.762
f,20822,fz,-33.957
f,20840,fz,-33.957
f,20841,fz,-33.957
f,20876,fz,-38.499
f,20877,fz,-58.856
f,20878,fz,-48.762
f,20930,fz,-63.398
f,20948,fz,-63.398
f,20949,fz,-63.398
f,20984,fz,-58.856
f,21002,fz,-38.499
f,21003,fz,-48.762
f,21038,fz,-33.957
f,21056,fz,-33.957
f,21057,fz,-33.957
f,21092,fz,-38.499
f,21093,fz,-58.856
f,21094,fz,-48.762
f,21146,fz,-63.398
f,21164,fz,-63.398
f,21165,fz,-63.398
f,21200,fz,-58.856
f,21218,fz,-38.499
f,21219,fz,-48.762
f,21254,fz,-33.957
f,21272,fz,-33.957
f,21273,fz,-33.957
f,21308,fz,-38.499
f,21309,fz,-58.856
f,21310,fz,-48.762
f,21362,fz,-63.398
f,21380,fz,-63.398
f,21381,fz,-63.398
f,21416,fz,-58.856
f,21434,fz,-38.499
f,21435,fz,-48.762
f,21470,fz,-33.957
f,21488,fz,-33.957
f,21489,fz,-33.957
f,21524,fz,-78.707
f,21525,fz,-99.063
f,21526,fz,-88.969
f,21578,fz,-103.61
f,21596,fz,-103.61
f,21597,fz,-103.61
f,21632,fz,-99.063
f,21650,fz,-78.707
f,21651,fz,-88.969
f,21686,fz,-74.333
f,21704,fz,-74.333
f,21705,fz,-74.333
f,21740,fz,-78.707
f,21741,fz,-99.063
f,21742,fz,-88.969
f,21794,fz,-103.61
f,21812,fz,-103.61
f,21813,fz,-103.61
f,21848,fz,-99.063
f,21866,fz,-78.707
f,21867,fz,-88.969
f,21902,fz,-74.333
f,21920,fz,-74.333
f,21921,fz,-74.333
f,21956,fz,-78.707
f,21957,fz,-99.063
f,21958,fz,-88.969
f,22010,fz,-103.61
f,22028,fz,-103.61
f,22029,fz,-103.61
f,22064,fz,-99.063
f,22082,fz,-78.707
f,22083,fz,-88.969
f,22118,fz,-74.333
f,22136,fz,-74.333
f,22137,fz,-74.333
f,22172,fz,-78.707
f,22173,fz,-99.063
f,22174,fz,-88.969
f,22226,fz,-103.61
f,22244,fz,-103.61
f,22245,fz,-103.61
f,22280,fz,-99.063
f,22298,fz,-78.707
f,22299,fz,-88.969
f,22334,fz,-74.333
f,22352,fz,-74.333
f,22353,fz,-74.333
f,22388,fz,-78.707
f,22389,fz,-99.063
f,22390,fz,-88.969
f,22442,fz,-103.61
f,22460,fz,-103.61
f,22461,fz,-103.61
f,22496,fz,-99.063
f,22514,fz,-78.707
f,22515,fz,-88.969
f,22550,fz,-74.333
f,22568,fz,-74.333
f,22569,fz,-74.333
f,22604,fz,-78.707
f,22605,fz,-99.063
f,22606,fz,-88.969
f,22658,fz,-103.61
f,22676,fz,-103.61
f,22677,fz,-103.61
f,22712,fz,-99.063
f,22730,fz,-78.707
f,22731,fz,-88.969
f,22766,fz,-74.333
f,22784,fz,-74.333
f,22785,fz,-74.333
f,22820,fz,-78.707
f,22821,fz,-99.063
f,22822,fz,-88.969
f,22874,fz,-103.61
f,22892,fz,-103.61
f,22893,fz,-103.61
f,22928,fz,-99.063
f,22946,fz,-78.707
f,22947,fz,-88.969
f,22982,fz,-74.333
f,23000,fz,-74.333
f,23001,fz,-74.333
f,23036,fz,-78.707
f,23037,fz,-99.063
f,23038,fz,-88.969
f,23090,fz,-103.61
f,23108,fz,-103.61
f,23109,fz,-103.61
f,23144,fz,-99.063
f,23162,fz,-78.707
f,23163,fz,-88.969
f,23198,fz,-74.333
f,23216,fz,-74.333
f,23217,fz,-74.333
f,23252,fz,-119.08
f,23253,fz,-139.44
f,23254,fz,-129.18
f,23306,fz,-143.98
f,23324,fz,-143.98
f,23325,fz,-143.98
f,23360,fz,-139.44
f,23378,fz,-119.08
f,23379,fz,-129.18
f,23414,fz,-114.54
f,23432,fz,-114.54
f,23433,fz,-114.54
f,23468,fz,-119.08
f,23469,fz,-139.44
f,23470,fz,-129.18
f,23522,fz,-143.98
f,23540,fz,-143.98
f,23541,fz,-143.98
f,23576,fz,-139.44
f,23594,fz,-119.08
f,23595,fz,-129.18
f,23630,fz,-114.54
f,23648,fz,-114.54
f,23649,fz,-114.54
f,23684,fz,-119.08
f,23685,fz,-139.44
f,23686,fz,-129.18
f,23738,fz,-143.98
f,23756,fz,-143.98
f,23757,fz,-143.98
f,23792,fz,-139.44
f,23810,fz,-119.08
f,23811,fz,-129.18
f,23846,fz,-114.54
f,23864,fz,-114.54
f,23865,fz,-114.54
f,23900,fz,-119.08
f,23901,fz,-139.44
f,23902,fz,-129.18
f,23954,fz,-143.98
f,23972,fz,-143.98
f,23973,fz,-143.98
f,24008,fz,-139.44
f,24026,fz,-119.08
f,24027,fz,-129.18
f,24062,fz,-114.54
f,24080,fz,-114.54
f,24081,fz,-114.54
f,24116,fz,-119.08
f,24117,fz,-139.44
f,24118,fz,-129.18
f,24170,fz,-143.98
f,24188,fz,-143.98
f,24189,fz,-143.98
f,24224,fz,-139.44
f,24242,fz,-119.08
f,24243,fz,-129.18
f,24278,fz,-114.54
f,24296,fz,-114.54
f,24297,fz,-114.54
f,24332,fz,-119.08
f,24333,fz,-139.44
f,24334,fz,-129.18
f,24386,fz,-143.98
f,24404,fz,-143.98
f,24405,fz,-143.98
f,24440,fz,-139.44
f,24458,fz,-119.08
f,24459,fz,-129.18
f,24494,fz,-114.54
f,24512,fz,-114.54
f,24513,fz,-114.54
f,24548,fz,-119.08
f,24549,fz,-139.44
f,24550,fz,-129.18
f,24602,fz,-143.98
f,24620,fz,-143.98
f,24621,fz,-143.98
f,24656,fz,-139.44
f,24674,fz,-119.08
f,24675,fz,-129.18
f,24710,fz,-114.54
f,24728,fz,-114.54
f,24729,fz,-114.54
f,24764,fz,-119.08
f,24765,fz,-139.44
f,24766,fz,-129.18
f,24818,fz,-143.98
f,24836,fz,-143.98
f,24837,fz,-143.98
f,24872,fz,-139.44
f,24890,fz,-119.08
f,24891,fz,-129.18
f,24926,fz,-114.54
f,24944,fz,-114.54
f,24945,fz,-114.54
f,24980,fz,-159.29
f,24981,fz,-179.65
f,24982,fz,-169.39
f,25034,fz,-184.19
f,25052,fz,-184.19
f,25053,fz,-184.19
f,25088,fz,-179.65
f,25106,fz,-159.29
f,25107,fz,-169.39
f,25142,fz,-154.75
f,25160,fz,-154.75
f,25161,fz,-154.75

f,25196,fz,-159.29
f,25197,fz,-179.65
f,25198,fz,-169.39
f,25250,fz,-184.19
f,25268,fz,-184.19
f,25269,fz,-184.19
f,25304,fz,-179.65
f,25322,fz,-159.29
f,25323,fz,-169.39
f,25358,fz,-154.75
f,25376,fz,-154.75
f,25377,fz,-154.75
f,25412,fz,-159.29
f,25413,fz,-179.65
f,25414,fz,-169.39
f,25466,fz,-184.19
f,25484,fz,-184.19
f,25485,fz,-184.19
f,25520,fz,-179.65
f,25538,fz,-159.29
f,25539,fz,-169.39
f,25574,fz,-154.75
f,25592,fz,-154.75
f,25593,fz,-154.75
f,25628,fz,-159.29
f,25629,fz,-179.65
f,25630,fz,-169.39
f,25682,fz,-184.19
f,25700,fz,-184.19
f,25701,fz,-184.19
f,25736,fz,-179.65
f,25754,fz,-159.29
f,25755,fz,-169.39
f,25790,fz,-154.75
f,25808,fz,-154.75
f,25809,fz,-154.75
f,25844,fz,-159.29
f,25845,fz,-179.65
f,25846,fz,-169.39
f,25898,fz,-184.19
f,25916,fz,-184.19
f,25917,fz,-184.19
f,25952,fz,-179.65
f,25970,fz,-159.29
f,25971,fz,-169.39
f,26006,fz,-154.75
f,26024,fz,-154.75
f,26025,fz,-154.75
f,26060,fz,-159.29
f,26061,fz,-179.65
f,26062,fz,-169.39
f,26114,fz,-184.19
f,26132,fz,-184.19
f,26133,fz,-184.19
f,26168,fz,-179.65
f,26186,fz,-159.29
f,26187,fz,-169.39
f,26222,fz,-154.75
f,26240,fz,-154.75
f,26241,fz,-154.75
f,26276,fz,-159.29
f,26277,fz,-179.65
f,26278,fz,-169.39
f,26330,fz,-184.19
f,26348,fz,-184.19
f,26349,fz,-184.19
f,26384,fz,-179.65
f,26402,fz,-159.29
f,26403,fz,-169.39
f,26438,fz,-154.75
f,26456,fz,-154.75
f,26457,fz,-154.75
f,26492,fz,-159.29
f,26493,fz,-179.65
f,26494,fz,-169.39
f,26546,fz,-184.19
f,26564,fz,-184.19
f,26565,fz,-184.19
f,26600,fz,-179.65
f,26618,fz,-159.29
f,26619,fz,-169.39
f,26654,fz,-154.75
f,26672,fz,-154.75
f,26673,fz,-154.75
f,26708,fz,-199.5
f,26709,fz,-219.86
f,26710,fz,-209.76
f,26762,fz,-224.4
f,26780,fz,-224.4
f,26781,fz,-224.4
f,26816,fz,-219.86
f,26834,fz,-199.5
f,26835,fz,-209.76
f,26870,fz,-194.96
f,26888,fz,-194.96
f,26889,fz,-194.96
f,26924,fz,-199.5
f,26925,fz,-219.86
f,26926,fz,-209.76
f,26978,fz,-224.4
f,26996,fz,-224.4
f,26997,fz,-224.4
f,27032,fz,-219.86
f,27050,fz,-199.5
f,27051,fz,-209.76
f,27086,fz,-194.96
f,27104,fz,-194.96
f,27105,fz,-194.96
f,27140,fz,-199.5
f,27141,fz,-219.86
f,27142,fz,-209.76
f,27194,fz,-224.4
f,27212,fz,-224.4
f,27213,fz,-224.4
f,27248,fz,-219.86
f,27266,fz,-199.5
f,27267,fz,-209.76
f,27302,fz,-194.96
f,27320,fz,-194.96
f,27321,fz,-194.96
f,27356,fz,-199.5
f,27357,fz,-219.86
f,27358,fz,-209.76
f,27410,fz,-224.4
f,27428,fz,-224.4
f,27429,fz,-224.4
f,27464,fz,-219.86
f,27482,fz,-199.5
f,27483,fz,-209.76
f,27518,fz,-194.96
f,27536,fz,-194.96
f,27537,fz,-194.96
f,27572,fz,-199.5
f,27573,fz,-219.86
f,27574,fz,-209.76
f,27626,fz,-224.4
f,27644,fz,-224.4
f,27645,fz,-224.4
f,27680,fz,-219.86
f,27698,fz,-199.5
f,27699,fz,-209.76
f,27734,fz,-194.96
f,27752,fz,-194.96
f,27753,fz,-194.96
f,27788,fz,-199.5
f,27789,fz,-219.86
f,27790,fz,-209.76
f,27842,fz,-224.4
f,27860,fz,-224.4
f,27861,fz,-224.4
f,27896,fz,-219.86
f,27914,fz,-199.5
f,27915,fz,-209.76
f,27950,fz,-194.96
f,27968,fz,-194.96
f,27969,fz,-194.96
f,28004,fz,-199.5
f,28005,fz,-219.86
f,28006,fz,-209.76
f,28058,fz,-224.4
f,28076,fz,-224.4
f,28077,fz,-224.4
f,28112,fz,-219.86
f,28130,fz,-199.5
f,28131,fz,-209.76
f,28166,fz,-194.96
f,28184,fz,-194.96
f,28185,fz,-194.96
f,28220,fz,-199.5
f,28221,fz,-219.86
f,28222,fz,-209.76
f,28274,fz,-224.4
f,28292,fz,-224.4
f,28293,fz,-224.4
f,28328,fz,-219.86
f,28346,fz,-199.5
f,28347,fz,-209.76
f,28382,fz,-194.96
f,28400,fz,-194.96
f,28401,fz,-194.96
f,28436,fz,-239.88
f,28437,fz,-260.06
f,28438,fz,-249.97
f,28490,fz,-264.61
f,28508,fz,-264.61
f,28509,fz,-264.61
f,28544,fz,-260.06
f,28562,fz,-239.88
f,28563,fz,-249.97
f,28598,fz,-235.33
f,28616,fz,-235.33
f,28617,fz,-235.33
f,28652,fz,-239.88
f,28653,fz,-260.06
f,28654,fz,-249.97
f,28706,fz,-264.61
f,28724,fz,-264.61
f,28725,fz,-264.61
f,28760,fz,-260.06
f,28778,fz,-239.88
f,28779,fz,-249.97
f,28814,fz,-235.33
f,28832,fz,-235.33
f,28833,fz,-235.33
f,28868,fz,-239.88
f,28869,fz,-260.06
f,28870,fz,-249.97
f,28922,fz,-264.61
f,28940,fz,-264.61
f,28941,fz,-264.61
f,28976,fz,-260.06
f,28994,fz,-239.88
f,28995,fz,-249.97
f,29030,fz,-235.33
f,29048,fz,-235.33
f,29049,fz,-235.33
f,29084,fz,-239.88
f,29085,fz,-260.06
f,29086,fz,-249.97
f,29138,fz,-264.61
f,29156,fz,-264.61
f,29157,fz,-264.61
f,29192,fz,-260.06
f,29210,fz,-239.88
f,29211,fz,-249.97
f,29246,fz,-235.33
f,29264,fz,-235.33
f,29265,fz,-235.33
f,29300,fz,-239.88
f,29301,fz,-260.06
f,29302,fz,-249.97
f,29354,fz,-264.61
f,29372,fz,-264.61
f,29373,fz,-264.61
f,29408,fz,-260.06
f,29426,fz,-239.88
f,29427,fz,-249.97
f,29462,fz,-235.33
f,29480,fz,-235.33
f,29481,fz,-235.33
f,29516,fz,-239.88
f,29517,fz,-260.06
f,29518,fz,-249.97
f,29570,fz,-264.61
f,29588,fz,-264.61
f,29589,fz,-264.61
f,29624,fz,-260.06
f,29642,fz,-239.88
f,29643,fz,-249.97
f,29678,fz,-235.33
f,29696,fz,-235.33
f,29697,fz,-235.33
f,29732,fz,-239.88
f,29733,fz,-260.06
f,29734,fz,-249.97
f,29786,fz,-264.61
f,29804,fz,-264.61
f,29805,fz,-264.61
f,29840,fz,-260.06
f,29858,fz,-239.88
f,29859,fz,-249.97
f,29894,fz,-235.33
f,29912,fz,-235.33
f,29913,fz,-235.33
f,29948,fz,-239.88
f,29949,fz,-260.06
f,29950,fz,-249.97
f,30002,fz,-264.61
f,30020,fz,-264.61
f,30021,fz,-264.61
f,30056,fz,-260.06
f,30074,fz,-239.88
f,30075,fz,-249.97
f,30110,fz,-235.33
f,30128,fz,-235.33
f,30129,fz,-235.33
f,30164,fz,-280.08
f,30165,fz,-300.44
f,30166,fz,-290.18
f,30218,fz,-304.98
f,30236,fz,-304.98
f,30237,fz,-304.98
f,30272,fz,-300.44
f,30290,fz,-280.08
f,30291,fz,-290.18
f,30326,fz,-275.54
f,30344,fz,-275.54
f,30345,fz,-275.54
f,30380,fz,-280.08
f,30381,fz,-300.44
f,30382,fz,-290.18
f,30434,fz,-304.98
f,30452,fz,-304.98
f,30453,fz,-304.98
f,30488,fz,-300.44
f,30506,fz,-280.08
f,30507,fz,-290.18
f,30542,fz,-275.54
f,30560,fz,-275.54
f,30561,fz,-275.54
f,30596,fz,-280.08
f,30597,fz,-300.44
f,30598,fz,-290.18
f,30650,fz,-304.98
f,30668,fz,-304.98
f,30669,fz,-304.98
f,30704,fz,-300.44
f,30722,fz,-280.08
f,30723,fz,-290.18
f,30758,fz,-275.54
f,30776,fz,-275.54
f,30777,fz,-275.54
f,30812,fz,-280.08
f,30813,fz,-300.44
f,30814,fz,-290.18
f,30866,fz,-304.98
f,30884,fz,-304.98
f,30885,fz,-304.98
f,30920,fz,-300.44
f,30938,fz,-280.08
f,30939,fz,-290.18
f,30974,fz,-275.54
f,30992,fz,-275.54
f,30993,fz,-275.54
f,31028,fz,-280.08
f,31029,fz,-300.44
f,31030,fz,-290.18
f,31082,fz,-304.98
f,31100,fz,-304.98
f,31101,fz,-304.98
f,31136,fz,-300.44
f,31154,fz,-280.08

f,31155,fz,-290.18
f,31190,fz,-275.54
f,31208,fz,-275.54
f,31209,fz,-275.54
f,31244,fz,-280.08
f,31245,fz,-300.44
f,31246,fz,-290.18
f,31298,fz,-304.98
f,31316,fz,-304.98
f,31317,fz,-304.98
f,31352,fz,-300.44
f,31370,fz,-280.08
f,31371,fz,-290.18
f,31406,fz,-275.54
f,31424,fz,-275.54
f,31425,fz,-275.54
f,31460,fz,-280.08
f,31461,fz,-300.44
f,31462,fz,-290.18
f,31514,fz,-304.98
f,31532,fz,-304.98
f,31533,fz,-304.98
f,31568,fz,-300.44
f,31586,fz,-280.08
f,31587,fz,-290.18
f,31622,fz,-275.54
f,31640,fz,-275.54
f,31641,fz,-275.54
f,31676,fz,-280.08
f,31677,fz,-300.44
f,31678,fz,-290.18
f,31730,fz,-304.98
f,31748,fz,-304.98
f,31749,fz,-304.98
f,31784,fz,-300.44
f,31802,fz,-280.08
f,31803,fz,-290.18
f,31838,fz,-275.54
f,31856,fz,-275.54
f,31857,fz,-275.54
f,31892,fz,-320.29
f,31893,fz,-340.65
f,31894,fz,-330.55
f,31946,fz,-345.19
f,31964,fz,-345.19
f,31965,fz,-345.19
f,32000,fz,-340.65
f,32018,fz,-320.29
f,32019,fz,-330.55
f,32054,fz,-315.75
f,32072,fz,-315.75
f,32073,fz,-315.75
f,32108,fz,-320.29
f,32109,fz,-340.65
f,32110,fz,-330.55
f,32162,fz,-345.19
f,32180,fz,-345.19
f,32181,fz,-345.19
f,32216,fz,-340.65
f,32234,fz,-320.29
f,32235,fz,-330.55
f,32270,fz,-315.75
f,32288,fz,-315.75
f,32289,fz,-315.75
f,32324,fz,-320.29
f,32325,fz,-340.65
f,32326,fz,-330.55
f,32378,fz,-345.19
f,32396,fz,-345.19
f,32397,fz,-345.19
f,32432,fz,-340.65
f,32450,fz,-320.29
f,32451,fz,-330.55
f,32486,fz,-315.75
f,32504,fz,-315.75
f,32505,fz,-315.75
f,32540,fz,-320.29
f,32541,fz,-340.65
f,32542,fz,-330.55
f,32594,fz,-345.19
f,32612,fz,-345.19
f,32613,fz,-345.19
f,32648,fz,-340.65
f,32666,fz,-320.29
f,32667,fz,-330.55
f,32702,fz,-315.75
f,32720,fz,-315.75
f,32721,fz,-315.75
f,32756,fz,-320.29
f,32757,fz,-340.65
f,32758,fz,-330.55
f,32810,fz,-345.19
f,32828,fz,-345.19
f,32829,fz,-345.19
f,32864,fz,-340.65
f,32882,fz,-320.29
f,32883,fz,-330.55
f,32918,fz,-315.75
f,32936,fz,-315.75
f,32937,fz,-315.75
f,32972,fz,-320.29
f,32973,fz,-340.65
f,32974,fz,-330.55
f,33026,fz,-345.19
f,33044,fz,-345.19
f,33045,fz,-345.19
f,33080,fz,-340.65
f,33098,fz,-320.29
f,33099,fz,-330.55
f,33134,fz,-315.75
f,33152,fz,-315.75
f,33153,fz,-315.75
f,33188,fz,-320.29
f,33189,fz,-340.65
f,33190,fz,-330.55
f,33242,fz,-345.19
f,33260,fz,-345.19
f,33261,fz,-345.19
f,33296,fz,-340.65
f,33314,fz,-320.29
f,33315,fz,-330.55
f,33350,fz,-315.75
f,33368,fz,-315.75
f,33369,fz,-315.75
f,33404,fz,-320.29
f,33405,fz,-340.65
f,33406,fz,-330.55
f,33458,fz,-345.19
f,33476,fz,-345.19
f,33477,fz,-345.19
f,33512,fz,-340.65
f,33530,fz,-320.29
f,33531,fz,-330.55
f,33566,fz,-315.75
f,33584,fz,-315.75
f,33585,fz,-315.75
/com
nall $call

TPX PF 6 & 7 Coil Pack and Case Structural Analysis Report

T. Schultheiss
Northup Grumman Corporation

August 10, 1995

TPX 14-950810-WEC-TSchultheiss-03

APPROVED:

P.A. Sanger
Westinghouse TPX Chief Scientist

APPROVED:

D. R. Potter
Westinghouse TPX Engineering Manager

Westinghouse Electric Corporation
Electronic Systems Group

401 East Hendy Avenue, Sunnyvale, California 94088-3499

PF6/PF7 Structural Report

1.0 Winding Pack Configuration

The PF6/PF7 ring coils are designed with 316LN conduits which house the current-carrying cable. The conduits are then wrapped with insulating Kapton which does not allow shear or tension transfer between the conduits and the glass/epoxy structure. Around the Kapton is 3-D composite glass/epoxy which is designated here as the turn wrap. Since the corners of the conduits and therefore the turn wrap are not square, the space between the corners is filled with 3-D glass/epoxy corner fill. Figure 1.1, shows the conduits, turn wrap, corner fill, 3-D blocks and ground wrap. The Kapton thickness is too small to show clearly in the figure. Each set of conduit, Kapton, turn wrap, and corner fill, designated as the conduit cell, are repeated for each of the 120 turns in PF6 and each of the 84 turns in PF7. PF6 is wound with 6 turns radially and 20 turns axially. Transition regions for the turns are filled with 3D glass/epoxy blocks. These blocks are located on the inner and outer radius of both PF6 and PF7 and alternate with the conduits for each pancake. A pancake, for both PF6 and PF7, is an axial (coordinate definitions are in next paragraph) layer consisting of the conduit cell and one filler block. Surrounding the cells and filler blocks is an insulation layer that is designated as ground wrap and is made of 2D glass/epoxy.

Right circular cylindrical coordinates are used in the analysis and are nominally the same as the overall TPX machine coordinate system. The axis of the coordinate system is therefore the common nominal vertical axis of coils PF6-7. The radial coordinate is the distance at constant height radially from the common axis and is by definition positive or zero. The axial coordinate is zero at the machine's nominal midplane and increases in the vertical direction. The circumferential or the hoop direction is in the direction of the current carrying wire, and also known as the azimuthal direction. The material properties and stress results presented in this report will be designated with this coordinate system; otherwise the coordinate system used will be explicitly noted.

Thermal stresses were analyzed for cooldown to 4K. The stresses are compared with limit stresses. Magnetic loading conditions were analyzed to compare the effect of a few configurations to show how each configuration shares the bending and hoop loads.

2.0 Slip Plane Considerations

The presence of a slip plane between the conduits and the glass/epoxy results in a unique type of structure. This structure will allow hoop loads to be shared between the conduits and the glass/epoxy, according to the usual ratio of membrane stiffness

(E_1A_1/E_2A_2) for two constituents 1 and 2, where E_1 is the Young's modulus and A_1 the cross-sectional area of the first constituent, and similarly for the second constituent. If no coil case is used, the bending loads are shared between the 316LN conduits and the glass/epoxy by the bending stiffness ratio (E_1I_1/E_2I_2), where I_1 and I_2 are the moments of inertia of the glass-epoxy and stainless-steel conduits, respectively. In calculating the moment of inertia of the glass-epoxy, the moment is calculated for the multiply-connected glass-epoxy as one single piece, ignoring possible cracks and defects that may be present. The moment of inertia of the conduits taken together is, however, taken to be the sum of the individual moments of inertia of the conduits, since the conduits are allowed to slip with respect to the glass/epoxy. As a result, the moment of inertia of the conduits as a unit is low and they resist less than 5% of the bending load. Without a coil case, 95% of the bending load would be resisted by the glass/epoxy structure. When a case is added, it carries almost all of the bending loads since its stiffness dominates the overall coil stiffness, and bending stresses in the interior drop dramatically from their no-case values. This structural report presents the sharing of magnetic loads between the 316LN stainless steel structure (with and without a coil case, or a radial band on the outer radius of the ground wrap which has been suggested as an alternative to the coil case) and the glass/epoxy and resulting stresses. For purposes of understanding the effects of the slip plane a design assuming a bond between the conduits and Kapton was also examined.

Analyses to determine the effects of magnetic loads were performed to achieve the following:

Separate bending loads from hoop loads.

Determine the level of stress in the glass/epoxy and 316LN for different configurations.

Determine the effects of a coil case.

Determine the effects of a radial band.

Determine the performance of a winding pack which has structurally failed in the glass epoxy and in which all bending loads are resisted in the conduits, assuming no coil case or radial band.

Solid finite element models were not used to determine the results of these configurations. Instead, beam models were used to input the azimuthal variation in radial and axial load and to obtain the bending moments, hoop loads, and shear loads separately. From the ratios of membrane stiffness and bending stiffness, the loads and stresses in the 316LN structure and the glass/epoxy were determined.

3.0 Thermal Load Case and Cooldown Results

Thermal stresses were determined from an axisymmetric finite element model, which included all the conduit cell components, the filler block, and the ground wrap; the effects of the coil case are not yet included. The model is the full width of the PF6 and PF7 coils, 6 turns. Only a partial height model was used (8 pancakes) since this is large enough to capture all the important thermal stress effects. Figure 3.1 shows the thermal model. It is an axisymmetric model and includes gap elements between the 316LN conduits and the Kapton. Figure 3.2 shows the material properties which were used in all of our analyses. Included are the properties from prior insulation configurations. The properties which are presently used are designated on the figure as 316LN, kapton, 3D weave, 3D corner fill, and ground wrap. The model was run to determine stresses due to only thermal loads set up from a reference temperature of 293K and assuming all materials are at 4K.

Figure 3.3 shows the maximum principal stress developed in the conduits. This value is compared with the limiting stress from fatigue crack growth which is 420 MPa. The maximum principal stress in the conduits is far below the fatigue crack limiting stress for cooldown. Stress limits for the glass/epoxy are given as follows. The equation to predict the failure for the 3D weave components under shear and normal compression are as follows:

Allowable shear/compression stress (MPa) = .7*compressive stress + 52 MPa

Tension only Allowable (MPa) = 46.12

Allowable shear/tension stress (MPa) = -1.13*tensile stress + 52 MPa

Figure 3.4 shows the maximum through-thickness stress in the turn wrap. This stress occurs near the upper surface at the intersection between the ground wrap and the corner fill. It is from the difference in Coefficient of Thermal Expansion (CTE) between the ground wrap in the fiber direction, the corner fill CTE and the 316LN CTE. Figure 3.5 shows the radial stresses that develop, and Figure 3.6 shows the hoop stresses. In Figure 3.6 the conduits near the ground wrap are in hoop tension and the ground wrap is in hoop compression. This is because during cooldown the higher CTE conduits and the lower CTE ground wrap work against each other. Locally, stresses also build in the corner fill and kapton. Table 3.1 shows maximum stresses in these regions. The shaded stress values indicate maximum stresses which occur in the model, and represent stresses and stress locations which are of concern since they occur at or very near interfaces which are likely to have few to no fibers.

Table 3.1 Thermal Stresses due to Cooldown.

Material	Max Tresca MPa	Max Principal MPa	Through Thickness MPa	Shear In Interlaminar Direction MPa	Max Stress Laminar Direction MPa	Hoop Stress MPa
316LN Conduit	118. MPa	127 MPa				
Kapton			2.6	4.3	31.8	19.7
Turn Wrap			11.8	17.5	128.1	34.0
Corner Fill			33.3	36.6	109.1	30.8
3D Block Fill			46.0	11.5	34.5	14.9
Ground Wrap			33.4	36.5	63.4	-11.1

The analysis that was completed was for the PF6 radial location. Cooldown analysis of PF7 will determine the effects of the larger radius, and will be completed in the next phase. The effects of the 316LN coil case will also be determined in the next phase.

The stresses shown in Table 3.2 indicate a level of risk which exists, since the characterization of the materials has not yet been completed. The next two sections show that the glass/epoxy is the primary structural material that resists bending when there is no coil case. The coil case relieves the glass/epoxy bending loads and eliminates its risk as a primary structure.

4.0 Magnetic Load Cases

Magnetic load cases were examined to determine the worst case magnetic loads for PF6 and PF7. Reference [1], memo by A. Radovinsky describes worst case load conditions for PF6 and PF7 and gives these conditions separately for radial and axial loads. Two conditions were identified for PF6, a disruption after equilibrium condition 9 which results in the worst case radial loads, and a disruption after equilibrium condition 19 which results in the worst case axial load. The largest bending stresses occur in the axial direction due to a summing of the bending loads from the azimuthal variation and plus the bending loads due to the vertical supports. From the coil currents for equilibrium condition 9 and turning off the plasma current, the axial load for equilibrium condition 9 increases to 7.83 MN. This is within 5% of the maximum axial load condition and gives the maximum radial loads; therefore the analysis for PF6 was done for equilibrium condition 9 with the plasma current off. The analysis for PF7 was done for equilbrium condition 18, which has the largest axial load, 3.58 MN. For both PF6 and PF7 these loads occur on the upper coils with the load downward toward the center of TPX.

The azimuthal variation of load is applied based on the equations provided by Mark Krefta, ref [2], Worst Case EM Loading of PF Coils. This equation provides enough detail to determine the bending stresses developed by the variational loads. Figures 4.1 and 4.2 show the magnetic loads as a function of angle around the circumference or azimuthal direction for the load cases described above, for PF6 and PF7 respectively.

5.0 Modeling, Winding Pack, Coil Case and Radial Band Support

The model is a 3-D beam model used to discretely determine hoop, shear, and bending loads. Five different configurations were analyzed as follows:

- Configuration 1 Baseline insulation design, no case, includes slip plane between the conduit and kapton
- Configuration 2 Assume no slip plane between the conduit and Kapton
- Configuration 3 With slip plane assume failure of glass/epoxy
- Configuration 4 CPDR Baseline: 5/8" Coil Case with slip plane
- Configuration 5 1.725 inch thick radial band on outer radial surface with slip plane

The boundary conditions which were used are shown on Figure 5.1. This figure shows that at the periodic boundary, 22.5 °, the six degrees of freedom are coupled. The vertical supports are at 8.0 inches either side of the PF/TF center. There is a .010 in. gap between the top of the PF6/PF7 coil case and the upper brackets to ensure that the coils do not bind up during operation. This allows motion in the radial direction and the three rotational directions.

The following tables show the moment of inertia for each of the configurations and shows the moment of inertia for the 316LN separate from the glass/epoxy. Effective hoop area assumes that all material is effective in determining the hoop load share and the hoop stress. The moment of inertia calculations assume that the center of the winding pack cross section is the center of curvature for bending.

Table 5.1 Configuration 1 parameters for PF6.
Baseline design which includes slip plane between the conduit and Kapton

Material	Effective Hoop Area m^2	Moment Of Inertia I_{rr} m^4	Moment Of Inertia I_{zz} m^4	Hoop Modulus GPa
316LN	.02039	.1211e-5	.1211e-5	205.
Glass Epoxy	.03323	.7436e-3	.1452e-3	32.

Table 5.2 Configuration 1 parameters for PF7.
Baseline insulation, no case: includes slip plane between the conduit and Kapton.

Material	Effective Hoop Area m^2	Moment Of Inertia I_{rr} m^4	Moment Of Inertia I_{zz} m^4	Hoop Modulus GPa
316LN	.01427	.8491e-6	.8491e-6	205.
Glass Epoxy	.02408	.2799e-3	.1038e-3	32.

Tables 5.3 and 5.4 show a large increase in moment of inertia for the conduits. This is due to the shear transfer between the conduits and glass/epoxy structure that is assumed. Consequently, the moment of inertia of the conduits includes the offset term, whereas for the slip plane case it only includes the individual contributions of each conduit. The following equation describes this effect.

$I_C = I_L + A_L \times d^2$, where
I_C = Contribution of local component to the composite structure
I_L = Moment of Inertia of local component about its own neutral axis
A_L = Area of local component
d^2 = Square of distance from local neutral axis to composite neutral axis.

The A_L multiplied by d^2 term is not included if shear transfer does not exist.

Table 5.3 Configuration 2 parameters for PF6.
Assuming no slip plane between the conduit and Kapton.

Material	Effective Hoop Area m^2	Moment Of Inertia I_{rr} m^4	Moment Of Inertia I_{zz} m^4	Hoop Modulus GPa
316LN	.02039	.3893e-3	.3818e-4	205.
Glass Epoxy	.03323	.7436e-3	.1452e-3	32.

Table 5.4 Configuration 2 parameters for PF7.
Assuming no slip plane between the conduit and Kapton.

Material	Effective Hoop Area m^2	Moment Of Inertia I_{rr} m^4	Moment Of Inertia I_{zz} m^4	Hoop Modulus GPa
316LN	.01427	.1336e-3	.2673e-4	205.
Glass Epoxy	.02408	.2799e-3	..1038e-3	32.

Tables 5.5 and 5.6 assume that repeated failure within the glass/epoxy structure has left it with no bending stiffness or hoop stiffness.

Table 5.5 Configuration 3 parameters for PF6.
With slip plane, assuming failure of glass/epoxy.

Material	Effective Hoop Area m^2	Moment Of Inertia I_{rr} m^4	Moment Of Inertia I_{zz} m^4	Hoop Modulus GPa
316LN	.02039	.1211e-5	.3818e-4	205.
Glass Epoxy	.0	.0	.0	32.

Table 5.6 Configuration 3 parameters for PF7.
With slip plane, assuming failure of glass/epoxy.

Material	Effective Hoop Area m^2	Moment Of Inertia I_{rr} m^4	Moment Of Inertia I_{zz} m^4	Hoop Modulus GPa
316LN	.01427	.8491e-6	.2673e-4	205.
Glass Epoxy	.0	.0	.0	32.

Tables 5.7 and 5.8 include a 5/8 inch coil case around each winding pack. The location of the neutral axis for the winding pack is the same as the location of the neutral axis for the coil case. From the moment of inertia equation given above we can conclude that there is no significant difference in moment of inertia of the winding pack/coil case structure even if the bond between the coil case and winding pack fails.

Table 5.7 Configuration 4 parameters for PF6.
CPDR Baseline: 5/8 in. Coil Case with slip plane.

Material	Effective Hoop Area m^2	Moment Of Inertia I_{rr} m^4	Moment Of Inertia I_{zz} m^4	Hoop Modulus GPa
316LN	.04288	.7628e-3	.1825e-4	205.
Glass Epoxy	.03323	.7436e-3	.1452e-3	32.

Table 5.8 Configuration 4 parameters for PF7.
CPDR Baseline: 5/8 in. Coil Case with slip plane.

Material	Effective Hoop Area m^2	Moment Of Inertia I_{rr} m^4	Moment Of Inertia I_{zz} m^4	Hoop Modulus GPa
316LN	.03206	.3336e-3	.1357e-4	205.
Glass Epoxy	.02408	.2799e-3	.1038e-3	32.

Tables 5.9 and 5.10 include the winding pack and a radial band on the outside edge of the ground wrap. Since the radial band has a neutral axis which is different from the neutral axis of the winding pack the bond between the ground wrap and band is very important, if this bond fails the radial band becomes ineffective.

Table 5.9 Configuration 4 parameters for PF6.
1.725 inch thick radial band on outer radial surface with slip plane.

Material	Effective Hoop Area m^2	Moment Of Inertia I_{rr} m^4	Moment Of Inertia I_{zz} m^4	Hoop Modulus GPa
316LN	.04202	.4408e-3	.1868e-4	205.
Glass Epoxy	.03323	.7436e-3	.1452e-3	32.

Table 5.10 Configuration 4 parameters for PF7.
1.725 inch thick radial band on outer radial surface with slip plane.

Material	Effective Hoop Area m^2	Moment Of Inertia I_{rr} m^4	Moment Of Inertia I_{zz} m^4	Hoop Modulus GPa
316LN	.02941	.1515e-3	.1275e-3	205.
Glass Epoxy	.02408	.2799e-3	.1038e-3	32.

The model was solved for each of these configurations, the loads were separated into hoop loads and bending loads based on modulus, hoop area, and moment of inertia.

6.0 Magnetic Load Results

Results of the analyses are shown in Figures 6.1-6.10. The bending stresses are shown for both 316LN and the glass epoxy, the bending stresses on the bottom surface of the winding pack are designated SBZ; the bending stresses on the outer radial surface are also shown and are designated SBR. The hoop stresses are also shown for both the glass/epoxy and 316LN.

The effects of variation of both hoop and axial load can be seen in all the figures. The maximum bending stress occurs on the lower axial surface for both PF6 and PF7. This is due to the summing of bending due to the axial load plus bending due to the variational load.

The effects of having a slip plane are shown clearly by the difference in results between Configuration 1 and Configuration 2. Configuration 1 results in about 95% of the bending load resisted by the glass/epoxy, while Configuration 2 results in the 316LN conduits resisting most of the bending load.

Figures 6.5 and 6.6 show stresses based on an assumption of failure within the glass/epoxy structure resulting in all bending stresses being resisted by the conduits. These results show that under these circumstances the conduits will fail. This is an important result since what we are showing is that the glass/epoxy must now work as a primary structure for resisting bending loads. The program has identified testing, which is in progress, to prove out the glass/epoxy structural concept. These tests include bending, at a liquid nitrogen temperatures, and cyclic loading. Results are not finalized which leaves risk with a design that does not include a coil case.

The results of adding a coil case are shown in figures 6.7 and 6.8 for PF6 and PF7 respectively. These results show that a coil case greatly reduces the load into the glass/epoxy from bending. This will lower the cycling loads on the glass/epoxy and increase its life. If cracks occur in the glass/epoxy due to thermal stresses, and/or local variations in glass/epoxy ratio (which changes its strength characteristics) the coil case can resist the bending loads. As stated before, a coil case does not require bonding to the ground wrap to provide bending stiffness.

The results of the radial band case figure 6.9 and 6.10 show that the bending stresses in the glass/epoxy are comparable to the coil case results. However, the radial band requires that the shear bond lasts all loading cycles, adding risk to this concept.

A summary of the maximum stresses resulting from the magnetic load analyses are given in Tables 6.1 through 6.4. The only stress that is above the allowable is bending stress in the 316LN conduits for the case assuming no contribution from the glass/epoxy. The glass/epoxy therefore must be considered the primary structure for resisting bending loads. Failure of the glass/epoxy in configuration 3 will lead to failure of the conduits.

Table 6.1 Summary of PF6 Max Hoop and Max Shear Stresses.

Configuration	Max Hoop 316LN Stress MPa SBR	Max Hoop Glass/Epoxy Stress MPa SBR	Max Shear Stress MPa 316LN SYZ	Max Shear Stress MPa Glass/Epoxy SYZ
PF6 Config 1	140.	21.8	.128	7.53
PF6 Config 2	140.	21.8	9.49	1.74
PF6 Config 3	175.	-	13.2	-
PF6 Config 4	74.2	11.6	5.15	1.01
PF6 Config 5	75.6	11.8	4.84	1.62

Table 6.2 Summary of PF6 Max Bending Stresses.

Configuration	Max Bending Stress MPa 316LN SBR	Max Bending Stress MPa Glass/Epoxy SBR	Max Bending Stress MPa 316LN SBZ	Max Bending Stress MPa Glass/Epoxy SBZ
PF6 Config 1	15.4	19.7	22.0	75.9
PF6 Config 2	49.4	7.71	113.0	17.6
PF6 Config 3	304.	-	2110.	-
PF6 Config 4	17.3	2.30	64.9	10.1
PF6 Config 5	17.9	2.79	102.0	16.0

Table 6.3 Summary of PF7 Max Hoop and Max Shear Stresses.

Configuration	Max Hoop 316LN Stress MPa SBR	Max Hoop Glass/Epoxy Stress MPa SBR	Max Shear Stress MPa 316LN SYZ	Max Shear Stress MPa Glass/Epoxy SYZ
PF7 Config 1	59.1	9.22	.261	7.96
PF7 Config 2	59.1	9.22	14.7	2.84
PF7 Config 3	74.6	-	31.5	-
PF7 Config 4	40.4	6.30	17.3	1.35
PF7 Config 5	42.3	6.61	1.53	2.63

Table 6.4 Summary of PF7 Max Bending Stresses.

Configuration	Max Bending Stress MPa 316LN SBR	Max Bending Stress MPa Glass/Epoxy SBR	Max Bending Stress MPa 316LN SBZ	Max Bending Stress MPa Glass/Epoxy SBZ
PF7 Config 1	12.7	16.2	33.5	81.0
PF7 Config 2	41.3	6.40	131.	20.4
PF7 Config 3	254.	-	1590.	-
PF7 Config 4	13.8	1.83	67.1	9.58
PF7 Config 5	15.4	2.40	118.	18.4

7.0 Conclusion

Cycling of the mechanical loads will can produce a degradation in the strength of both the corner fill, the ground wrap, and the turn wrap. The baseline design for PF6 shows that thermal stresses are near the capability of the glass/epoxy structure. Since PF7 is at a larger radius we can at best expect the same type of results for PF7. Relying on the glass/epoxy for bending loads presents a risk that can be avoided with a coil case or radial band. However, the radial band would require an epoxy bond between it and the ground wrap, bringing with it its own risk. Additionally the radial band does little to improve the radial bending due to TF ripple current. The coil case will resist all of the bending loads. Since the coil case has the same centroid as the winding pack a bond between it and the ground wrap is not required. Use of a winding pack without a coil case should be considered only if extensive cold verification testing with realistic models, and detailed stress analyses are performed. These tests and analyses should include study of stress concentrations in and around discontinuities and include high-cycle fatigue behavior with inital cracks and defects assumed to be present.

8.0 References

[1] A.L. Radovinsky, "The Worst Fault Load Cases on the Coils of the TPX PF Set due to a Vertical Plasma Disruption Followed by a System Dump with Shorted PF Coils Terminals at the Twenty-Three Equilibria", TPX Memorandum TPX-950327, March 27, 1995.

[2] M. Krefta and B. Hannan, "Worst Case EM Loading of PF Coils", TPX.STC.MPK.STC.BH.M006.02.22.95, February 23, 1995.

[3] PF Magnet System Specification, TPX-SPEC-14-0001, Revision 1.

[4] "TPX Structural and Cryogenic Design Criteria", TPX Document 94-950117-PPPL-IZuts-01, January 17, 1995.

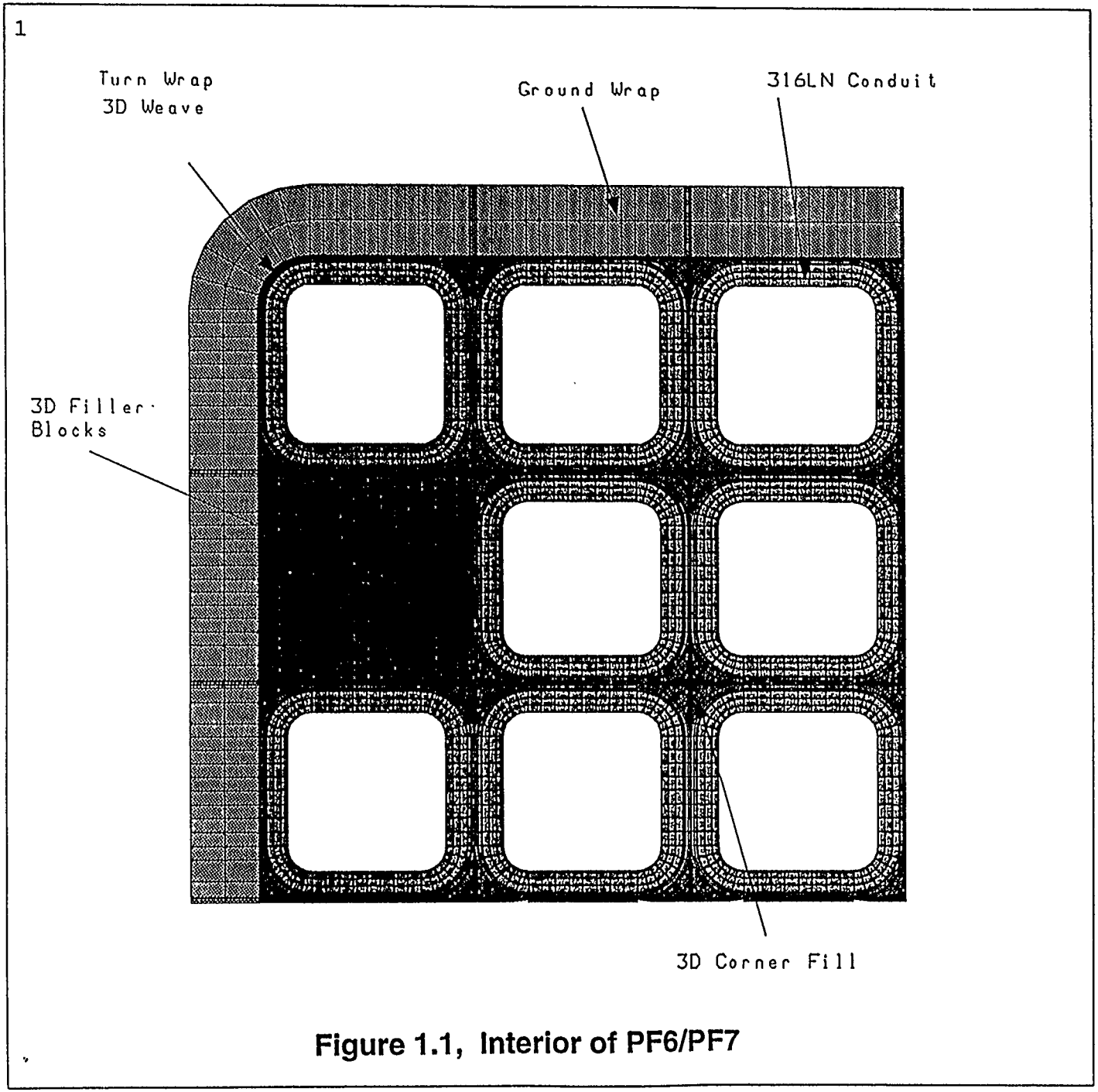


Figure 1.1, Interior of PF6/PF7

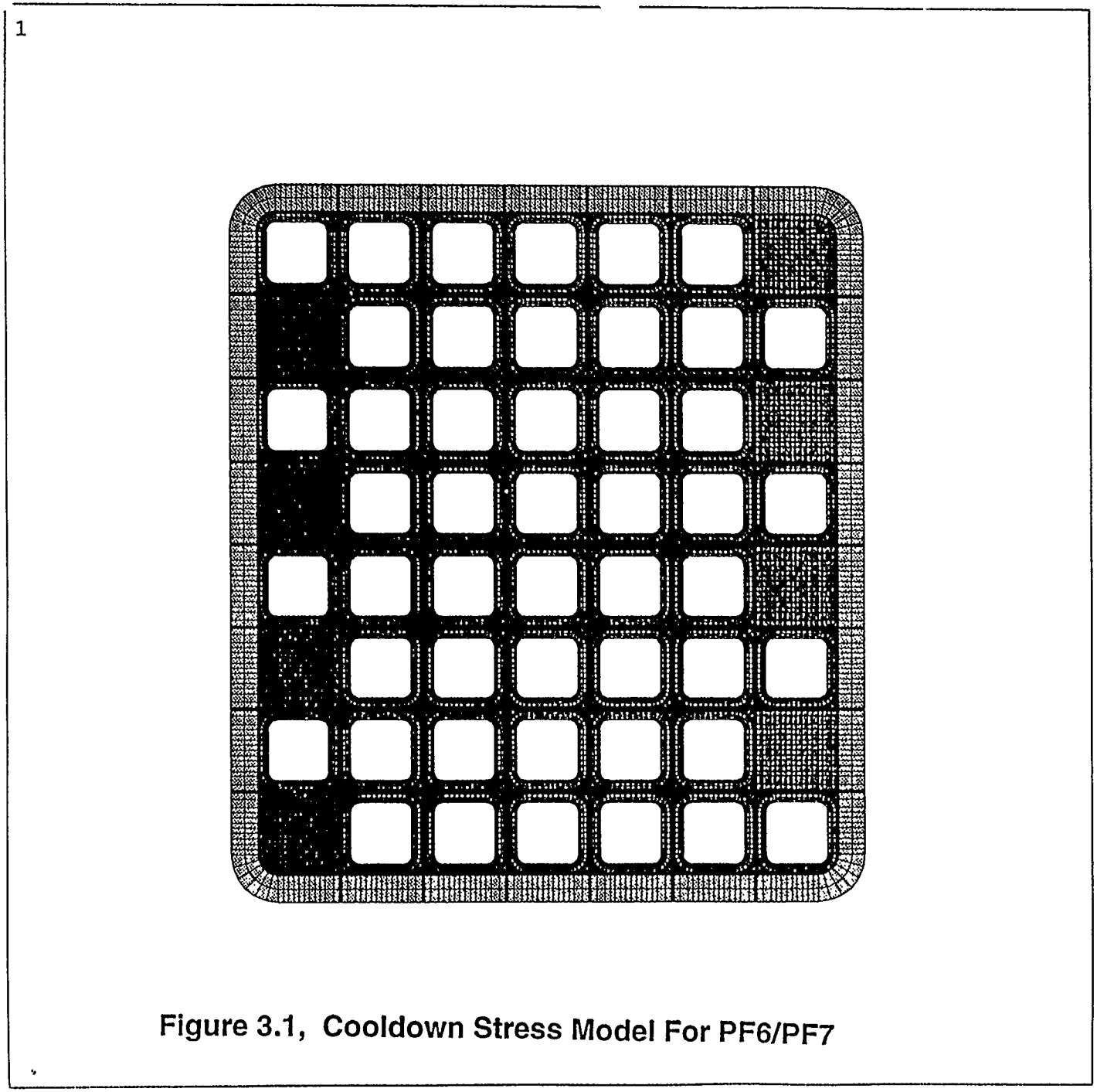


Figure 3.1, Cooldown Stress Model For PF6/PF7

Present State of the TPX Material Property Data Base (4K) for use in Finite Element Modeling
(Superscripts are key to references shown in Note 2)

Material	E_x [GPa]	E_y [GPa]	E_z [GPa]	α_x [μ/K]	α_y [μ/K]	α_z [μ/K]	G_{xy} [GPa]	G_{xz} [GPa]	G_{yz} [GPa]	υ_{xy}	υ_{xz}	υ_{yz}
316LN SS	205[1]	205[1]	205[1]	10.3[1]	10.3[1]	10.3[1]	81[2]	81[2]	81[2]	0.282[2]	0.282[2]	0.282[2]
Incoloy 908	185[1]	185[1]	185[1]	5.59[1]	5.59[1]	5.59[1]	71[2]	71[2]	71[2]	0.299[2]	0.299[2]	0.299[2]
Conduit Wrap	19.7[1]	29.6[1]	29.6[1]	19.9[1]	6.7[1]	6.7[1]	7.6[3]	7.6[3]	10.7[3]	0.26[4]	0.26[4]	0.26[4]
Ground Wrap	19.7[1]	29.6[1]	29.6[1]	19.9[1]	6.7[1]	6.7[1]	7.6[3]	7.6[3]	10.7[3]	0.26[4]	0.26[4]	0.26[4]
Roving Corner Fill	19.7[1]	19.7[1]	29.6[1]	19.9[1]	19.9[1]	6.7[1]	7.6[4]	7.6[4]	7.6[4]	0.26[4]	0.26[4]	0.26[4]
HP Laminate (G11)	24.0[1]	36.0[1]	36.0[1]	24.9[1]	8.3[1]	8.3[1]	9.0[3]	9.0[3]	11.6[3]	0.26[4]	0.26[4]	0.26[3]
Resin	6.9[1]	6.9[1]	6.9[1]	40[1]	40[1]	40[1]	2.7[5]	2.7[5]	2.7[5]	0.3[4]	0.3[4]	0.3[4]
3D Weave	16[11]	32[11]	32[11]	12[11]	10[11]	10[11]	8.5[11]	8.5	10.7	0.26	0.26	0.26
3D Corner Fill	16[11]	32[11]	32[11]	12[11]	10[11]	10[11]	8.5[11]	8.5	10.7	0.26	0.26	0.26
Araldite at 296K	18[8]	18[8]	18[8]	10[8]	10[8]	10[8]	6.9[5]	6.9[5]	6.9[5]	0.3	0.3	0.3
Kapton	4.8[12]	5.5[12]	5.5[12]	43.2[13]	13.0[10]	15.8[10]	0.37[10]	0.37[10]	0.37[10]	0.34[9]	0.34	0.34
SC Cable	0.6[7]	0.6[7]	60[7]	7.24[7]	7.24[7]	7.24[7]	0.23[5]	0.23[5]	0.23[5]	0.3[4]	0.3[4]	0.3[4]

Notes:

1. Values come from the references listed below, and are open to discussion. They do not come from PPPL's material property committee.
2. Coordinate system: x is thru-thick, y is parallel to wrap direction, z is parallel to conductor axis.
3. Key to references on next page.

J. F. Roach, WSTC, Electrical Systems
TPX Program
3/24/95

Figure 3.2, Material Properties For Analyses

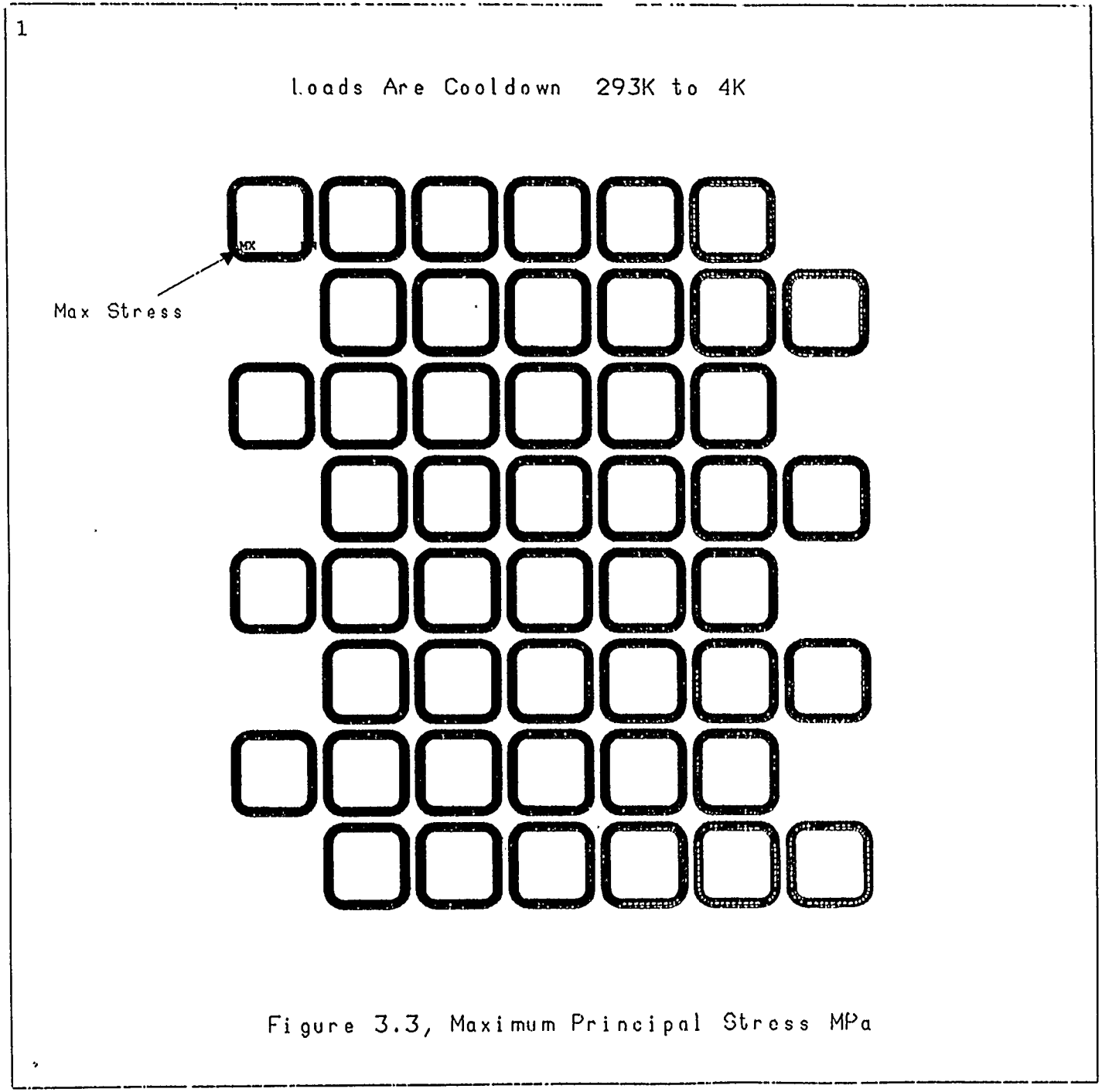


Figure 3.3, Maximum Principal Stress MPa

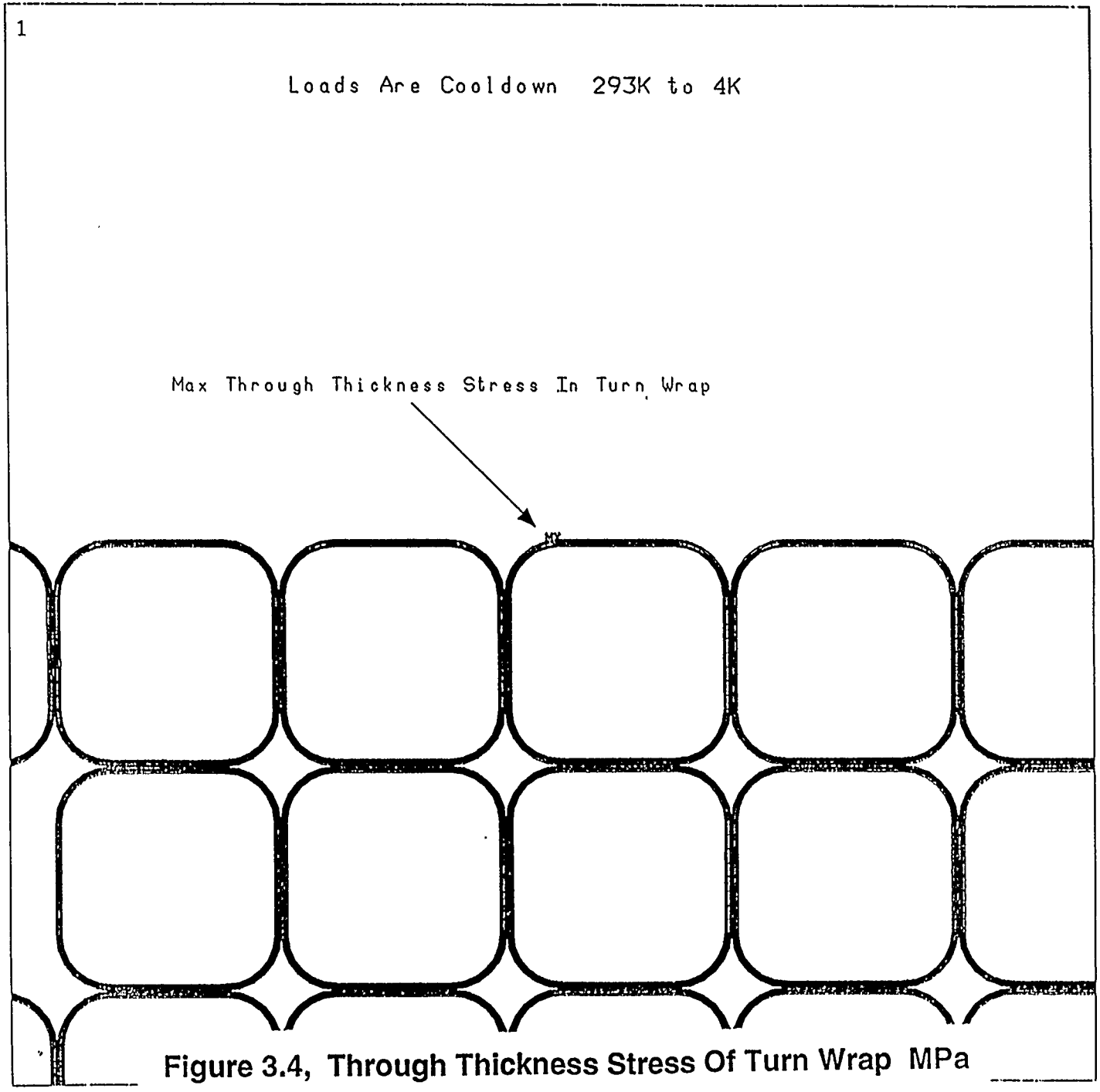
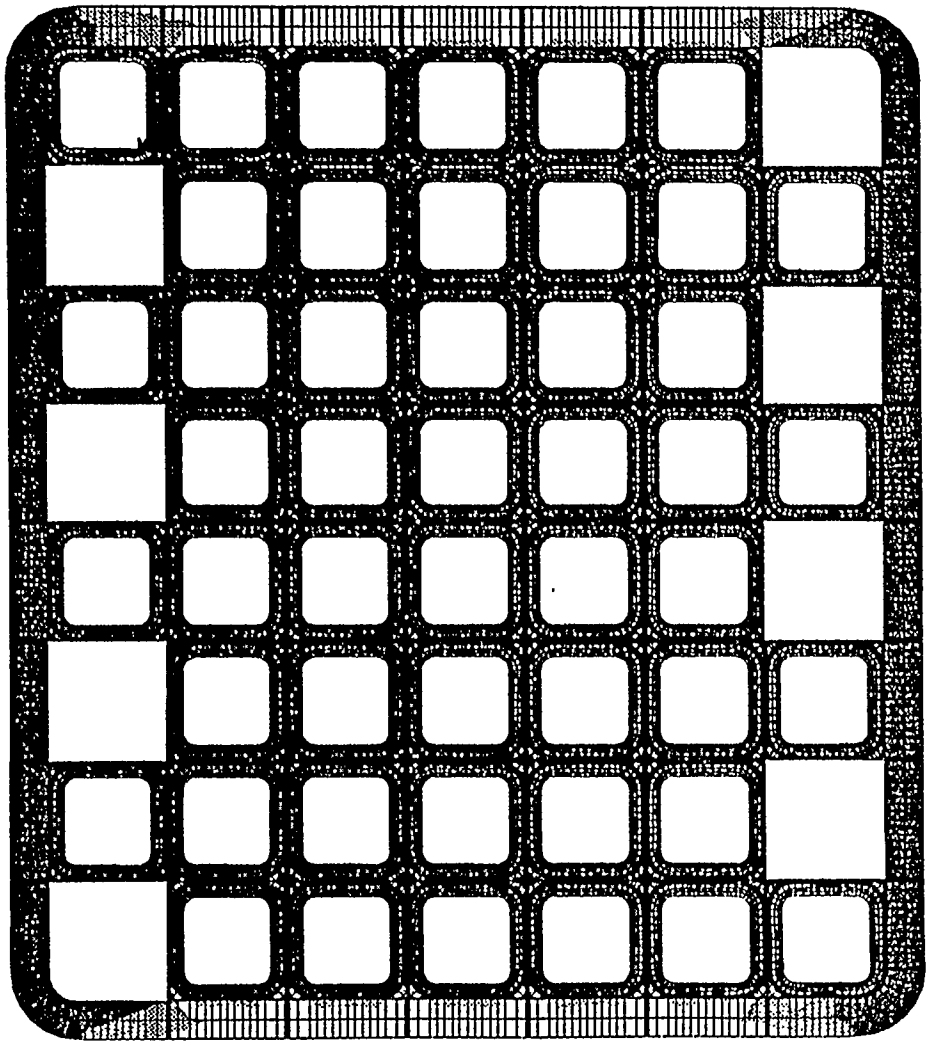


Figure 3.4, Through Thickness Stress Of Turn Wrap MPa

1

Loads Are Cooldown 293K to 4K



ANSYS 5.1
AUG 14 1995
10:10:37
PLOT NO. 1
NODAL SOLUTION
STEP=3
SUB =1
TIME=3
SX (AVG)
RSYS=0
DMX =0.00306
SMN =-104.186
SMX =125.216

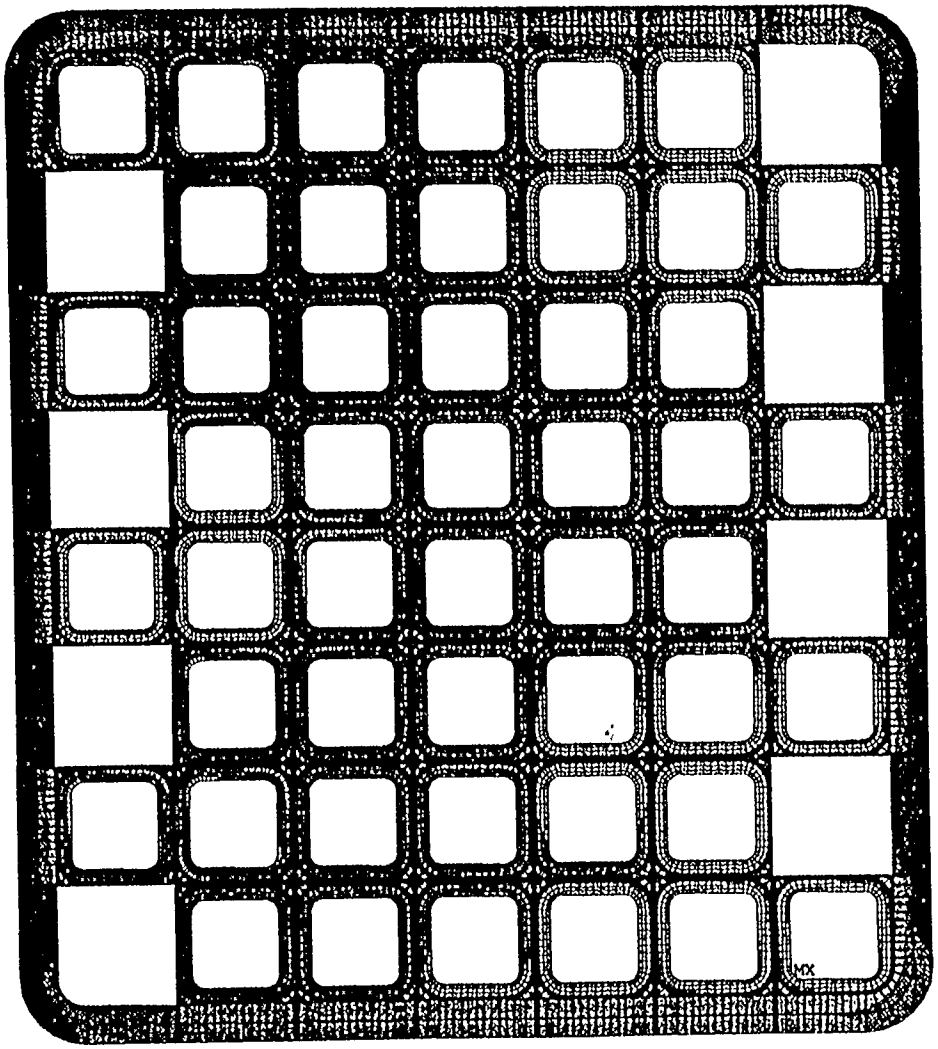
-104.186
-78.697
-53.208
-27.719
-2.229
23.26
48.749
74.238
99.727
125.216

3D Filler Blocks Not Icluded In Figure

Figure 3.5, Radial Stress MPa

1

Loads Are Cooldown 293K to 4K



ANSYS 5.1
AUG 14 1995
10:28:20
PLOT NO. 1
NODAL SOLUTION
STEP=3
SUB =1
TIME=3
SZ (AVG)
RSYS=0
DMX =0.00306
SMN =-44.409
SMX =61.368

-44.409
-32.656
-20.903
-9.15
2.603
14.356
26.109
37.862
49.615
61.368

3D Filler Blocks Not Icluded In Figure

Figure 3.6, Hoop Stress MPa

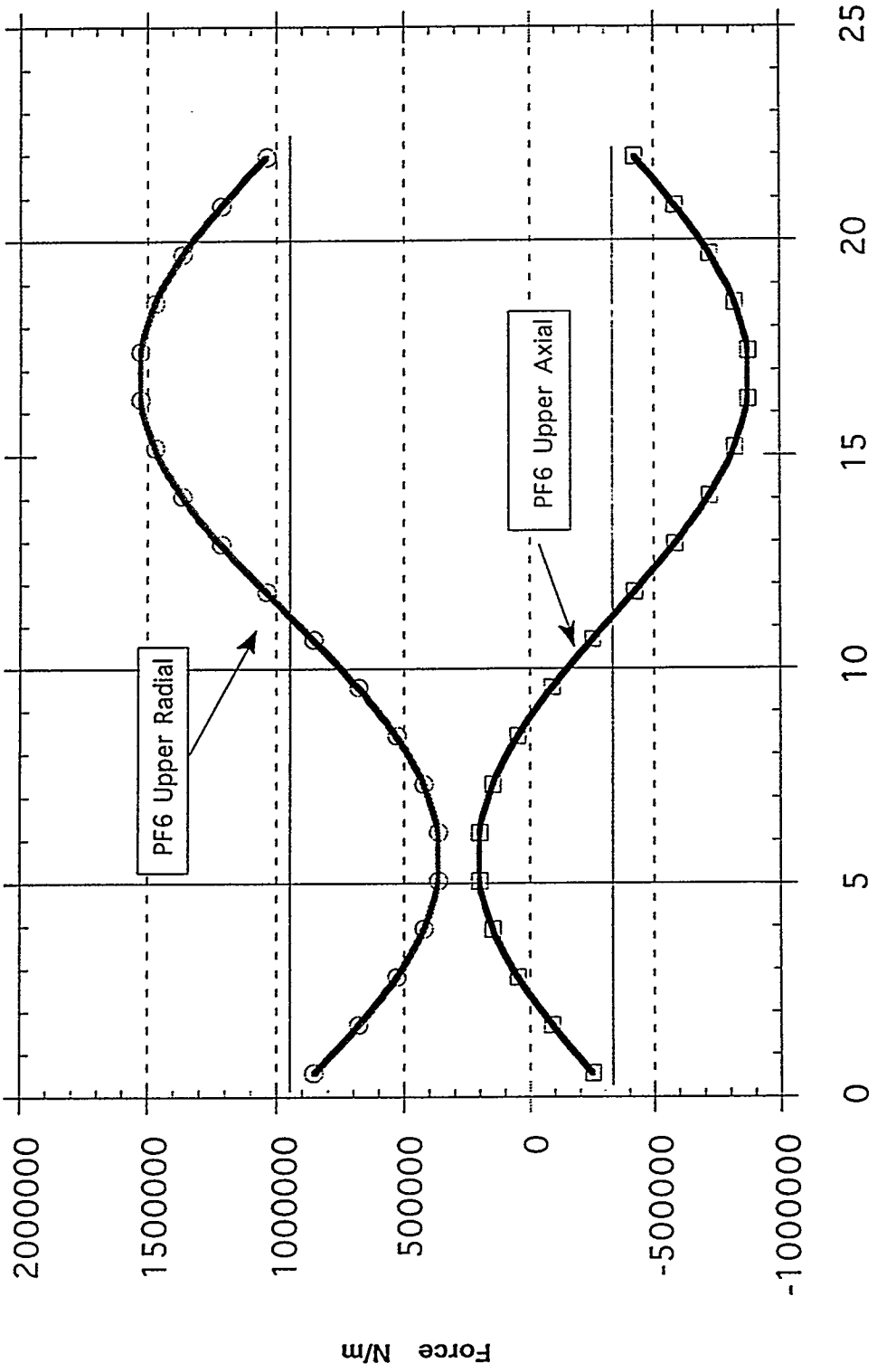


Figure 4.1, PF 6Circumferential Variation Of Force Radial And Axial

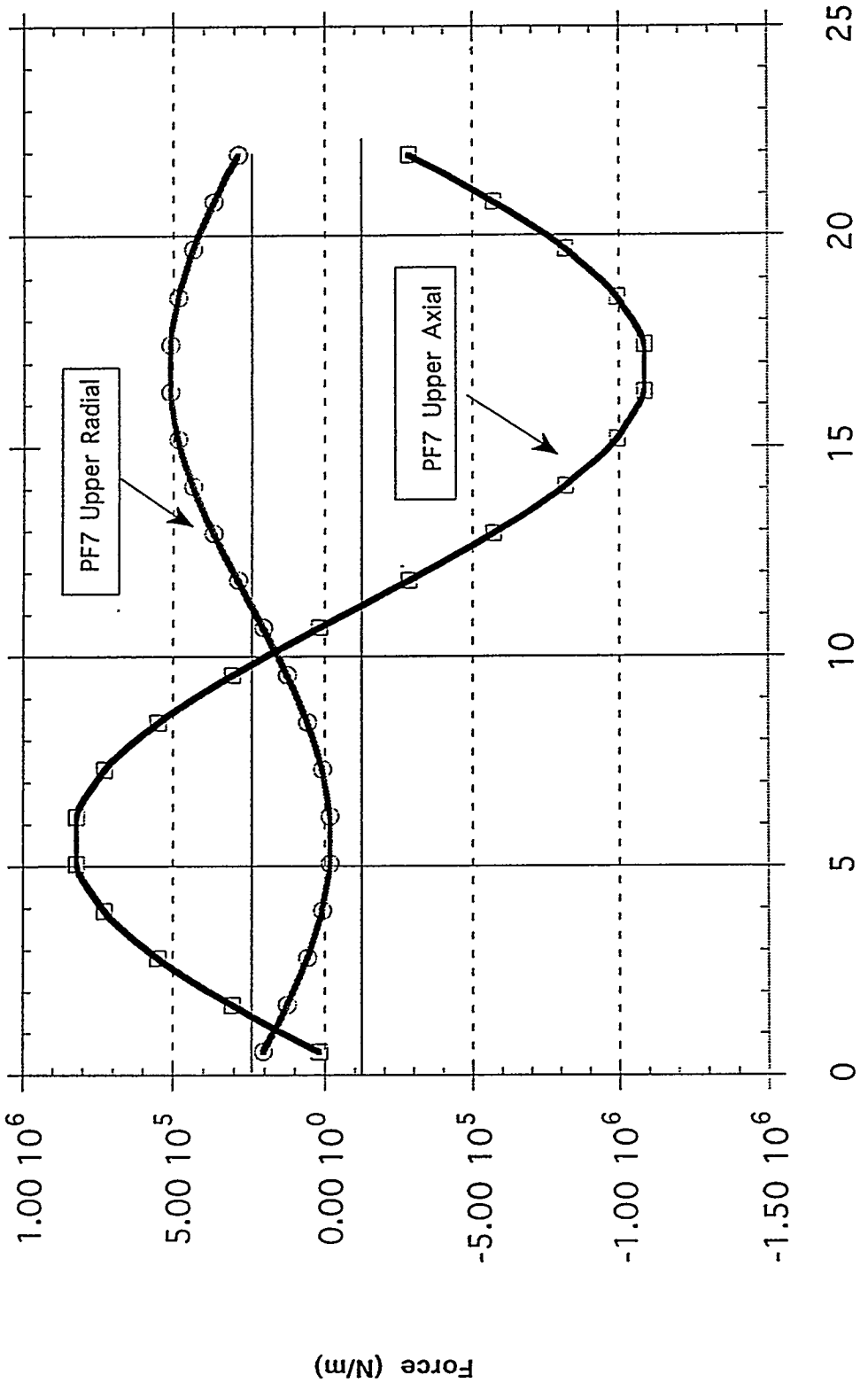


Figure 4.2, Circumferential Variation Of Force Radial And Axial

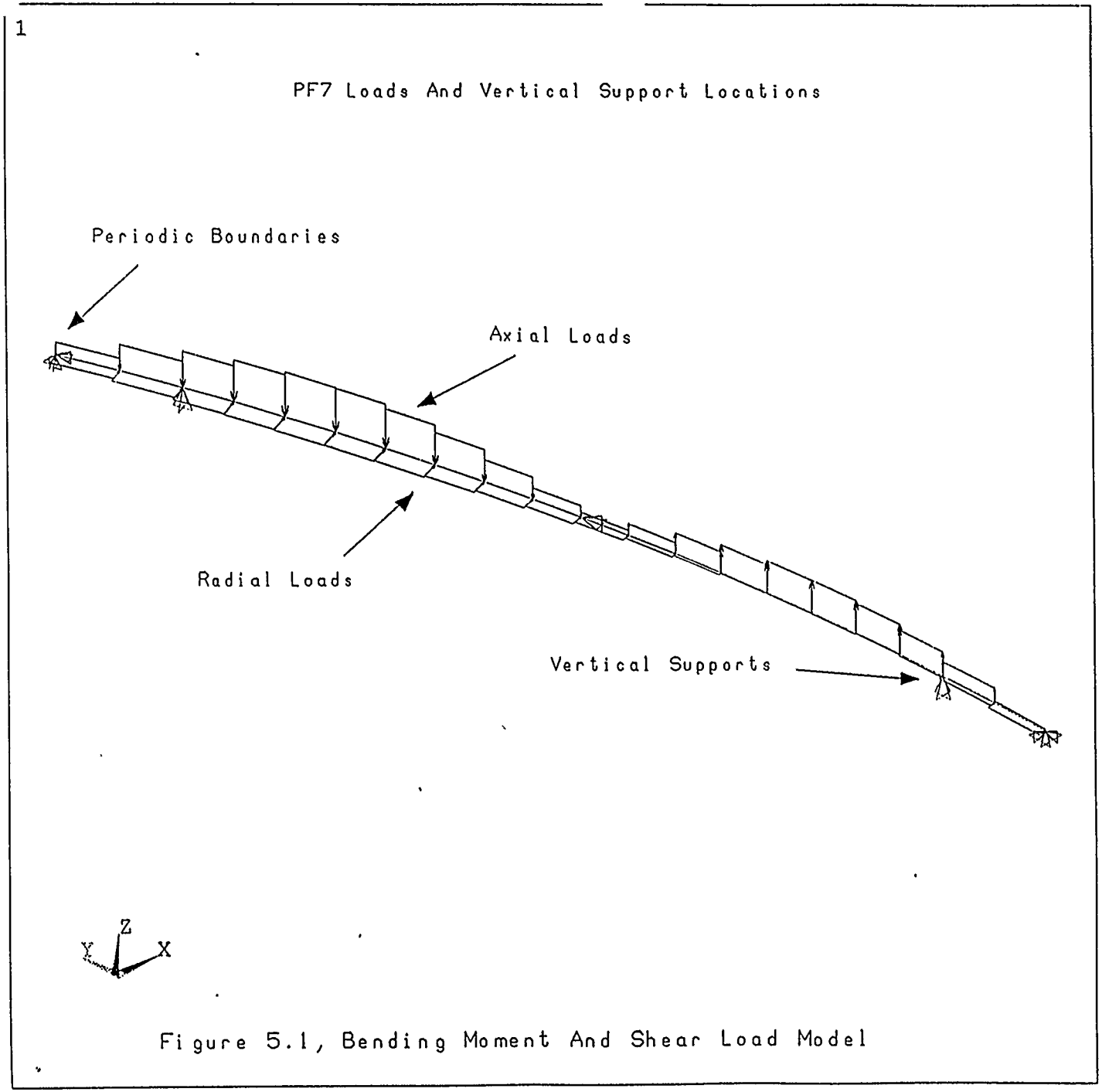


Figure 5.1, Bending Moment And Shear Load Model

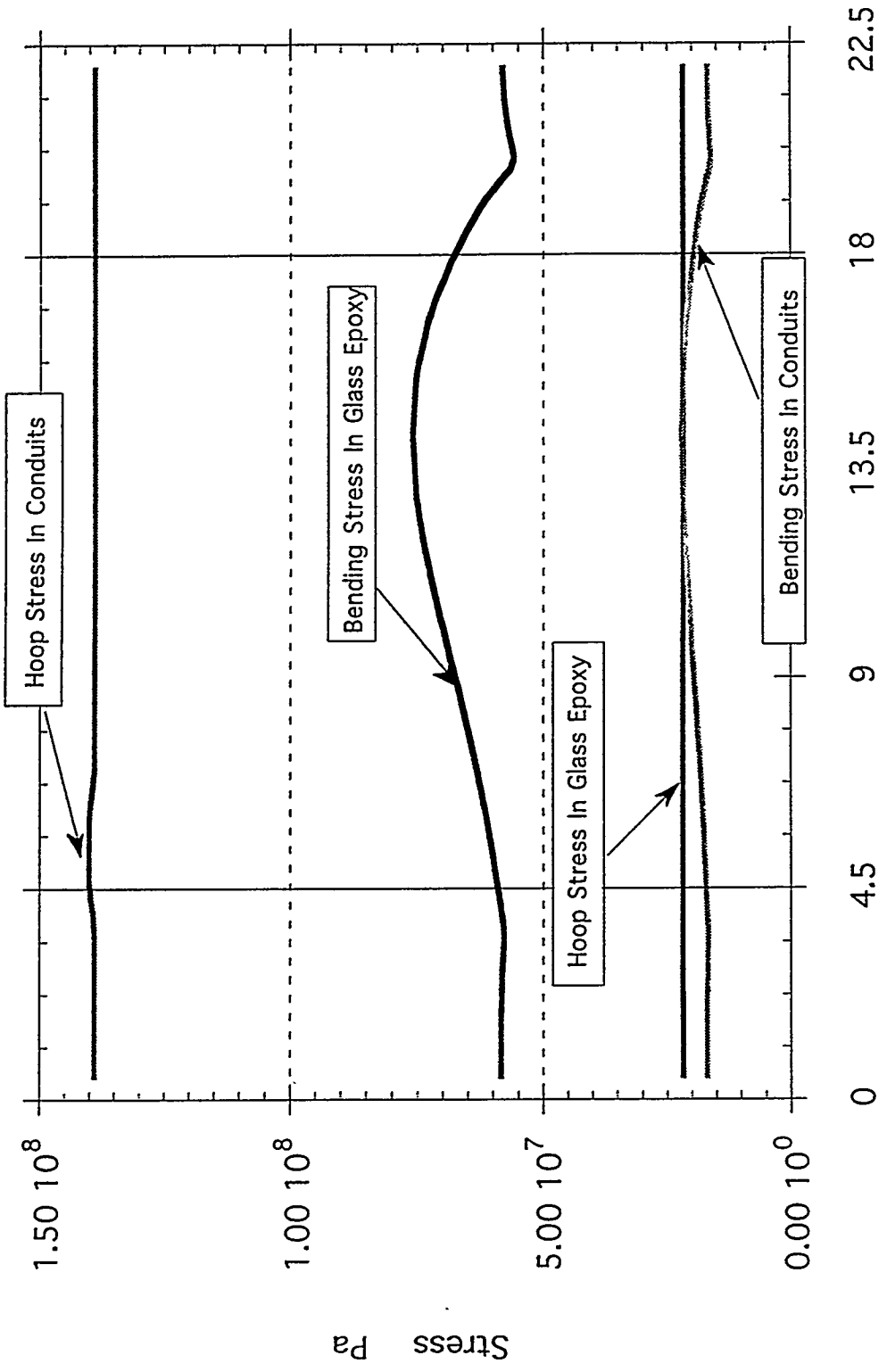


Figure 6.1, Hoop And Bending Stress PF6 Configuration 1

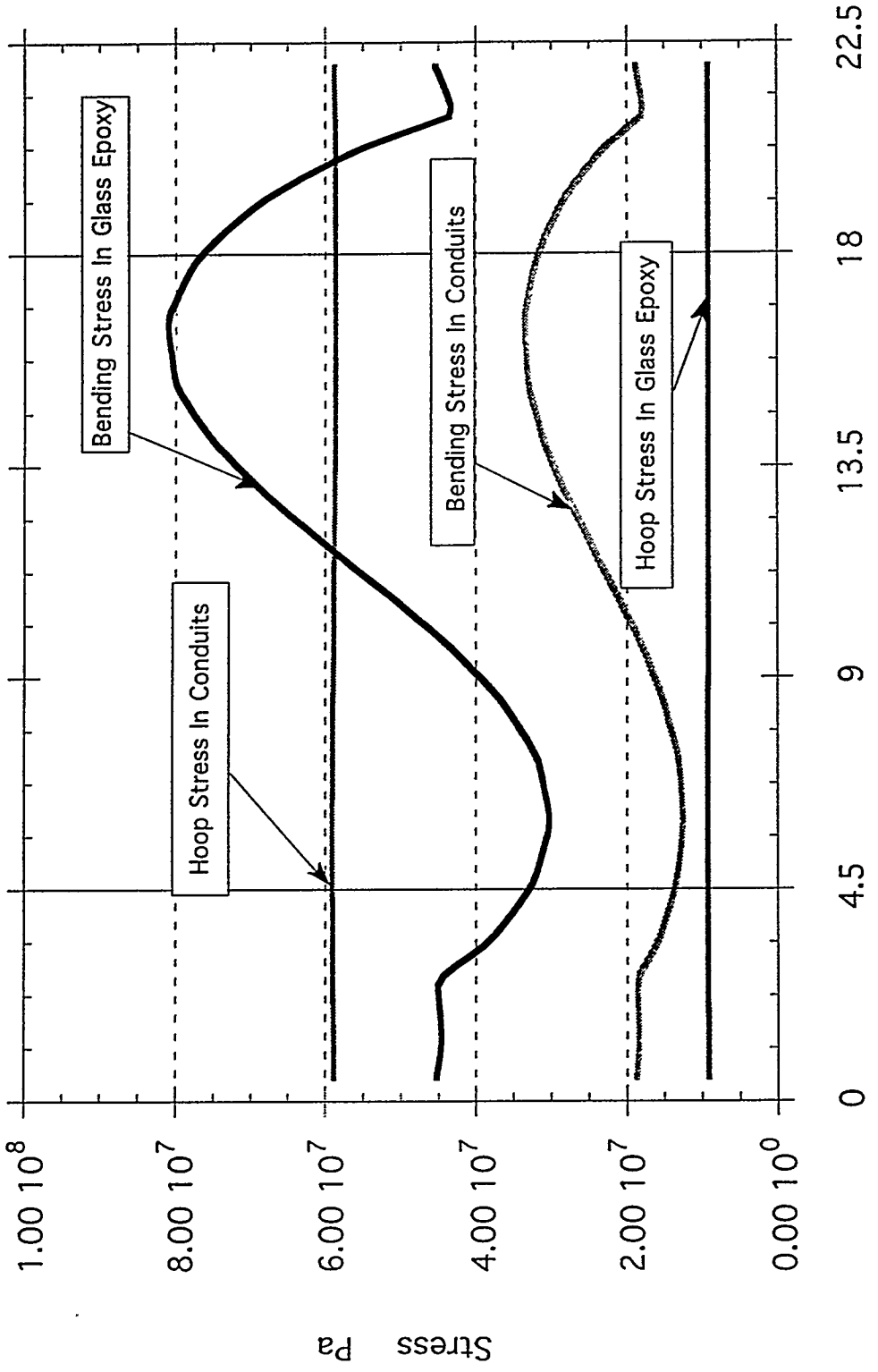


Figure 6.2, Hoop And Bending Stress PF7 Configuration 1

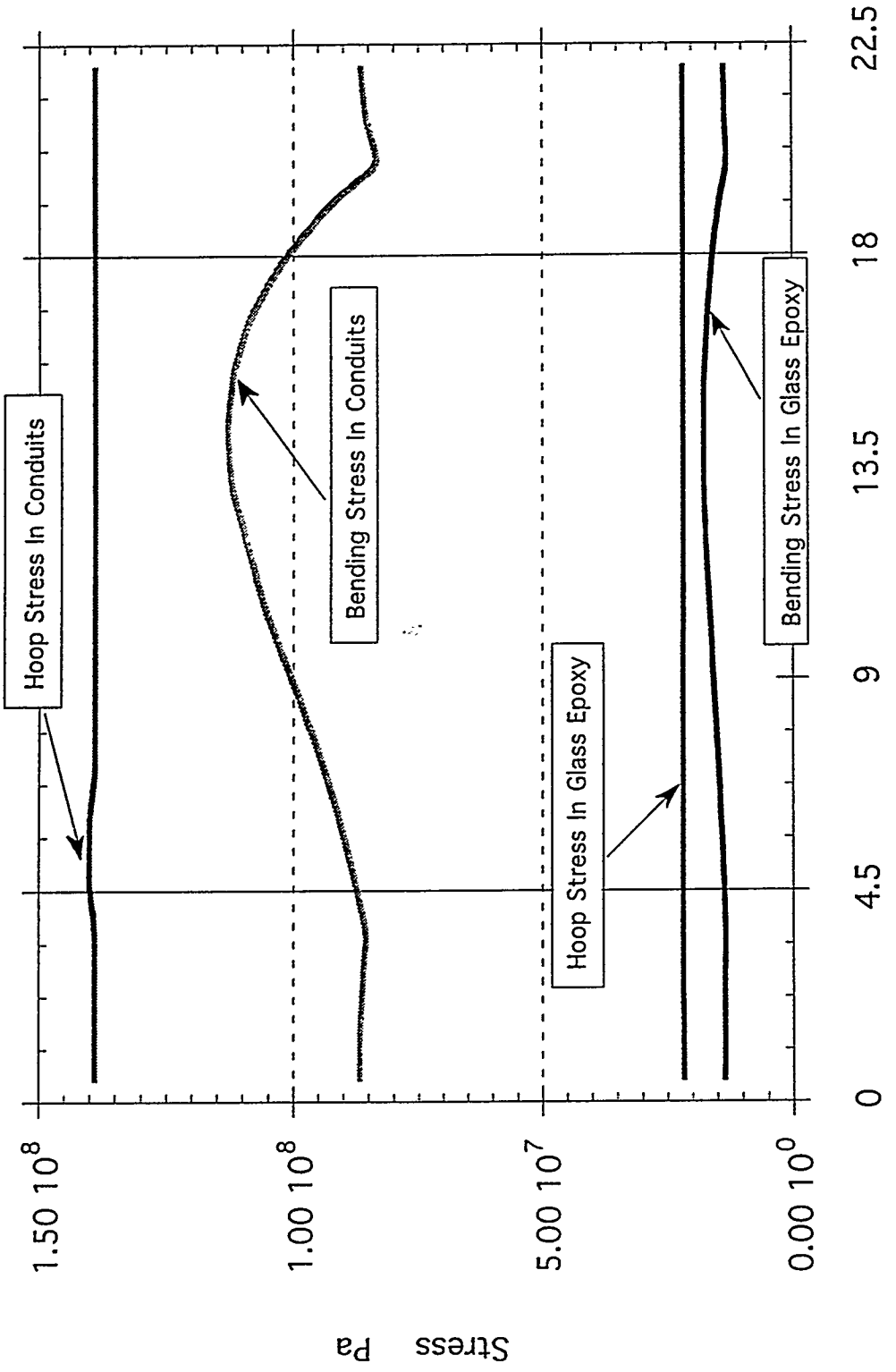


Figure 6.3, Hoop And Bending Stress PF6 Configuration 2

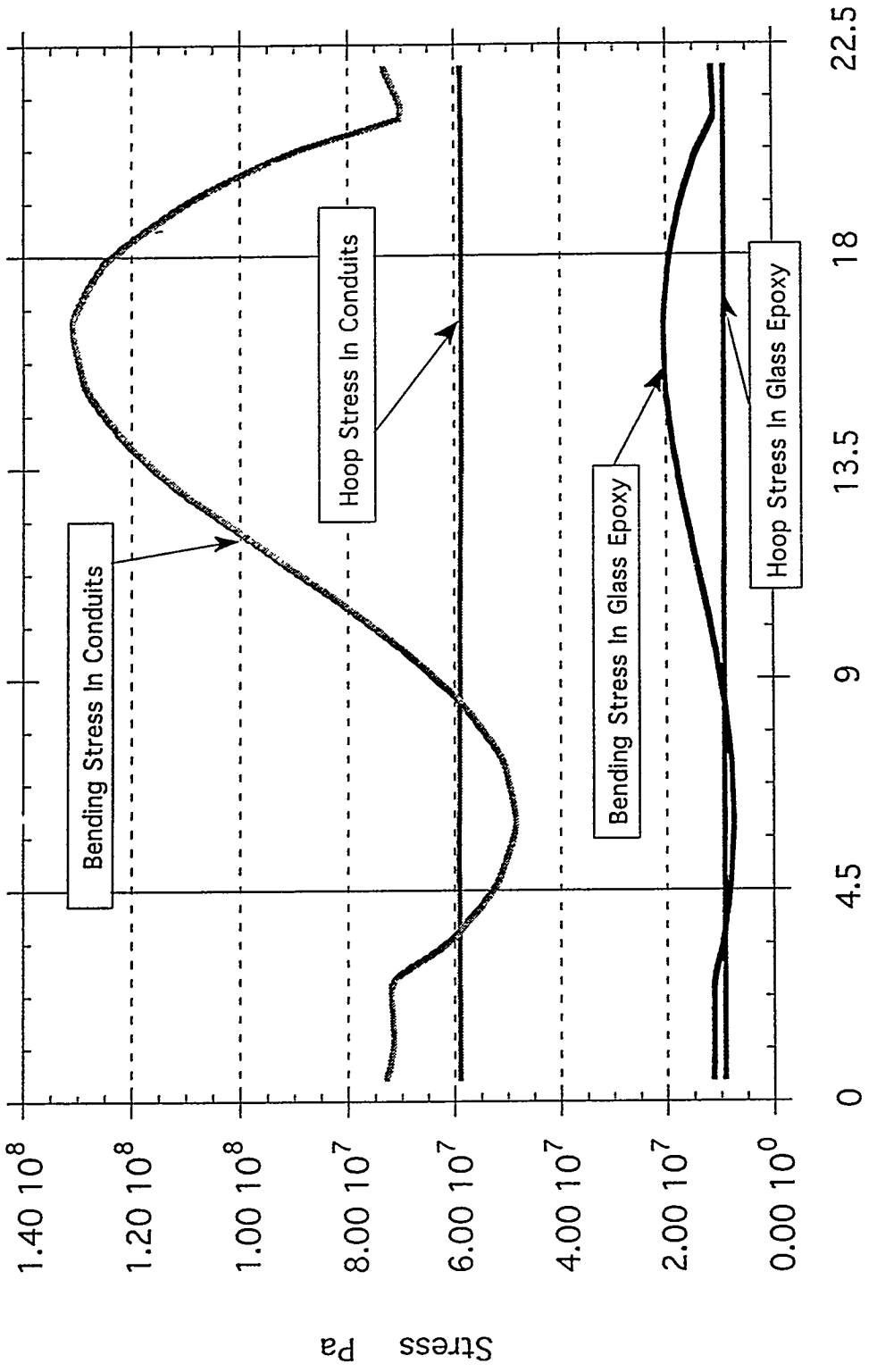


Figure 6.4, Hoop And Bending Stress PF7 Configuration 2

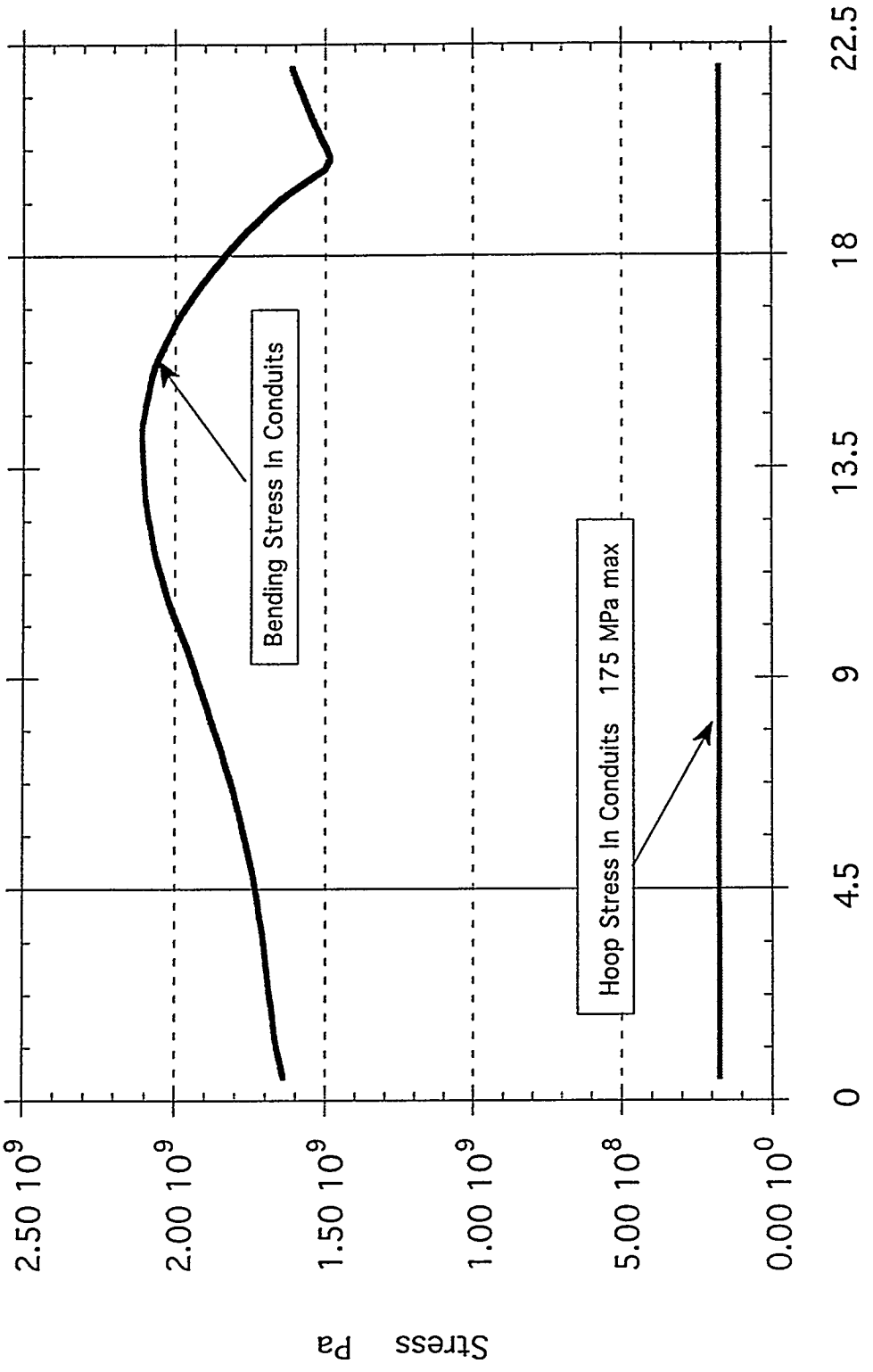


Figure 6.5, Hoop And Bending Stress PF6 Configuration 3

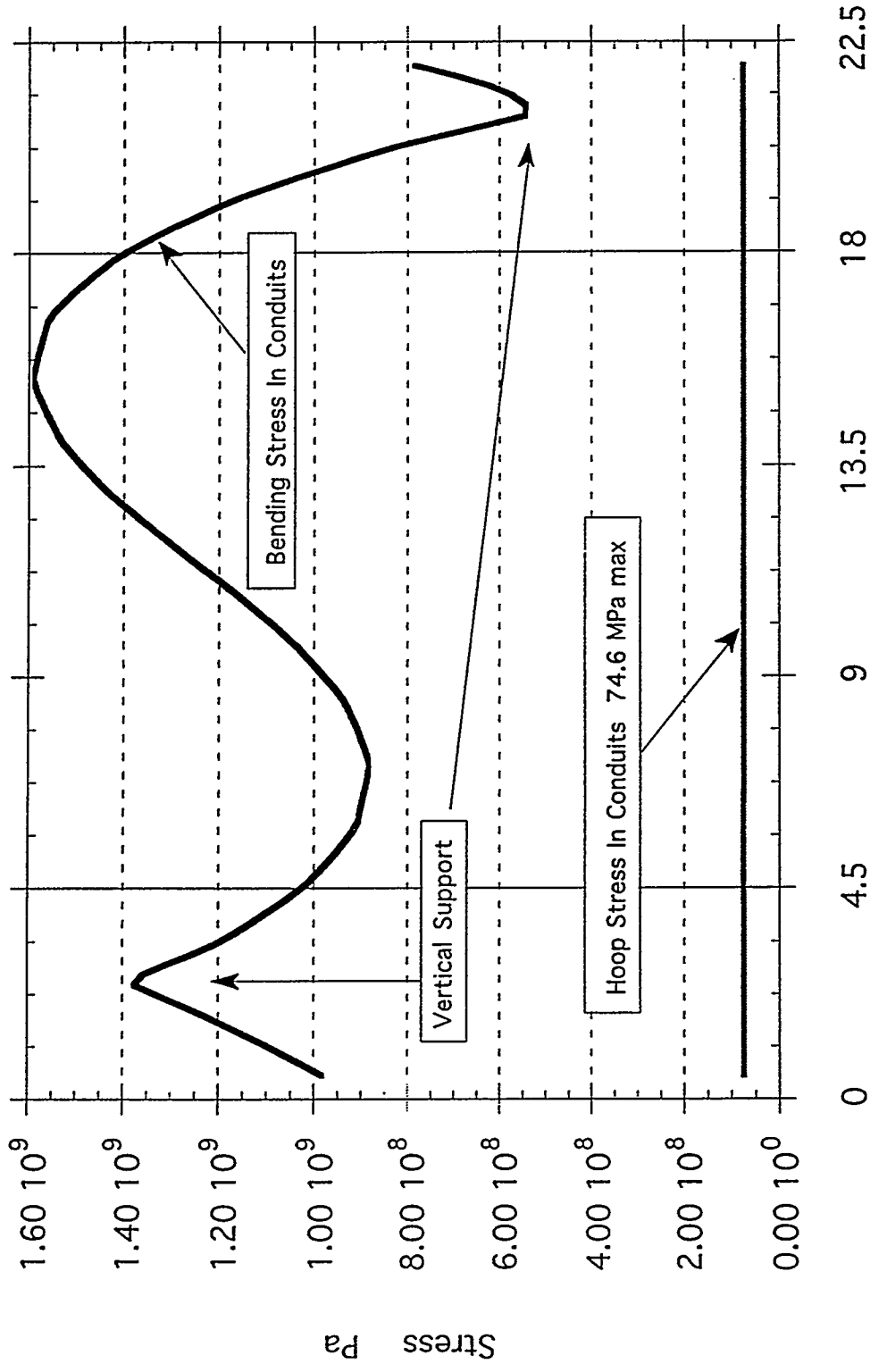


Figure 6.6, Hoop And Bending Stress PF7 Configuration 3

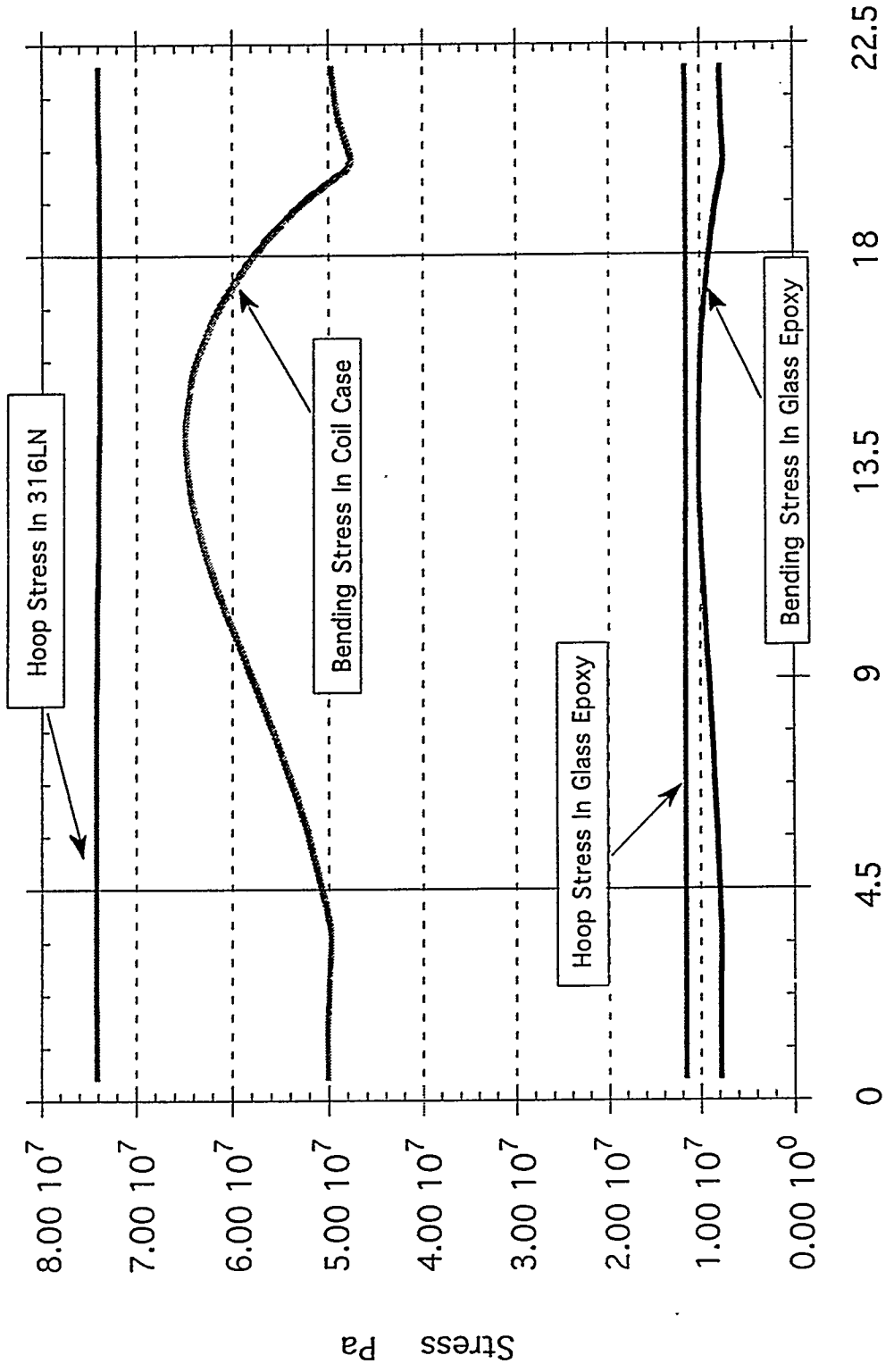


Figure 6.7, Hoop And Bending Stress PF6 Configuration 4

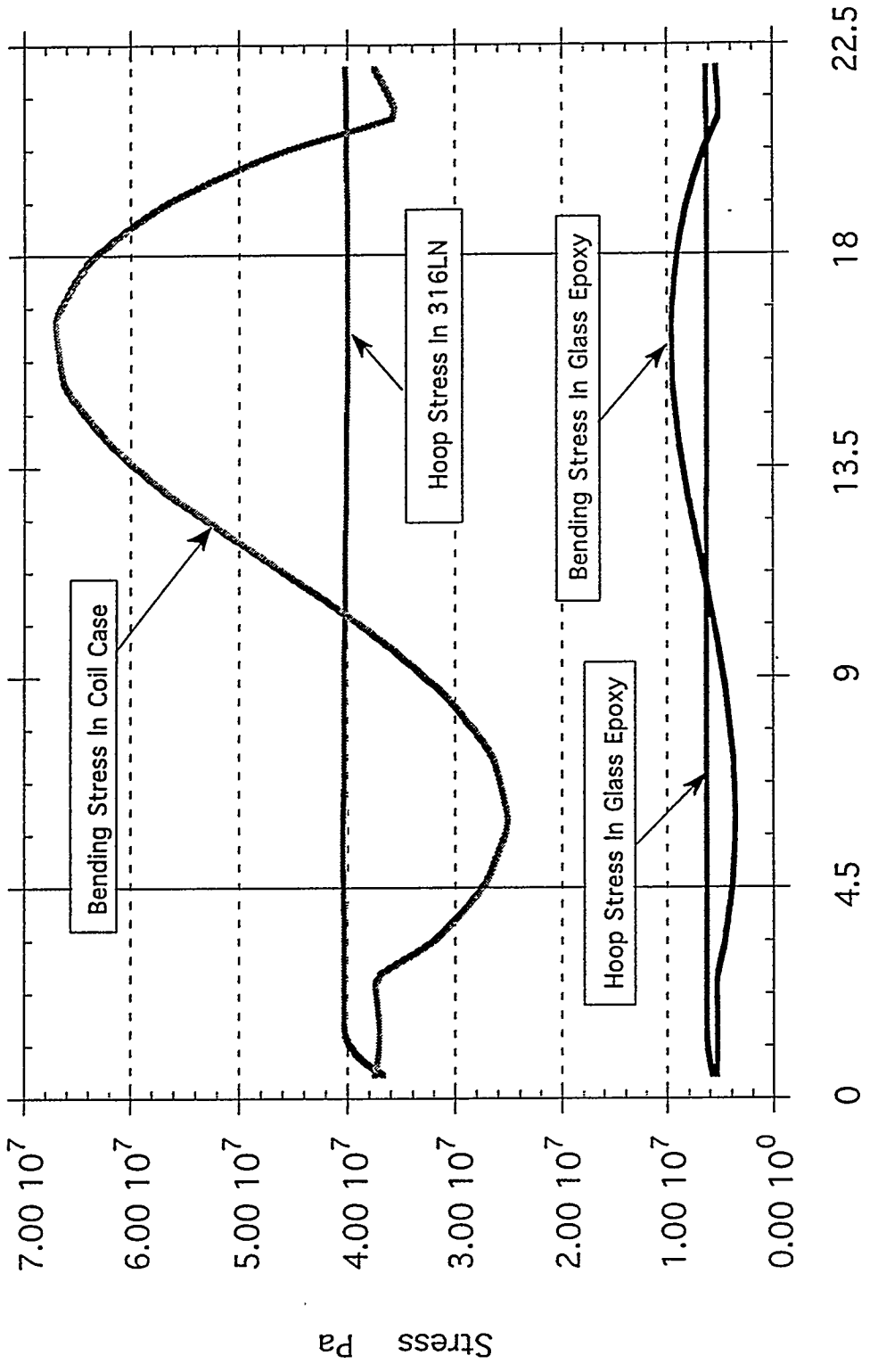


Figure 6.8, Hoop And Bending Stress PF7 Configuration 4

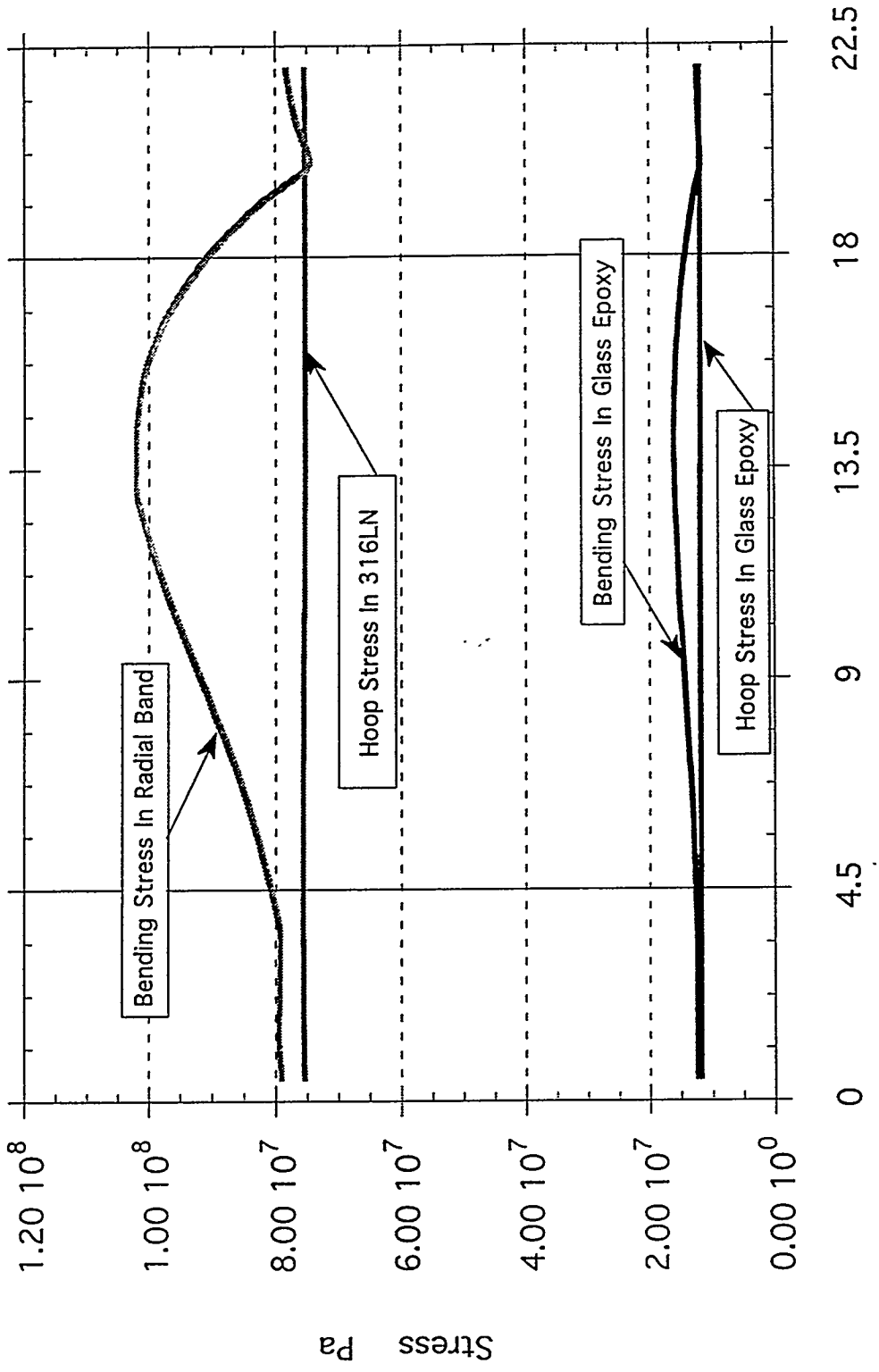


Figure 6.9, Hoop And Bending Stress PF6 Configuration 5

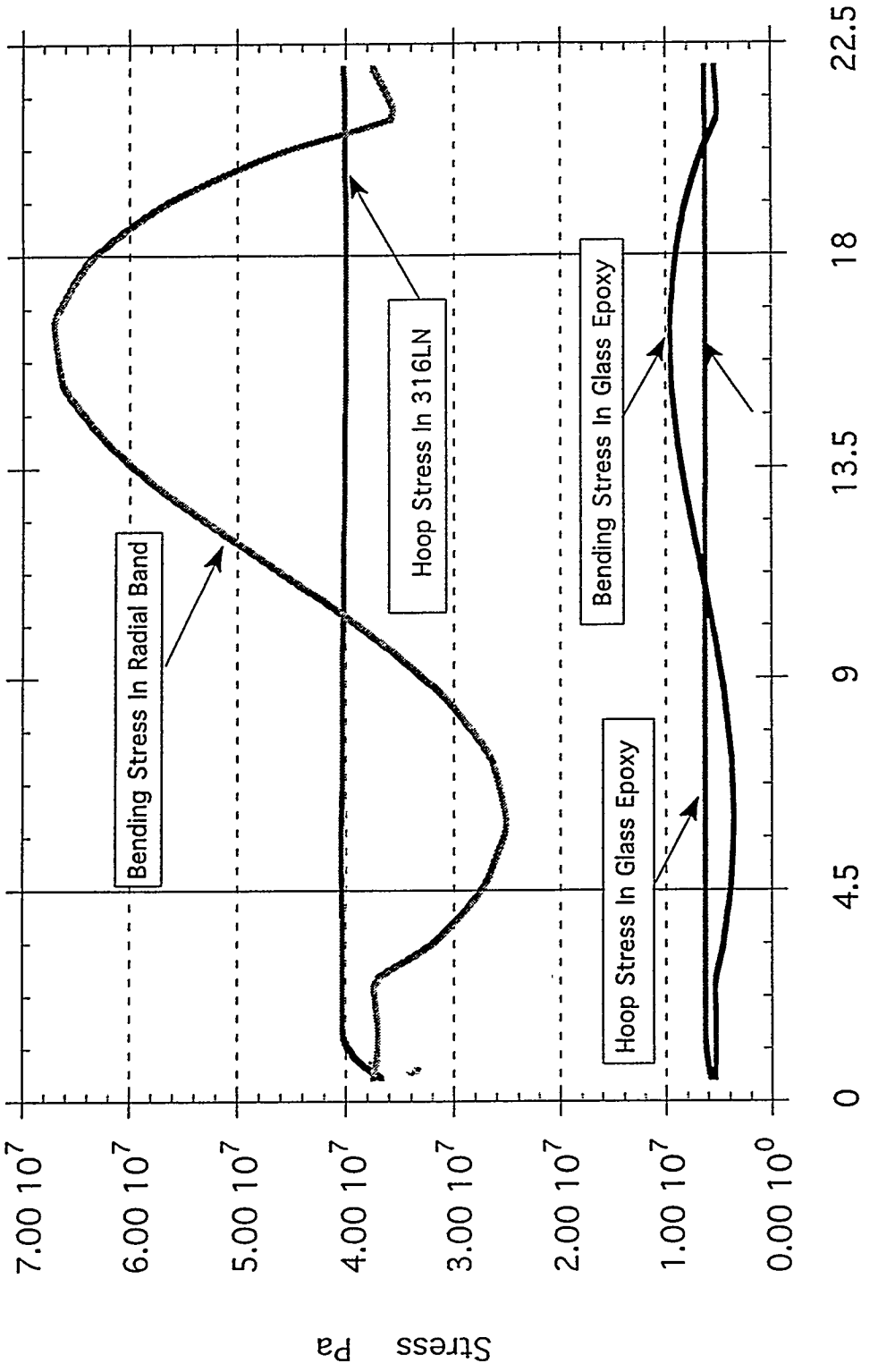


Figure 6.10, Hoop And Bending Stress PF7 Configuration 5

Verification of Margin in PF 2 & 5 - Thermal Analysis of TPX Poloidal Field Coils

Owen Christianson
STC Advanced Electromagnetic Systems Department

July 31, 1995

TPX 14-950731-WEC-OChristianson-02

APPROVED:

P. A. Sanger
Westinghouse TPX Chief Scientist

APPROVED:

D. R. Potter
Westinghouse TPX Engineering Manager

Westinghouse Electric Corporation
Electronic Systems Group

401 East Hendy Avenue, Sunnyvale, California 94088-3499

CONTENTS

LIST OF FIGURES iv

ABSTRACT vi

1. OBJECTIVE - VERIFY MIT MARGIN CALCULATION 1-1

2. INTRODUCTION - REVIEW MIT CALCULATION, DESCRIBE WSTC METHODOLOGY 2-1

3. WSTC CALCULATIONAL PROCEDURES 3-1

   3.1 QUENCHER MODIFICATIONS AND ADAPTATIONS 3-1

   3.2 SUPERCONDUCTOR CRITICAL SURFACE: IC AND LOAD LINE, CURRENT SHARING, MARGIN 3-3

4. PF5 ANALYSIS 4-1

5. PF2 ANALYSIS 5-1

6. RATCHETING 6-1

7. CONCLUSIONS 7-1

8. REFERENCES 8-1

LIST OF FIGURES

Figure 2.1 — MIT calculated temperature rise in the PF coils. 2-2

Figure 2.2 — MIT calculated temperature margin for the PF coils. 2-2

Figure 3.1 — Characteristic interturn heat transport temperature distribution calculated at steady-state. 3-4

Figure 3.2 — The critical surface of the superconductor illustrating different quantities deifning the conductor operation, including quench, critical current, current sharing, and critical temperature. 3-6

Figure 4.1 — The deposited energy in one double pancake in PF 5 from AC losses 4-2

Figure 4.2 — Power loss in a PF 5 double pancake. 4-2

Figure 4.3 — The AC power loss in a PF 5 double pancake. 4.3

Figure 4.4 — Quencher calculated temperature rise in PF 5. An approximate solution is also included. 4-5

Figure 4.5 — Pressure rise in PF 5 predicted by Quencher. 4-5

Figure 4.6 — Mass flow predicted by Quencher calculations in PF 5 showing mass flow reversal. 4-6

Figure 4.7 — PF 5 operating point and superconducting critical surface at a point in the HC scenario. 4-7

Figure 4.8 — The coil current, magnetic field, and temperature margin during the HC scenario. 4-8

Figure 5.1 — The deposited energy in one double pancake in PF 2 from AC losses. 5-1

Figure 5.2 — Power loss in a PF 2 double pancake. 5-2

Figure 5.3 — The AC power loss in a PF 2 double pancake. 5-3

Figure 5.4 — Quencher calculated temperaure rise in PF 2. An approximate solution is also included. 5-5

Figure 5.5 — PF 2 operating point and superconducting critical surface at a point in the HC scenario. 5-5

Figure 5.6 — The coil current, magnetic field, and temperature margin during the HC scenario. 5-6

Figure 6.1 — The temperature distribution with no heating showing the cooling front propagating down the PF 2 conduit. This simulates the cooling front during the dwell time between pulses. 6-2

ABSTRACT

The MIT temperature margin calculations for the PF coil system during the HC scenario are verified in this analysis. Coils PF 2 & 5 are analyzed. The computer code Quencher is used to calculate the temperature rises due to AC losses and nuclear heating. Current sharing temperatures are found from the superconducting temperature, peak magnetic field, and the transport current. Temperature margin and headroom system requirements are met. Flow reversal occurs during the initial and final heating parts of the HC scenario. Ratcheting is addressed, and a minimum dwell time is proposed.

1. OBJECTIVE - VERIFY MIT MARGIN CALCULATION

TPX program requirements ensure that the superconductor remains superconducting during coil ramp by requiring a temperature margin greater than 1 K and a temperature headroom greater than 2 K. This requirement must be met during coil ramping. MIT analyzed the dynamic HC scenario to see that the margin and headroom requirements are met.[1] The computer code TOKSCPF simulated the scenario and confirmed that the superconducting requirments are met.

This work is an independent verification of the temperature margin and headroom for selected cases in the HC scenario. Results give close agreement with MIT calculations, thus confirming the superconductors should remain superconducting throughout the HC scenario.

2. INTRODUCTION - REVIEW MIT CALCULATION, DESCRIBE WSTC METHODOLOGY

Pillsbury and Schultz evaluated the HC scenario for TPX to ensure that the superconducting margin and temperature headroom met the program requirements. The scenario was simulated with TOKSCPF. Field changes were calculated at every time point and every location in the PF coils. Radial and axial fields were calculated separately to allow inculsion of losses due to field rotation. Hysteresis, coupling, and eddy current losses were calculated independently and summed. All heat was added to the helium enthalpy adiabatically.

The dynamic simulation gave peak temperatures of 5.6 K. An inlet temperature of 5 K and a temperature headroom of 2 K dictates that the current sharing temperature by no lower than 7 K. A margin of 1 K dictates that the current sharing temperature be no lower than 6.6 K. The minimum current sharing temperature was 8.0 K, so neither temperature margin nor temperature headroom constraints were violated in the scenario. MIT results are graphed in Figures 2.1 and 2.2.

To verify these calculations, WSTC uses the MIT transient code Quencher, and evaluates the two coils PF5 and PF2 for the HC scenario. Quencher determined temperatures are compared to an approximate solution that use conservation of energy and the physical properties of supercritical helium. Current sharing temperatures are determined through a numerical procedure that uses the superconducting critical surface described by Summers.[2]

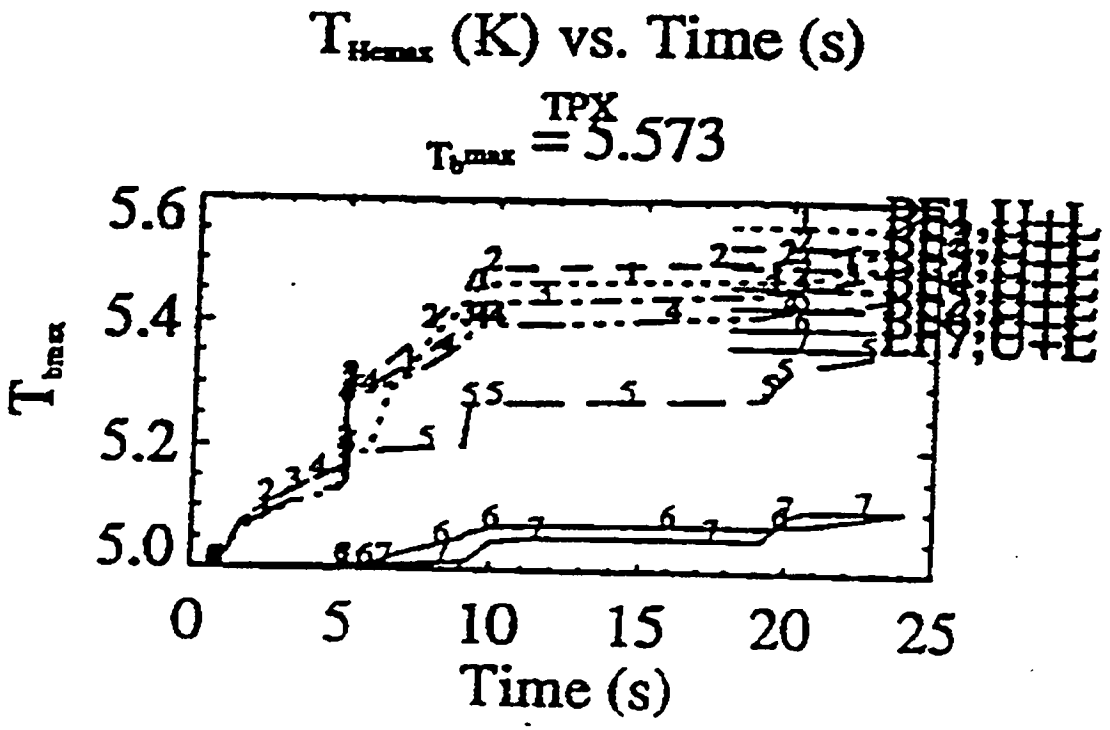


Figure 2.1 —MIT calculated temperature rise in the PF coils.

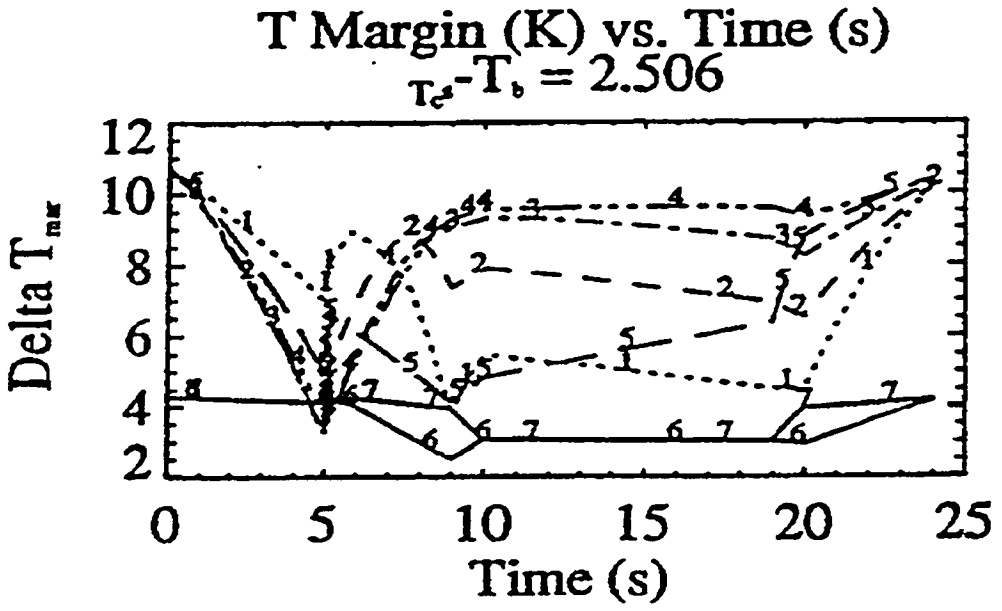


Figure 2.2 — MIT calculated temperature margin for the PF coils.

3. WSTC CALCULATIONAL PROCEDURES

3.1 QUENCHER MODIFICATIONS AND ADAPTATIONS

Chronology of Quencher Modifications:
- o Received Quencher From MIT - Sep.
- o Installed Quencher on SUN with NAG - Dec
- o NAG Free Quencher - Jan.
- o Boundary Conditions Applied - Feb.
- o Steady-State Comparison to WETMAP and EXP - Mar
- o Interturn Heat Transport Added - April

Westinghouse performs transient thermal analysis on the TPX PF coils using a modification of the computer code Quencher. Westinghouse received Quencher from MIT in September 1994. Between Oct. and Dec. Quencher was installed on a SUN workstation at STC. The NAG library was also installed as part of a free trial program. Both NAG and Quencher operated properly. Calculations were compared to trial runs performed by MIT. It was decided not to purchase the NAG libraries. Quencher was modified to run NAG free in Jan. Comparisons were made to previous runs. Quencher originally calculates Helium temperature, pressure, density for a quench using appropriate boundary conditions. To run the transient scenarios for the TPX PF coils the boundary conditions were modified in Feb. MIT furnished the appropriate boundary conditions which were implemented in Quencher at WSTC. Comparisons were made to steady-state calculations performed by WSTC and experimental results. These calculations were reported at the

February TIM. In March, Quencher was modified to incorporate interturn heat transport in pancake windings such as PF 2 & 5.

Features:
o Interturn Heat Transport
o Dynamic Node Remeshing
o Input Parameters Define Geometry
o One double pancake (adiabatic)
o User Heat Input

Modifications were made to Quencher to calculate interturn heat transport for spiral wound coils and constant radius wound coils. Dynamic node remeshing is preserved in the modified Quencher. The geometry of the coil is defined by input parameters. These include the location of the starting turn, conductor width, insulation thickness, and effective thermal conductivity. Only one double pancake is analyzed. The user will specify the heat input. This is implemented in subroutine SQUEN.

User Input Produces the Following Values:
o Turn start and lengths, including transition
o Total conductor length
o Integrated overlap area
o Interturn heat transport between nodes
o Wall temperature calculation

The code calculates the location of the beginning of each turn, and the length of each turn. The transition from the lower layer to the upper layer is included. The total conductor length is calculated. The overlap area, that is the area over which heat is transferred, is calculated from approximate analytic expressions. Since the

node spacing changes with each time step, and the overlap area is a function of angle around the coil, the heat transfer area is actually integrated over a node. Each node is mapped to corresponding nodes for heat transfer. The heat flux between nodes is computed, and used to calculate the wall temperature. This allows modification of the code without making any changes to the solver.

To demonstrate that the modified code calculates interturn heat transport, comparisons were made to steady-state TF calculations. The characteristic interturn heat transport temperature distributrion is obtained. Temperatures are in reasonable agreement. However, this was not a one to one comparison to calculations for the TF coil. The code presently handles circular coils, so the geometry is not exactly the same. The heat input was taken to be smooth, see A. Shajii thesis. A spiral wound coil was analyzed. The KA/dx effective thermal conductivity was scaled to approximate the constant radius case. Results compare well. (A constant radius winding may also be analyzed now.)

3.2 SUPERCONDUCTOR CRITICAL SURFACE: IC AND LOAD LINE, CURRENT SHARING, MARGIN

The critical surface of the Nb_3Sn superconductor is described by Summers, et al.,[2] emperical relationship

$$J_c(B,T,\varepsilon) = C(\varepsilon)\left(B_{c2}(T,\varepsilon)\right)^{-½}(1-t2)^2 b^{-½}(1-b)^2$$

where

$$B_{c2}(T,\varepsilon(= B_{c2o}(\varepsilon((1-t2([1-0.31t2(1-1.77\ln t(]$$

and

$$t = T/T_{co}(\varepsilon)$$

$$b = B/B_{c2}(T,\varepsilon)$$

$$C(\varepsilon) = C_o\left(1-a|\varepsilon|^u\right)^{½}$$

where C_0 is a coefficient independent of temperature, field, and strain.

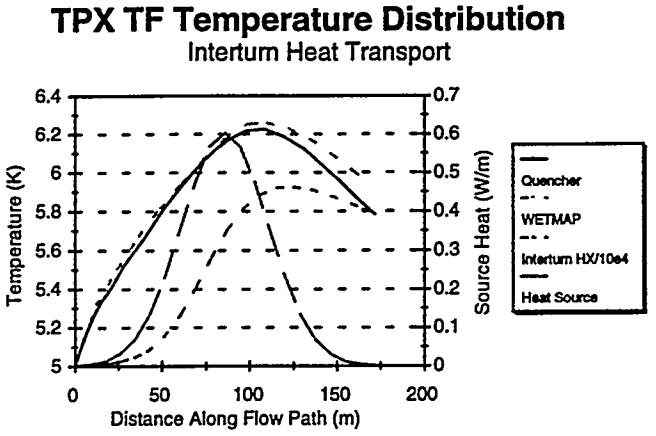


Figure 3.1 — Characteristic interturn heat transport temperature distribution calculated at steady-state.

$$B_{c2o}(\varepsilon) = B_{c20m}\left(1 - a|\varepsilon|^{u}\right)$$

$$T_{c0}(\varepsilon) = T_{c0m}\left(1 - a|\varepsilon|^{u}\right)^{1/w}$$

where B_{c20m} and T_{c0m} are the values of B_{c20} and T_{c0} at zero intrinsic strain. Also,

a=900 for $\varepsilon<0$, a=1250 for $\varepsilon>0$

u=1.7

w=3.

The values used in this calculation are given in Table 3.1.

Table 3.1 — Nb_3Sn Superconducting Parameters

ε		-0.003
T_{c0m}	K	16
B_{c20m}	T	27.5
C_o	$AT^{1/2}/m^2$	10.56×10^9

The critical surface and the magnet load line are used to specify how close the conductor operating point is to the critical surface. This can be done in terms of current, magnetic field, or temperature, and is usually called the margin. Depending on which parameter one uses to define the margin, it is usually depicted as a projection of the load line on a plane cutting the superconducting critical surface. These different margins are really not independent, but are related through the superconducting critical surface.[3]

Using the superconducting critical surface, one can define specific quantities that define the operation of the magnet and the conductor, see Figure 3.2. The operating point is the current specified in the conductor to give an operational magnetic field. The load line is a line from the operating temperature at zero current and magnetic field through the operating point. If magnetic materials are present this load line is not linear, and its curvature is defined by a transfer function. The intersection of the load line with the critical surface gives the quench current, quench temperature, and quench magnetic field. The critical current of the conductor is defined by the intersection of a line beginning at the operating field and temperature but zero current going vertically through the operating point. The current sharing temperature is found by the intersection of a line from the operating point through the critical surface where temperature is increased but current and magnetic field are constant. Continuing to increase temperature and following the critical surface until the current is zero defines the critical temperature.

Usually these quantities are defined by a two dimensional representation where the superconducting critical current is displayed as a function of magnetic field with temperature being held constant, see Figure 3.2. The current sharing temperature is found by increasing the temperature until the critical current line moves down over the operating point. Continuing to increase the temperature will yield the critical temperature when the critical current is zero at the operating magnetic field and at zero current.

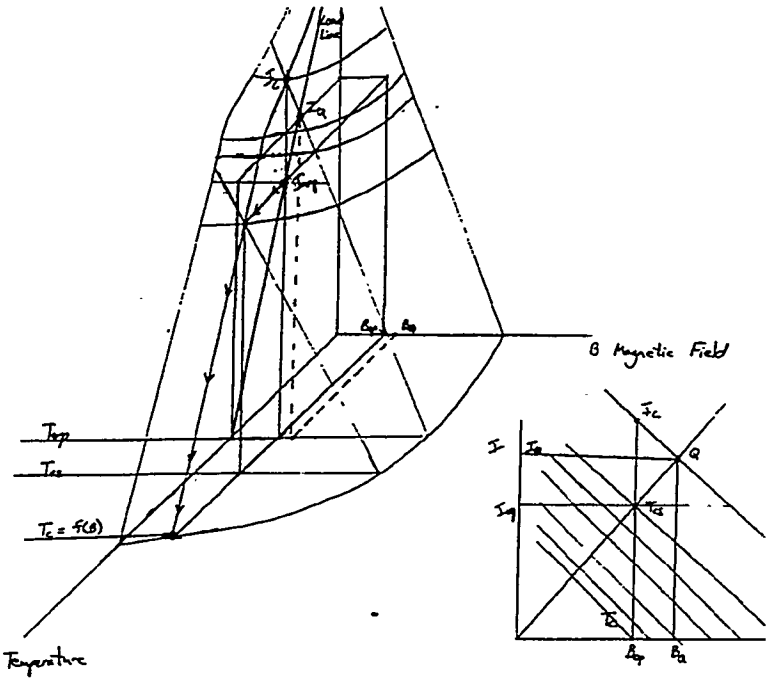


Figure 3.2 — The critical surface of the superconductor illustrating different quantities defining the conductor operation, including quench, critical current, current sharing, and critical temperature.

The operating point, quench point, critical current, current sharing, and critical temperature can be defined quantitatively. Numerical procedures are used to evaluate these points.

The temperature margin is defined as

$$TM=T_{cs}-T_{sc}$$

where TM is temperature margin, T_{cs} is the current sharing temperature, and T_{sc} is the temperature of the conductor. Additionally, one can define the headroom as the difference between the conductor temperature and the inlet temperature.

4. PF5 ANALYSIS

Pillsbury at MIT calculated the AC losses in the individual turns of the PF coil system for the HC Scenario.[4] He used the computer program TOKSCPF modified to output turn-by-turn losses. The total PF coil losses were 113 kJ, versus 220 kJ in an early calculation. PF 5 had the highest losses in the PF coil system of about 12.5 kJ. The PF 5 coil is chosen for analysis because of this high heating and because its temperature margin, along with PF 2, is the lowest in the Nb_3Sn coils in the PF coil system.

Pillsbury's tabulated results are graphically portrayed in Figure 4.1 for one double pancake in PF 5. The initial heating until 5.185 seconds and the heating from 19 to 24 seconds accounts for most of the deposited energy. The total deposited energy is over 2 kJ. The double pancake graphed in Figure 4.1 has the largest heating in the PF 5 coil pack, and is the double pancake analyzed for temperature rise and margin.

The power loss as a function of time is found from the deposited energy and shown in Figure 4.2. The initial heating until 5.0 seconds is large at 171 W, followed by an extremely high heating of 2900 W and 800 W from 5.0 to 5.085 seconds and 5.085 to 5.185 seconds, respectively. From 5.185 to 19 seconds the heating is small, with the smallest at 7 W from 10 to 19 seconds. At 19 seconds the power loss increases to 374 W for one second, and then decreases to 100 W for the remainder of the scenario.

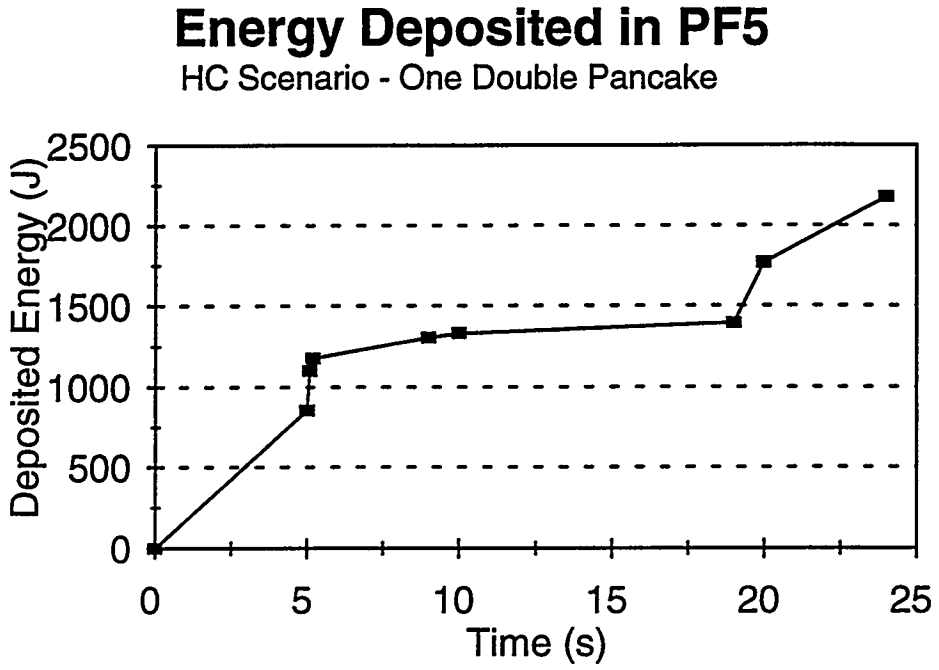


Figure 4.1 — The deposited energy in one double pancake in PF 5 from AC losses.

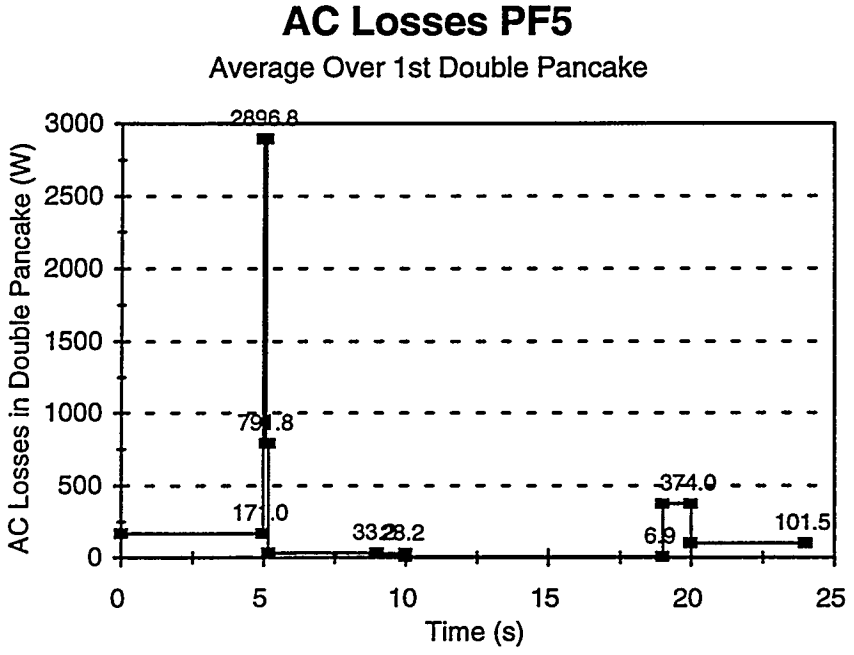


Figure 4.2 — Power loss in a PF 5 double pancake.

The AC heating is displayed on in logarithmic plot in Figure 4.3 to more clearly differentiate the different heating rates which span almost three orders of magnitude.

The computer code Quencher is used to calculate the temperature rise in this PF 5 double pancake. The input file is shown in Insert 1. Quencher was run with and without interturn heat transfer with no significant difference in the temperature rise. For this problem interturn heat transfer has little effect because the time constants are several hundred seconds compared to a scenario time of 24 seconds. The interturn heat transfer module was turned off for the PF 5 analysis.

Results of the Quencher calculations are shown in Figure 4.4. The initial heating causes a 0.1 K temperature rise. The very large heating at 5 seconds causes an abrupt temperature rise of 0.05 K with an apparent slight cooling after the heating reduces to small values. At 19 seconds the heating increases and the temperature rises to its final value of about 5.22 K.

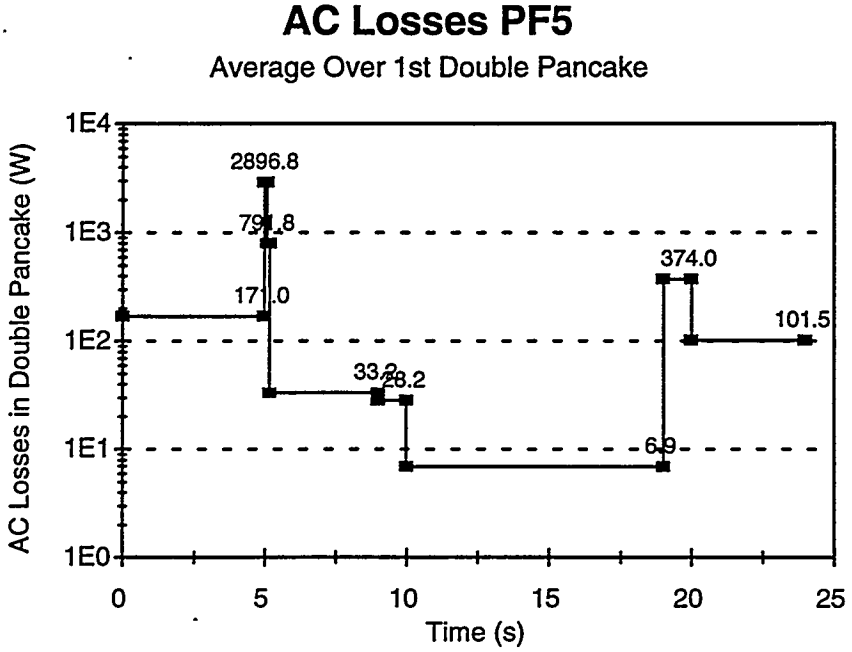


Figure 4.3 — The AC power loss in a PF 5 double pancake.

An approximate solution is also obtained and graphed in Figure 4.4. The approximate solution involves a back of the envelope calculation where all of the heating goes into the helium at a uniform temperature, that is no axial temperature distribution. The temperature rise is found by equating the enthalpy to the deposited energy at times throughout the scenario. The enthalpy is obtained from the computer code Cryodata.[5] During intense heating the pressure is assumed to increase with temperature. When the heating is small, it is assumed that the pressure is the inlet pressure. The density of the helium is recalculated at each point. This is equivalent to allowing the helium to expel from the conduit, or flow into the conduit. Results agree well with Quencher results.

Insert 1 . Quencher input file for PF5.

```
W TPX PF5
-----------------------------------------------------------------------
tmax,  dt1,   dt2,   dt3,  t12,    t23
24.0d00, 5.d-2, 5.0d-3, 1.0d-1, 10.001d00, 10.050d00
-----------------------------------------------------------------------
NS00, L0,    L1,    L,     Ns01, Ns12, Ns23
30,  41.0d00, 82.0d00, 122.996d00, 10,  10,  10
-----------------------------------------------------------------------
Lq,   Sq,   Xq,   tq
122.996d00, 35.6d00,  61.498d00, 24d00
-----------------------------------------------------------------------
Tin,   Pin,   Pout
5.0d00,  3.8d+5, 3.5d+5
-----------------------------------------------------------------------
Tcs,   Tcr
9.3d00,  12.97d00
-----------------------------------------------------------------------
Ah(cable), Ah(hole), dh(cable), dh(hole), Pwall,
1.114d-4,  0.00d00,   4.68d-4,   0.0d00,   0.06992d00
-----------------------------------------------------------------------
k(cable), k(hole)   ( Note: friction factor = f = k * 0.184/Re**0.2 )
2,      2
-----------------------------------------------------------------------
Asc,   isc, Acu,      Aw,       epssc
2.548d-5, 1,   1.4654d-4,  1.792d-4,  -0.003d00
-----------------------------------------------------------------------
I0,    tdet,    tdump,   RRR
2.7875d+4, 24.0d00,  7.143d00,  75d00
-----------------------------------------------------------------------
ip4, tol1,  tol2,  tol3,  tol4
3,   1.d-5,  1.d-5,  1.d-5,  1.0d-2
-----------------------------------------------------------------------
effk, tkns,  cdr,   rto,   lwin,  nturn
0.07,  1.61d-3,  0.0223,  1.1176,  0,  8
-----------------------------------------------------------------------
ntpr, tpri(i)
10,  0.01,1,5,5.085,5.185,9,10,19,20,24
```

In addition, Quencher also calculates the pressure rise, see Figure 4.5, and the mass flow rates, see Figure 4.6. For large heating the temperature rises, see for example the time period between 0 and 5.185 seconds. The pressure also rises causing flow reversal. This appears as a negative mass flow in Figure 4.6.

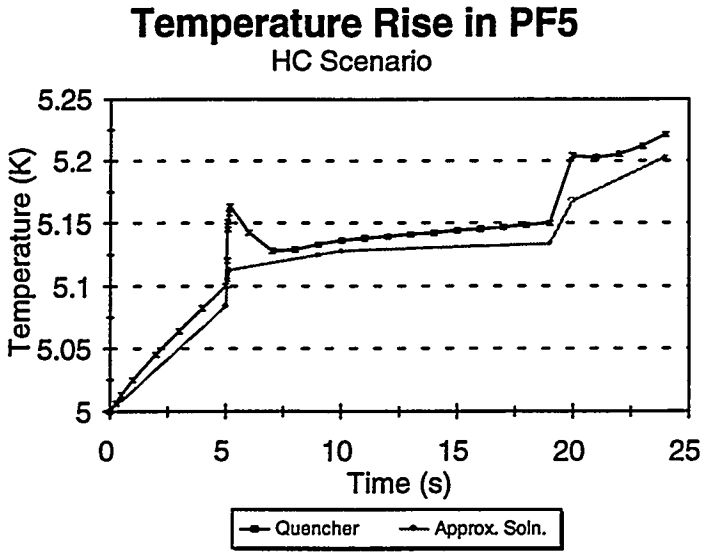


Figure 4.4 — Quencher calculated temperature rise in PF 5. An approximate solution is also included.

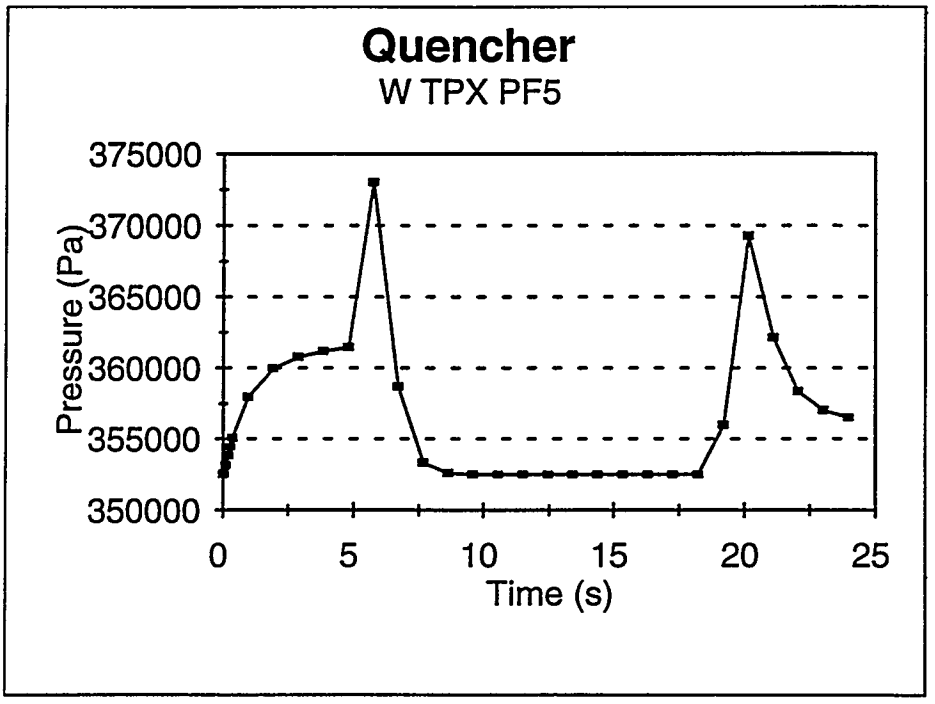


Figure 4.5 — Pressure rise in PF 5 predicted by Quencher.

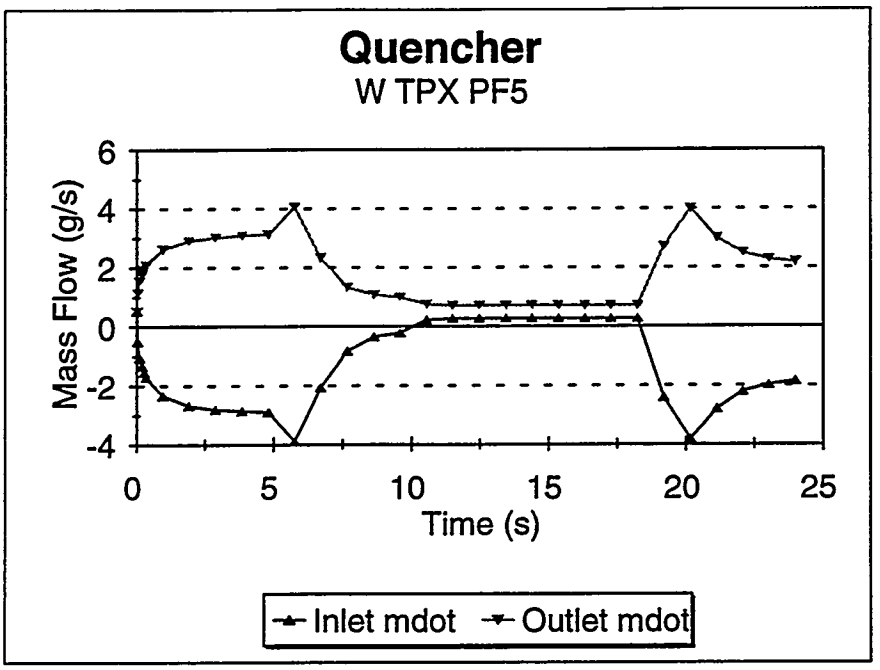


Figure 4.6 — Mass flow predicted by Quencher calculations in PF 5 showing mass flow reversal.

The PF 5 superconductor operating point is about 70% along the load line at its lowest temperature margin during the HC scenario, see Figure 4.7. The currents, magnetic field, and temperature of the superconductor change throughout the HC scenario. These three parameters are input to a code to evaluate the operating point and critical surface of the superconductor at each transition point of the scenario, as well as intermediate points. Values for the currents and peak magnetic field were given by MIT. These are included in the following Table. PF 5 meets both the temperature margin and temperature headroom requirement. (The values of the current sharing temperature are slightly lower than those calculated by MIT. This slightly low current sharing is probably due to conservatively assuming the peak magnetic field occurs at the peak temperature.)

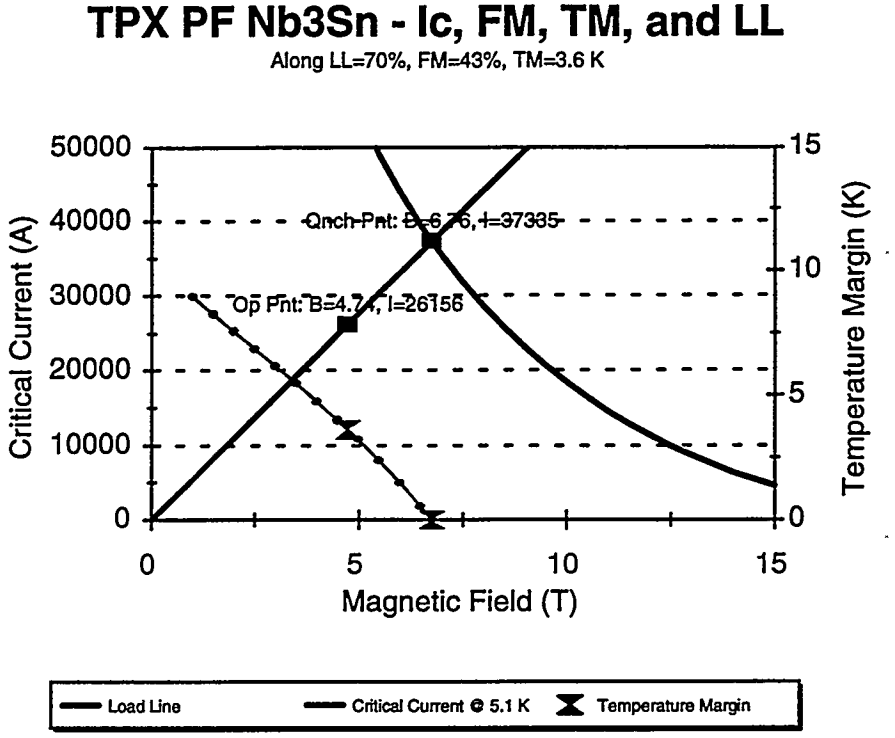


Figure 4.7 — PF 5 operating point and superconducting critical surface at a point in the HC scenario.

Time	Quencher	Approx. Soln.	Current	Magnetic Field	%LL	Tcs	TcsMIT	Tmargin	Thead room
0	5.00	5.00	0	0.00	0.00	15.75	15.75	10.75	10.75
5	5.10	5.08	21641	4.52	62.91	9.48	10.15	4.40	4.48
5.085	5.15	5.11	18359	3.90	53.99	10.38	11.19	5.27	5.38
5.185	5.16	5.11	16563	3.51	48.62	10.90	11.78	5.79	5.90
9	5.13	5.13	26156	4.74	70.02	8.77	9.32	3.64	3.77
10	5.14	5.13	24102	4.35	64.41	9.35	10.02	4.22	4.35
19	5.15	5.13	19258	3.36	50.41	10.74	11.61	5.60	5.74
20	5.20	5.17	9445	1.62	24.55	13.17	14.08	8.01	8.17
24	5.22	5.20	0	0.01	0.00	15.75	15.75	10.54	10.75

The currents in the coil, the peak magnetic field, and the temperature margin are graphed in Figure 4.8. The lowest temperature margin is 3.6 K occurring at 9 seconds where the current is the largest. The temperature margin is driven by the magnetic field and the coil current, with the superconducting temperature contributing minor variations.

The PF 5 coil meets the temperature margin and headroom requirements, and this analysis verifies the MIT calculations.

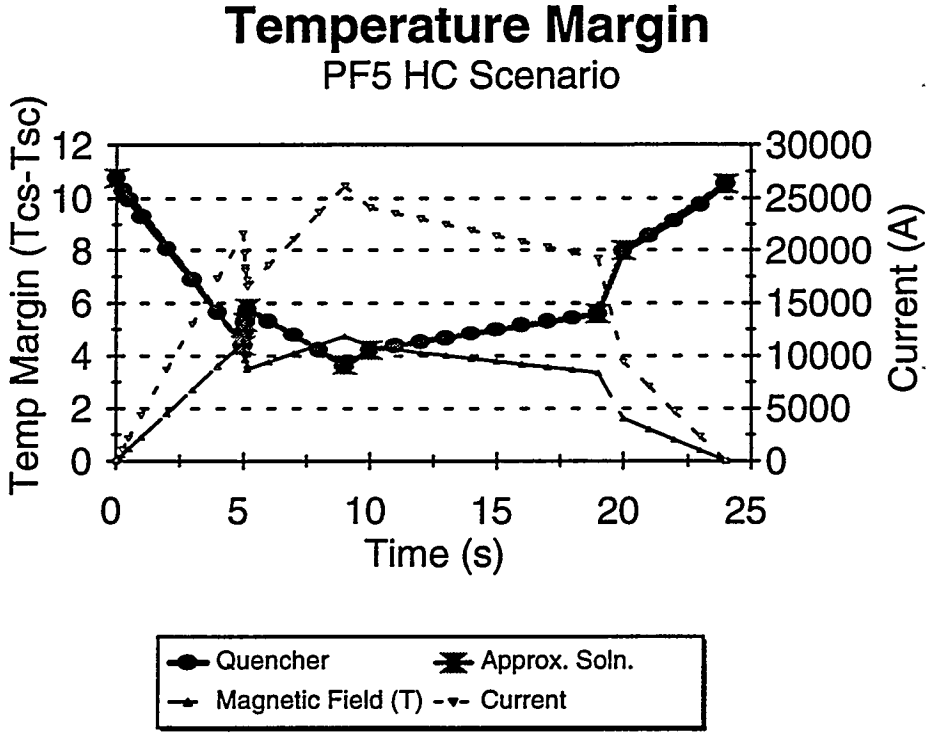


Figure 4.8 — The coil current, magnetic field, and temperature margin during the HC scenario.

5. PF2 ANALYSIS

Pillsbury at MIT calculated the AC losses in the individual turns of the PF coil system for the HC Scenario.[4] He used the computer program TOKSCPF modified to output turn-by-turn losses. The total PF coil losses were 113 kJ, versus 220 kJ in an early calculation. The PF 2 coil is chosen for analysis because its temperature margin is the lowest in the Nb_3Sn coils in the PF coil system.

Pillsbury's tabulated results are graphically portrayed in Figure 5.1 for one double pancake in PF 2. The initial heating until 9 seconds and the heating from 19 to 24 seconds accounts for most of the deposited energy. The total deposited energy is slightly less than 2 kJ. The double pancake graphed in Figure 5.1 has the largest heating in the PF 2 coil pack, and is the double pancake analyzed for temperature rise and margin.

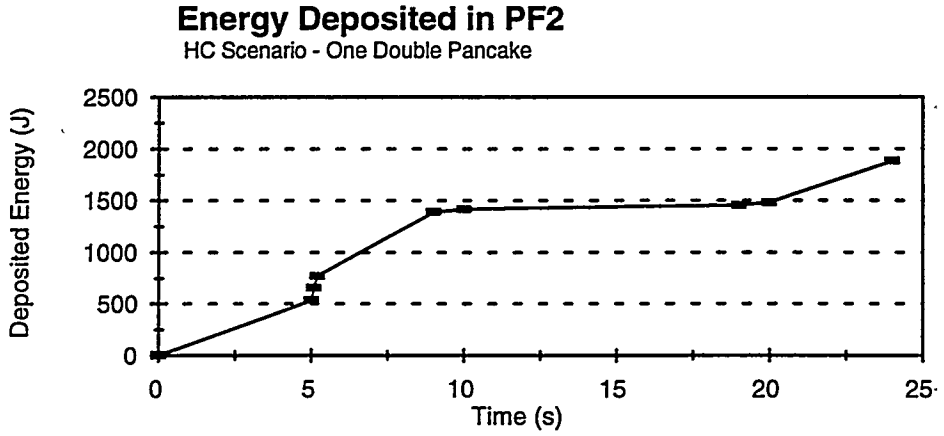


Figure 5.1 — The deposited energy in one double pancake in PF 2 from AC losses.

The power loss as a function of time is found from the deposited energy and shown in Figure 5.2. The initial heating until 5.0 seconds is large at 107 W, followed by an extremely high heating of 1470 W and 1110 W from 5.0 to 5.085 seconds and 5.085 to 5.185 seconds, respectively. From 5.185 to 9 seconds the heating is large at 162 W. From 9 to 19 seconds the heating is small, with the smallest at 4 W from 10 to 19 seconds. At 19 seconds the power loss increases to 25 W for one second, and then increases to 100 W for the remainder of the scenario.

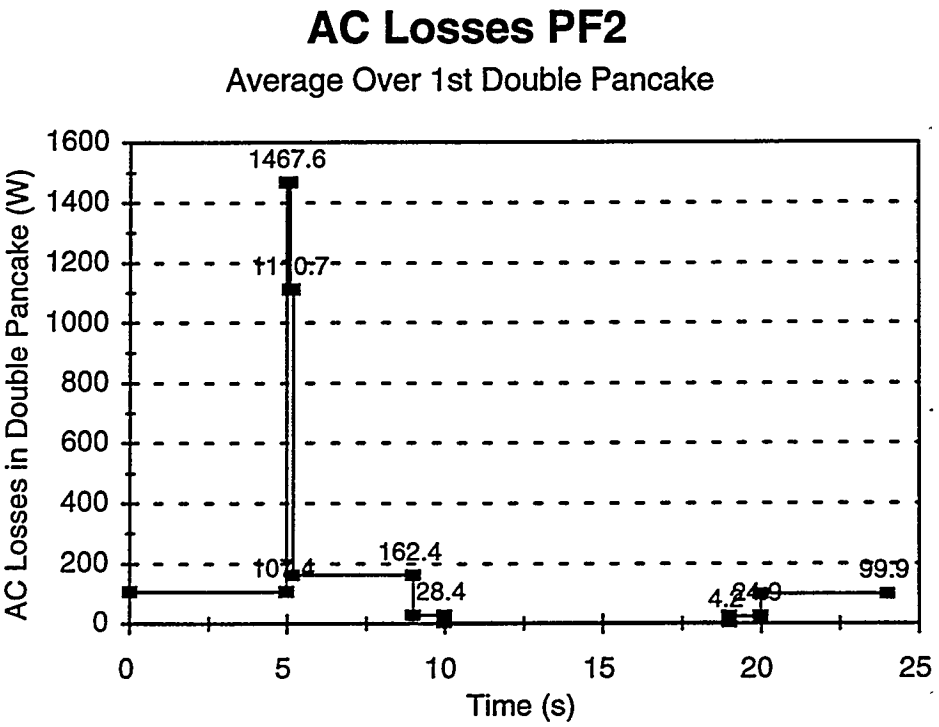


Figure 5.2 — Power loss in a PF 2 double pancake.

The AC heating is displayed on in logarithmic plot in Figure 5.3 to more clearly differentiate the different heating rates which span almost three orders of magnitude.

The computer code Quencher is used to calculate the temperature rise in this PF 2 double pancake. The input file is shown in Insert 2. Quencher was run with and without interturn heat transfer with no significant difference in the

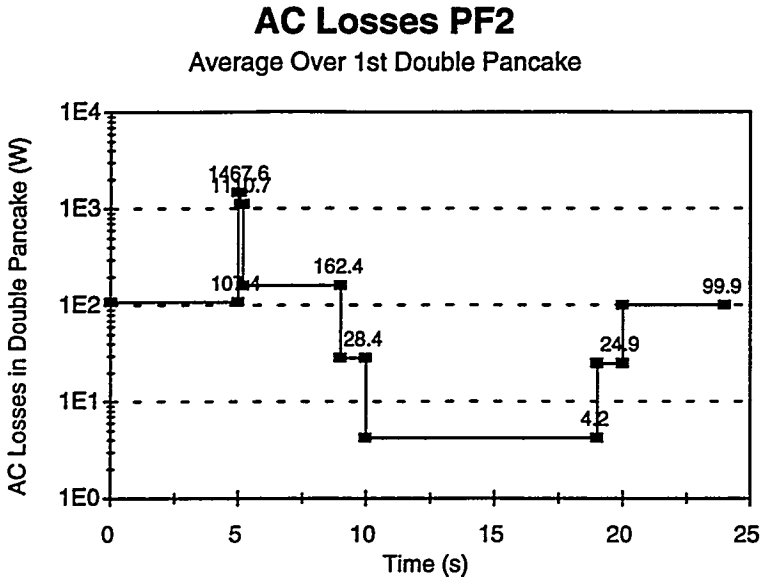


Figure 5.3 — The AC power loss in a PF 2 double pancake.

temperature rise. For this problem interturn heat transfer has little effect because the time constants are several hundred seconds compared to a scenario time of 24 seconds. The interturn heat transfer module was turned off for the PF 2 analysis.

Results of the Quencher calculations are shown in Figure 5.4. The initial heating causes a 0.1 K temperature rise. The very large heating at 5 seconds causes an abrupt temperature rise of 0.05 K, with continued heating to 9 seconds and a temperature rise of 0.1 K. At 19 seconds the heating increases and the temperature rises to its final value of about 5.32 K.

An approximate solution is also obtained and graphed in Figure 5.4. The approximate solution involves a back of the envelope calculation where all of the heating goes into the helium at a uniform temperature, that is no axial temperature distribution. The temperature rise is found by equating the enthalpy to the deposited energy at times throughout the scenario. The enthalpy is obtained from the computer code Cryodata.[5] During intense heating the pressure is assumed to increase with temperature. When the heating is small, it is assumed that the pressure is the inlet pressure. The density of the helium is recalculated at each

point. This is equivalent to allowing the helium to expel from the conduit, or flow into the conduit. Results agree well with Quencher results.

The PF 2 superconductor operating point is about 77% along the load line at its lowest temperature margin during the HC scenario, see Figure 5.5. The currents, magnetic field, and temperature of the superconductor change throughout the HC scenario. These three parameters are input to a code to evaluate the operating point and critical surface of the superconductor at each transition point of the scenario, as well as intermediate points. Values for the currents and peak magnetic field were given by MIT. These are included in the following Table. PF 2 meets both the temperature margin and temperature headroom requirement. (The values of the current sharing temperature are slightly lower than those calculated by MIT. This slightly low current sharing is probably due to conservatively assuming the peak magnetic field occurs at the peak temperature.)

Insert 2 . Quencher input file for PF5.

```
W TPX PF2
-----------------------------------------------------------------
tmax,  dt1,   dt2,   dt3,  t12,   t23
24.0d00, 5.d-2, 5.0d-3, 1.0d-1, 10.001d00, 10.050d00
-----------------------------------------------------------------

NS00, L0,   L1,   L,    Ns01, Ns12, Ns23 30,   20.384d00,
40.767d00, 61.151d00, 10,  10,  10
-----------------------------------------------------------------
Lq,   Sq,   Xq,   tq
61.151d00, 12.304d00, 30.575d00, 24d00
-----------------------------------------------------------------
Tin,   Pin,   Pout
5.0d00, 3.52d+5, 3.5d+5
-----------------------------------------------------------------
Tcs,   Tcr
9.3d00, 12.97d00
-----------------------------------------------------------------
Ah(cable), Ah(hole), dh(cable), dh(hole), Pwall,
1.114d-4, 0.00d00,  4.68d-4,  0.0d00,   0.06992d00
-----------------------------------------------------------------
k(cable), k(hole)   ( Note: friction factor = f = k * 0.184/Re**0.2 )
2,     2
-----------------------------------------------------------------
Asc,   isc, Acu,    Aw,     epssc
2.548d-5, 1,  1.4654d-4, 1.792d-4, -0.003d00
-----------------------------------------------------------------
I0,    tdet,   tdump,  RRR
2.7875d+4, 24.0d00, 7.143d00, 75d00
-----------------------------------------------------------------
ip4, tol1, tol2, tol3, tol4
3,  1.d-5, 1.d-5, 1.d-5, 1.0d-2
-----------------------------------------------------------------
effk, tkns, cdr, rto, lwin, nturn
0.07,  1.61d-3, 0.0223, 0.738, 0,  6
-----------------------------------------------------------------
ntpr, tpri(i)
10,  0.01,1,5,5.085,5.185,9,10,19,20,24
```

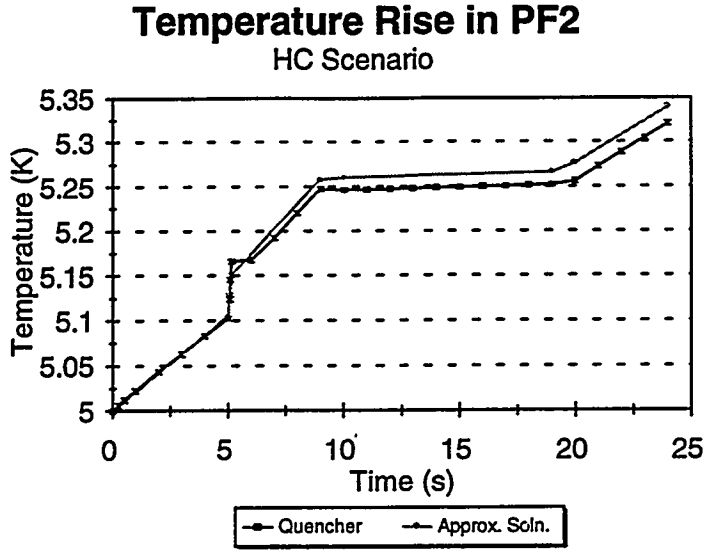


Figure 5.4 — Quencher calculated temperature rise in PF 2. An approximate solution is also included.

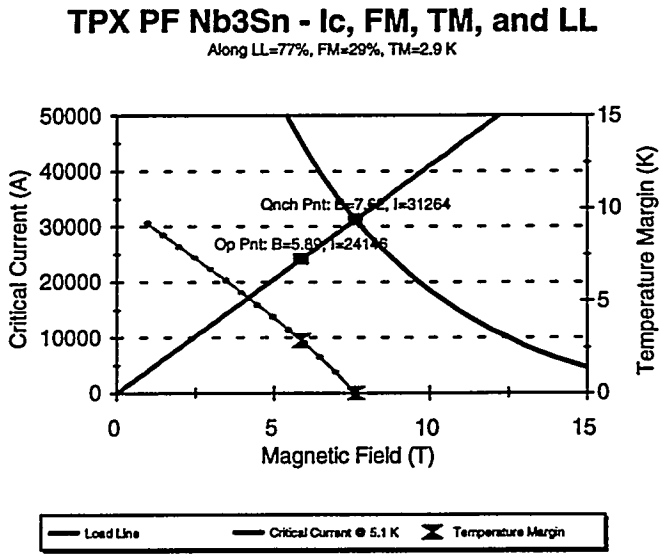


Figure 5.5 — PF 2 operating point and superconducting critical surface at a point in the HC scenario.

Time	Quencher	Approx. Soln.	Current	Magnetic Field	%LL	Tcs	TcsMIT	Tmargin	Thead room
0	5.000	5.000	0	0.000	0.00	15.75	15.75	10.75	10.75
5	5.103	5.105	24146	5.886	77.24	7.97	8.38	2.86	2.97
5.085	5.124	5.130	21438	5.204	68.52	8.92	9.55	3.79	3.92
5.185	5.166	5.152	17844	4.672	59.87	9.81	10.58	4.66	4.81
9	5.247	5.258	-7073	3.658	37.45	12.02	12.79	6.77	7.02
10	5.246	5.260	-6615	2.939	31.56	12.57	13.35	7.31	7.57
19	5.252	5.266	-11240	3.589	43.12	11.48	12.37	6.21	6.48
20	5.256	5.276	-13365	3.793	47.58	11.06	11.96	5.78	6.06
24	5.321	5.340	0	0.006	0.00	15.75	15.75	10.41	10.75

The currents in the coil, the peak magnetic field, and the temperature margin are graphed in Figure 5.6. The lowest temperature margin is 2.9 K occurring at 5 seconds where the current is the largest. The temperature margin is driven by the magnetic field and the coil current, with the superconducting temperature contributing minor variations.

The PF 2 coil meets the temperature margin and headroom requirements, and this analysis verifies the MIT calculations.

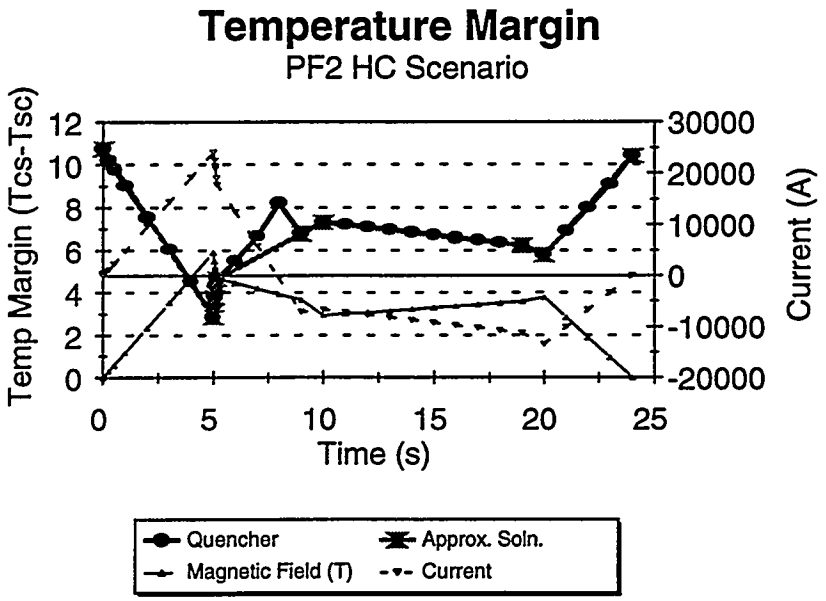


Figure 5.6 — The coil current, magnetic field, and temperature margin during the HC scenario.

6. RATCHETING

Succeeding pulses in the HC scenario are separated by a dwell time to allow the CIC temperature to recover. For short dwell times succeeding pulses will add to the conductor temperature rise, and decrease the margin. This process is called ratcheting.

The minimum dwell time to prevent ratcheting is estimated with Quencher by simulating the cooling front propagating down the flow path, see Figure 6.1. (Other methods, such as an SSC finite difference code to calculate cooling wave propagation in accelerator magnets or analytic methods, could also be used to solve this part of the scenario.)

For PF2, the cooling front propagates at 0.05 m/s, suggesting a minimum dwell time of 20 minutes between pulses to prevent ratcheting. For PF5 the minimum dwell time will be larger because of the longer path length. Assuming the same cooling velocity as for PF2, the minimum dwell time for PF5 is 40 minutes.

Interturn heat transport is not included in this quick estimate. It should spread out the temperature distribution. Capability exists to include interturn heat transport in the analysis.

This quick analysis suggests that dwell times of 20 and 40 minutes will prevent ratcheting in coils PF2 and PF5, respectively. A more in-depth analysis could be performed in TPX Phase II.

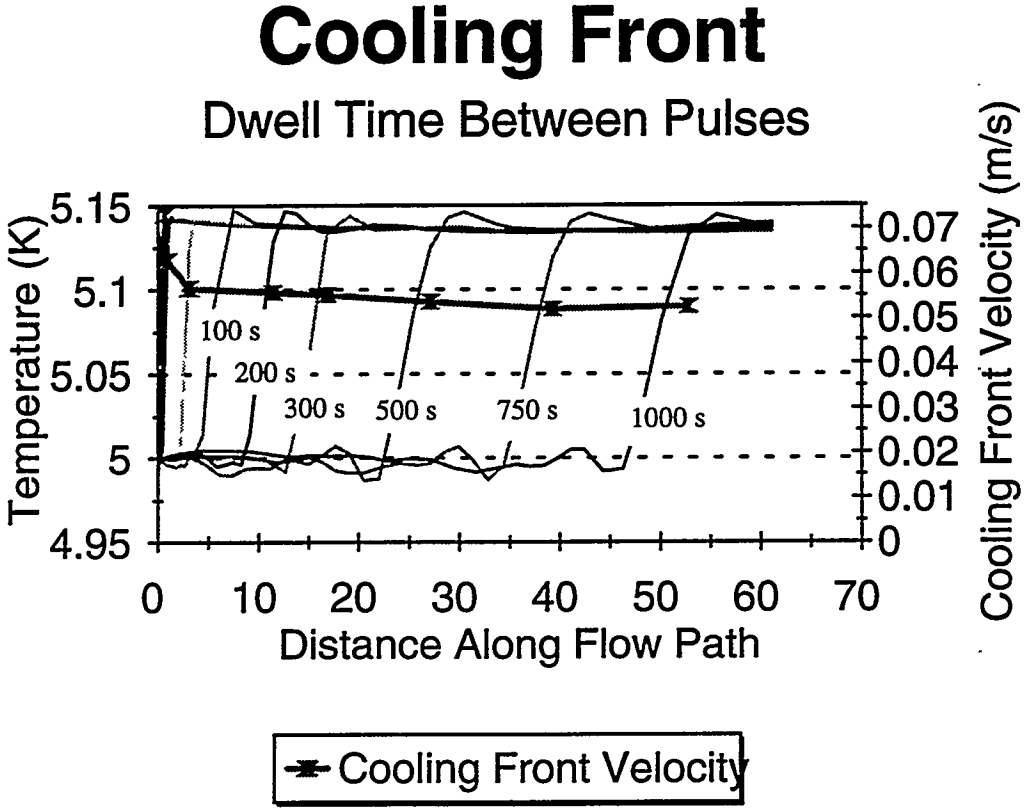


Figure 6.1 — The temperature distribution with no heating showing the cooling front propagating down the PF 2 conduit. This simulates the cooling front during the dwell time between pulses.

7. CONCLUSIONS

The purpose of this analysis is to verify MIT temperature margin calculations in the PF coil system. Two coils are analyzed, PF 2&5.

The computer Quencher is used to calculate temperature rises in the coils. Results agree well with MIT calculations. The temperatures are slightly less than in the MIT analysis because the AC heating is reduced. The temperature distributions agree well with the MIT calculations.

Calculations of current sharing temperature uses the temperature of the superconductor, peak magnetic field, and the current. The values found in this analysis are slightly lower than the MIT values, probably because it is conservatively assumed that the peak temperature and magnetic field occur at the same location.

Both coils, PF 2&5, meet the temperature margin and headroom system requirements. Results in this study closely, but not exactly, match the MIT values, indicating this analysis confirms the MIT margin calculations.

In addition, it is found that during the initial heating and final heating parts of the HC scenario flow reversal occurs, that is helium coolant is expelled out the inlet of the conduit. Flow is re-established when the heating decreases at about 10 seconds. The flow reversal does not thermally impact the cooling of the PF coils.

A quick analysis suggests that dwell times of 20 and 40 minutes will prevent ratcheting in coils PF2 and PF5, respectively.

8. REFERENCES

1. 14-940802-MIT/RPillsbury-01, "Evaluation of the HC Scenario for TPX -- Superconductors and Refrigerators."

2. L. T. Summers, M. W. Guinan, J. R. Miller, and P. A. Hahn, "A Model For The Prediction of Nb_3Sn Critical Current as a Function of Field, Temperature, Strain, and Radiation Damage," IEEE Transactions on Magnetics, Vol. 27, No. 2, March 1991, pp. 2041-2044.

3. O. R. Christianson, H. L. Chuboy, M. P. Krefta, and S. K. Singh, "High Energy Booster Dipole Model Magnet (HDMM) Margin," Supercollider 5, Edited by P. Hale, Plenum Press, New York, 1994, pp. 197-200.

4. R. D. Pillsbury, Jr., "Turn-by-turn AC Loss Estimates in the PTX PF Coil System," 14-950523-MIT-RPillsbury-01, May 23, 1995.

5. Cryodata, Inc. Wimot, CO.

FORM S-60-10

Westinghouse STC Center

TECHNICAL DOCUMENT SUMMARY

Contract-Required Document. Internal Distribution Only.

This document is not to be distributed outside the Westinghouse Electric Corporation. (For information, contact Contracts Management.)

STC Document No. 95-8TM4-TPXAC-R3

1. REPORT NO. (RN)	2. PROPRIETARY CLASS (PC)	3. AVAILABILITY (AV)
95-8TM4-TPXAC-R3	CRD	STC-LIB

4. ORIGINATING SOURCE (OS)	5. CONTRACT NO. (CN)
STC	

6. FUNDING SOURCE/SPONSOR (FS)	7. NOTES (NT)
Marine Division	

8. AUTHOR/S (AU)
O. R. Christianson

9. TITLE (TI)
VERIFICATION OF MARGIN IN PF 2 & 5

10. DATE (DA) - YYMMDD	11. PAGES, REFS., TABLES, FIGS. (PA)
950728	25 p., 8 refs., 18 figs.

12. KEYWORDS (KW)
TRANSIENT. THERMAL. ANALYSIS. MARGIN. SUPERCONDUCTING. RAMP. A-C. LOSSES. NUCLEAR. HEATING. CURRENTS. SHARING.

13. **ABSTRACT** (AB) - PURPOSE, SCOPE, APPROACH, RESULTS, CONCLUSIONS, SIGNIFICANCE

This document is an STC Contract Required Document. It cannot be distributed without the clearance of the Contracts Management Department. Please contact the author for further information.

TO STC CENTER LIBRARY

SEND COPY OF DOCUMENT NO. 95-8TM4-TPXAC-R3 **TO:**

Name _____

Plant/Div. (Complete Name) _____

Location (City & State) _____

Charge No. _____

(print plainly; this is your mailing label)

☐ **Hard Copy*** ☐ **Microfiche**

* No charge until out of stock. Then, hard copy will be furnished only when you request it and include your complete charge number to cover the $0.50/page charge and a $1.00 service charge. Otherwise, once hard copies are gone microfiche copies will be furnished routinely, at no cost.

Eddy-Current and Nuclear Heating in TPX PF 6 and 7 Ring Coils Cases

P. L. Walstrom Ph.D.
Northrop Grumman Corporation

August 15, 1995

TPX-14-950815-WEC-PWalstrom-01

APPROVED:

P.A. Sanger
Westinghouse TPX Chief Scientist

APPROVED:

D. R. Potter
Westinghouse TPX Engineering Manager

Westinghouse Electric Corporation
Electronic Systems Group

401 East Hendy Avenue, Sunnyvale, California 94088-3499

Eddy-Current and Nuclear Heating in TPX's PF 6 and 7

General Considerations

The addition of stainless-steel cases to PF-6 and PF-7 in TPX increases the total load to the 4K part of the TPX cryogenic system in two ways: first, the total nuclear heat load (coil case plus windings) is increased over the value for the uncased windings alone because more material is present to intercept neutrons, and, second, eddy currents are induced in the coil case by the changing self-fields of coils and by the external changing fields from the other PF coils.

I have recently obtained from Tom Kupiszewski (Westinghouse) some preliminary nuclear-heating numbers for the cased and uncased coils.[1,2] The numbers he gave me were:

PF6- total power with case- 132 watts for one coil (77 W to case+55 W to windings).
-total power , uncased coil- 112 watts for one coil.

PF7- total power with case- 420 W for one coil (254W to case+166W to windings).
- total power , uncased coil- 339 W watts for one coil.

The above numbers seem to imply that about half of the incident neutron flux is absorbed by the case, which acts as a neutron shield for the windings. However, my recollection from the July TIM was that the coil case was not quite this effective in shielding the windings. If I take these numbers as is, though, I see a major benefit to the coil reliability in that the stability margin of the windings is increased. This increase is paid for with only a relatively small (20%) increase in required cooling capacity of the refrigerator. Even if the above numbers are not the final word in nuclear heating, they are, however, a useful reference by which to judge the significance of eddy-current heating, discussed below.

Eddy-Current Heating- Analytic Treatment

In all of the following discussion I shall assume that the coil cases have at least one insulation break to stop a net current that forms a closed loop all around the major coil circumference (this can be called a primary eddy current). Without such a break, the eddy-current effects would be intolerably large, so the no-break case is not worth considering- we must have the break. With the break present, the eddy-current pattern involves currents that flow around the major circumference, but with various signs at various points on the minor perimeter of the coil case. These currents cross over near the break. At points away from the break, the currents are all normal to the minor cross section and must add up to zero.

In the present analysis, I shall neglect more complicated 3-D eddy-current pattern near the insulating break and treat only the essentially 2-D current pattern away from the break. Also, I shall neglect the curvature of the coil case and treat the windings and case as an infinitely long straight buss in a case. I shall then calculate heating per unit length, etc. These are good approximations in view of the large ratio of the circumference to the cross-section of these coils.

Another simplifying assumption that I shall make is to calculate the eddy currents in the full-penetration limit. This means that the changing fields due to eddy currents themselves are neglected. This assumption is conservative in that it leads to an overestimate of the eddy-current heating. It can be justified by computing the classical skin depth for stainless steel at the frequencies of interest- I take the upper frequency limit to be about 10 Hz. The classical skin-depth formula is

$$\delta = \left(\frac{2\rho}{\omega\mu}\right)^{1/2}, \qquad (1)$$

where ρ is the resistivity (5.5×10^{-7} ohm-m for 316 SS), ω the angular frequency, and μ the permeability. Here, we take μ to be the permeability of free space since non-magnetic stainless steel is used. The result is 12 cm, which is much greater than the 1.6 cm case thickness.

The eddy-current density is now calculated by using the usual relation between the vector potential and the electric field, i.e.,

$$E_z = -\frac{\partial A_z}{\partial t} \quad . \tag{2}$$

Both the electric field and the vector potential have only one component, the z component, which is along the length of the buss. In the present approximation, A_z is due entirely to the coil-winding currents and has the same phase everywhere. Also, in order to enforce the condition that the net current in the cross section is zero, A_z is shifted by an additive constant that makes its average over the stainless-steel cross section zero. The current density is obtained from Eq. 2 by use of Ohm's law, i.e.,

$$j_z = \frac{E_z}{\rho} = -\frac{1}{\rho}\frac{\partial A_z}{\partial t} \tag{3}$$

The vector potential in Eq. 3 can be considered to be the sum of contributions from the coil in question (the self field) and from all of the other coils (the external field).

In calculating the vector potential from the external field, one can take the external magnetic field to be constant over the cross section at any instant of time, since the other coils are relatively far away. The external magnetic field has two components, B_x and B_y. In terms of these components, the external vector potential in a coordinate system centered in the buss is

$$A_z^{ext} = yB_x - xB_y \quad , \tag{4}$$

and the current density due to the changing external field

$$j_z^{ext} = \frac{1}{\rho}\left(y\dot{B}_x - x\dot{B}_y\right) \quad . \tag{5}$$

Because the origin of the coordinate system was chosen to be the center of the coil, A_z averages to zero over the coil-case cross section, as required to keep the net current zero.

The total eddy-current power per unit length *if* the external fields alone were present is obtained by integrating the power density due to the external fields over the case cross section:

$$P^{ext} = \int \rho j_z^2 \, dS = \frac{1}{\rho}\int \left(y\dot{B}_x - x\dot{B}_y\right)^2 dS \quad . \tag{6}$$

Eq. 6 can be rewritten in the form

$$P^{ext} = C_{xx}\dot{B}_x^2 + C_{xy}\dot{B}_x\dot{B}_y + C_{yy}\dot{B}_y^2 \quad , \tag{7}$$

where

$$C_{xx} = \frac{1}{\rho}\int y^2 dS$$

$$C_{xy} = -\frac{2}{\rho}\int xy\, dS$$

$$C_{yy} = \frac{1}{\rho}\int x^2 dS \qquad (8)$$

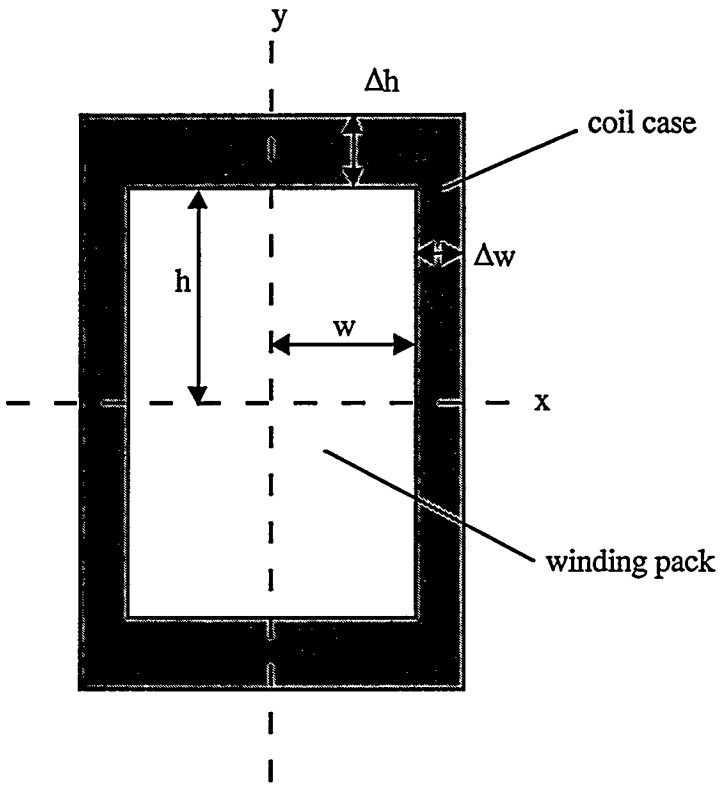


Fig. 1. Coil case geometry

Of course, strictly speaking, eddy currents due to external and self fields, not powers, should be added together when estimating total power, and Eqs. 7and 8 apply only to the fictitious case of no self field.

The eddy currents due to the self field are obtained by using the analytical expression for the vector potential of a rectangle with constant current density perpendicular to the plane of the paper (see Fig. 1).

This is

$$A_z = \frac{\mu_0 I}{16\pi hw}\sum_{i=1}^{2}\sum_{j=1}^{2}(-1)^{i+j}\left\{u_i v_j\left[\log(u_i^2+v_j^2)-3\right]+u_i^2\tan^{-1}\frac{v_j}{u_i}+v_i^2\tan^{-1}\frac{u_j}{v_i}\right\}, \qquad (9)$$

where I is the total ampere-turns in the winding pack, $u_1=w-x$, $u_2=w+x$, $v_1=h-y$, and $v2=h+y$. The numerical average of this expression over the case $\bar{A}_z$ is subtracted from A_z to get currents that add to zero.

Numerical Values for TPX- PF 6 and 7 coils

I used the dimensions (meters) in the following table for the winding pack and case:

Coil	w	h	Δw	Δh
PF-6	0.0715	0.239	0.0159	0.0159
PF-7	0.0715	0.1675	0.0159	0.0159

The case material is nonmagnetic stainless steel with a resistivity of 55×10^{-8} ohm-m.

I haven't had the time to put together a model to find the entire time dependence of the external field at PF6 and 7, but I estimate that the maximum external dB/dt at the coils is no more than 0.01 T/sec. Using Eqs. 6-8, this leads to power levels of less than 1W/m. I therefore neglect this contribution to the eddy current heating of the coil cases.

I wrote a short computer program (CASEPOWER) to evaluate self field eddy-current effects. Fig. 2 is a plot of contours of A_z, obtained by evaluating Eq. 9; these contours are also flux lines. The case outline is superimposed on the flux-line plot. (The apparent inward bulging of the case is an optical illusion). Fig. 3 is a plot of the vector potential, shifted by the average value over the case cross section to give a zero average, along half of the perimeter at various radial depths in the case. The case shown is for PF6, which has the larger eddy-current heating due to its greater height in the y direction. The eddy currents, which are out of the plane of the figure, switch signs as the sign of the time derivative of $\bar{A}_z$ changes. Fig. 4 is a plot of the corresponding relative power density in the case. Peaking is about three to one, peak to average power density, with the maximum power density at the corners.

In obtaining the ampere-turns *vs* time history for PF6 and PF7, I used values from an EXCEL spreadsheet supplied by Mark Krefta of Westinghouse. These profiles are for the "HC" scenario and are shown in Fig. 5. Profiles of $(NdI/dt)^2$ derived from this curve are shown in Fig. 6. Finally, I averaged the square of NdI/dt over the 24-sec. cycle and multiplied this number by the normalized power in PF6 and PF7 from my program CASEPOWER to get final numbers for the cycle. These numbers are the heat load for the entire case of a particular coil and are shown in the following table:

Coil	Total heat, 24 sec cycle	Av. power, 24 sec. cycle
PF6	2030 joules	85 watts
PF7	840 joules	35 watts

The numbers are a significant addition to the nuclear heating, but should be tolerable. Again, there should be a net improvement in the coil stability margin if most of this heat is intercepted by coil-case cooling.

Coil-case cooling

This is not only a 2-D (or 3-D, if end effects are considered) problem, but a transient one, since diffusion times through the 5/8 in. stainless case and ground-wall insulation are both on the order of 5 seconds at 4K. However, a simple 1-D calculation with constant properties can give some insight into

the heat flow paths when the volume of the case is heated by either neutrons or eddy currents and the heat removed from the outside. The basic geometry is illustrated in Fig. 7.

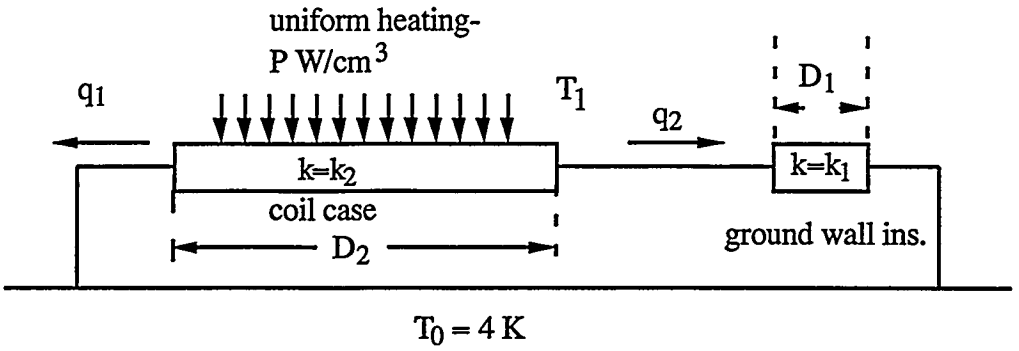


Fig. 7. Simplified schematic of heat flow in case with uniform volume heating and fixed 4K-temperature boundaries at the outside of the case and at the inside of the ground wall insulation.

The result of this very simple linear, constant-properties model is that if the outside of the case is cooled over its entire perimeter, the ratio of heat that flows through the ground-wall insulation to the total case heat q_1+q_2 is just

$$\frac{q_2}{q_{tot}} = \frac{1}{2}\frac{k_1 D_2}{k_2 D_1 + k_1 D_2} \qquad (10)$$

Plugging in numbers D_1= 1/3 in., D_2=5/8 in., k_1= 5×10^{-4} W/cm-K, and k_2=2.5×10^{-3} W/cm-K gives q_2/q_{tot}= 0.15; i.e, at best 15% of the case heat gets into the windings. With less than 100% outside coverage, this figure would be higher. A detailed conductor stability analysis may show that we want internal cooling. This is a complication, but not a major one from a fabrication point of view.

References

1. T. Kupiszewski, private communicaton.

2. TPX Report 14-950721-WEC-TKUPISZEWSKI-01

Attachments

Fig. 2. Contours of constant Az for PF6 (zero external field).

Fig. 3. Distribution of the shifted vector potential in PF6 coil case.

Fig. 4. Distribution of the power density in the PF6 coil case.

Fig. 5. Time dependence of ampere-turns in PF6 and PF7 in the "HC" scenario.

Fig. 6 Time dependence of $(NdI/dt)^2$ for PF6 and PF7 in the "HC" scenario.

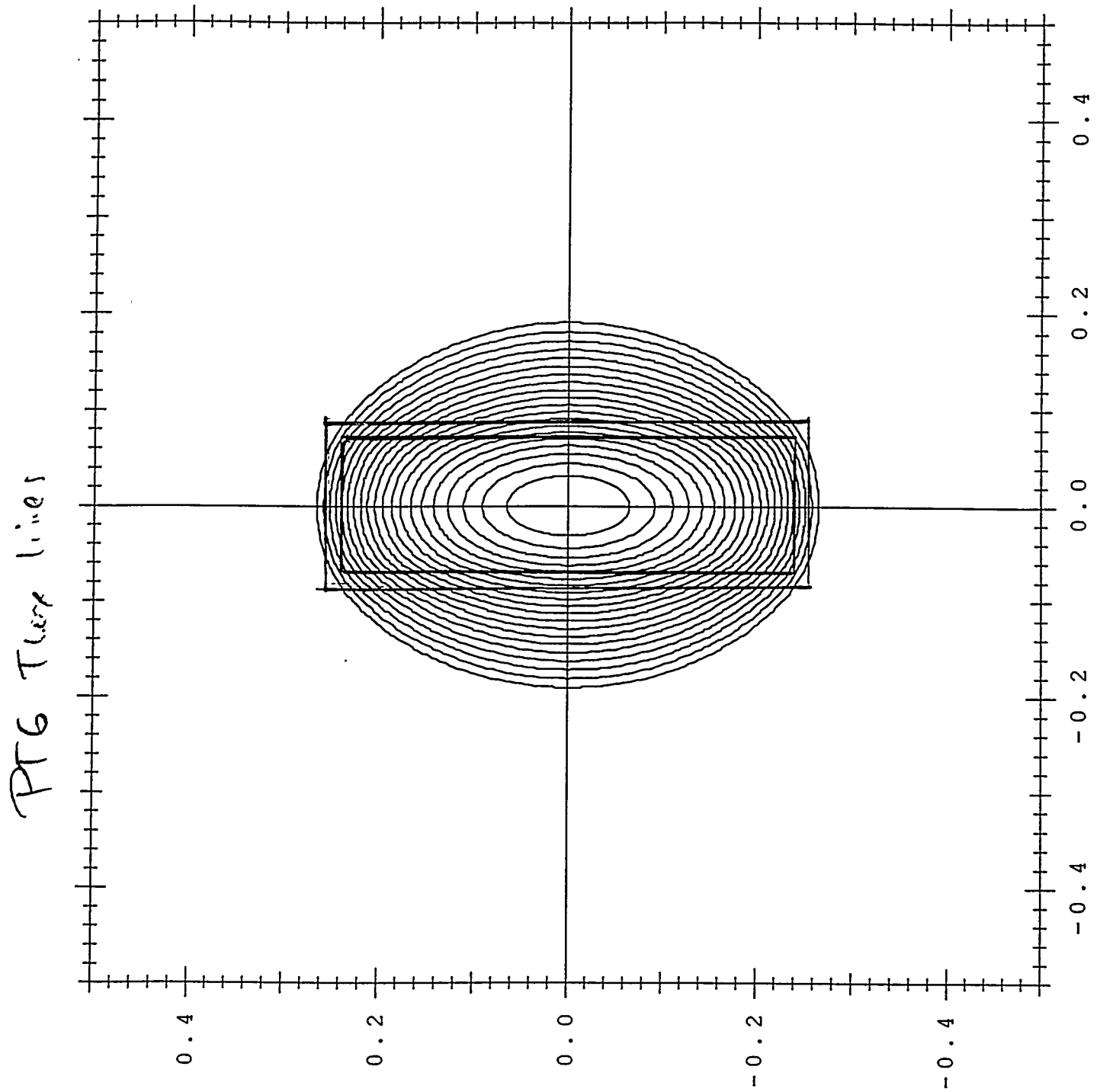


Fig. 2. Contours of constant A_z for PF6 (zero external field).

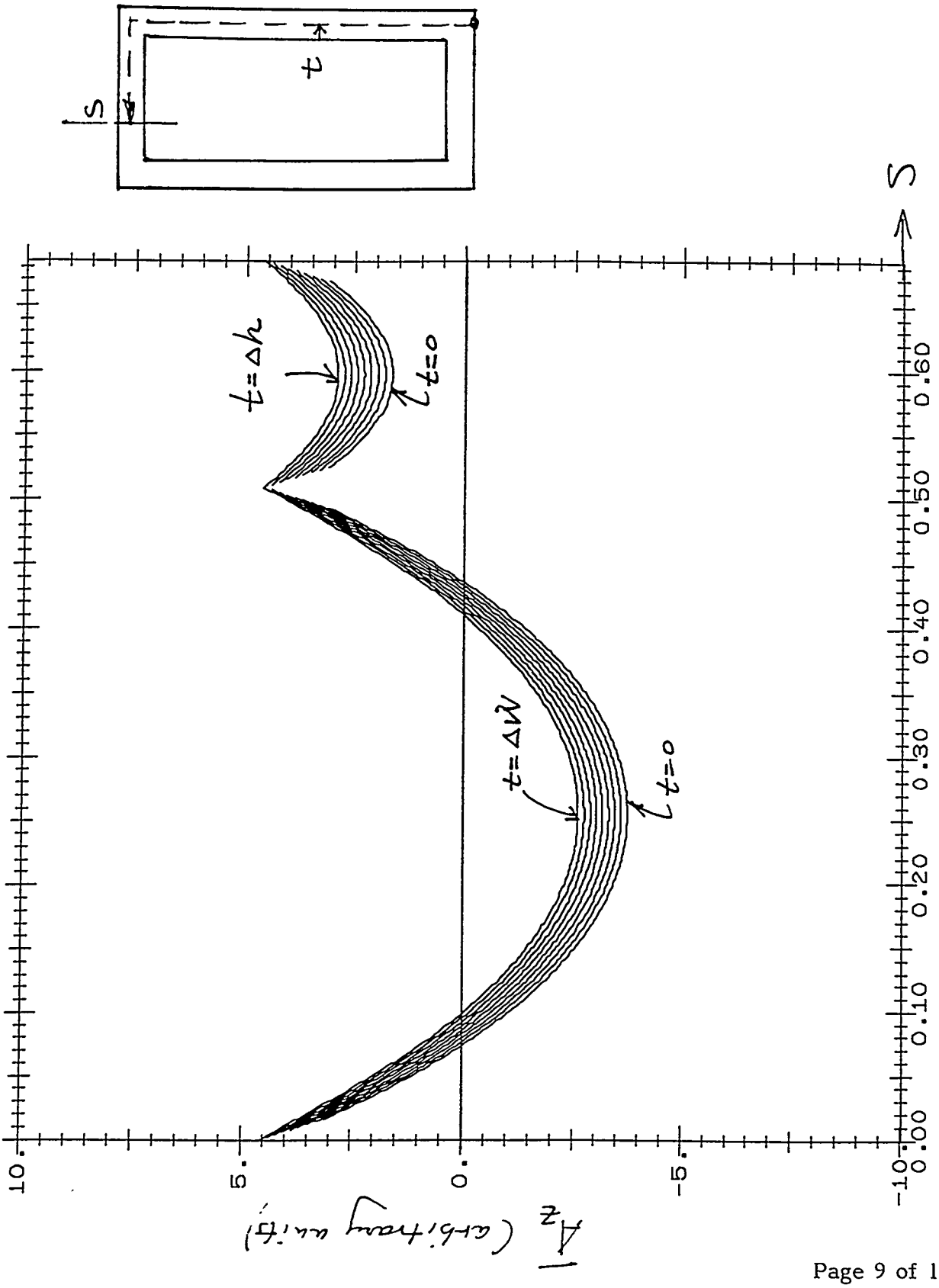


Fig. 3. Distribution of the shifted vector potential in PF6 coil case.

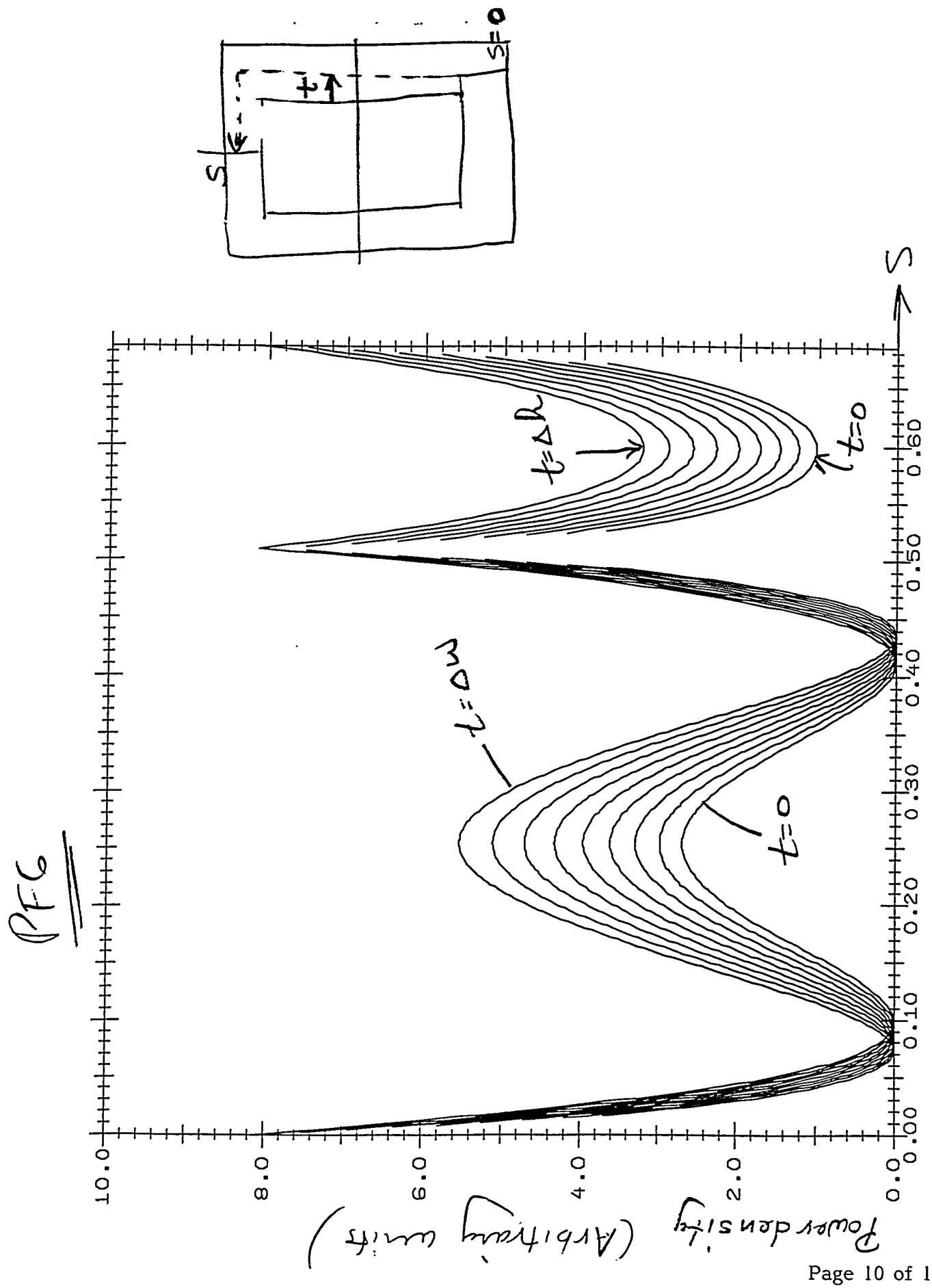


Fig. 4. Distribution of the power density in the PF6 coil case.

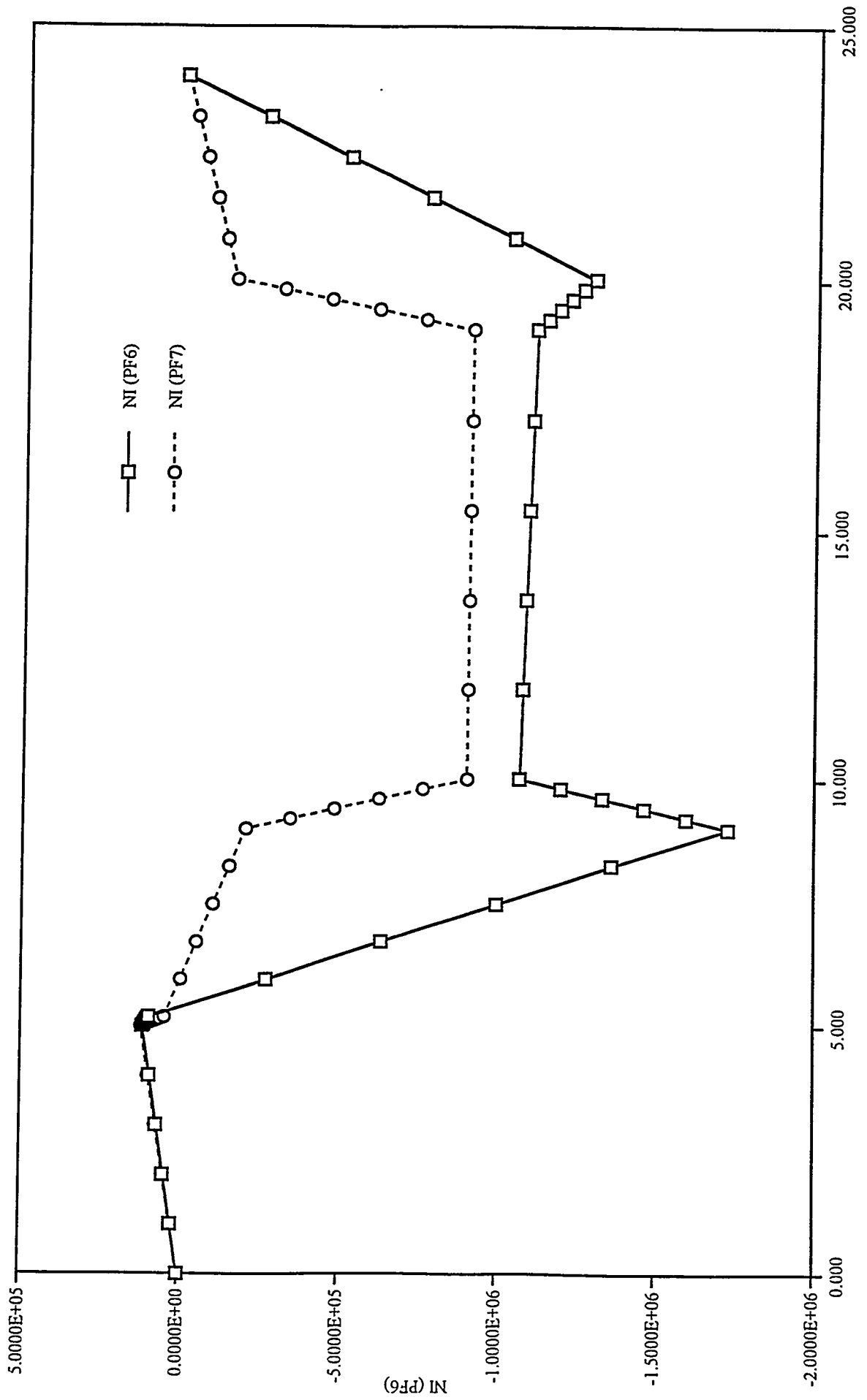


Fig. 5. Time dependence of ampere-turns in PF6 and PF7 in the "HC" scenario.

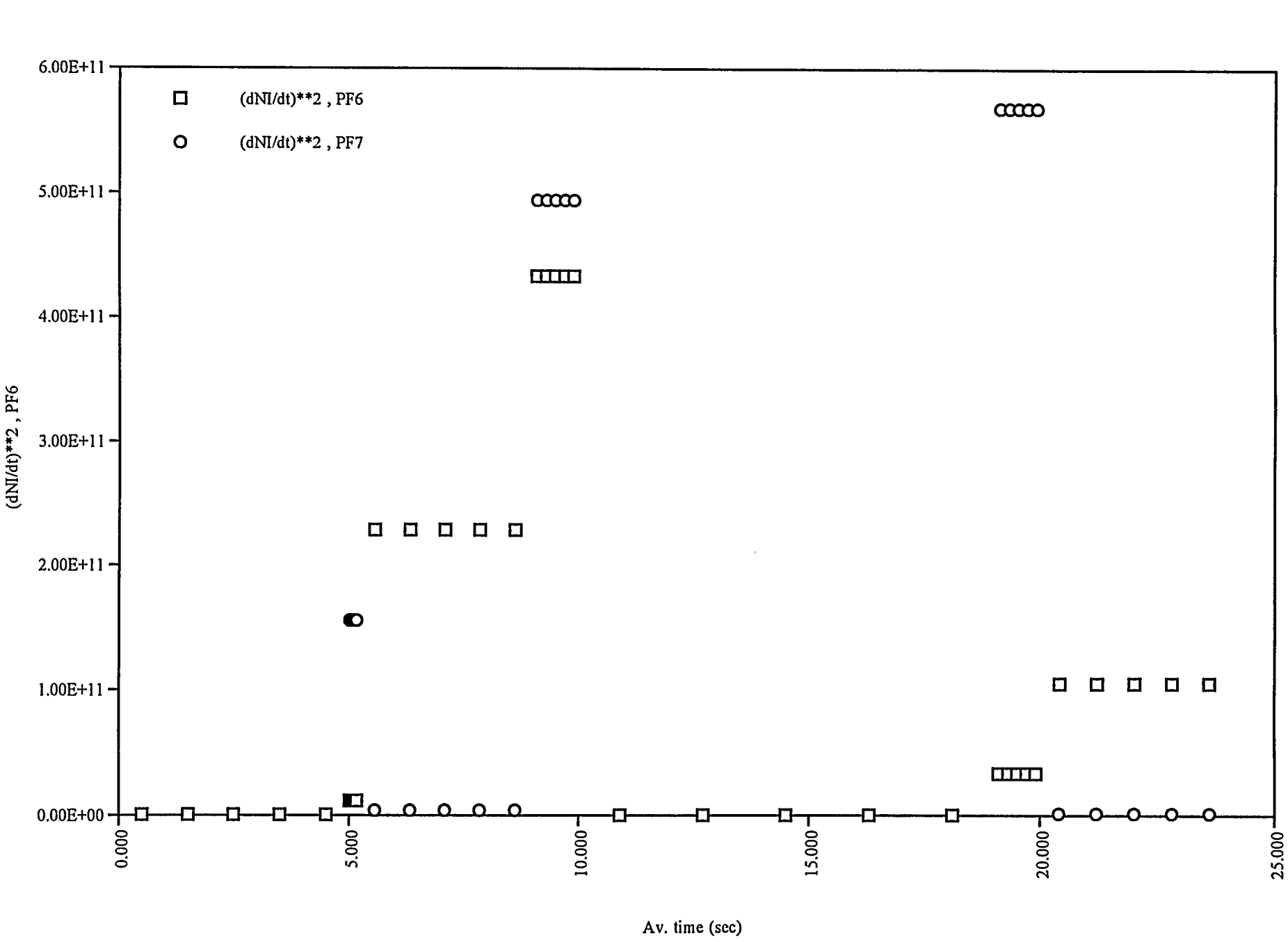


Fig. 6 Time dependence of $(NdI/dt)^2$ for PF6 and PF7 in the "HC" scenario.

Westinghouse
Electric Corporation

David R. Potter

Phone: (408) 735-2959
FAX: (408) 735-2048
E: svdrp@halley.svale.wec.com

Marine Division
Energy Systems Engineering

401 E. Hendy Avenue
Sunnyvale, California 94088-3499

Revision A, 12 April, 1995
14-950403-WEC-DPotter-01

To: Mark Jackson
TPX PF Magnet Subcontractor Technical Representative
Lawrence Livermore National Laboratory

cc: Seng-Liek Liew
Princeton Plasma Physics Laboratory

Subject: Nuclear Heat Rate assumptions for analysis of PF coils for PDR.

Author: David R. Potter, Westinghouse

Background

Westinghouse is under contract to perform preliminary analysis and design in support of a PF Magnet PDR in September 1995. Analysis planned included thermal analysis of the PF magnets given nuclear and pulsed heat loads. Pulsed heat loading data is currently being calculated by R. Pillsbury and is expected out in the week of April 10. The nuclear heat load analysis update is to be perfromed by Seng-Liek Liew of PPPL between July 1 and August 31. Our preliminary analysis needs to be complete by the end of May to support system or component design effort that may arise from analysis results. Additionally, his plans do not include calculating the load in the CS coils.

In order to perform our thermal analysis in light of the schedule mis-match, a reasonable set of assumptions have been made. We will use these heat load assumptions to allow us to move ahead with our preliminary analysis. This analysis is necessary for the PDR to support an assessment of feasibility that our preliminary designs meets the thermal criteria. Our models will be ready to accept PPPL's calculated values once we are under phase 2 contract.

Approach

Total heat loads in PF 5, 6, and 7 are available based on previous analysis by Seng-Liek at PPPL via reference (1). There has not been assessment of CS heat load to date, in that the load is relatively insignificant based on the ample shielding provided by the TF structure and coil packs.

The approach for the three ring coils is to assume a reasonable distribution based on a reduction factor as the radiation progresses through the coil pack. The sum of that distribution is then equated to the overall heat load presented in reference (1) to solve for the heating in each turn of the hottest double pancake.

The CS has no total heat load data available, therefore the heating in the two outer turns of the inboard leg of the TF coil pack will be extrapolated out through the TF case nose to the outermost CS coil pack turn. An equivalent reduction factor will be calculated for the nose metal and for a turn of the CS conductor based on the density and the configuration. That CS conductor reduction factor is then used to determine the successive heat load in each turn of a CS coil from the outside turn inward.

The calculations are for case 1, (unshielded ports and ducts) and a load of 7.5e16 DD n/s per reference (2).

Calculations

Central Solenoid:

The radiation in the CS coils, PF 1-4, is incident radially inward passing through the TF coil pack, through the 2.5 inch thick nose region, and into the outer turns of the CS coils. The few centimeters of space between each TF coil pack at the nose is solid case material through the entire radial thickness of the coil pack, and therefore this region can be ignored.

The heating used as a basis for CS is the average heating in the TF coil pack nearest to the CS coils. This region is defined as region P1 in reference (2). The 7th turn radially and layers 1-12 are the closest to the CS coils. Reference (2) addresses the first through sixth layer of the TF as t = 1, 2, and 3. t=1 is the total of layers 3, 4, 5 and 6; t=2 is layer 2 and t=3 is layer 1, the remaining six can be considered symmetric to the first six. The region is 113 cm tall (per reference (3)), by the 2.261 conductor width, by the 2.718 conductor depth. The heat load in the 7 th turn of layers 3-6 (t=1) is 0.375 W for the volume of these TF conductors. For layer 2 (t=2) the heat load reduces to 0.093 W, for layer 1 (t=3) the heat load is slightly lower at 0.089 W. The average heat is (0.375 + 0.093 + 4*0.089)/6 = **0.093 W.**

The heating rate in the outer turn of a CS coil will be less due to 1) the TF conductor being greater in depth in the radial direction, and 2) the CS being an additional layer further from the source and beyond the 6.35 cm **(2.5 inch)** thick nose of the TF case.

The equivalent thickness of the TF conductor is calculated as if there were no void space (assume 60% fill) in the conduit. Conduit area + strand area = [(0.890x1.070)-(0.700x0.880)] + [60%(0.700x0.880)] = 0.706 in^2. Divided by the TF width 0.706/.89 = **0.793 inch** equivalent thickness. In other words, the 1.070 inch dimension collapses to 0.793 if it had no void space.

The equivalent thickness of the CS conductor is calculated as if there were no void space (assume 60% fill) in the conduit. Conduit area + strand area = [(0.878x0.878)-(0.688x0.688)] + [60%(0.688x0.688)] = 0.582 in^2. Divided by the CS width 0.582/.878 = **0.662 inch** equivalent thickness. In other words, the 0.878 inch dimension collapses to 0.662 if it had no void space.

Liew recommends a 30% reduction for each layer inward (each successive layer has 70% the heat of the previous). A quick review of reference (2) indicates that the reductions of heat load per turn depth at various regions in the TF range from 32% to 5%. The 30% assumption is conservative when one is conserving the total load and looking for a distribution within the pack and will therefore be used for the ring coils, PF 5,6, and 7. However, to extrapolate the load in the outer

layer of the TF near the CS, the more correct approach would be to model the reduction in the 6th to 7th turn in the TF coil near the CS. This reduction is 0.894/1.15 = **0.78** per reference (2).

The appropriate reduction factor for a CS conductor would be:

$$0.78^{(0.662/0.793)} = \mathbf{0.81}$$ per layer inward of the CS conductor.

The appropriate reduction factor for the nose piece of the TF case is:

$$0.78^{(2.5/0.793)} = \mathbf{0.457}.$$

The volume of this 7th turn TF conductor is:

Length x width x equivalent thickness

113 cm x (0.89 x2.54) x (0.793x2.54) = 514 cm^3

The average heat in this conductor per unit volume is:

0.093 W / 514 cm^3 = 1.81e-4 W/cm^3.

Reducing this for the TF case thickness:

1.81e-4 W/cm^3 x 0.457 = 8.27e-5 W/cm^3.

The heat load per CS unit length in outer turn:

0.82 x 8.27e-5 W/cm^3. x (0.878x2.54) x (0.662x2.54) = **2.54e-4 W/cm.**

Using the 0.81 per turn inward reduction factor, the following heat load per unit length is calculated:

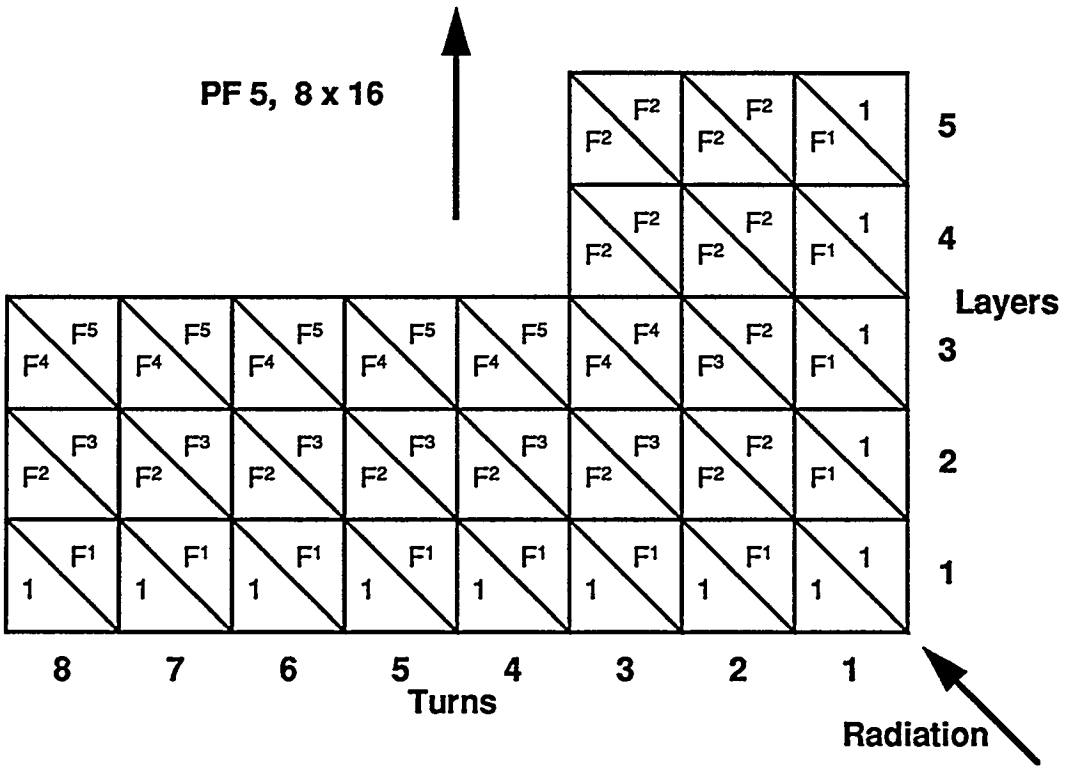
Turn	PF1-4 (W/cm)
1	2.54E-04
2	2.06E-04
3	1.67E-04
4	1.35E-04
5	1.09E-04
6	8.86E-05

As a sanity check the total heat load of a PF 1 is calculated:

Turn	PF1-4 (W)
1	0.129
2	0.105
3	0.085
4	0.069
5	0.056
6	0.045
Per layer	0.488
PF 3 - 10 Layers	4.9 Watts
All CS	55 Watts

PF 5:

The radiation in PF 5U is incident at the lower, outside turn of the coil pack, and is incident at apporximately 45 °. In a cross-sectional view, each coil pack conductor was divided into 2 with a bisecting line in the direction of the neutronic load. Each successive triangular section as the neutronic load goes deeper into the pack received an F= 70% portion of the previous triangular region. Therefore a given 1/2 conductor receives F^n fraction of the corner conductor if it is "n" triangle inward. A unit heat load was assigned to the closest corner and the remaining 127 conductors were tallyed with the average reduction factor of its two triangles.



The total load of 35.6 watts from ref. 1 was then used to calculate the heat load in the closest conductor such that the total load would be conserved. The net load incident on each of the first two (lowest) layers is as follows:

	Fraction of Maximum	Load (Watts) in Conductor	Load per unit length (W/cm)
Heat in turn 1, pancake 1	1	0.503	6.62E-04
Heat in turn 2-8, pancake 1	0.85	0.427	5.62E-04
Heat in turn 1, pancake 2	0.85	0.427	5.62E-04
Heat in turn 2, pancake 2	0.49	0.246	3.24E-04
Heat in turn 3-8, pancake 2	0.4165	0.209	2.76E-04

PF 6:

The heating in PF 6U is incident at the lower, inside turn of the coil pack, and is incident at apporximately 45 °. As done for PF 5U, in a cross-sectional view, each coil pack conductor was divided into 2 with a bisecting line in the direction of the neutronic load. Each successive triangular section as the neutronic load goes deeper into the pack received a 70% portion of the previous triangular region. A unit heat load was assigned to the closest corner and the remaining 127 conductors were tallyed with the reduction factor. The total load of 223 watts from ref. 1 was then used to calculate the heat load in the closest conductor such that the total load would be conserved. The net load incident on each of the first two (lowest) layers is as follows:

	Fraction of Maximum	Load (Watts) in Conductor	Loaded Circumference	Load per unit length (W/cm)
Heat in turn 1, pancake 1	1	2.896	1697	1.71E-03
Heat in turn 2-6, pancake 1	0.85	2.462	1697	1.45E-03
Heat in turn 1, pancake 2	0.85	2.462	1697	1.45E-03
Heat in turn 2, pancake 2	0.49	1.419	1697	8.36E-04
Heat in turn 3-6, pancake 2	0.4165	1.206	1697	7.11E-04

PF 7:

The heating in PF 7U is incident at the lower, inside turn of the coil pack, and is conservatively incident at 45 °. As done for PF 5U, in a cross-sectional view, each coil pack conductor was divided into 2 with a bisecting line in the direction of the neutronic load. Each successive triangular section as the neutronic load goes deeper into the pack received a 70% portion of the previous triangular region. A unit heat load was assigned to the closest corner and the remaining 85 conductors were tallyed with the reduction factor. The total load of 677 watts from ref. 1 was then used to calculate the heat load in the closest conductor such that the total load would be conserved. The net load incident on each of the first two (lowest) layers is as follows:

	Fraction of Maximum	Load (Watts) in Conductor	Loaded Circumference	Load per unit length
Heat in turn 1, pancake 1	1	11.820	2036	5.81E-03
Heat in turn 2-6, pancake 1	0.85	10.047	2036	4.94E-03
Heat in turn 1, pancake 2	0.85	10.047	2036	4.94E-03
Heat in turn 2, pancake 2	0.49	5.792	2036	2.84E-03
Heat in turn 3-6, pancake 2	0.4165	4.923	2036	2.42E-03

References:

1) S.L. Liew, "Nuclear Heating Rates in Outer PF Coils with Shielded Pumping Ducts", 94-941128-PPPL/SLiew-01.
2) S.L. Liew, "3D Calculations of Nuclear Heating Rates in TPX TF Coils", 94-940329-PPPL/SLiew-01
3) R.D. Pillsbury, "Nuclear Heating Applied to the 3 Dimensional TF Structure", 13-940517-MIT/RPillsbury-01.

Preliminary Draft of a TPX Insulation Acceptance Criteria

L. Myatt, MIT/PFC

April 13, 1995

I. Mechanical Requirements:

1. The structural respond of the insulated winding pack to mechanical loading shall remain unchanged over the design life of the magnet, such that:

(i) The effective elastic modulus of the coil shall not vary by more than 10% over the design life of the machine,

(ii) The local slope of the force-deflection curve shall not vary by more than 10% over the expected load range of the winding pack.

2. Small cracks in the insulation system may be inevitable and are acceptable if it can be shown that they:

(i) arrest early in the life of the machine,
(ii) do not propagate across the primary electrical conductor barrier,
(iii) do not lead to delimitation of conductor turns.

II. Electrical Requirements:

1. Help!

Feasibility of Cooling the Superconducting Outer Ring Coils - Thermal Analysis of TPX Poloidal Field Coils

Thomas Kupiszewski
STC Advanced Electromagnetic Systems Department

July 21, 1995

TPX 14-950721-WEC- TKupiszewski -01

APPROVED:

P. A. Sanger
Westinghouse TPX Chief Scientist

APPROVED:

D. R. Potter
Westinghouse TPX Engineering Manager

Westinghouse Electric Corporation
Electronic Systems Group

401 East Hendy Avenue, Sunnyvale, California 94088-3499

Steady-State Poloidal Field Magnet Thermal Design Analysis (W.B.S. 14.3.1.2.3.5)

Feasibility of Cooling the Superconducting Outer Ring Coils in the TPX Tokamak

Thomas Kupiszewski
Advanced Electromechanical Systems

Westinghouse Science & Technology Center
1310 Beulah Road
Pittsburgh, PA 15235

ABSTRACT

Westinghouse Electric Corporation is under contract with the Lawrence Livermore National Laboratory to perform the preliminary design of the poloidal field coils in the TPX Tokamak for the Princeton Plasma Physics Laboratory. This report documents an analysis evaluating the feasibility of cooling the two largest PF coil pairs during operation within a neutron heating environment characterized by a design fluence of 7.5×10^{16} neutrons per second [1]. The forced flow-cooled, cable-in-conduit (CIC) superconductors of these coils are required to have operating temperature and energy margins of at least 1K and 300 mJ/cc, respectively. Results of steady-state thermal hydraulic computer simulations using non uniform heating profiles indicate these requirements are met by the baseline design for the PF6 coil pair, but not for the PF7 coil pair. Surrounding the winding packs with an external case structure sufficiently mitigates the peaking factors in the PF7 coil heat distribution to ensure these requirements are met based on estimated attenuation in the case. An estimate of the minimum coolant flow capacity needed to remove the total nuclear heat load is also calculated.

Table of Contents

	Page
ABSTRACT	i
List of Figures	iv
List of Tables	v
1. INTRODUCTION	1-1
1.1 BACKGROUND	1-1
1.2 REQUIREMENTS	1-1
1.3 OBJECTIVES	1-3
2. BASELINE COOLING DESIGN DESCRIPTION	2-1
2.1 INITIAL BASELINE	2-1
2.1.1 Conductor Configuration	2-1
2.1.2 Hydraulic Circuit	2-2
2.1.3 Conductor Insulation	2-3
2.2 BASELINE MODIFICATION OPTIONS	2-3
3. TECHNICAL APPROACH	3-1
3.1 OVERVIEW	3-1
3.2 ASSUMPTIONS	3-2
3.2.1 Thermal Loads	3-3
3.2.2 Conductor Load Line	3-5
3.2.3 Jc Degradation	3-6
3.2.4 Thermal Interface Boundary Conditions	3-6
3.2.5 Intra-Conductor Heat Transfer	3-7
3.2.6 Steady-State Operation	3-8
3.3 WETMAP THERMAL-HYDRAULIC COMPUTER MODEL	3-9
3.3.1 Model Description	3-9
3.3.2 Numerical Implementation	3-10
3.3.3 Validation	3-15
3.4 MATERIALS AND MATERIAL PROPERTIES	3-16

Table of Contents (Cont'd)

	Page
3.5 MARGIN PREDICTION	3-16
3.5.1 Temperature Margin and Headroom	3-16
3.5.2 Energy Margin	3-17
4. RESULTS	4-1
4.1 TEMPERATURE MARGIN AND HEADROOM PREDICTIONS	4-1
4.2 ENERGY MARGIN	4-4
4.3 HELIUM RESIDENCE TIMES	4-4
4.4 PRELIMINARY FLOW BUDGET ESTIMATE	4-4
5. CONCLUSIONS	5-1
6. RECOMMENDATIONS	6-1
7. REFERENCES	7-1
APPENDIX A - Winding Pack Nuclear Heat Distributions	A-1
APPENDIX B - Nuclear Heat Distributions With External Case	B-1
APPENDIX C - Non Nuclear Heat Load Calculations	C-1
APPENDIX D - Inter-turn Heat Transfer Model	D-1
APPENDIX E - WETMAP Helium Property Macro Validation Plots	E-1
APPENDIX F - Validation of WETMAP Computer Model	F-1
APPENDIX G - Current Sharing Temperature Calculations	G-1
APPENDIX H - WETMAP Output Plots for Worst Case PF6 Coil	H-1
APPENDIX I - WETMAP Output Plots for Worst Case PF7 Coil with Case	I-1

List of Figures

Page

Figure 1 - Three-dimensional view illustrating spatial arrangement of superconducting magnet coils in TPX Tokamak 1-2

Figure 2 - Schematic of initial baseline hydraulic circuit 2-2

Figure 3 - Modified baseline design using effluent-cooled external case to reduce coil heat 2-4

Figure 4 - Modified baseline design using extra outlet stub at bore of worst case pancake 2-4

Figure 5 - Methodology used to assess cooling design feasibility 3-2

Figure 6 - Staggered-grid nodal mesh for thermal-hydraulic model 3-11

Figure 7 - Thermal equivalent circuit model of turn-to-turn heat transfer 3-13

Figure 8 - Calculation of temperature margin, $\Delta T_M = T_{cs} - T_{hotspot}$ 3-17

List of Tables

	Page
Table 1 - Goals for PF Coil Thermal Performance	1-3
Table 2 - Conductor Cooling Design Parameters and Values	2-1
Table 3 - Hydraulic Circuit Design Parameters and Values	2-3
Table 4 - Winding Pack Nuclear Heating w/ and w/o External Case	3-4
Table 5 - Thermal-Hydraulic Simulation Parameters and WETMAP-Predicted Results	4-2
Table 6 - Summary of Preliminary Flow Budget Estimate for PF6 & PF7	4-5

1. INTRODUCTION

1.1 BACKGROUND

The Toroidal Physics eXperiment (TPX) is a large magnetic confinement fusion device intended to replace the Tokamak Fusion Test Reactor at the Princeton Plasma Physics Laboratory. As illustrated in Figure 1, the array of TPX poloidal field (PF) coils consists of 14 circular coils situated around a torus of 16 Dee-shaped toroidal field (TF) coils. Although all coils are superconducting, the PF units are tasked with producing time-varying magnetic fields to inductively-heat and position a ring of D-D fueled plasma with a design fluence of 7.5×10^{16} neutrons per second [1] during a thermonuclear burn lasting 1000 seconds. This nuclear radiation load will deposit heat on the order of several hundred watts in PF6U/L and PF7U/L, where U and L designate coil locations respectively above and below the horizontal midplane of the Tokamak. Such heat generation is sufficient to be the principal cause of temperature elevation within these "outer ring" coils. Careful control of superconductor temperature during the burn is crucial to achieving stable coil operation.

Since both PF6 and PF7 coil pairs will use niobium titanium superconductor, the extent of wire temperature rise consistent with sustained superconducting operation is bounded between the NbTi critical state maximum temperature limit of 9.3K and the inlet temperature of cryogenic coolant, typically in the 4K to 5K range. Consequently, the thermal design challenge associated with PF6/7 is to limit the wire temperature rise to 2K or less. This challenge is exacerbated by the fact these coils have mean diameters of roughly 8 meters, implying stringent temperature tolerances must be maintained within the physical envelope of large structures. Furthermore, uncertainties in thermal loads, combined with a high degree of variability in cryogenic heat transfer properties, mandate a conservative approach to cooling design. In this work, cooling feasibility of the PF6/7 coil design baseline is analyzed from the perspective of superconductor temperature margin and includes evaluation of baseline modifications offering the promise of improved temperature margins.

1.2 REQUIREMENTS

A set of cryogenic design criteria [2] have been defined as guidelines for designing TPX coils. Several of these criteria establish limiting values for conductor thermal performance parameters. For the PF6 and PF7 coils, the key thermal performance allowables of interest are

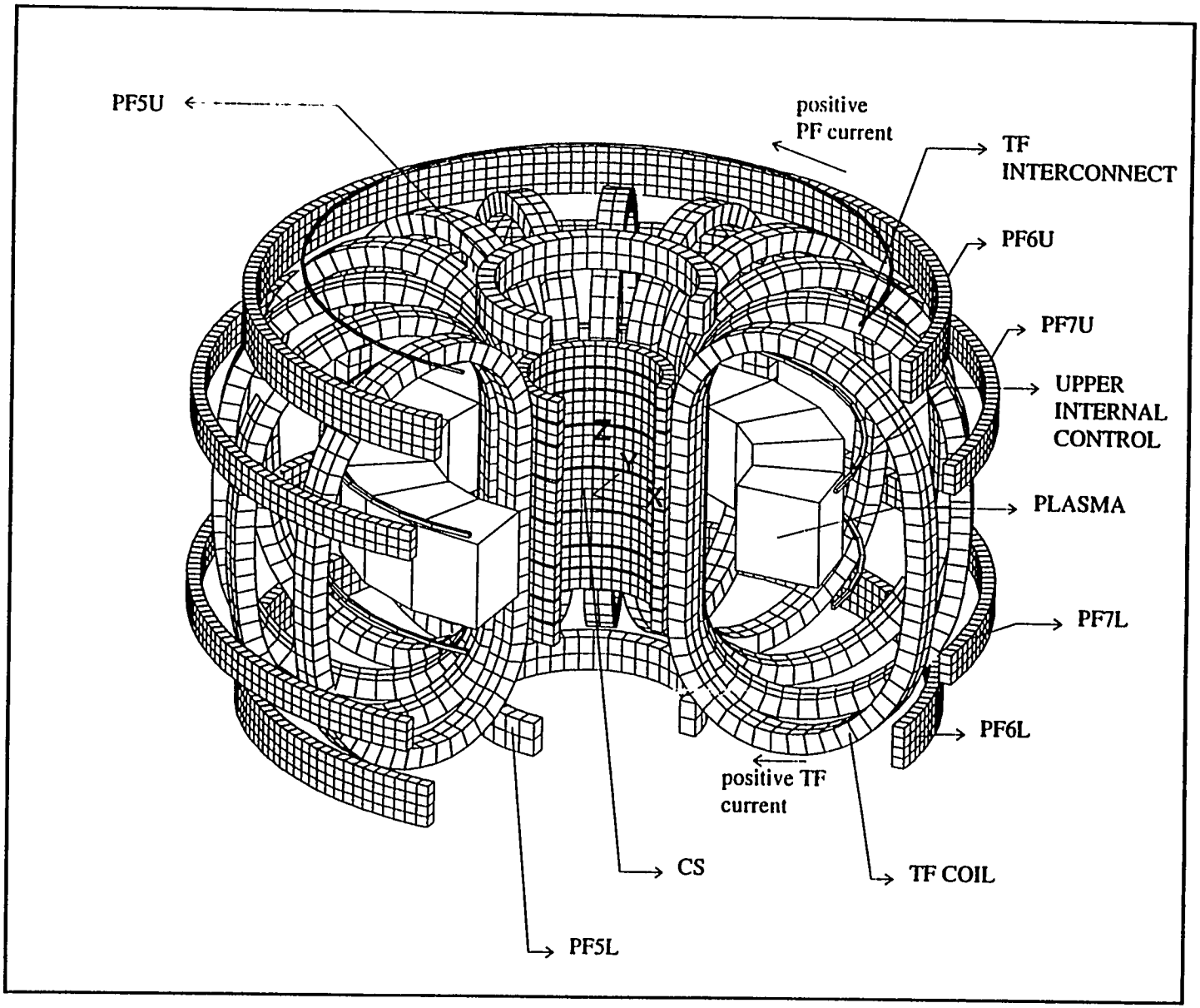


Figure 1 - Three-dimensional view illustrating spatial arrangement of superconducting magnet coils in TPX Tokamak.

shown in Table 1. The helium inlet temperature and outlet pressure associated with these allowables is 5K and 0.3 $\pm$ 0.05 MPa, respectively.

Table 1 -- Goals for PF Coil Thermal Performance

Requirement	Parameter	Units	Value
Temperature Margin	ΔT_M	(K)	≥ 1
Temperature Headroom	ΔT_H	(K)	≥ 2
Energy Margin	ΔU_M	(mJ/cm^3)	≥ 300

The aforementioned criteria provide a benchmark against which the feasibility of the PF6 and PF7 coil cooling designs is evaluated.

1.3 OBJECTIVES

A steady-state thermal-hydraulic analysis was undertaken to address the following issues:

- Is it possible to cool the baseline PF6 and PF7 coil configuration so that both margin and headroom requirements are met during operation, given the nonuniform neutron heating distributions associated with TPX?
- What coil modification options are available to improve cooling design feasibility?
- What coolant mass flow rate and inlet pressure are needed?

2. BASELINE COOLING DESIGN DESCRIPTION

For all TPX coils, internal heat generation is dissipated via forced convection heat transfer with supercritical helium serving as the ventilating fluid. Cable-in-conduit conductor (CICC) has been selected as the preferred conductor packaging topology to implement this cooling philosophy. This section documents the key thermal-hydraulic design data associated with the CICC-based approach to cooling the baseline PF6/7 coil configuration. Two baseline design modification options are also presented.

2.1 INITIAL BASELINE

2.1.1 Conductor Configuration

The baseline PF6/7 CICC conductor [3] consists of a four-stage, fully-transposed, cable of 120 twisted wire triplets compacted within a square 316LN stainless steel sheath (conduit). The cable is a hybrid of 120 pure copper strands interspersed among 240 NbTi/Cu composite strands characterized by a Cu:SC ratio of 2.5 ± 0.25. Void space within the cable volume provides a network of passages through which supercritical Helium flows. The cable is isolated from the conduit interior wall by a buffering layer of stainless steel foil wrap. Relevant design parameter values are tabulated in Table 2.

Table 2 -- Conductor Cooling Design Parameters and Values

Parameter	Units	Value
Coolant flow area	mm^2	111.4
Tot. no. of cable strands	-------	360.0
Strand diameter	mm	0.78
Conduit external dimension	mm	22.3
Conduit wall thickness	mm	2.41
Conduit corner outside radius	mm	5.10
Cable foil wrap thickness	mm	0.051
Cable space wetted perimeter	mm	735.0
Conduit wetted perimeter	mm	65.0
Conduit cross-section area	mm^2	179.2

2.1.2 Hydraulic Circuit

The PF6/7 coils are assembled as stacks of constant radius-wound, double-pancake coils. These coils form a continuous electrical circuit with electrical joints located only at the power supply leads. Coolant, however, follows multiple parallel-connected paths through the winding assembly.

For each double-pancake coil, supercritical helium at a temperature of 5K is introduced through a single inlet tube welded to the conductor conduit at the outside diameter. Inlet flow bifurcates into two separate streams, with each stream routing through a different double pancake coil, as illustrated by the schematic shown in Figure 2. The division of mass flow between the streams is not equal since flow impedance becomes a function of heat generation for a compressible fluid, like supercritical helium, and heat generation varies from pancake to pancake. In each double-pancake, helium flows inward through the six turns of the first single-pancake, from the outside diameter towards the inside diameter, where it indexes to the next single-pancake, and flows back out through another six turns towards the outside diameter, eventually departing the winding pack via an outlet stub. All inlet stubs for both PF6 and PF7 receive

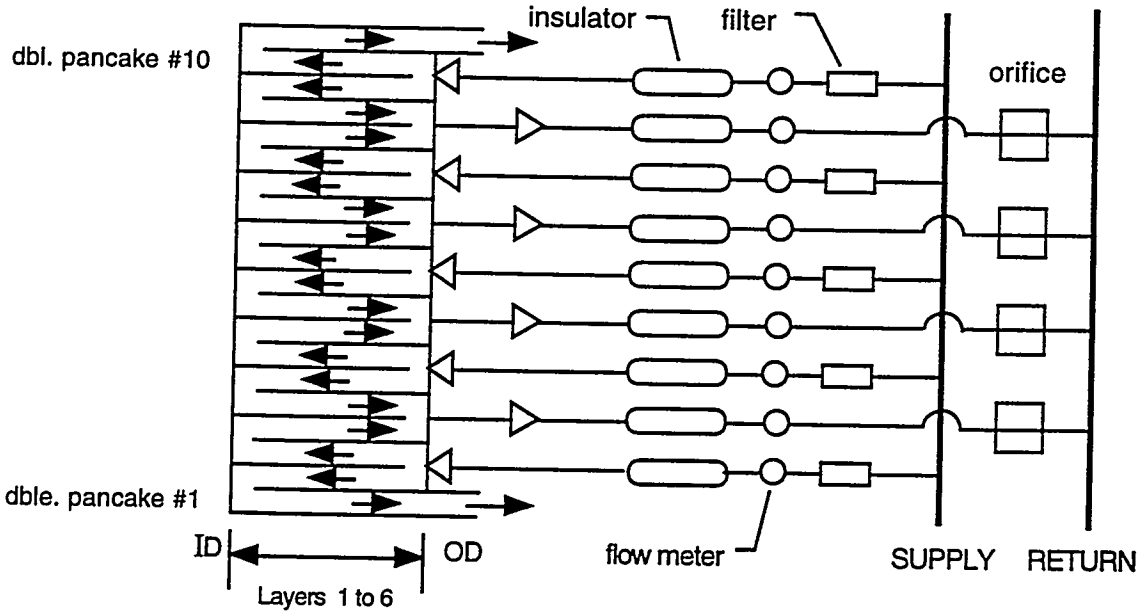


Figure 2 -- Schematic of initial baseline hydraulic circuit. Parallel flow paths in PF6 winding pack are illustrated.

helium from a common supply manifold and all outlet stubs exhaust into a common return manifold [4]. Relevant design parameter values are presented in Table 3.

Table 3 -- Hydraulic Circuit Design Parameters and Values

Parameter (units)	PF6 Value	PF7 Value
Winding pack inside radius (m)	3.687	4.225
Winding pack outside radius (m)	3.830	4.369
No. of turns per double-pancake	12	12
Flow channel length (m)	283.4	324.0
Total no.of double-pancakes	10	7
No. of coolant inlet stubs	5	4
No. of coolant outlet stubs	6	4

2.1.3 Conductor Insulation

The baseline electrical turn insulation consists of two layers of half-lapped Kapton tape, providing a total build of 0.004 inch (0.102 mm), which is surrounded by an overwrap comprised of a single, half-lapped layer of 0.014 inch thick 3D glass fabric tape. No interpancake barriers are provided, so both turn-to-turn and layer-to-layer spacing is 0.064" (1.63 mm). Conduit corner region void filler consists of 3D glass fiber weave shapes. Both void filler and insulation overwrap are epoxy-impregnated to endow the insulation with structural rigidity for the purpose of restricting gross conduit movement.

2.2 BASELINE MODIFICATION OPTIONS

Two variations of the baseline cooling design were considered in the course of conducting the feasibility analysis. The first variation evaluates additional neutron shielding provided by an external case structure which is forced flow-cooled to intercept neutron-deposited thermal energy before it conducts across the ground wall electrical insulation. Implementation options consist of routing pancake effluent through the case, as illustrated in Figure 3, or shunting additional coolant directly from the supply manifold.

As illustrated in Figure 4, the second variation adds a single outlet stub at the inside diameter turn of the double-pancake with the worst case neutron heating, thereby reducing its flow path length by 50%. In this manner, coolant mass flow is increased locally, where peaking factors are greatest, without requiring supply pressure to increase.

flow path length by 50%. In this manner, coolant mass flow is increased locally, where peaking factors are greatest, without requiring supply pressure to increase.

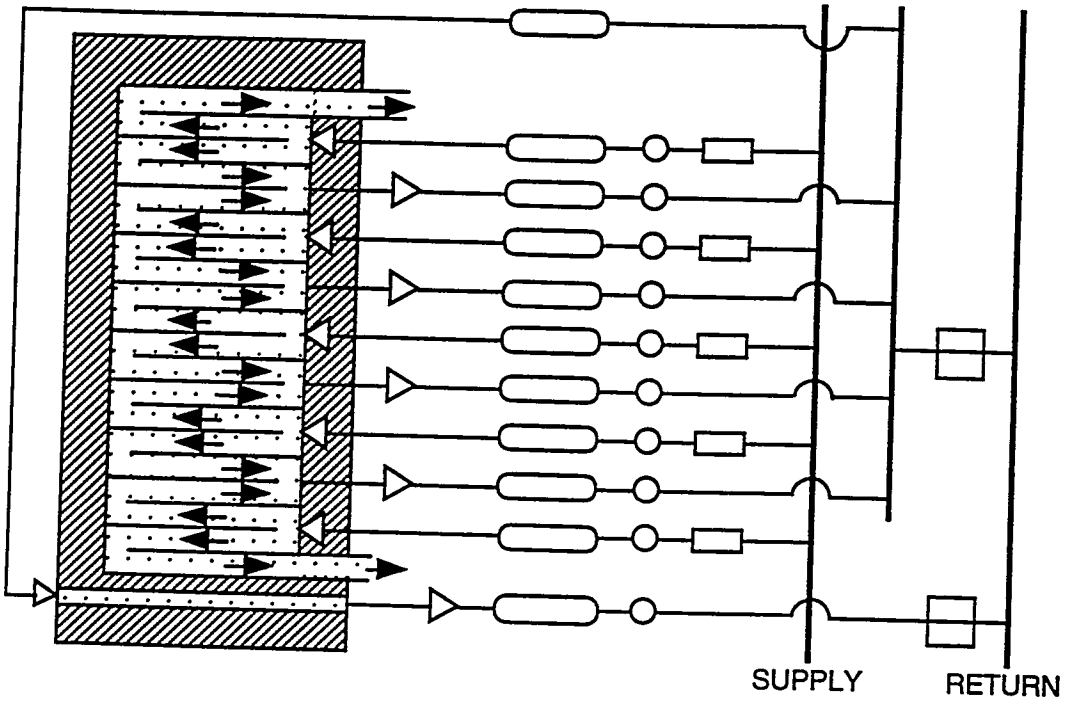


Figure 3 -- Modified baseline design using effluent-cooled external case to reduce coil heat.

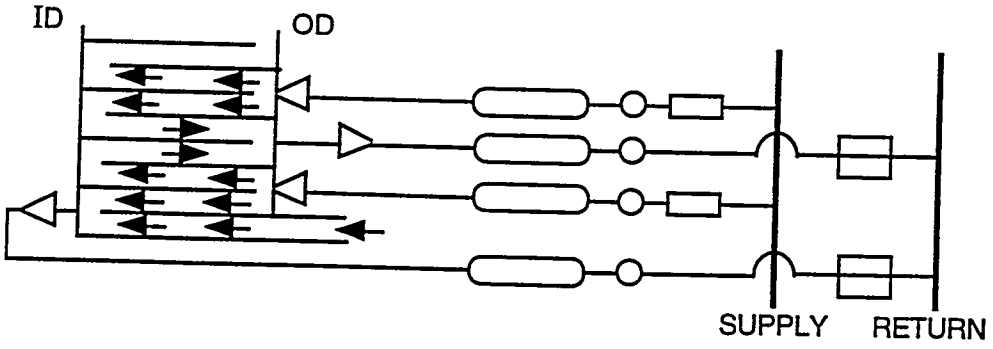


Figure 4 -- Modified baseline design using extra outlet stub at bore of worst case pancake.

3. TECHNICAL APPROACH

3.1 OVERVIEW

The analysis methodology consisted primarily of an iterative eight step process as shown in Figure 5. Nominally, these steps were:

(1) Develop a generic TF/PF coil, steady-state, thermal-hydraulic computer model using Westinghouse Electric Thermal Mapping and Analysis Program (WETMAP).

(2) Validate WETMAP model against available test data and other thermal-hydraulic simulations used by TPX project team member organizations.

(3) Modify validated WETMAP model to incorporate approximated heating distributions and baseline electrical insulation design.

(4) Calculate current sharing temperature based on worst case maximum conductor electrical current and peak magnetic field strength, using a piece-wise linear expression for the NbTi critical temperature [5].

(5) For PF6/7 double pancake coil with worst case heat load, run WETMAP model to predict cable hot spot temperature.

(6) If temperature margin exceeds 1K, go to step (7). Otherwise, update WETMAP model input with new Helium inlet conditions (pressure and/or temperature) and mass flow rates, then repeat step (5).

(7) If the headroom margin exceeds 2K, go to step (8). Otherwise, update WETMAP model input with new Helium inlet conditions (pressure and/or temperature) and mass flow rates, then repeat step (5).

(8) If the WETMAP-predicted outlet pressure falls within the 0.25 to 0.35 MPa range, then feasibility is confirmed. Otherwise, update WETMAP model input with new Helium inlet conditions (pressure and/or temperature) and steady mass flow rates and repeat step (5).

In the event results obtained by this process indicated all margin and outlet pressure constraints could not be met simultaneously, the process could be repeated using WETMAP models updated to reflect suitable design modifications.

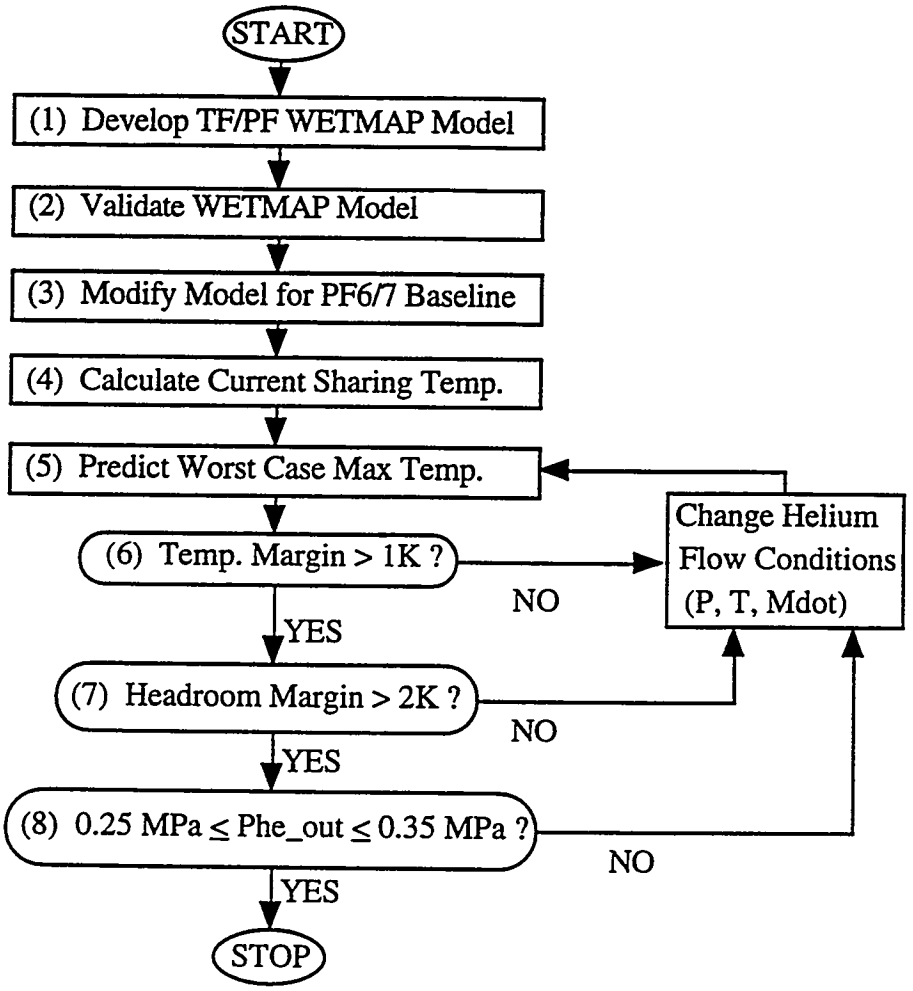


Figure 5 -- Methodology used to assess cooling design feasibility.

3.2 ASSUMPTIONS

A number of simplifying assumptions were made to leverage the analysis. This section presents these assumptions, along with their underlying basis.

3.2.1 Thermal Loads

PF6 & PF7 thermal loads, which are sustained for time periods exceeding 100 seconds, consist primarily of neutron heat generation, but include cryostat heat leaks and magnet interface heat transfer. This section presents the basis for estimating these loads.

Neutron Heat Generation

A previous thermal-hydraulic analysis of outer ring coils by Wang [6] assumed spatially-uniform nuclear heating of 15.2 Watt and 54.6 Watt per double-pancake for PF6 and PF7

respectively, based on a preliminary estimate of nuclear heating rates by Liew [7]. A subsequent calculation of nuclear heating rates by Liew [8] indicated total thermal loads of 223 Watts for PF6U/L and 677 Watts for PF7U/L, or roughly 11.2 Watts and 48.4 Watts respectively when averaged on a per double-pancake basis.

To evaluate the adverse effect of peaking factors, Potter [9] proposed a method for approximating a nuclear heating distribution consistent with Liew's revised calculation of total nuclear heating rates. According to Potter's method, each square conductor is split diagonally into two triangular cells with the hypotenuse side of each cell oriented parallel to the neutron path, assumed to have a 45 degree angle of incidence with respect to horizontal. With an assumed neutron flux attenuation of 70% per triangular conductor cell, the heating in a given cell is a fraction, F = 0.7, of the heating in an adjacent cell previously penetrated by the particle track. Consequently, the largest nuclear thermal loads are experienced by the bottom side double pancake in PF6U/7U and the top side double pancake in PF6L/7L.

Implementing Potter's method to quantify the heating distribution involves normalizing the net conductor heating fractions such that a value of 1 is assigned to the turn with the maximum heating. This turn is located at the entrance to the coil bore. Each normalized fraction value is then scaled by the ratio of the total heat input divided by the sum of the normalized fraction values in order to obtain the nuclear heat input to each conductor on a per turn basis. The results for the entire PF6 and PF7 winding pack cross-sections are documented in the spreadsheet calculations residing in Appendix A. Note the aforementioned computational procedure ignores circumferential variations in the heat input arising from localized shielding effects due to topological features of the TF coil structure assembly. This simplification is not expected to introduce significant error since the spatial extent of circumferential heating variations is a small fraction of the flow path length and the large helium heat capacity acts to smooth resulting perturbations in temperature profiles.

Potter's method was invoked to determine the beneficial effect of surrounding the winding pack with a stainless steel case having a wall thickness equivalent to the exterior dimension of the square conductor conduit. Here, the case was also partitioned into triangular cells and neutron attenuation of 0.7 was again assumed. Note the external case actually *increases* total *coil* heating since additional energy is deposited by neutrons penetrating the case volume situated *beyond* the winding outside diameter. However, as predicted by spreadsheet calculations documented in Appendix B, *double-pancake* total heating *decreases* due to the

shielding effect of the case volume interposed between the plasma and winding pack. This reduction in double-pancake thermal load is achieved only if most of the case heat is intercepted by auxiliary coolant flow before it conducts across the ground wall insulation. Table 4 presents thermal loads predicted for a stand-alone winding pack versus an encased winding pack, if all case heat is intercepted. The indicated distribution of thermal load is a result of "thin" coil geometry and neutron incidence angle.

Table 4 - Winding Pack Nuclear Heating w/ and w/o External Case

Pancake Number	Double-Pancake Number	Nuclear Heat (Watt)			
		PF6 Winding Pack		PF7 Winding Pack	
		No Case	With Case	No Case	With Case
1 & 2	1	23.91	11.73	97.58	47.78
3 & 4	2	11.32	5.55	46.18	22.61
5 & 6	3	9.63	4.72	39.3	19.24
7 & 8	4	9.52	4.66	38.85	19.02
9 & 10	5	9.52	4.66	38.85	19.02
11 & 12	6	9.52	4.66	38.85	19.02
13 & 14	7	9.52	4.66	38.85	19.02
15 & 16	8	9.52	4.66		
17 & 18	9	9.52	4.66		
19 & 20	10	9.52	4.66		
	Total (Watts)	111.5	54.6	338.5	165.7

Cryostat Heat Leak

To estimate the PF6/7 thermal load associated with heat leak from the cryostat vacuum boundary to the Tokamak cold mass, an effective, spatially-uniform, average radiant heat flux, Qr, was computed. This was done by dividing the cold mass surface area of 600 m^2 [10] into the estimated cold mass heat leak of 170 Watt [9] to obtain Qr = 0.283 Watt/m^2, or roughly 0.3 Watt/m^2. This incident surface heat flux value was multiplied by the exposed surface areas of each coil to determine the associated coil thermal load, assuming radiative heat input to the exposed PF-to-TF mount surfaces is also eventually conducted to the PF winding mass. The thermal load was then treated as a uniform heat input applied to each conductor conduit face situated adjacent and parallel to the extreme outer perimeter of the winding pack cross-section. The extent of this virtual heat transfer boundary, however, was postulated differently for each

coil. For PF6, the effective external heat transfer perimeter was defined to include the inside diameter, outside diameter, top, and bottom surfaces. Under these assumptions, the estimated heat input to either PF6U or PF6L due to cryostat heat leak was 8.8 Watts, or about 8% of the PF6 nuclear thermal load. For PF7, the effective external heat transfer perimeter did not include the inside diameter because negligible optical window area exists for radiative heat transfer to this surface due to the large radius of curvature of the TF case and small standoff clearance between PF7 and the TF intercoil structure in this region. Consequently, the estimated heat input to either PF7U or PF7L due to cryostat heat leak was 5.1 Watts, or about 1.5% of the PF7 nuclear thermal load Details of these calculations reside in Appendix C.

TF-to-PF Magnet Interface Heat Flows

Conduction heat flow between TF and PF6/7 was taken to equal a total of 2 Watts per each PF magnet [11]. The direction of this heat flow was assumed to be from TF to PF. The associated thermal load was treated as a uniform heat input applied to each conductor conduit face situated parallel and immediately adjacent to only the top and bottom winding pack surfaces. These surfaces are clamped, so they present lower thermal impedance to heat flow than the outer and inner diameter surfaces. This approach further increases conservatism of the analysis since it has the effect of slightly increasing the peaking factor in the total heat input distribution. Details of these calculations also reside in Appendix C.

3.2.2 Conductor Load Line

For purposes of calculating conductor operating margin, the coil load line was assumed to extend from the origin of the superconducting (I,B,T) state space, where I is conductor current, B is magnetic field, and T is temperature, through a locus of points with coordinates (Bmax, |Imax|), where Bmax and |Imax| are the worst case peak magnetic field strength and worst case absolute value of conductor current respectively.

According to Pillsbury [12], Bmax equals 3.28 Tesla for PF6 and 2.31 Tesla for PF7. These values include TF compensation and plasma position control currents for the High Current (HC) Scenario and for the q=3* Double Null (DN) flexibility space. From tabulated values of PF currents [12] for various corners of the DN flexibility space, |Imax| was identified as 2.373 MA-t (19.775 kA per turn) for PF6 at DN corner point (l_i=0.5,β_N=2.2) during a vertical translation of the outboard strike-point and 1.315 MA-t (15.655 kA per turn) for PF7 at DN corner point (l_i=1.2,β_N=5.0) during a radial shift of the plasma. These currents are within 0.5 kA of the peak

currents in the PF Magnet System Specification and will be updated with the approved currents when additional analysis is performed in the future.

3.2.3 Jc Degradation

No degradation of the NbTi strand critical current density, Jc, was assumed. This assumption was made on the following basis .

Coil Pack Fabrication

Residual tensile strains after cabling, jacketing, and winding operations are expected to be insignificant, so zero Jc degradation is assumed prior to reactor operation.

Strain & Fatigue During Plasma Initiation & Burn

Results of experimental studies by Ekin [13] suggest NbTi/Cu composite strands suffer negligible Jc degradation at static tensile strain levels less than 0.5% while fatigue damage tends to be limited to the Cu matrix and occurs beyond 10^5 cycles if the peak-to-peak cyclic strain amplitude exceeds 0.4%. Assuming the principal conduit stresses in the outer ring coils due to Lorentz Forces never exceed 60 ksi [14], one can estimate a conservative maximum hoop strain of roughly 0.2% based on dividing the aforementioned stress value by the Young's Modulus of 316LN, or about 30,000 ksi. This magnitude of hoop strain would also be experienced by the conductor cable since the cable never detaches from the ID side of the conduit wall due to radial Lorentz forces. Therefore, on the basis of this simplified estimate and Ekin's empirical findings, no strain-related safety factor was applied to the wire critical surface when computing operating margins. Furthermore, no additional safety factor was allocated to compensate for accumulation of fatigue damage to the strands over the operating life of the coils since the magnet life cycle requirements are well within the 10^5 cycle regime.

3.2.4 Thermal Interface Boundary Conditions

To advance the analysis, two assumptions were made regarding the heat transfer characteristics of the various interface boundaries contained by the winding pack.

First, the thermal contact impedance between the 316 LN conduit and the unbonded Kapton tape layer of the turn insulation was ignored. The paucity of empirical data for this surface combination as well as the uncertainties associated with the contact pressures which would occur at cold operating temperatures provide justification. This assumption also injects conservatism into the analysis since an underprediction of inter-turn thermal impedance translates

into an overprediction of hot spot temperature due to the "counterflow heat exchanger" effect [15] characteristic of forced flow-cooled double pancake coils.

Second, for the purpose of determining design feasibility, inter-turn heat transfer from one double pancake to another was ignored. The justification for assuming a virtual adiabatic boundary plane sandwiched between adjacent double pancakes follows from the characteristics of the assumed heating distribution, as well as the existence of a parallel flow condition on either side of this plane (see Figure 2). Inspection of the nuclear heating distribution data presented in Appendix A reveals that, except for layers 3 through 6 at the pancake 2-to-3 boundary and layers 5 & 6 at the pancake 4-to-5 boundary, no significant difference between heating rates exists across double-pancake boundaries throughout most of the winding pack. Furthermore, on a net single-pancake basis, the only significant differential between cumulative heat deposition in two adjacent single-pancakes, where both single-pancakes form either the inlet half or the outlet half of an entire flow channel, is associated with the pancake 2-to-3 boundary. Therefore, except at the pancake 2-to-3 boundary, no significant average temperature drop should be established between facing inlet halves or between facing outlet halves of adjacent double-pancakes.

3.2.5 Intra-Conductor Heat Transfer

Heat flow within CICC is dominated entirely by convection. That is, heat convection in all transverse directions (radial & axial) far exceeds heat conduction along either the conduit or the cable. This assumption applies to those regions sufficiently removed from flow stubs and is supported by the following considerations.

For TPX-relevant mass flow rates and CICC hydraulic diameters, the Dittus-Boelter correlation yields turbulent flow convective heat transfer coefficients far in excess of 100 W/m^2-K. The transverse heat flow conductance therefore exceeds 73.5 W/K per meter of cable, for cable-to-helium convection heat transfer, and exceeds 6.5 W/K per meter of conduit for helium-to-foil convection heat transfer, based on the cable space and conduit wetted perimeter values presented in Table 2. In comparison, the heat flow conductance associated with heat conduction down a 1 m long section of PF CICC equals 0.2 W/K (= 1180 W/m-K x 0.000172 m^2 / 1m) at 5K if the CICC composition is entirely pure copper with RRR = 150 and zero background magnetic field. The corresponding conductance value for a one meter length of PF6/7 316 LN conduit, with a cross-section area of 0.000179 m^2, is 6 x 10^{-5} W/K. Clearly, both of these

conductances are multiple orders of magnitude less than those for cable space convection. Thus, they can be neglected.

The foil-to-conduit interface also constitutes a region in which forced convection heat transfer dominates other thermal transport processes. Since the foil is not hermetic, void spaces at this interface will be wetted fully by helium bled from the cable space and will be subjected to the same pressure gradients as the cable space. (These void spaces are created during the cable compaction process when the foil partially conforms to the rounded contours of the strands at the cable periphery.) Therefore, a small amount of Helium must flow between the foil and the conduit inner wall surface.

If this flow is assumed to be fully-developed laminar flow, Nusselt number values span the range of 4 to 8.2, depending on the channel geometry [16,17], and are independent of Reynolds Number. These Nusselt number values imply large heat transfer coefficients in excess of 400 W/m^2-K for Helium thermal conductivities of roughly 0.02 W/m-K and hydraulic diameters on the order of 0.1mm. Since the convection surface area exposed by these voids is considerably larger than the surface area associated with point/line contact zones between the conduit and the peripheral cable strands, the low impedance path for conduit-to-cable heat transfer is established by convection "shunts" on both sides of the foil wrap surrounding the cable. Thus, the heat flow impedance between the cable and the conduit is approximately three times what it would be if the foil wrap was eliminated, but considerably less than that associated with contact temperature drop alone.

3.2.6 Steady-State Operation

Since the TPX device operates in a pulsed mode, steady-state generation of fusion output power can be achieved in an approximate sense only, as duty cycles *approach* the 100% limit. Present operating goals [18] are a 22% duty cycle, or roughly 1 plasma burn of 1000 seconds duration every 76 minutes. During the plasma burn interval, the thermal-hydraulic performance of the outer ring coils is assumed to attain steady-state and therefore avails itself to simulation by steady-state computational techniques. This assumption is based on the helium residency time in any coil flow channel being less than 1000 seconds. Numerical results presented in section 4 substantiate this assumption.

3.3 WETMAP THERMAL-HYDRAULIC COMPUTER MODEL

3.3.1 Model Description

WETMAP is a Westinghouse-proprietary computer program specifically designed for thermal-hydraulic modeling of Tokamak magnets wound with CIC conductor [19,20]. For the TPX outer ring coil heating scenario, WETMAP was modified to solve the coupled steady-state heat conduction and convection problem in a generic TF/PF double pancake coil, assuming nonadiabatic *internal* boundary conditions and adiabatic *external* boundary conditions for conduction heat transfer.

The kernel of the WETMAP solver is based on a simplified formulation of the coupled Navier-Stokes equations for supercritical helium, including the effects of finite compressibility [21]. For one-dimensional steady flow, this formulation [22] consists of two ordinary differential equations derived from an enthalpy balance on a control volume:

$$\frac{dP}{dx} = \frac{-2fG^2/(\rho D) + 4qG\beta/(\rho D(C_p - u^2\beta))}{1 - (G^2/\rho)(\kappa + \beta\phi)} \qquad (1)$$

and

$$\frac{dT}{dx} = \frac{-2fG^2\phi/(\rho D) + 4q/(GD(C_p - u^2\beta))}{1 - (G^2/\rho)(\kappa + \beta\phi)} \qquad (2)$$

where:

P = bulk helium pressure (Pa)
T = bulk helium temperature (K)
x = position coordinate (m) along helium flow path with x = 0 at inlet
f = Fanning friction factor
G = specific mass flow rate (kg/m^2-s)
ρ = density (kg/m^3)
D = hydraulic diameter (m)
q = heat input flux ($Watt/m^2$)
C_p = constant pressure specific heat (J/kg-K)
u = bulk flow velocity (m/s)
β = bulk expansivity (K^{-1})
κ = bulk compressibility (Pa^{-1})

and the parameter ϕ is defined as

$$\phi = (\mu_j C_p + u^2\kappa) / (C_p - u^2\beta)$$

with μ_j as the Joule-Thomson coefficient (K/Pa) of helium. The temperature gradient formula (Eqn. 2) includes the effects of viscous friction heating of the fluid.

In equations 1 and 2, the convective heat input flux, q, is given by a control volume energy balance:

$$q = q_S + q_C \tag{3}$$

where q_S is a spatially-distributed source term consisting of the net internal heat generation per unit convective surface area and q_C is the net conduction heat transfer flux. This flux is given by:

$$q_C = \nabla(k\nabla T^*) \tag{4}$$

where k is the effective temperature-dependent thermal conductivity of the winding pack material, T* is the material temperature, and ∇ is the vector operator, *grad.* For nuclear heating, the distributed heating source term, q_S, is partitioned between the cable and conduit spaces according to their relative volumes. (For pulsed field thermal loads, $q_S = 0$ everywhere except in the cable space.) Since negligible amounts of winding pack heat conduct circumferentially, equation 4 pertains to transverse heat flow external to the cable.

3.3.2 Numerical Implementation

Equations 1 through 4 are solved using a combined finite difference and equivalent circuit technique employing a staggered-grid, nodal mesh similar to that used by the CICC program [23]. This mesh is shown in Figure 6. The control volumes for the helium state equations (Eqn. 1 & Eqn. 2) are staggered relative to the control volumes for the Fourier heat conduction equation (Eqn. 4). Centers of the conduction elements are co-located with edges of

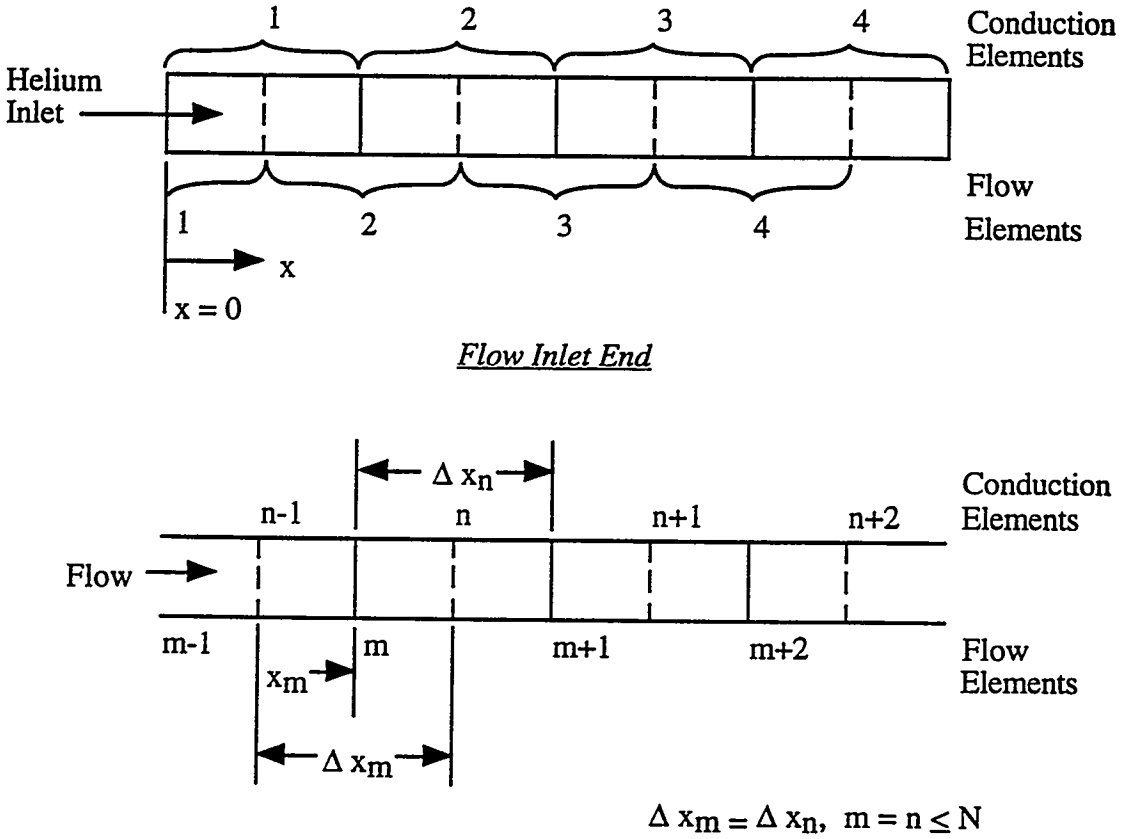


Figure 6 -- Staggered-grid nodal mesh for thermal-hydraulic model. Element numbering and coordinates are shown.

the flow elements and centers of the flow elements are co-located with edges of the conduction elements. The first and last elements of either type are located at the inlet and outlet, respectively. The conductor inlet coincides with the center of the first flow element and the boundary of the first conduction element. Similarly, the conductor outlet coincides with the center of the last flow element and the boundary of the last conduction element. Flow elements are half elements only at either conductor end, whereas conduction elements are full elements everywhere within the nodal grid. Uniform temperatures and pressures within a given element are assumed.

Equation solutions based on this grid are developed iteratively due to the excessive nonlinearity exhibited by Helium thermal properties within the nominal operating regime of the

TPX coils. The solution process begins with initializing q_s based on the problem-specific nuclear heating distribution. Once q_s is initialized, a four step loop is repeated until convergence of the helium temperature profile is achieved such that absolute relative residuals change by less than 0.5%. These steps are outlined in the following paragraphs.

The iterative portion of the algorithm begins with numerical integration of equations 1 and 2 via the Euler forward difference technique. Flow boundary conditions consist of the helium inlet temperature and pressure. The Fanning friction factor, f, which appears in the temperature and pressure gradient formulas, is evaluated for each flow element using Hooper's correlation [24] to Lue's CIC data [25]. At any given grid location, both helium state gradients are computed based on helium properties evaluated at the pressure and temperature of the adjacent "upstream" element. Consequently, WETMAP solutions propagate "downstream", from inlet to outlet.

The next step is calculation of transverse heat flow conductances associated with interturn heat transfer between any given conduction element (i,j,k) and its neighboring elements ($i' \neq i$, $j' \neq j$, $k' = k$) where i designates pancake number (i=1 or 2), j designates turn number, and k designates circumferential location along the flow path. The winding pack thermal properties associated with these conductances are evaluated at the average helium temperature along the flow channel. The thermal equivalent circuit model shown in Figure 7 was used to quantify these conductances. According to this circuit model, heat deposited in the cable node flows directly to the helium node while heat deposited in the conduit node is dissipated along 2 paths. One path is from the conduit node through the cable foil wrap to the helium node. The other path is from the conduit node through electrical insulation to the conduit node of a neighboring turn. The second path subdivides into two parallel paths, one corresponding to heat flow between the flat side wall sections of adjacent conduits, the other corresponding to heat flow between the rounded corners of adjacent conduits. In spiral-wound double pancake coils , like PF5, the area overlap in the side wall region changes continuously for heat flow in the pancake-to-pancake direction. In constant radius-wound coils like PF6/7, this overlap is constant, so quantifying the interturn heat transfer is comparatively less complicated. To quantify the insulation effective thermal conductance in the conduit corner void region, a more detailed thermal equivalent circuit model was developed to account for the rounded surfaces. This model, along with the details of parameterizing the conductance, are documented in Appendix D.

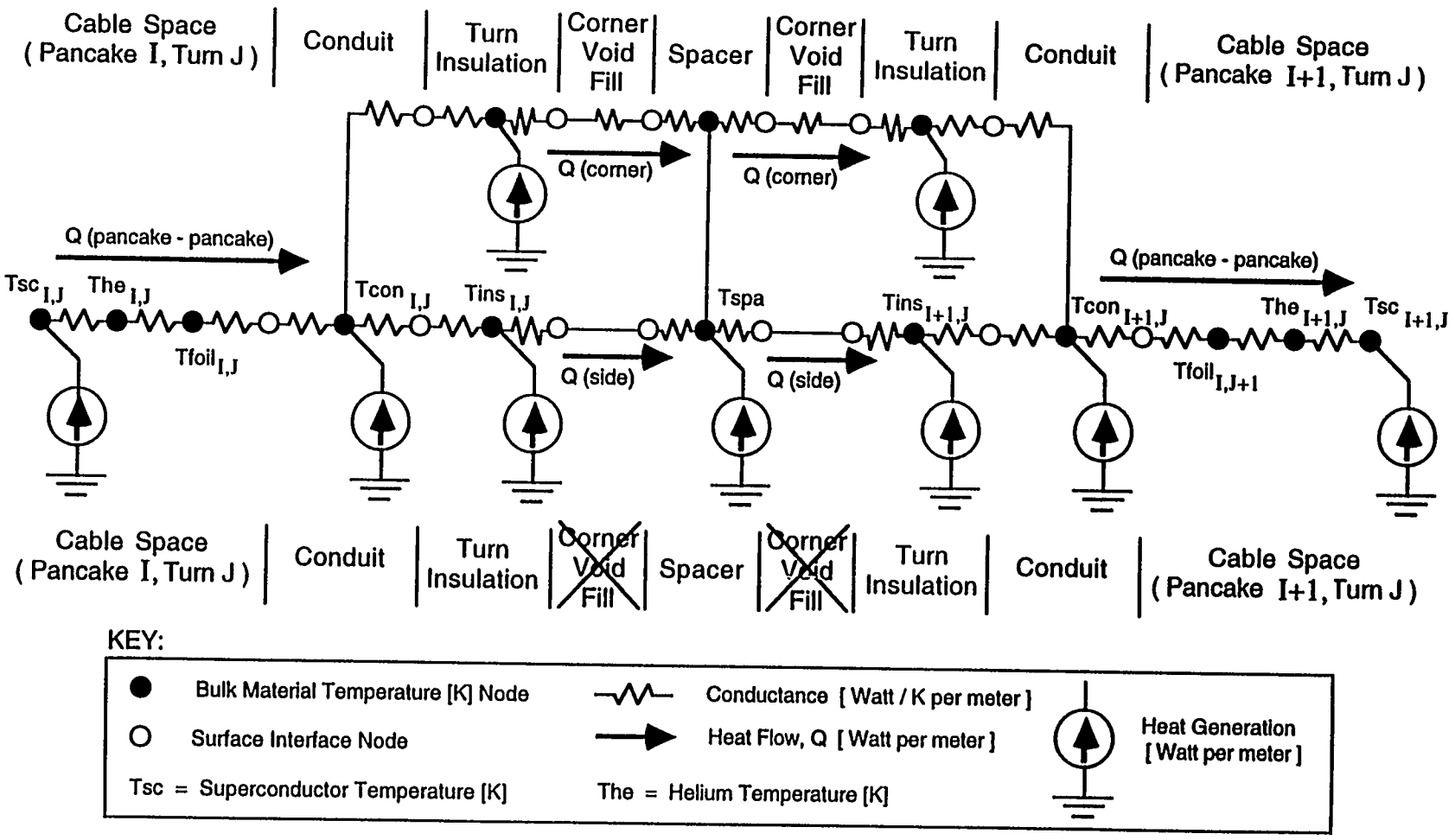


Figure 7 -- Thermal equivalent circuit model of turn-to-turn heat transfer between pancakes.

The third step in the solution process consists of calculating conduit and cable temperatures. For the cable, all of the deposited neutron heat flows directly into the helium, with the small driving temperature difference being set by the convective surface area and the steady-state turbulent forced convective heat transfer coefficient. This coefficient is obtained from the Giarratano-modified [26] Dittus-Boelter correlation. If the resulting value exceeded the 600 W/m^2-K limit [2] for NbTi CIC conductor, the limiting value was used instead. For the conduit, the deposited neutron heat, minus the inter-turn heat transport, is dissipated by the helium. In general, the conduit-to-helium temperature difference exceeds the cable-to-helium temperature difference due to the relative difference in wetted perimeters. For both heat flows, the log mean temperature difference (LMTD) was invoked to calculate the cable-to-helium temperature drop. The LMTD formulation [27] takes advantage of the staggered-grid model to produce physically-valid conduit and cable temperatures which exceed the helium temperature anywhere along the flow channel.

The final step is to calculate the interturn heat transport based on the conduit temperatures calculated during the third step and the heat flow conductances calculated during the second step. The interturn heat transport is combined with the nuclear heating distribution to obtain a new total heating distribution according to equation 3, see section 3.3.1. The process then repeats with this updated net heating distribution serving as the helium heat input for recomputation of the helium temperature and pressure profiles. Typically, fewer than 12 iterations are required to achieve solution convergence whereby maximum absolute relative residuals are less than 0.1%.

The four step algorithm was implemented using commercially-available spreadsheet software running on a Power Macintosh 7100/66AV equipped with 32 MB RAM. Nominal run times, including data post-processing, are roughly 4 hours with the maximum possible amount of RAM allocated to the spreadsheet application software.

The spreadsheet version of WETMAP utilizes an embedded helium property data base consisting of lookup tables for thermal conductivity and viscosity as well as the five thermal properties appearing in the helium state gradient equations. The lookup tables contain reference property values along isobars and isotherms. A bilinear interpolation macro is used to estimate property values as functions of pressure and temperature. The reference isobar and isotherm data points are spaced exponentially in the pressure-temperature plane to increase interpolation accuracy near the critical point coordinates (0.23 MPa, 5.2K). Reference property values were

obtained from Cryodata Inc.'s HEPAK software output which is consistent with NIST's 1992 Tech Note 1334. To validate the property interpolation macro, the average absolute relative discrepancy of the macro output versus HEPAK was computed over an array of 48 temperature values from 3K to 18K and 7 pressure values from 0.25 MPa to 2 MPa for a total of 336 points per helium property. The results are shown in a series of plots contained in Appendix E. Over this data set of 2352 points, the average absolute relative discrepancy between HEPAK and the macro was less than 4.5%, which is an indicator of acceptable accuracy.

3.3.3 Validation

The WETMAP model was validated against available experimental test data as well as simulation results predicted by the thermal-hydraulic computer models, CICC and QUENCHER. Results of this validation effort were reported previously during a briefing [28] at the 4th Magnet System Interchange Meeting, so they are only summarized here. (For archival purposes, copies of the relevant viewgraphs are contained in Appendix F and the interested reader is encouraged to refer to these pages for more detail.)

In general, the WETMAP model performed well in simulating experiments [29] of helium gas flow within long smooth tubes. It also correlated well against QUENCHER [30], which had been modified by Westinghouse's Owen Christianson [31] to approximate the steady-state thermal-hydraulic response of an adiabatic CIC conductor to a uniformly-distributed heat input of 37.5 Watts along its length without inter-turn heat transfer. For this validation case, WETMAP and QUENCHER produced virtually identical results and both models exhibited good performance in terms of conservation of energy. Compared to a CICC simulation of the TF 5kW nuclear heating scenario [32], WETMAP underpredicted the hotspot temperature by 0.4K, but did well in matching CICC's predicted pressure drop of roughly 2.2 atm. This discrepancy still remains an open issue.

Since QUENCHER and CICC are both transient solution codes while WETMAP is a steady-state code, WETMAP was also compared against results predicted by HESS3D [33]. The comparison case was that of PF7 double-pancake subjected to 54.6 Watts of steady nuclear heat input and cooled by 3 g/s flow at an outlet pressure of 3 atm. Table 4 (Section 4) presents the corresponding WETMAP results, which reside in the row designated as Run #1. These results were comparable with the HESS3D prediction of cable hot spot temperature and helium inlet/outlet conditions.

3.4 MATERIALS AND MATERIAL PROPERTIES

Additional WETMAP data base macros were written to calculate thermal conductivity of the conduit and the electrical insulation. These macros utilize validated polynomial curve fits to thermal conductivity data identified for the insulation constituent materials [34] and 300-series stainless steel alloy [35].

3.5 MARGIN PREDICTION

3.5.1 Temperature Margin and Headroom

The procedure used to predict temperature margin is shown in Figure 8, which illustrates the projection of the magnet load line (field versus current characteristic) and the critical surface into the (I,B) plane of the superconducting (I,B,T) space. A spreadsheet calculation, utilizing a piece-wise linear expression [5] for the NbTi critical temperature, quantified critical current versus field at a constant temperature. It was benchmarked against Morgan's correlation and found to be conservative, see Appendix G. The current sharing temperature, T_{cs}, was determined by recomputing critical current at gradually increasing temperatures until critical current matched operating current. Referring to Figure 8, this procedure has the effect of translating the projection of the critical surface downward until the operating point along the load line coincides with the critical surface. The results for the PF6/7 coils with a composite wire Cu:SC ratio of 2.5:1 are also presented in Appendix G.

The difference between T_{cs} and the WETMAP-predicted hot spot temperature, $T_{hotspot}$, yields the temperature margin, ΔT_M. In reality, ΔT_M is a function of position within the winding pack since magnetic field and temperature are not spatially uniform. However, a lower bound margin is determined by assuming the peak magnetic field and hot spot temperature locations coincide. This is equivalent to routing the load line projection through the operating point with coordinates (B_{max}, I_{max}) where B_{max} is the worst case peak magnetic field and I_{max} is the maximum magnitude of operating current. In a similar manner, headroom margin, ΔT_H, is determined by subtracting helium inlet temperature from the minimum value of T_{cs}.

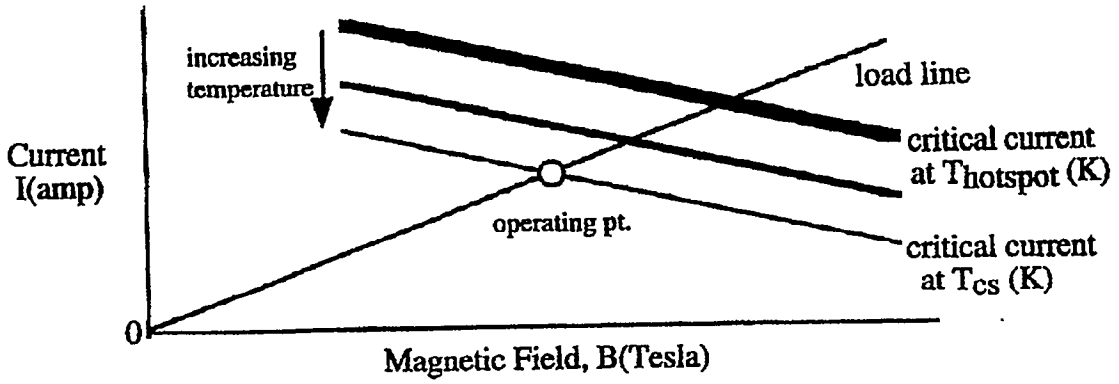


Figure 8 – Calculation of temperature margin, $\Delta T_M = T_{cs} - T_{hotspot}$.

3.5.2 Energy Margin

Energy margin and energy headroom were estimated by calculating differences in helium internal energy, assuming that a negligible fraction of available cable space energy resides in the wire. Accordingly, energy margin, ΔU_m, is given approximately by:

$$\Delta U_m \geq \int_{T_{hotspot}}^{T_{cs}} (\rho\, C_v) dT \qquad 5)$$

where ρ is density and C_V is the constant volume specific heat of helium. This integral is evaluated at a constant density equal to the helium density at the hot spot location.

4. RESULTS

4.1 TEMPERATURE MARGIN AND HEADROOM PREDICTIONS

The results of 23 WETMAP runs are presented in Table 5. Results of runs 1 through 17 and 19 through 21 support the feasibility analysis of the baseline PF7 and PF6 cooling designs, respectively. The results of run 1, 18, 22, and 23 support the feasibility analysis of PF7 design baseline modifications intended to improve temperature margins.

Results of run 1 confirm that the PF7 temperature margin and headroom criteria can be met when the nuclear heating peak-to-average factor is 1 (i.e., uniform heating). All subsequent runs investigated the effects of increasing the nuclear heating peak-to-average factor, according to Potter[8]. In runs 2 through 9, the effect of increased inlet pressures and mass flow rates was investigated. The maximum predicted temperature margin was 0.72K for outlet pressures above the 0.23 MPa critical value. To increase margin predictions beyond the required 1K, subcooling the inlet helium was investigated with runs 10 through 17 in the hopes of reducing hot spot temperature due to more efficient utilization of the hump in the helium specific heat curve. Although the results suggest this approach would increase temperature margins beyond the 1K requirement, they also indicate such margins could not be achieved without incurring excessive helium pressure drop into the undesirable two phase flow regime upstream of the outlet.
It is believed the fractional temperature margins predicted for the PF7 baseline are a consequence of long flow path lengths combined with the worst case double-pancake thermal load peaking to the 100 Watt mark. One possible fix is to decrease the flow path length by 50%. Implementation would involve adding one helium outlet stub at the bore turn of the double-pancake coil with the worst case heating, thereby establishing a parallel flow condition in pancakes 1 & 2. On average, the heat load intercepted by either parallel flow stream would be roughly 50 watts, which is comparable to the 48.4 Watt load case analyzed previously by Wang [33] with HESS3D. Interturn heat transfer would tend to level the local peaking factors so that the net heat load actuals would certainly approach the 50 Watt average value. The implication is that the single pancake cooling modification should be feasible. This contention is made on the following basis.

The 54. 6 Watt uniform heating case was simulated with WETMAP in run 1 to confirm cooling feasibility at this level of heat input and to establish a frame of reference for comparison purposes. A favorable temperature margin of 1.26 K for 3 g/s at an inlet pressure of 5.8 atm and

Table 5 -- Thermal-hydraulic simulation parameters and WETMAP-predicted results.

Run No.	Coil	Pancake No.'s	Channel Length(m)	Case	Heating Distribution	Heating Input(W)	Flow (g/s)	Inlet T(K)	Inlet P(atm)	Outlet P(MPa)	Outlet T(K)	Hot Spot Ths(K)	Tcs (K)	Temp. Margin(K)	Headroom Margin(K)	Residence Time(s)
1	PF7	1 & 2	324	no	uniform	54.6	3	5	5.8	0.31	5.99	6.43	7.69	1.26	2.69	916
2	PF7	1 & 2	324	no	nonuniform	100.2	3.75	5	7.5	0.26	6.55	7.33	7.69	0.36	2.69	
3	PF7	1 & 2	324	no	nonuniform	100.2	4	5	8	0.29	6.54	7.33	7.69	0.36	2.69	
4	PF7	1 & 2	324	no	nonuniform	100.2	4.5	5	8.5	< 0.23	5.82	6.88	7.69	0.81	2.69	
5	PF7	1 & 2	324	no	nonuniform	100.2	4.5	5	9	0.34	6.56	7.37	7.69	0.32	2.69	
6	PF7	1 & 2	324	no	nonuniform	100.2	4.5	5	9.4	0.39	6.81	7.58	7.69	0.11	2.69	
7	PF7	1 & 2	324	no	nonuniform	100.2	5	5	9.4	0.26	5.98	6.97	7.69	0.72	2.69	
8	PF7	1 & 2	324	no	nonuniform	100.2	5	5	10	0.37	6.59	7.4	7.69	0.29	2.69	
9	PF7	1 & 2	324	no	nonuniform	100.2	5.5	5	10	< 0.23	5.27	6.73	7.69	0.96	2.69	
10	PF7	1 & 2	324	no	nonuniform	100.2	5	4.7	9.4	0.3	6.1	7	7.69	0.69	2.99	
11	PF7	1 & 2	324	no	nonuniform	100.2	3.5	4.7	7	0.25	6.52	7.33	7.69	0.36	2.99	
12	PF7	1 & 2	324	no	nonuniform	100.2	3	3.8	4.4	< 0.23	-	6.1	7.69	1.59	3.89	
13	PF7	1 & 2	324	no	nonuniform	100.2	3	3.8	4.5	< 0.23	-	6.18	7.69	1.51	3.89	
14	PF7	1 & 2	324	no	nonuniform	100.2	3	3.8	4.8	< 0.23	-	6.37	7.69	1.32	3.89	
15	PF7	1 & 2	324	no	nonuniform	100.2	3	3.8	5.2	< 0.23	-	6.53	7.69	1.16	3.89	
16	PF7	1 & 2	324	no	nonuniform	100.2	3	3.8	5.4	< 0.23	-	6.63	7.69	1.06	3.89	
17	PF7	1 & 2	324	no	nonuniform	100.2	3	3.8	5.6	< 0.23	-	6.79	7.69	0.9	3.89	
18	PF7	1 & 2	324	yes	nonuniform	47.8	3.17	5	5.8	0.31	5.84	6.22	7.69	1.47	2.69	
19	PF6	1 & 2	283.4	no	nonuniform	26.6	3.8	5	5.8	0.32	5.57	5.81	7.08	1.27	2.08	
20	PF6	1 & 2	283.4	no	nonuniform	26.6	4.8	5	7	0.32	5.53	5.81	7.08	1.27	2.08	711
21	PF6	9 & 10	283.4	no	nonuniform	10.2	4.8	5	7	0.34	5.36	5.64	7.08	1.44	2.08	
22	PF7	1 & 2	324	yes	nonuniform	47.8	4	5	7	0.33	5.84	6.29	7.69	1.4	2.69	850.7
23	PF7	7 & 8	324	yes	nonuniform	19	4.4	5	7	0.32	5.49	5.95	7.69	1.74	2.69	879.3

NOTE: Flow rates are per double pancake coil.

an outlet pressure of 0.31 MPa was predicted. If the same 0.28 MPa pressure drop was sustained over half the path length (i.e, the single pancake flow configuration), the resulting pressure gradient doubling, in principle, should be able to drive as much as a 40% increase in mass flow rate, assuming pressure drop is approximately proportional to the square of mass flow rate at sufficiently low heat input values. This 40% increase in mass flow rate translates to a 40% increase in heat removal, assuming outlet temperature and pressure remain fixed at 6K and 0.31 MPa respectively. Since this percentage increase in heat removal capacity exceeds the 18% increase in the total flow stream heat input from 54.6 Watts (reference value) to 64.5 Watts (pancake 1 w/o case), it appears the parallel flow cooling scheme for the worst case PF7 double pancake offers much promise in terms of achieving temperature margins $\geq$ 1K.

Referring back to Table 5, the beneficial thermal effect of inserting PF7 within an external case structure was investigated in runs 18, 22, and 23, assuming all case heat is intercepted by case coolant. The results show ample temperature margins of at least 1.4K, spanning an inlet pressure range of 5.8 to 7 atm. A point worth noting is that reduction of total heat input from 47.8 Watts in pancakes 1 & 2 to 19 Watts in pancakes 7 & 8 resulted in a 10% increase in mass flow rate with pressure drop remaining virtually constant. This result demonstrates that the flow resistance associated with compressible fluids increases with heat input. The implication for refrigerator sizing is that valuable cooling capacity will not be distributed optimally since channels with less heat input will "rob" a portion of the available coolant from channels with greater heat input.

In runs 19 through 21, margins predicted for the PF6 baseline exceed the 1K requirement by at least 0.25K, so investigation of an external case was not done to establish PF6 cooling feasibility since predicted margins would increase. Note that predicted headroom, however, exceeds the 2K requirement by a slim 0.08K buffer.

For archival purposes, graphical outputs from WETMAP for the worst case double pancakes in a free-standing PF6 (run 20) and an encased PF7 (run 22) reside in Appendices H & I, respectively. The wire temperature profile plots in particular illustrate the extent of hot spot temperature racheting attributable to inter-turn heat transfer between adjacent pancakes. Also noteworthy are plots of the converged solution helium heat capacity profiles along the flow channel. The upward-looping characteristic of these profiles suggests that the "hump" in the helium heat capacity curves is utilized effectively for the indicated values of the simulation parameters.

4.2 ENERGY MARGIN

For PF6, at the worst case 5.81K hot spot location, the predicted helium pressure is roughly 0.44 MPa for 3.8 g/s flow. The associated density and helium internal energy for these pressure and temperature conditions is 101.8 kg/m^3 and 16047 J/kg, respectively. Substituting these values into equation (5) yields a minimum energy margin of 349 mJ/cm^3, based on a helium internal energy of 19477 J/kg at the 7.08K current sharing temperature. This value exceeds the 300 mJ/cm^3 minimum set by the design criteria.

For PF7, at the worst case 6.29K hot spot location, the predicted helium pressure is roughly 0.52 MPa for 4g/s flow. The associated density and helium internal energy for these pressure and temperature conditions is 92.27 kg/m^3 and 18614 J/kg, respectively. Substituting these values into equation (5) yields an energy margin of 358 mJ/cm^3, based on a helium internal energy value of 22492 J/kg at the 7.69K current sharing temperature. This value also exceeds the 300 mJ/cm^3 minimum set by the design criteria.

4.3 HELIUM RESIDENCE TIMES

Helium residence time within the coil flow channels was calculated in runs 1, 20, 22, and 23 (see Table 5) as a check on the validity of assuming a steady-state thermal response occurs within the 1000 second plasma burn. Residence time was computed by dividing the length of each flow element in the WETMAP model by the local flow velocity to obtain an estimate of the helium transit time through each element. (The flow velocity was determined by dividing the steady mass flow rate by the product of flow area and local density. Flow velocity increases along the channel since density decreases due to expansion of the helium as it absorbs coil heat.) The transit times were summed to yield the total residency time. For the aforementioned runs, the longest predicted residency time was 916 seconds, implying PF6/7 flow channels are completely flushed at least once during the plasma burn. So, the assumption of steady-state response appears to be reasonable for present parameter values, but could become invalid if flow rates decrease sufficiently.

4.4 PRELIMINARY FLOW BUDGET ESTIMATE

Based on the results presented in Table 5, an estimate of the total required mass flow rate for the *encased* PF7U/L *winding packs* is 60.8 g/s (30.4 g/s for both PF7U and PF7L winding packs only). This estimate assumes double-pancake inlet and outlet pressures of 7 atm and 0.33

MPa, respectively, with 4.4 g/s coolant flow in six double pancakes and 4 g/s coolant flow in the double pancake with the worst case heating. Since an external case around PF7U/L would increase the *total* PF7 nuclear heat load from 677 watts to an estimated 836 watts (calculated from data in Appendix B), extra cooling capacity is needed to remove the additional 159 Watts of heat. This extra amount can be realized in different ways, depending on the case coolant plumbing scheme of choice.

Assuming 5K helium is shunted from the supply manifold at 7 atm (0.71 MPa) and exits the PF7 case at 0.32 MPa and 5.49K (the predicted outlet conditions for pancakes 7 & 8), the required case coolant flow rate would be 126 g/s, based on inlet and outlet enthalpies of 15320 J/kg and 19250 J/kg, respectively. Case coolant flow rate would increase to 197 g/s, if the case coolant temperature rise was only 0.4K, but would decrease to 83 g/s if the temperature rise was 0.6K, see Table 6. These estimates are also based on the assumption that all 518 Watts of combined nuclear and interface heat input to the case is intercepted completely by the case coolant and no heat transfers via conduction across the ground wall insulation.

Table 6 -- Summary of Preliminary Flow Budget Estimate for PF6 & PF7

	Coil				Case					Coil+Case
	Inlet	Outlet		Flow	Inlet		Outlet		Flow	Flow
	P(MPa)	T(K)	P(MPa)	(g/s)	T(K)	P(MPa)	T(K)	P(MPa)	(g/s)	(g/s)
PF6 (no case)	0.709	5.36	0.34	96					0	96
PF7 (w/ case)	0.709	5.49	0.32	60.8	5	0.709	5.4	0.32	197	257.8
	0.709	5.49	0.32	60.8	5	0.709	5.49	0.32	126	186.8
	0.709	5.49	0.32	60.8	5	0.709	5.6	0.32	83	143.8
PF7 (w/case &	0.709	5.49	0.32	60.8	5.49	0.32	5.43	0.25	60.8	60.8
coil effluent)	0.709	5.49	0.32	60.8	5.49	0.32	5.68	0.29	60.8	60.8

Alternatively, case effluent at a combined total flow rate of 60.8 g/s can be routed through the PF7 case. Assuming the bulk mixed state of the coil effluent upon entering the case was approximately equivalent to that of the central pancake outlets (0.32 MPa and 5.49K), helium temperature would actually drop to 5.43K upon exiting the case at an outlet pressure of 0.25 MPa due to Joule-Thomson effect. If case outlet pressure was higher, say 0.29 MPa, coolant would exit at roughly 5.7K, or about 0.6K less than the predicted hot spot temperature in PF7. Again, no significant parasitic heat conduction from the case to the coils is assumed. This assumption needs to be checked by detailed simulation, but should remain valid if gross case temperatures are not elevated significantly above the case coolant outlet temperature.

Similarly, based on the results presented in Table 5, an estimate of the total required mass flow rates for PF6U/L is 96 g/s (48 g/s for both PF6U and PF6L, or 4.8 g/s per double pancake). The underlying assumptions are no external case, inlet pressure is 7 atm, and outlet pressures are in the 0.32 to 0.34 MPa range. When an external case is added, the most flow-conservative method for removing case heat deposited beyond the winding pack is to use coil effluent for case coolant, as suggested by the results presented in the previous paragraph. Accordingly, the need for additional PF6 flow beyond the 96 g/s estimate is not anticipated at this juncture for the purpose of removing case nuclear heat.

Based on the aforementioned considerations, the estimated *minimum* total coolant flow requirement of the outer ring coils (PF6U/L & PF7U/L) is roughly 160 g/s. This value represents a significant increase from a previously-allocated value [36] of 106 g/s for all PF5 through PF7 coils. Furthermore, it should also be noted that no reserve has been provided to account for variability in CICC friction factors and eddy current heating of the cases.

5. CONCLUSIONS

Steady-state thermal-hydraulic computer simulations of the NbTi outer ring coils in the TPX Tokamak were conducted to analyze cooling design feasibility. Based on the results of this analysis, the following conclusions are reached:

- PF6 Coils -The cooling design of the baseline PF6 configuration is adequate for dissipating steady-state thermal loads during Tokamak operation. Calculations indicate the temperature margin requirement is exceeded by at least 0.25K while the temperature headroom requirement is exceeded by 0.08K. Predicted energy margin exceeds the requirement by roughly 50 mJ/cc^3. From a thermal-hydraulics perspective, the design satisfies the design criteria of temperature margin, temperature headroom, and energy margin.
- PF7 Coils - The cooling design of the baseline PF7 configuration is inadequate for dissipating steady-state thermal loads during Tokamak operation. Specifically, the predicted design temperature margin is less than required (i.e., 0.11K to 0.72K versus 1K). From a thermal-hydraulics perspective, the need for modifications is indicated to satisfy the design criteria.
- Baseline Modifications - Shielding the PF7 winding pack with a ventilated external case structure is an effective design solution. Computer simulation results indicate winding pack neutron heating load decreases sufficiently so that temperature margin, temperature headroom, and energy margin criteria can be satisfied. However, total system refrigeration burden increases by nearly 160 Watts. A single pancake flow configuration for only the worst case double-pancake also offers much promise, but a more rigorous analysis, than that which was not possible during the performance of this work, would be beneficial to establish feasibility of this option in a definitive manner.
- Coolant Flow Budget - Preliminary estimates of helium mass flow rates for PF6U/L and PF7U/L indicate a *lower bound* of 160 g/s. This value significantly exceeds previous estimates, suggesting a need for additional refrigeration capacity. The associated design caveats are all PF6 and PF7 coils are contained by a case, coil effluent is used to cool the case, coil inlet pressure is 7 atm, and coil outlet pressure is in the 0.3 to 0.35 MPa range.

6. RECOMMENDATIONS

The following steady-state analyses should be undertaken to leverage the next phase of the coil design effort:

- Since an external case is mandated by structural considerations, a neutron transport analysis is needed to predict a detailed heating distribution which includes the case and accounts for the ground wall insulation wrap. Coordination of this effort with design analysts at Westinghouse would be beneficial in terms of formatting data input to thermal-hydraulics analyses. The present WETMAP computer models of PF6 and PF7 would require modification to self-consistently calculate heat conduction coupling between the coil thermal response and the case temperature distribution, including multiple double-pancakes.
- Further optimization could be performed to identify approaches for reducing/refining the required flow capacity estimate. This study would be leveraged by WETMAP simulations to investigate case cooling options and hydraulic circuit changes for optimal flow redistribution.
- Sensitivity studies should be performed to assess the adverse effects of variability in CICC friction factors and Cu:SC ratio upon pressure drop and mass flow capacity requirements.

7. REFERENCES

[1] PF Magnet System Specification, TPX-SPEC-14-0001, Revision 1.

[2] "TPX Structural and Cryogenic Design Criteria", TPX Document 94-950117-PPPL-IZutz-01, January 17, 1995.

[3] R. D. Pillsbury, Jr., "Conductor Specifications for the Poloidal Field Coil System for TPX", TPX Memorandum 14-941107-MIT-RPillsbury-01, November 11, 1994.

[4] B. Felker, "Cryogenic Helium System Design and Schematic", CRYO FLOW SHEET 7, TPX Memorandum 72-950426-LLNL-BFelker-01, April 26, 1995.

[5] J. R. Hale, "Self-Consistent Calculation of Tc for NbTi in CICC Design Spreadsheet", TPX Memorandum 1314-931209-MIT/JRHale-01, December 9, 1993.

[6] P. W. Wang, "TPX PF ring coil steady-state heat removal", TPX Memorandum 14-940713-MIT/PWang-01, July 13, 1994.

[7] S. L. Liew, "Preliminary Estimates of Nuclear Heating Rates in TPX Outer PF Coils", TPX Memorandum 14-940512-PPPL/SLiew-01, May 12, 1994.

[8] S. L. Liew, "Nuclear Heating Rates in Outer PF Coils with Shielded Pumping Ducts", TPX Memorandum 94-941128-PPPL/Sliew-01, November 28, 1994.

[9] D. R. Potter, "Nuclear Heat Rate assumptions for analysis of PF coils for PDR", TPX Memorandum 14-950403-WEC-DPotter-01, Revision A, April 12, 1995.

[10] B. Felker briefing, "MLI Issues for TPX", presented at Engineering Meeting, PPPL, November 1, 1994.

[11] B. R. Smith, "TPX Primary Interface Control Document - Toroidal Field Magnet System (WBS 13) to Poloidal Field Magnet System (WBS 14)", TPX-ICDP-1314-0001, Revision 1, May 1, 1995.

[12] R. D. Pillsbury, Jr., "PF6 and PF7 Conductor Selection", TPX Memorandum 14-950607-MIT-RPillsbury-01, June 7, 1995.

[13] Ekin, J.W., "Fatigue and Stress Effects in NbTi and Nb3Sn Multifilamentary Superconductors", Adv, Cryo. Eng., Vol. 24, pg. 306, Plenum Press, New York, 1978.

[14] Northrop-Grumman presentation at 5th TPX Technology Interchange Meeting, by Swarn Kalsi, 4/27/95.

[15] R. L. Wong, et. al., "Thermo-Hydraulic Analysis of Superconducting Toroidal-Field Magnets for the Tokamak Physics Experiment", presented at CEWC-93, July 1993, LLNL Preprint UCRL-JC-112762.

[16] W. M. Kays, Convective Heat and Mass Transfer, McGraw-Hill, San Francisco, CA (1966), pg 117.

[17] W. E. Ranz and W. R. Marshall, Jr., Chem. Eng. Prog. 48:141-146,173-180, 1952.

[18] D. S. Slack, "TPX Helium Heat Load", TPX Memo 72-940901-LLNL/DSlack-01, September 6, 1994.

[19] D. Natelson, T. Kupiszewski, O. R. Christianson, "A Thermal-Hydraulic Steady-State Model of the ITER Central Solenoid", STC Memorandum 92-1TM4-ADEMS-M1, Westinghouse Electric Corp. Science & Technology Center, August 12, 1992.

[20] D. Natelson, T. Kupiszewski, O. R. Christianson, "A Thermal-Hydraulic Steady-State Model of the TPX Toroidal Field Coils", STC Report 93-1TM4-ADEMS-R1, Westinghouse Electric Corp. Science & Technology Center, August 27, 1993.

[21] V. Arp, "Forced Flow, Single Phase Helium Cooling Systems", Adv. Cryog. Eng. Vol. 17, pg 342, 1972.

[22] S. W. Van Sciver, Helium Cryogenics, pg 248, Plenum Press, 1986.

[23] R. L. Wong, "Program CICC, Flow and Heat Transfer in Cable-In-Conduit Conductors--Equations & Verification, LLNL Report UCID-21733, May 22, 1989.

[24] R. J. Hooper, "Friction Factor Correlations for Cable-In-Conduit Conductors", ORNL memorandum FEDC-M-84-E/M-016, Fusion Engineering Design Center, Oak Ridge National Laboratory, March 5, 1984.

[25] J. W. Lue, J. R. Miller, J. C. Lottin, "Pressure Drop Measurement on Forced Flow Cable Conductors", IEEE Transactions on Magnetics, Vol. mag-15, no. 1, January, 1979, pgs. 53-55.

[26] P. J. Giarratano, R. C. Hess, M. C. Jones, "Forced Convection Heat Transfer to Supercritical Helium", Cryogenics, 11, pgs. 385-393 (1971).

[27] J. P. Holman, Heat Transfer, 5th edition, pg 449, McGraw-Hill, Inc., 1981.

[28] S. K. Singh Briefing, "Thermal Analysis" presented at the 4th Magnet Systems Interchange Meeting, March 2, 1995.

[29] J. W. Dean, W. Stewart, and J. K. Hoffer, "Temperature Profiles in a Long Gaseous-Helium-Cooled Tube", *Adv. Cryo. Eng.*, 23:250, 1978.

[30] A. Shajii, "QUENCHER (v1.0) User's Manual", Plasma Fusion Center Report PFC/RR-94-9, MIT, September, 1994.

[31] O. R. Christianson, "Verification of MIT Margin Calculation for PF1-5", TPX Memo 14-950731-WEC-OChristianson-01, July 31, 1995.

[32] R. L. Wong, "Thermo-Hydraulic Analysis of Superconducting Toroidal-Field Magnets for the Tokamak Physics Experiment", *Adv. Cryo. Eng.*, 39:1715-1722, 1994.

[33] P. W. Wang, "TPX PF Ring Coil Steady-State Heat Removal", TPX Memo 14-940713 - MIT/PWang-01, July 13, 1994.

[34] T. Kupiszewski, "Insulation Thermal Conductivity Values", TPX Memo 14-950418-WEC-TKupiszewski-01, April 18, 1995.

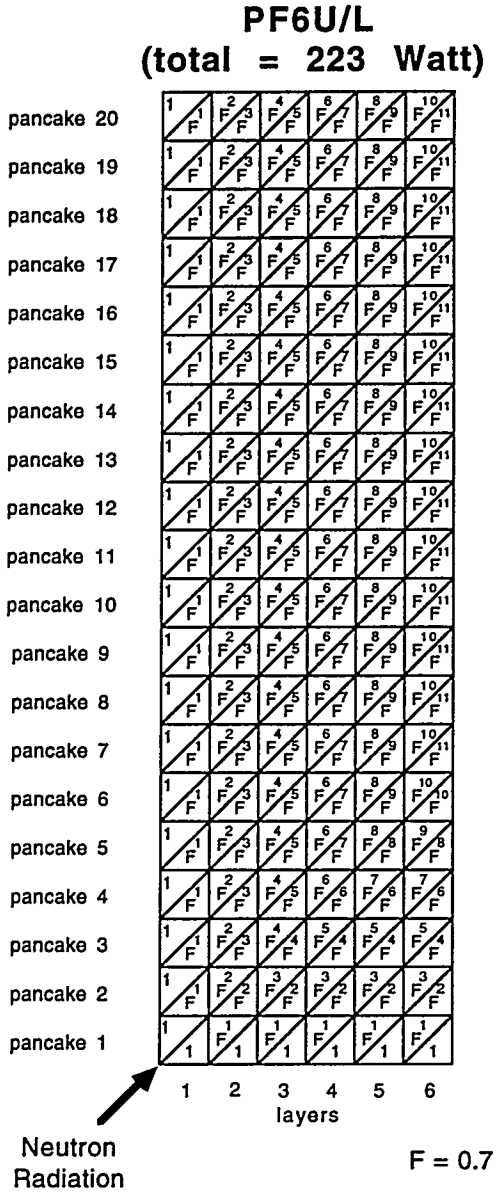
[35] R. F. Barron, Cryogenic Systems, 2nd ed., Oxford University Press, NY, 1985.

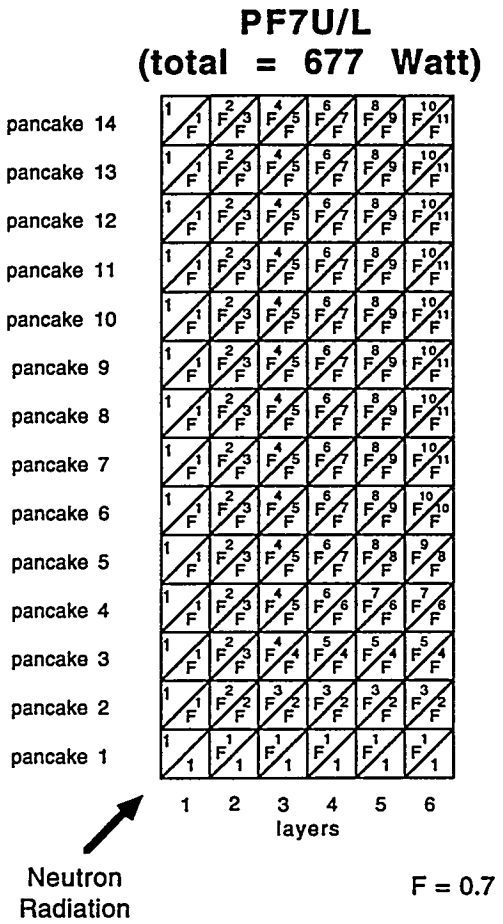
[36] B. Felker, "Lower output pressure to 2.5 atm and adjust Helium flows for 5e16 N/s pulsed operation", TPX Memorandum 72-950510-LLNL-BFelker-01, May 10, 1995.

APPENDIX A

Winding Pack Nuclear Heat Distributions

Nuclear Heat Distribution without Case (fluence = 7.5e16 DD n/s)





nuclear heating												
(fractions of max value)												
			layer	layer	layer	layer	layer	layer		fraction subtotals		
F=	0.7		1	2	3	4	5	6				
pancake	1		1	0.85	0.85	0.85	0.85	0.85			5.25	
pancake	2		0.85	0.49	0.4165	0.417	0.417	0.417			3.006	
pancake	3		0.85	0.4165	0.2401	0.204	0.204	0.204			2.119	
pancake	4		0.85	0.4165	0.2041	0.118	0.1	0.1			1.788	
pancake	5		0.85	0.4165	0.2041	0.1	0.058	0.049			1.677	
pancake	6		0.85	0.4165	0.2041	0.1	0.049	0.028			1.648	
pancake	7		0.85	0.4165	0.2041	0.1	0.049	0.024			1.644	
pancake	8		0.85	0.4165	0.2041	0.1	0.049	0.024			1.644	
pancake	9		0.85	0.4165	0.2041	0.1	0.049	0.024			1.644	
pancake	10		0.85	0.4165	0.2041	0.1	0.049	0.024			1.644	
pancake	11		0.85	0.4165	0.2041	0.1	0.049	0.024			1.644	
pancake	12		0.85	0.4165	0.2041	0.1	0.049	0.024			1.644	
pancake	13		0.85	0.4165	0.2041	0.1	0.049	0.024			1.644	
pancake	14		0.85	0.4165	0.2041	0.1	0.049	0.024			1.644	
pancake	15		0.85	0.4165	0.2041	0.1	0.049	0.024			1.644	
pancake	16		0.85	0.4165	0.2041	0.1	0.049	0.024			1.644	
pancake	17		0.85	0.4165	0.2041	0.1	0.049	0.024			1.644	
pancake	18		0.85	0.4165	0.2041	0.1	0.049	0.024			1.644	
pancake	19		0.85	0.4165	0.2041	0.1	0.049	0.024			1.644	
pancake	20		0.85	0.4165	0.2041	0.1	0.049	0.024			1.644	
								fraction total =			38.5	
nuclear heating												
values [Watt]												
			layer	layer	layer	layer	layer	layer			totals	
F=	0.7		1	2	3	4	5	6			(coils)	
pancake	1		2.896	2.4617	2.4617	2.462	2.462	2.462			15.205	
pancake	2		2.462	1.4191	1.2062	1.206	1.206	1.206			8.706	
pancake	3		2.462	1.2062	0.6954	0.591	0.591	0.591			6.136	
pancake	4		2.462	1.2062	0.5911	0.341	0.29	0.29			5.179	
pancake	5		2.462	1.2062	0.5911	0.29	0.167	0.142			4.857	
pancake	6		2.462	1.2062	0.5911	0.29	0.142	0.082			4.772	
pancake	7		2.462	1.2062	0.5911	0.29	0.142	0.07			4.76	
pancake	8		2.462	1.2062	0.5911	0.29	0.142	0.07			4.76	
pancake	9		2.462	1.2062	0.5911	0.29	0.142	0.07			4.76	
pancake	10		2.462	1.2062	0.5911	0.29	0.142	0.07			4.76	
pancake	11		2.462	1.2062	0.5911	0.29	0.142	0.07			4.76	
pancake	12		2.462	1.2062	0.5911	0.29	0.142	0.07			4.76	
pancake	13		2.462	1.2062	0.5911	0.29	0.142	0.07			4.76	
pancake	14		2.462	1.2062	0.5911	0.29	0.142	0.07			4.76	
pancake	15		2.462	1.2062	0.5911	0.29	0.142	0.07			4.76	
pancake	16		2.462	1.2062	0.5911	0.29	0.142	0.07			4.76	
pancake	17		2.462	1.2062	0.5911	0.29	0.142	0.07			4.76	
pancake	18		2.462	1.2062	0.5911	0.29	0.142	0.07			4.76	
pancake	19		2.462	1.2062	0.5911	0.29	0.142	0.07			4.76	
pancake	20		2.462	1.2062	0.5911	0.29	0.142	0.07			4.76	
							total nuclear heat [W] =				111.5	

interface heat flow (TF_to_PF + cryostat heat leak)											
values [Watt]											
			layer	layer	layer	layer	layer	layer			totals
F=	0.7		1	2	3	4	5	6			(interface)
pancake	1		0.505	0.3359	0.3359	0.336	0.336	0.505			2.35385
pancake	2		0.169	0	0	0	0	0.169			0.33846
pancake	3		0.169	0	0	0	0	0.169			0.33846
pancake	4		0.169	0	0	0	0	0.169			0.33846
pancake	5		0.169	0	0	0	0	0.169			0.33846
pancake	6		0.169	0	0	0	0	0.169			0.33846
pancake	7		0.169	0	0	0	0	0.169			0.33846
pancake	8		0.169	0	0	0	0	0.169			0.33846
pancake	9		0.169	0	0	0	0	0.169			0.33846
pancake	10		0.169	0	0	0	0	0.169			0.33846
pancake	11		0.169	0	0	0	0	0.169			0.33846
pancake	12		0.169	0	0	0	0	0.169			0.33846
pancake	13		0.169	0	0	0	0	0.169			0.33846
pancake	14		0.169	0	0	0	0	0.169			0.33846
pancake	15		0.169	0	0	0	0	0.169			0.33846
pancake	16		0.169	0	0	0	0	0.169			0.33846
pancake	17		0.169	0	0	0	0	0.169			0.33846
pancake	18		0.169	0	0	0	0	0.169			0.33846
pancake	19		0.169	0	0	0	0	0.169			0.33846
pancake	20		0.505	0.3359	0.3359	0.336	0.336	0.505			2.35385
							tot. interface heat[W] =				10.8
total heat input (nuclear + interface)											
values [Watt]											
			layer	layer	layer	layer	layer	layer			totals
F=	0.7		1	2	3	4	5	6			(coils)
											0
pancake	1		3.401	2.7976	2.7976	2.798	2.798	2.967			17.558
pancake	2		2.631	1.4191	1.2062	1.206	1.206	1.375			9.044
pancake	3		2.631	1.2062	0.6954	0.591	0.591	0.76			6.475
pancake	4		2.631	1.2062	0.5911	0.341	0.29	0.459			5.517
pancake	5		2.631	1.2062	0.5911	0.29	0.167	0.311			5.196
pancake	6		2.631	1.2062	0.5911	0.29	0.142	0.251			5.111
pancake	7		2.631	1.2062	0.5911	0.29	0.142	0.239			5.098
pancake	8		2.631	1.2062	0.5911	0.29	0.142	0.239			5.098
pancake	9		2.631	1.2062	0.5911	0.29	0.142	0.239			5.098
pancake	10		2.631	1.2062	0.5911	0.29	0.142	0.239			5.098
pancake	11		2.631	1.2062	0.5911	0.29	0.142	0.239			5.098
pancake	12		2.631	1.2062	0.5911	0.29	0.142	0.239			5.098
pancake	13		2.631	1.2062	0.5911	0.29	0.142	0.239			5.098
pancake	14		2.631	1.2062	0.5911	0.29	0.142	0.239			5.098
pancake	15		2.631	1.2062	0.5911	0.29	0.142	0.239			5.098
pancake	16		2.631	1.2062	0.5911	0.29	0.142	0.239			5.098
pancake	17		2.631	1.2062	0.5911	0.29	0.142	0.239			5.098
pancake	18		2.631	1.2062	0.5911	0.29	0.142	0.239			5.098
pancake	19		2.631	1.2062	0.5911	0.29	0.142	0.239			5.098
pancake	20		2.967	1.5421	0.9269	0.626	0.478	0.575			7.114
							total input heat[W] =				122.3

WETMAP PF6 Heating Profile Function											
values (fraction of average dbl. pancake coil heat input per turn)											
			layer	layer	layer	layer	layer	layer		heating totals [W]	
F=	0.7		1	2	3	4	5	6		(dbl. pancake coils)	
pancake	1		1.534	1.262	1.262	1.262	1.262	1.338		26.602	
pancake	2		1.187	0.6401	0.5441	0.544	0.544	0.62			
pancake	3		2.633	1.207	0.6958	0.591	0.591	0.761		11.992	
pancake	4		2.633	1.207	0.5914	0.341	0.29	0.459			
pancake	5		3.063	1.4044	0.6881	0.337	0.194	0.362		10.307	
pancake	6		3.063	1.4044	0.6881	0.337	0.165	0.292			
pancake	7		3.096	1.4196	0.6956	0.341	0.167	0.281		10.196	
pancake	8		3.096	1.4196	0.6956	0.341	0.167	0.281			
pancake	9		3.096	1.4196	0.6956	0.341	0.167	0.281		10.196	
pancake	10		3.096	1.4196	0.6956	0.341	0.167	0.281			
pancake	11		3.096	1.4196	0.6956	0.341	0.167	0.281		10.196	
pancake	12		3.096	1.4196	0.6956	0.341	0.167	0.281			
pancake	13		3.096	1.4196	0.6956	0.341	0.167	0.281		10.196	
pancake	14		3.096	1.4196	0.6956	0.341	0.167	0.281			
pancake	15		3.096	1.4196	0.6956	0.341	0.167	0.281		10.196	
pancake	16		3.096	1.4196	0.6956	0.341	0.167	0.281			
pancake	17		3.096	1.4196	0.6956	0.341	0.167	0.281		10.196	
pancake	18		3.096	1.4196	0.6956	0.341	0.167	0.281			
pancake	19		2.585	1.1853	0.5808	0.285	0.139	0.235		12.212	
pancake	20		2.915	1.5154	0.9109	0.615	0.47	0.565			
							tot. coil heat[W] =			122.3	

nuclear heating									
(fractions of max value)									
		layer	layer	layer	layer	layer	layer		fraction subtotals
F=	0.7	1	2	3	4	5	6		
pancake	1	1	0.85	0.85	0.85	0.85	0.85		5.25
pancake	2	0.85	0.49	0.4165	0.417	0.417	0.417		3.006
pancake	3	0.85	0.4165	0.2401	0.204	0.204	0.204		2.119
pancake	4	0.85	0.4165	0.2041	0.118	0.1	0.1		1.788
pancake	5	0.85	0.4165	0.2041	0.1	0.058	0.049		1.677
pancake	6	0.85	0.4165	0.2041	0.1	0.049	0.028		1.648
pancake	7	0.85	0.4165	0.2041	0.1	0.049	0.024		1.644
pancake	8	0.85	0.4165	0.2041	0.1	0.049	0.024		1.644
pancake	9	0.85	0.4165	0.2041	0.1	0.049	0.024		1.644
pancake	10	0.85	0.4165	0.2041	0.1	0.049	0.024		1.644
pancake	11	0.85	0.4165	0.2041	0.1	0.049	0.024		1.644
pancake	12	0.85	0.4165	0.2041	0.1	0.049	0.024		1.644
pancake	13	0.85	0.4165	0.2041	0.1	0.049	0.024		1.644
pancake	14	0.85	0.4165	0.2041	0.1	0.049	0.024		1.644
							fraction total		28.64
nuclear heating									
values [Watt]									
		layer	layer	layer	layer	layer	layer		totals
F=	0.7	1	2	3	4	5	6		(coils)
pancake	1	11.82	10.046	10.046	10.05	10.05	10.05		62.05
pancake	2	10.05	5.7914	4.9227	4.923	4.923	4.923		35.528
pancake	3	10.05	4.9227	2.8378	2.412	2.412	2.412		25.043
pancake	4	10.05	4.9227	2.4121	1.391	1.182	1.182		21.135
pancake	5	10.05	4.9227	2.4121	1.182	0.681	0.579		19.823
pancake	6	10.05	4.9227	2.4121	1.182	0.579	0.334		19.476
pancake	7	10.05	4.9227	2.4121	1.182	0.579	0.284		19.426
pancake	8	10.05	4.9227	2.4121	1.182	0.579	0.284		19.426
pancake	9	10.05	4.9227	2.4121	1.182	0.579	0.284		19.426
pancake	10	10.05	4.9227	2.4121	1.182	0.579	0.284		19.426
pancake	11	10.05	4.9227	2.4121	1.182	0.579	0.284		19.426
pancake	12	10.05	4.9227	2.4121	1.182	0.579	0.284		19.426
pancake	13	10.05	4.9227	2.4121	1.182	0.579	0.284		19.426
pancake	14	10.05	4.9227	2.4121	1.182	0.579	0.284		19.426
						total nuclear heat [W] =			338.46

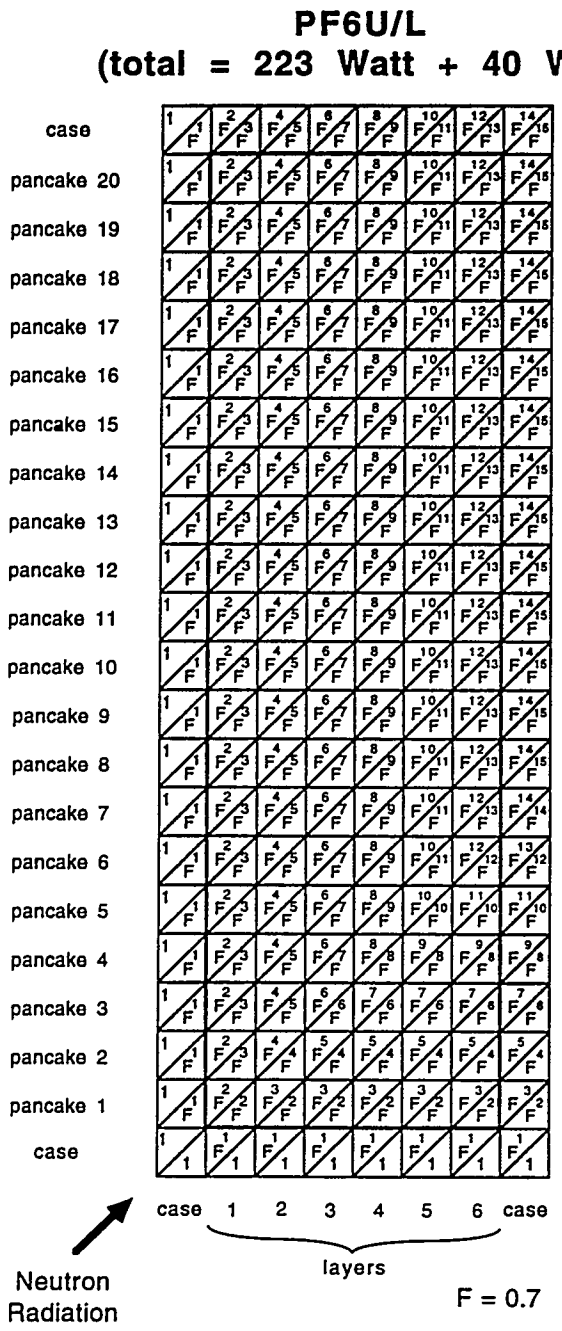
interface heat flow (TF_to_PF + cryostat heat leak)											
values [Watt]											
			layer	layer	layer	layer	layer	layer			totals
F=	0.7		1	2	3	4	5	6			(interface)
pancake	1		0.367	0.3667	0.3667	0.367	0.367	0.567			2.4
pancake	2		0	0	0	0	0	0.2			0.2
pancake	3		0	0	0	0	0	0.2			0.2
pancake	4		0	0	0	0	0	0.2			0.2
pancake	5		0	0	0	0	0	0.2			0.2
pancake	6		0	0	0	0	0	0.2			0.2
pancake	7		0	0	0	0	0	0.2			0.2
pancake	8		0	0	0	0	0	0.2			0.2
pancake	9		0	0	0	0	0	0.2			0.2
pancake	10		0	0	0	0	0	0.2			0.2
pancake	11		0	0	0	0	0	0.2			0.2
pancake	12		0	0	0	0	0	0.2			0.2
pancake	13		0	0	0	0	0	0.2			0.2
pancake	14		0.367	0.3667	0.3667	0.367	0.367	0.567			2.4
							tot. interface heat[W] =				7.2
total heat input (nuclear + interface)											
values [Watt]											
			layer	layer	layer	layer	layer	layer			totals
F=	0.7		1	2	3	4	5	6			(coils)
											0
pancake	1		12.19	10.413	10.413	10.41	10.41	10.61			64.45
pancake	2		10.05	5.7914	4.9227	4.923	4.923	5.123			35.728
pancake	3		10.05	4.9227	2.8378	2.412	2.412	2.612			25.243
pancake	4		10.05	4.9227	2.4121	1.391	1.182	1.382			21.335
pancake	5		10.05	4.9227	2.4121	1.182	0.681	0.779			20.023
pancake	6		10.05	4.9227	2.4121	1.182	0.579	0.534			19.676
pancake	7		10.05	4.9227	2.4121	1.182	0.579	0.484			19.626
pancake	8		10.05	4.9227	2.4121	1.182	0.579	0.484			19.626
pancake	9		10.05	4.9227	2.4121	1.182	0.579	0.484			19.626
pancake	10		10.05	4.9227	2.4121	1.182	0.579	0.484			19.626
pancake	11		10.05	4.9227	2.4121	1.182	0.579	0.484			19.626
pancake	12		10.05	4.9227	2.4121	1.182	0.579	0.484			19.626
pancake	13		10.05	4.9227	2.4121	1.182	0.579	0.484			19.626
pancake	14		10.41	5.2893	2.7788	1.549	0.946	0.85			21.826
							total input heat[W] =				345.7

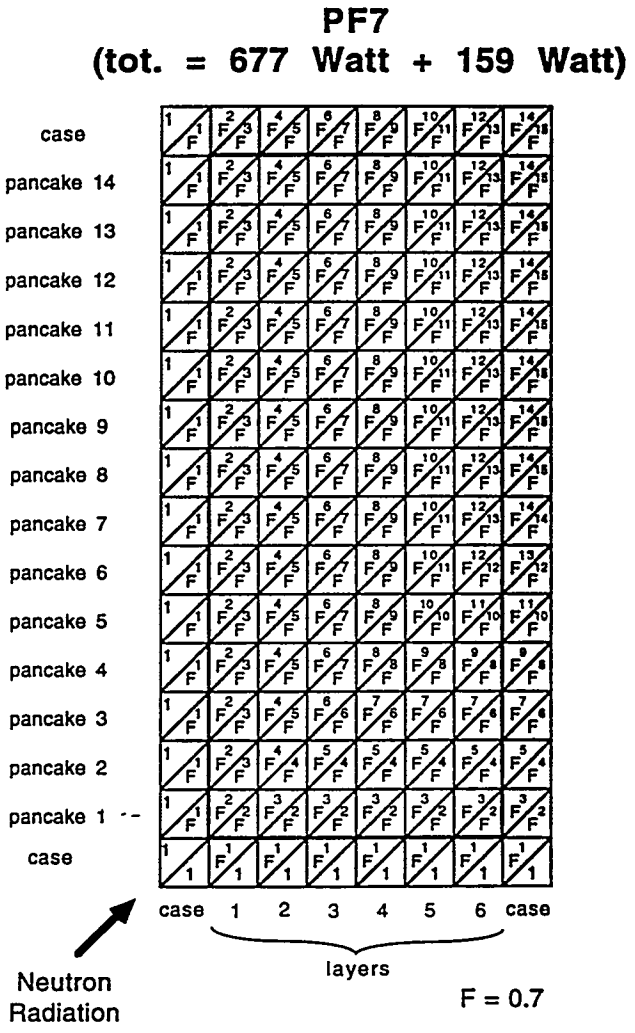
WETMAP PF7 Heating Profile Function											
values (fraction of average dbl. pancake coil heat input per turn)											
			layer	layer	layer	layer	layer	layer		heating totals [W]	
F=	0.7		1	2	3	4	5	6		(dbl. pancake coils)	
pancake	1		1.46	1.2473	1.2473	1.247	1.247	1.271		100.178	
pancake	2		1.203	0.6937	0.5897	0.59	0.59	0.614			
pancake	3		2.588	1.2682	0.7311	0.621	0.621	0.673		46.578	
pancake	4		2.588	1.2682	0.6214	0.358	0.305	0.356			
pancake	5		3.037	1.488	0.7291	0.357	0.206	0.236		39.699	
pancake	6		3.037	1.488	0.7291	0.357	0.175	0.161			
pancake	7		3.071	1.5049	0.7374	0.361	0.177	0.148		39.252	
pancake	8		3.071	1.5049	0.7374	0.361	0.177	0.148			
pancake	9		3.071	1.5049	0.7374	0.361	0.177	0.148		39.252	
pancake	10		3.071	1.5049	0.7374	0.361	0.177	0.148			
pancake	11		3.071	1.5049	0.7374	0.361	0.177	0.148		39.252	
pancake	12		3.071	1.5049	0.7374	0.361	0.177	0.148			
pancake	13		2.908	1.4251	0.6983	0.342	0.168	0.14		41.452	
pancake	14		3.014	1.5312	0.8044	0.448	0.274	0.246			
							tot. coil heat[W] =			345.7	

APPENDIX B

Nuclear Heat Distributions With External Case

Nuclear Heat Distribution with External Case (fluence = 7.5e16 DD n/s)





nuclear heating												
(fractions of max value)												
		case	layer	layer	layer	layer	layer	layer	case		fraction subtotals	
F=	0.7		1	2	3	4	5	6			(partial case)	
case		1	0.85	0.85	0.85	0.85	0.85	0.85	0.85		6.95	
pancake	1	0.85	0.49	0.4165	0.4165	0.417	0.417	0.417	0.417		3.839	
pancake	2	0.85	0.417	0.2401	0.2041	0.204	0.204	0.204	0.204		2.527	
pancake	3	0.85	0.417	0.2041	0.1176	0.1	0.1	0.1	0.1		1.988	
pancake	4	0.85	0.417	0.2041	0.1	0.058	0.049	0.049	0.049		1.775	
pancake	5	0.85	0.417	0.2041	0.1	0.049	0.028	0.024	0.024		1.696	
pancake	6	0.85	0.417	0.2041	0.1	0.049	0.024	0.014	0.012		1.669	
pancake	7	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.007		1.662	
pancake	8	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	9	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	10	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	11	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	12	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	13	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	14	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	15	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	16	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	17	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	18	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	19	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	20	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
case		0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
								fraction total :			45.36	
nuclear heating												
values [Watt]												
		case	layer	layer	layer	layer	layer	layer	case		totals	totals
F=	0.7		1	2	3	4	5	6			(w/case)	(coils)
case		2.9	2.464	2.4642	2.4642	2.464	2.464	2.464	2.464		20.148	
pancake	1	2.46	1.421	1.2074	1.2074	1.207	1.207	1.207	1.207		11.129	7.46
pancake	2	2.46	1.207	0.6961	0.5916	0.592	0.592	0.592	0.592		7.326	4.27
pancake	3	2.46	1.207	0.5916	0.3411	0.29	0.29	0.29	0.29		5.764	3.01
pancake	4	2.46	1.207	0.5916	0.2899	0.167	0.142	0.142	0.142		5.146	2.54
pancake	5	2.46	1.207	0.5916	0.2899	0.142	0.082	0.07	0.07		4.916	2.38
pancake	6	2.46	1.207	0.5916	0.2899	0.142	0.07	0.04	0.034		4.839	2.34
pancake	7	2.46	1.207	0.5916	0.2899	0.142	0.07	0.034	0.02		4.819	2.33
pancake	8	2.46	1.207	0.5916	0.2899	0.142	0.07	0.034	0.017		4.816	2.33
pancake	9	2.46	1.207	0.5916	0.2899	0.142	0.07	0.034	0.017		4.816	2.33
pancake	10	2.46	1.207	0.5916	0.2899	0.142	0.07	0.034	0.017		4.816	2.33
pancake	11	2.46	1.207	0.5916	0.2899	0.142	0.07	0.034	0.017		4.816	2.33
pancake	12	2.46	1.207	0.5916	0.2899	0.142	0.07	0.034	0.017		4.816	2.33
pancake	13	2.46	1.207	0.5916	0.2899	0.142	0.07	0.034	0.017		4.816	2.33
pancake	14	2.46	1.207	0.5916	0.2899	0.142	0.07	0.034	0.017		4.816	2.33
pancake	15	2.46	1.207	0.5916	0.2899	0.142	0.07	0.034	0.017		4.816	2.33
pancake	16	2.46	1.207	0.5916	0.2899	0.142	0.07	0.034	0.017		4.816	2.33
pancake	17	2.46	1.207	0.5916	0.2899	0.142	0.07	0.034	0.017		4.816	2.33
pancake	18	2.46	1.207	0.5916	0.2899	0.142	0.07	0.034	0.017		4.816	2.33
pancake	19	2.46	1.207	0.5916	0.2899	0.142	0.07	0.034	0.017		4.816	2.33
pancake	20	2.46	1.207	0.5916	0.2899	0.142	0.07	0.034	0.017		4.816	2.33
case		2.46	1.207	0.5916	0.2899	0.142	0.07	0.034	0.017		4.816	
							total nuclear heat [W] =				131.5	54.6

interface heat flow (TF_to_PF + cryostat heat leak)												
values [Watt]												
		case	layer	layer	layer	layer	layer	layer	case		totals	totals
F=	0.7		1	2	3	4	5	6			(w/case)	(coils)
case		0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18		1.44	
pancake	1	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	2	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	3	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	4	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	5	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	6	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	7	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	8	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	9	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	10	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	11	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	12	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	13	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	14	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	15	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	16	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	17	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	18	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	19	0.18	0	0	0	0	0	0	0.18		0.36	0
pancake	20	0.18	0	0	0	0	0	0	0.18		0.36	0
case		0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18		1.44	
							tot. interface heat[W] =				10.1	0
total heat input (nuclear + interface)												
values [Watt]												
		case	layer	layer	layer	layer	layer	layer	case		totals	totals
F=	0.7		1	2	3	4	5	6			(w/case)	(coils)
case		3.08	2.644	2.6442	2.6442	2.644	2.644	2.644	2.644		21.588	
pancake	1	2.64	1.421	1.2074	1.2074	1.207	1.207	1.207	1.387		11.489	7.458
pancake	2	2.64	1.207	0.6961	0.5916	0.592	0.592	0.592	0.772		7.686	4.27
pancake	3	2.64	1.207	0.5916	0.3411	0.29	0.29	0.29	0.47		6.124	3.01
pancake	4	2.64	1.207	0.5916	0.2899	0.167	0.142	0.142	0.322		5.506	2.54
pancake	5	2.64	1.207	0.5916	0.2899	0.142	0.082	0.07	0.25		5.276	2.383
pancake	6	2.64	1.207	0.5916	0.2899	0.142	0.07	0.04	0.214		5.199	2.341
pancake	7	2.64	1.207	0.5916	0.2899	0.142	0.07	0.034	0.2		5.179	2.335
pancake	8	2.64	1.207	0.5916	0.2899	0.142	0.07	0.034	0.197		5.176	2.335
pancake	9	2.64	1.207	0.5916	0.2899	0.142	0.07	0.034	0.197		5.176	2.335
pancake	10	2.64	1.207	0.5916	0.2899	0.142	0.07	0.034	0.197		5.176	2.335
pancake	11	2.64	1.207	0.5916	0.2899	0.142	0.07	0.034	0.197		5.176	2.335
pancake	12	2.64	1.207	0.5916	0.2899	0.142	0.07	0.034	0.197		5.176	2.335
pancake	13	2.64	1.207	0.5916	0.2899	0.142	0.07	0.034	0.197		5.176	2.335
pancake	14	2.64	1.207	0.5916	0.2899	0.142	0.07	0.034	0.197		5.176	2.335
pancake	15	2.64	1.207	0.5916	0.2899	0.142	0.07	0.034	0.197		5.176	2.335
pancake	16	2.64	1.207	0.5916	0.2899	0.142	0.07	0.034	0.197		5.176	2.335
pancake	17	2.64	1.207	0.5916	0.2899	0.142	0.07	0.034	0.197		5.176	2.335
pancake	18	2.64	1.207	0.5916	0.2899	0.142	0.07	0.034	0.197		5.176	2.335
pancake	19	2.64	1.207	0.5916	0.2899	0.142	0.07	0.034	0.197		5.176	2.335
pancake	20	2.64	1.207	0.5916	0.2899	0.142	0.07	0.034	0.197		5.176	2.335
case		2.64	1.387	0.7716	0.4699	0.322	0.25	0.214	0.197		6.256	
							total input heat[W] =				141.6	54.7

WETMAP PF6 Heating Profile Function											
values (fraction of average dbl. pancake coil heat input per turn)											
		case	layer	layer	layer	layer	layer	layer	case	heating totals [W]	
F=	0.7		1	2	3	4	5	6		(dbl. pancake coils)	
case											
pancake	1		1.453	1.2354	1.2354	1.235	1.235	1.235		11.728	
pancake	2		1.235	0.7122	0.6054	0.605	0.605	0.605			
pancake	3		2.611	1.2792	0.7374	0.627	0.627	0.627		5.55	
pancake	4		2.611	1.2792	0.6268	0.361	0.307	0.307			
pancake	5		3.067	1.5029	0.7364	0.361	0.208	0.177		4.724	
pancake	6		3.067	1.5029	0.7364	0.361	0.177	0.102			
pancake	7		3.103	1.5203	0.7449	0.365	0.179	0.088		4.67	
pancake	8		3.103	1.5203	0.7449	0.365	0.179	0.088			
pancake	9		3.103	1.5203	0.7449	0.365	0.179	0.088		4.67	
pancake	10		3.103	1.5203	0.7449	0.365	0.179	0.088			
pancake	11		3.103	1.5203	0.7449	0.365	0.179	0.088		4.67	
pancake	12		3.103	1.5203	0.7449	0.365	0.179	0.088			
pancake	13		3.103	1.5203	0.7449	0.365	0.179	0.088		4.67	
pancake	14		3.103	1.5203	0.7449	0.365	0.179	0.088			
pancake	15		3.103	1.5203	0.7449	0.365	0.179	0.088		4.67	
pancake	16		3.103	1.5203	0.7449	0.365	0.179	0.088			
pancake	17		3.103	1.5203	0.7449	0.365	0.179	0.088		4.67	
pancake	18		3.103	1.5203	0.7449	0.365	0.179	0.088			
pancake	19		3.103	1.5203	0.7449	0.365	0.179	0.088		4.67	
pancake	20		3.103	1.5203	0.7449	0.365	0.179	0.088			
case											
							tot. coil heat[W] =			54.7	

nuclear heating												
(fractions of max value)												
		case	layer	layer	layer	layer	layer	layer	case	fraction subtotals		
F=	0.7		1	2	3	4	5	6		(partial case)		
case		1	0.85	0.85	0.85	0.85	0.85	0.85	0.85		6.95	
pancake	1	0.85	0.49	0.4165	0.4165	0.417	0.417	0.417	0.417		3.839	
pancake	2	0.85	0.417	0.2401	0.2041	0.204	0.204	0.204	0.204		2.527	
pancake	3	0.85	0.417	0.2041	0.1176	0.1	0.1	0.1	0.1		1.988	
pancake	4	0.85	0.417	0.2041	0.1	0.058	0.049	0.049	0.049		1.775	
pancake	5	0.85	0.417	0.2041	0.1	0.049	0.028	0.024	0.024		1.696	
pancake	6	0.85	0.417	0.2041	0.1	0.049	0.024	0.014	0.012		1.669	
pancake	7	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.007		1.662	
pancake	8	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	9	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	10	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	11	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	12	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	13	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
pancake	14	0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
case		0.85	0.417	0.2041	0.1	0.049	0.024	0.012	0.006		1.661	
								fraction total =			35.394	
nuclear heating												
values [Watt]												
		case	layer	layer	layer	layer	layer	layer	case		totals	totals
F=	0.7		1	2	3	4	5	6			(w/case)	(coils)
case		11.81	10.04	10.038	10.038	10.04	10.04	10.04	10.04		82.079	
pancake	1	10.04	5.787	4.9188	4.9188	4.919	4.919	4.919	4.919		45.338	30.381
pancake	2	10.04	4.919	2.8356	2.4102	2.41	2.41	2.41	2.41		29.844	17.395
pancake	3	10.04	4.919	2.4102	1.3894	1.181	1.181	1.181	1.181		23.481	12.262
pancake	4	10.04	4.919	2.4102	1.181	0.681	0.579	0.579	0.579		20.965	10.348
pancake	5	10.04	4.919	2.4102	1.181	0.579	0.334	0.284	0.284		20.028	9.706
pancake	6	10.04	4.919	2.4102	1.181	0.579	0.284	0.163	0.139		19.713	9.536
pancake	7	10.04	4.919	2.4102	1.181	0.579	0.284	0.139	0.08		19.63	9.511
pancake	8	10.04	4.919	2.4102	1.181	0.579	0.284	0.139	0.068		19.618	9.511
pancake	9	10.04	4.919	2.4102	1.181	0.579	0.284	0.139	0.068		19.618	9.511
pancake	10	10.04	4.919	2.4102	1.181	0.579	0.284	0.139	0.068		19.618	9.511
pancake	11	10.04	4.919	2.4102	1.181	0.579	0.284	0.139	0.068		19.618	9.511
pancake	12	10.04	4.919	2.4102	1.181	0.579	0.284	0.139	0.068		19.618	9.511
pancake	13	10.04	4.919	2.4102	1.181	0.579	0.284	0.139	0.068		19.618	9.511
pancake	14	10.04	4.919	2.4102	1.181	0.579	0.284	0.139	0.068		19.618	9.511
case		10.04	4.919	2.4102	1.181	0.579	0.284	0.139	0.068		19.618	
							total nuclear heat [W] =				418	165.7

interface heat flow (TF_to_PF + cryostat heat leak)												
values [Watt]												
		case	layer	layer	layer	layer	layer	layer	case		totals	totals
F=	0.7		1	2	3	4	5	6			(w/case)	(coils)
case		0.202	0.202	0.2018	0.2018	0.202	0.202	0.202	0.202		1.61433	
pancake	1	0.042	0	0	0	0	0	0	0.202		0.24346	0
pancake	2	0.042	0	0	0	0	0	0	0.202		0.24346	0
pancake	3	0.042	0	0	0	0	0	0	0.202		0.24346	0
pancake	4	0.042	0	0	0	0	0	0	0.202		0.24346	0
pancake	5	0.042	0	0	0	0	0	0	0.202		0.24346	0
pancake	6	0.042	0	0	0	0	0	0	0.202		0.24346	0
pancake	7	0.042	0	0	0	0	0	0	0.202		0.24346	0
pancake	8	0.042	0	0	0	0	0	0	0.202		0.24346	0
pancake	9	0.042	0	0	0	0	0	0	0.202		0.24346	0
pancake	10	0.042	0	0	0	0	0	0	0.202		0.24346	0
pancake	11	0.042	0	0	0	0	0	0	0.202		0.24346	0
pancake	12	0.042	0	0	0	0	0	0	0.202		0.24346	0
pancake	13	0.042	0	0	0	0	0	0	0.202		0.24346	0
pancake	14	0.042	0	0	0	0	0	0	0.202		0.24346	0
case		0.202	0.202	0.2018	0.2018	0.202	0.202	0.202	0.202		1.61433	
							tot. interface heat[W] =				**6.6**	**0**

total heat input (nuclear + interface)												
values [Watt]												
		case	layer	layer	layer	layer	layer	layer	case		totals	totals
F=	0.7		1	2	3	4	5	6			(w/case)	(coils)
case		12.01	10.24	10.24	10.24	10.24	10.24	10.24	10.24		83.693	
pancake	1	10.08	5.787	4.9188	4.9188	4.919	4.919	4.919	5.121		45.582	30.381
pancake	2	10.08	4.919	2.8356	2.4102	2.41	2.41	2.41	2.612		30.087	17.395
pancake	3	10.08	4.919	2.4102	1.3894	1.181	1.181	1.181	1.383		23.724	12.262
pancake	4	10.08	4.919	2.4102	1.181	0.681	0.579	0.579	0.78		21.209	10.348
pancake	5	10.08	4.919	2.4102	1.181	0.579	0.334	0.284	0.485		20.271	9.706
pancake	6	10.08	4.919	2.4102	1.181	0.579	0.284	0.163	0.341		19.957	9.536
pancake	7	10.08	4.919	2.4102	1.181	0.579	0.284	0.139	0.282		19.873	9.511
pancake	8	10.08	4.919	2.4102	1.181	0.579	0.284	0.139	0.27		19.861	9.511
pancake	9	10.08	4.919	2.4102	1.181	0.579	0.284	0.139	0.27		19.861	9.511
pancake	10	10.08	4.919	2.4102	1.181	0.579	0.284	0.139	0.27		19.861	9.511
pancake	11	10.08	4.919	2.4102	1.181	0.579	0.284	0.139	0.27		19.861	9.511
pancake	12	10.08	4.919	2.4102	1.181	0.579	0.284	0.139	0.27		19.861	9.511
pancake	13	10.08	4.919	2.4102	1.181	0.579	0.284	0.139	0.27		19.861	9.511
pancake	14	10.08	4.919	2.4102	1.181	0.579	0.284	0.139	0.27		19.861	9.511
case		10.24	5.121	2.612	1.3828	0.78	0.485	0.341	0.27		21.232	
							total input heat[W] =				**424.7**	**165.7**

WETMAP PF7 Heating Profile Function											
values (fraction of average dbl. pancake coil heat input per turn)											
		case	layer	layer	layer	layer	layer	layer	case	heating totals [W]	
F=	0.7		1	2	3	4	5	6		(dbl. pancake coils)	
case											
pancake	1		1.453	1.2355	1.2355	1.235	1.235	1.235		47.776	
pancake	2		1.235	0.7122	0.6054	0.605	0.605	0.605			
pancake	3		2.611	1.2792	0.7374	0.627	0.627	0.627		22.61	
pancake	4		2.611	1.2792	0.6268	0.361	0.307	0.307			
pancake	5		3.068	1.5031	0.7365	0.361	0.208	0.177		19.242	
pancake	6		3.068	1.5031	0.7365	0.361	0.177	0.102			
pancake	7		3.103	1.5205	0.745	0.365	0.179	0.088		19.022	
pancake	8		3.103	1.5205	0.745	0.365	0.179	0.088			
pancake	9		3.103	1.5205	0.745	0.365	0.179	0.088		19.022	
pancake	10		3.103	1.5205	0.745	0.365	0.179	0.088			
pancake	11		3.103	1.5205	0.745	0.365	0.179	0.088		19.022	
pancake	12		3.103	1.5205	0.745	0.365	0.179	0.088			
pancake	13		3.103	1.5205	0.745	0.365	0.179	0.088		19.022	
pancake	14		3.103	1.5205	0.745	0.365	0.179	0.088			
case											
							tot. coil heat[W] =			165.7	

APPENDIX C

Non Nuclear Heat Load Calculations

Westinghouse STC Calculation Sheet

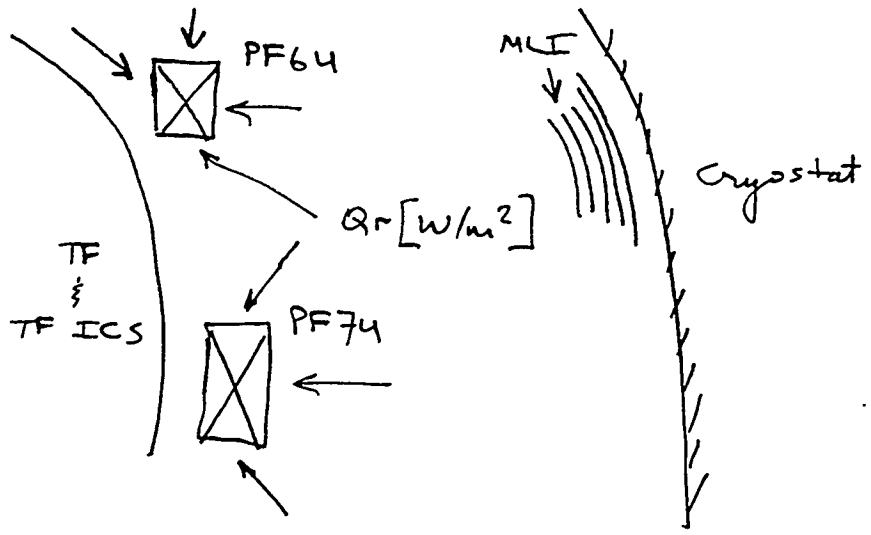
Proprietary Class 2

Title: Non Nuclear Heat Inputs to PF6&7 **Page** 1 **of** 9

Project: TPX PFMTDA **Calculation No.** 1

Author: T. Kupiszewski **Date:** 5/25/95

Thermal Radiation Load



From "MLI Issues for TPX" presented at 11/1/94 Engineering Meeting at PPPL by B. Felker, we have:

Cryostat Heat Leak to Cold Mass = 170 Watt
Total Cold Mass Surface Area = 600 m² } → $Q_r = \frac{170\,W}{600\,m^2}$

$= 0.283$

$\simeq 0.3\ W/m^2$

Westinghouse STC Calculation Sheet

Proprietary Class 2

Title: Non Nuclear Heat Inputs to PF6 & 7 **Page** 2 of 9

Project: TPX PFMTDA **Calculation No.** 1

Author: T. Kupiszewski **Date:** 5/25/95

Assumptions:

1. Q_r is uniform
2. PF 7 surfaces exposed to Q_r are Top, Bottom, & OD.
3. PF6 surfaces exposed to Q_r are Top, Bottom, OD, ID.
4. radiant heat input to PF mount surfaces conducts to winding pack.
5. no heat flow from TF or TF ICS to PF ID surface.

PF coil geometric data (units are m.)

Coil	R_1	R_2	Z_1	Z_2
PF6	3.687	3.83	1.905	2.383
PF7	4.225	4.369	0.946	1.281

Source = 14-940803-MIT/RPillsbury-01.

PF Coil Radiant Surface Areas

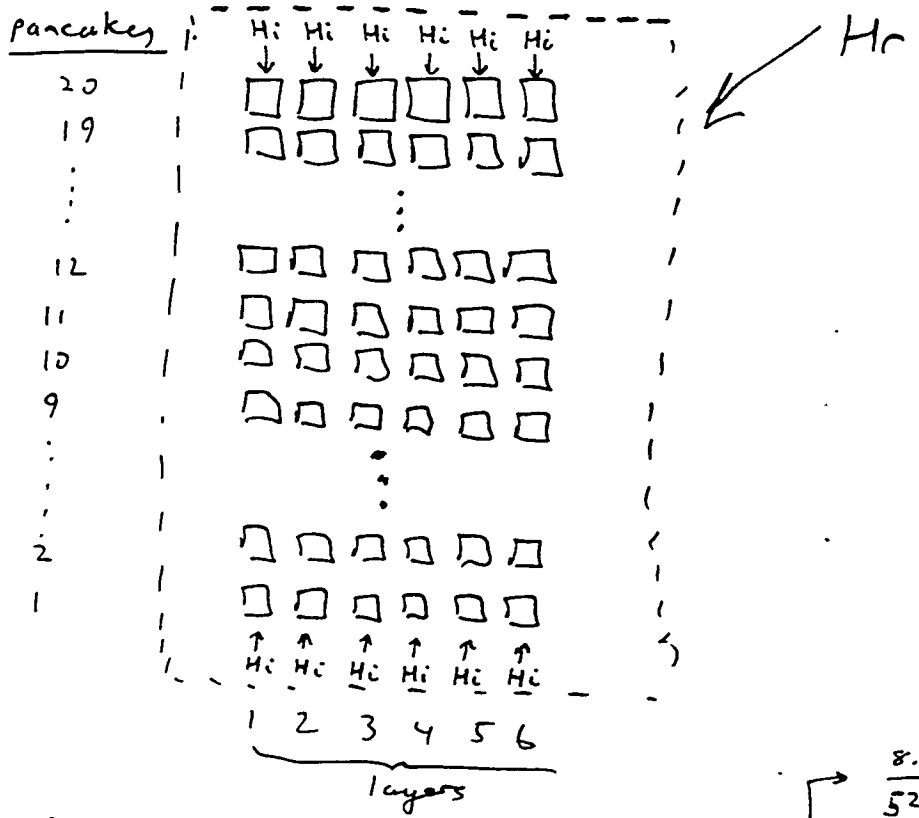
$$S_{PF6} = 2\pi\left(R_{-2}^2 - R_{-1}^2\right) + 2\pi(R_{-1}+R_{-2})(Z_{-2}-Z_{-1})$$

$$= 6.754 + 22.576 = \boxed{29.33\ m^2}$$

$$S_{PF7} = 2\pi\left(R_{-2}^2 - R_{-1}^2\right) + 2\pi R_{-2}(Z_{-2}-Z_{-1})$$

$$= 7.882 + 9.196 = \boxed{17.08\ m^2}$$

PF6 interface heat input



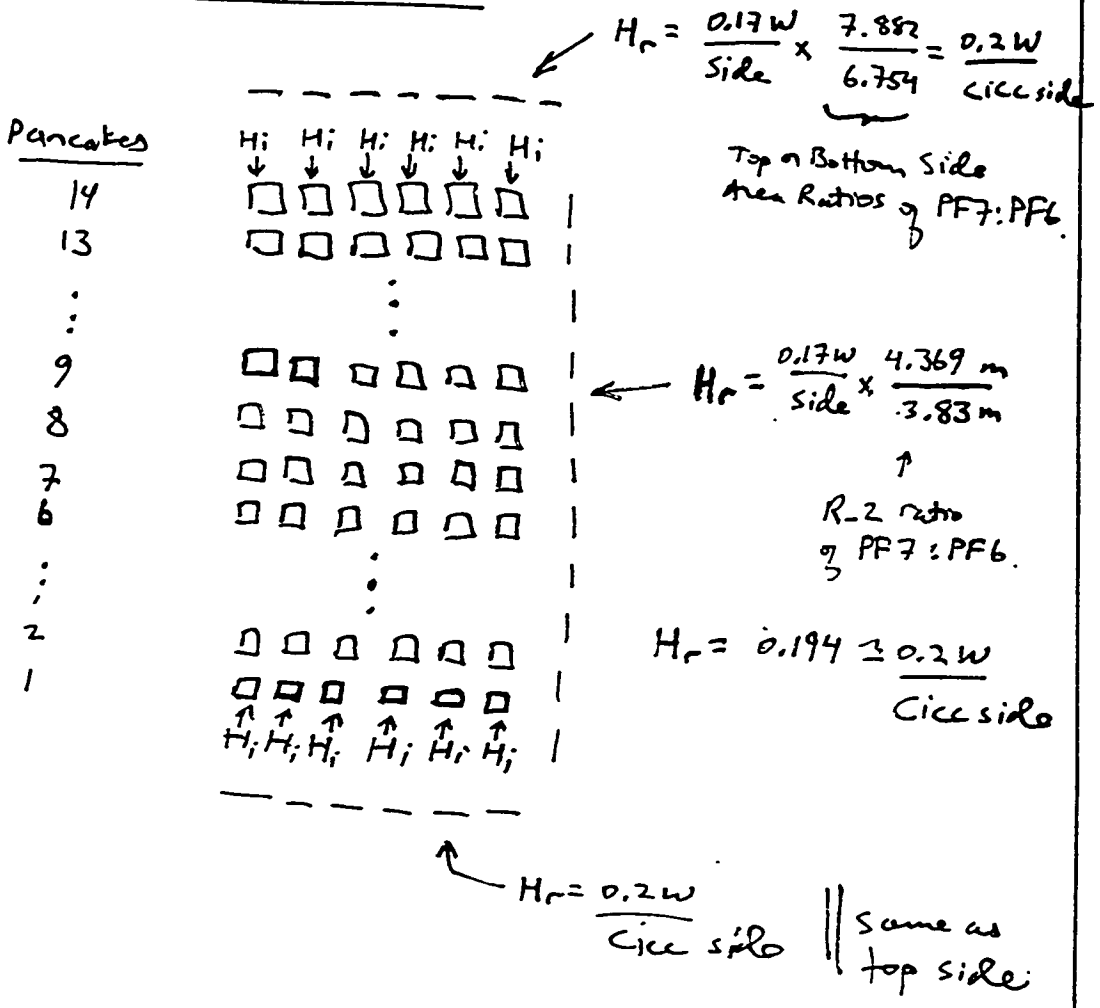
$H_r = Q_r \cdot S_{PF6} = 0.3 \frac{W}{m^2} \times 29.33\ m^2 = 8.8\ Watts$ → $\frac{8.8\ W}{52\ \text{cicc sides}} = 0.17$ watt per cicc side

$H_i = \frac{2\ Watt}{12\ \text{cicc sides}}$ (TPX Primary ICD, TPX-ICDP-1314-0001 Rev 1, 5/1/95)

$= 0.17\ Watt$ per cicc side

$H_i \equiv$ TF-PF interface heat flow

PF 7 interface heat input



Again, $H_i \equiv$ TF-to-PF interface heat flow

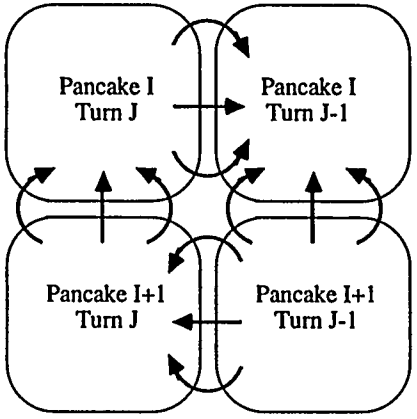
$= \frac{2W}{12\ sides} \cong 0.17$ watt per cicc side

APPENDIX D

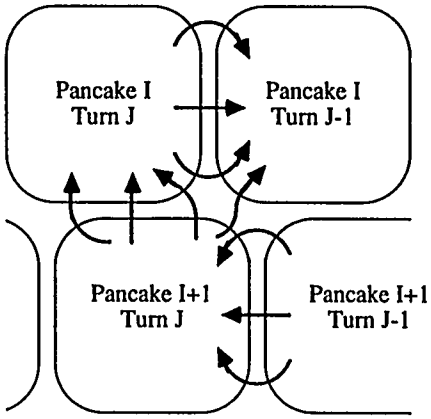
Inter-Turn Heat Transfer Model

DOUBLE SPIRAL-WOUND PANCAKE COIL
Conduction Heat Flow Scenarios

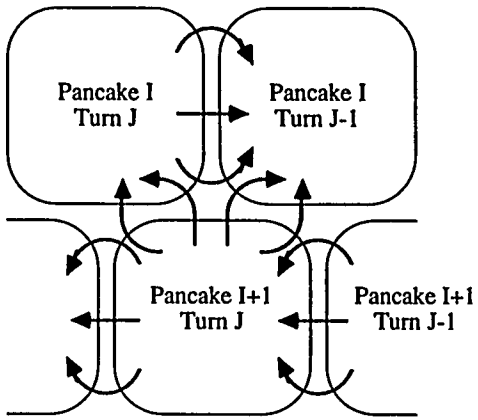
Minimum Interpancake Heat Conduction Impedance ($\theta = 0$)



Increasing Interpancake Heat Conduction Impedance ($0 < \theta < \pi$)



Maximum Interpancake Heat Conduction Impedance ($\theta = \pi$)



Conductor Temperatures: $T_{I+1,J-1,K} > T_{I+1,J,K} > T_{I,J,K} > T_{I,J-1,K}$

Coolant Pressures: $P_{I+1,J-1,K} < P_{I+1,J,K} < P_{I,J,K} < P_{I,J-1,K}$

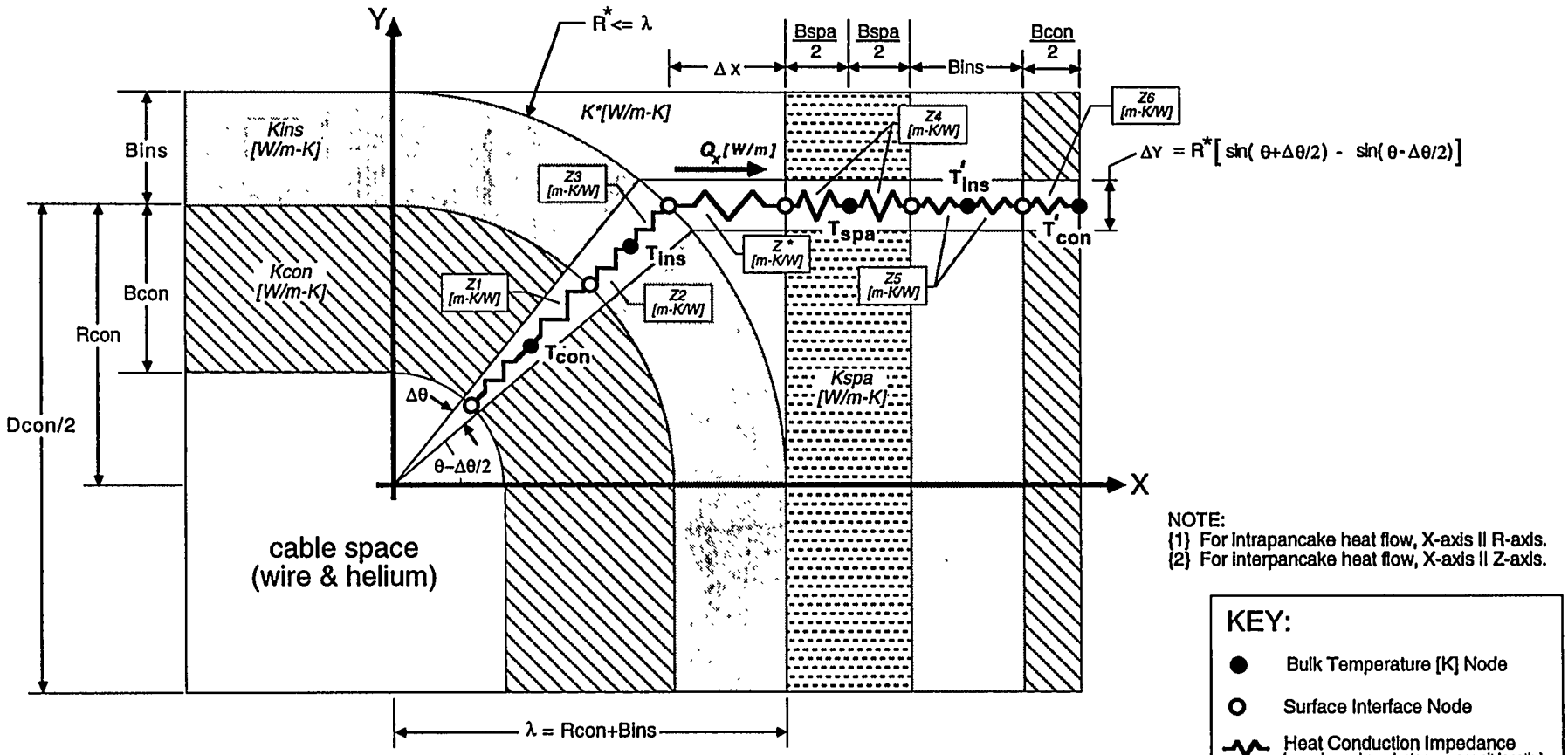
Legend

→ Conduction Heat Flow

I = pancake index
J = turn index
K = circumferential location index

T. Kupiszewski
1/24/95

WINDING CELL
Corner Region Thermal Circuit Model Parameters



NOTE:
{1} For intrapancake heat flow, X-axis ∥ R-axis.
{2} For interpancake heat flow, X-axis ∥ Z-axis.

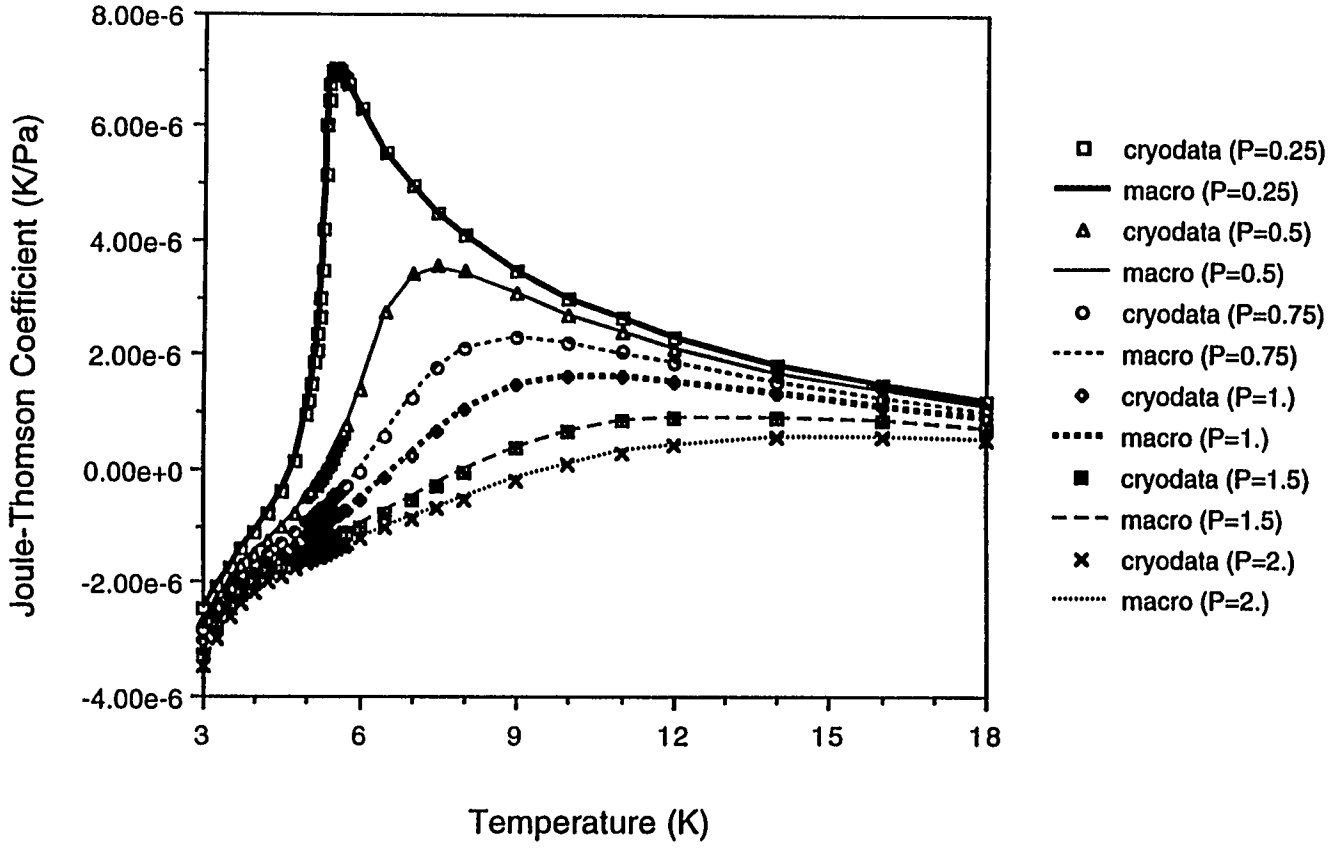
KEY:
- Bulk Temperature [K] Node
- Surface Interface Node
- Heat Conduction Impedance (= reciprocal conductance per unit length)
- Conduit
- Turn Insulation
- Corner Fill (e.g., glass + epoxy)
- Spacer Strip or Sheet

NOTE: The original generic model is depicted. This model was used to describe both the original CDR design w/ barriers and the new CPDR insulation design w/o barriers by setting K* = Kspa and Bspa = twice the thickness of the insulation overwrap, with the corner region turn-to-turn impedance being given by the expression: 2(Z1+Z2+Z3+Z*+Z4).

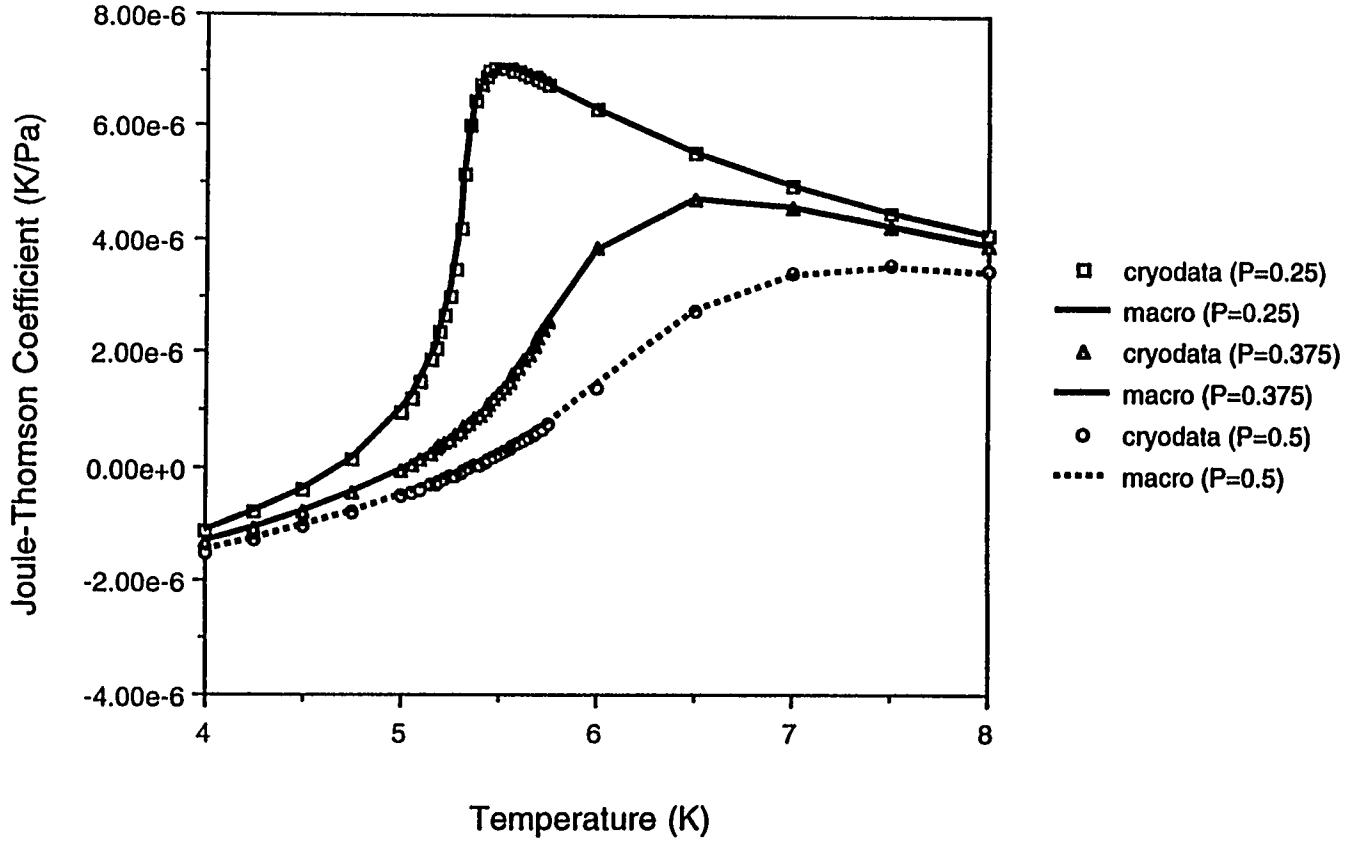
APPENDIX E

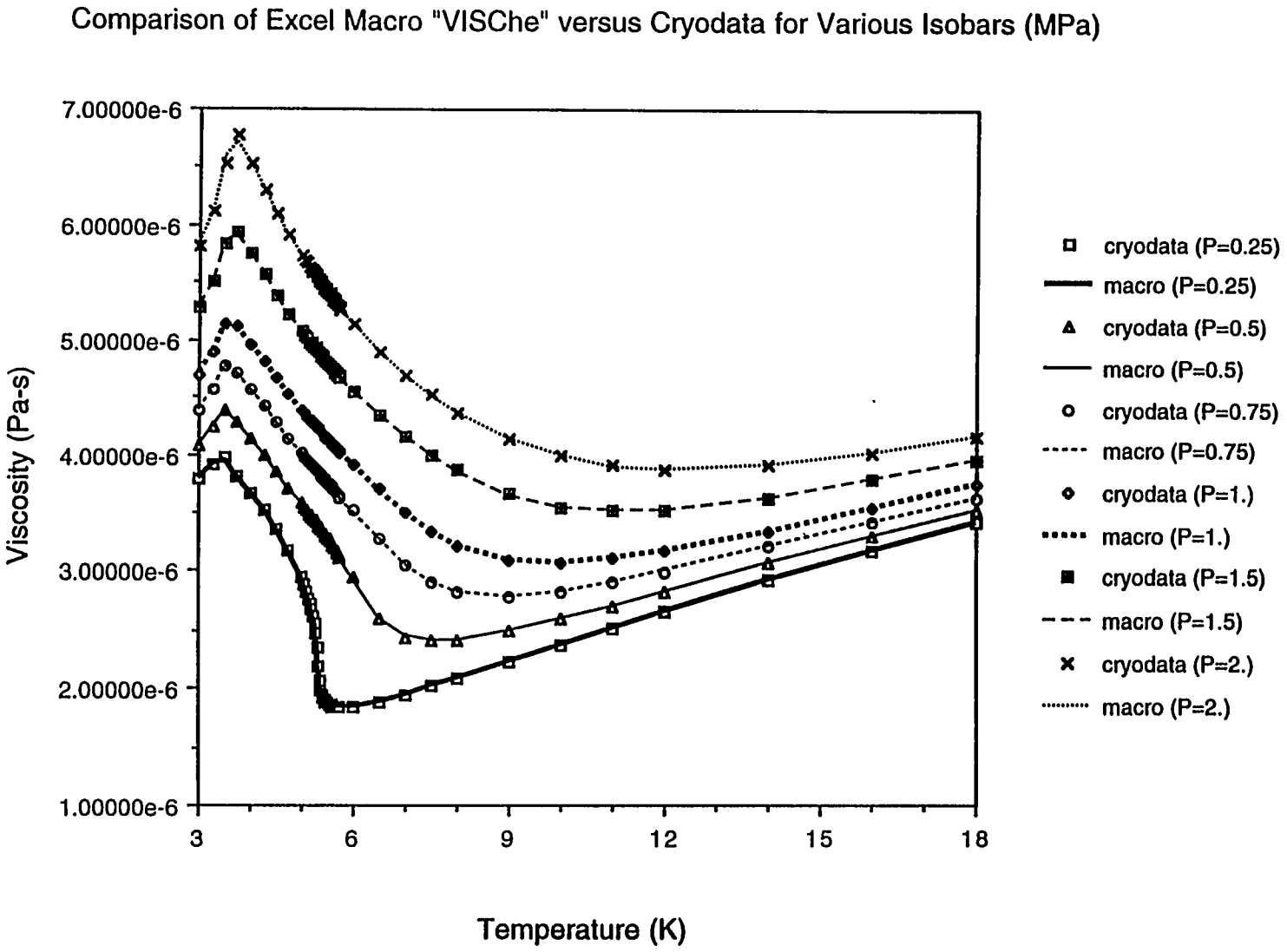
WETMAP Helium Property Macro Validation Plots

Comparison of Excel Macro "JTCOEFhe" versus Cryodata for Various Isobars (MPa)

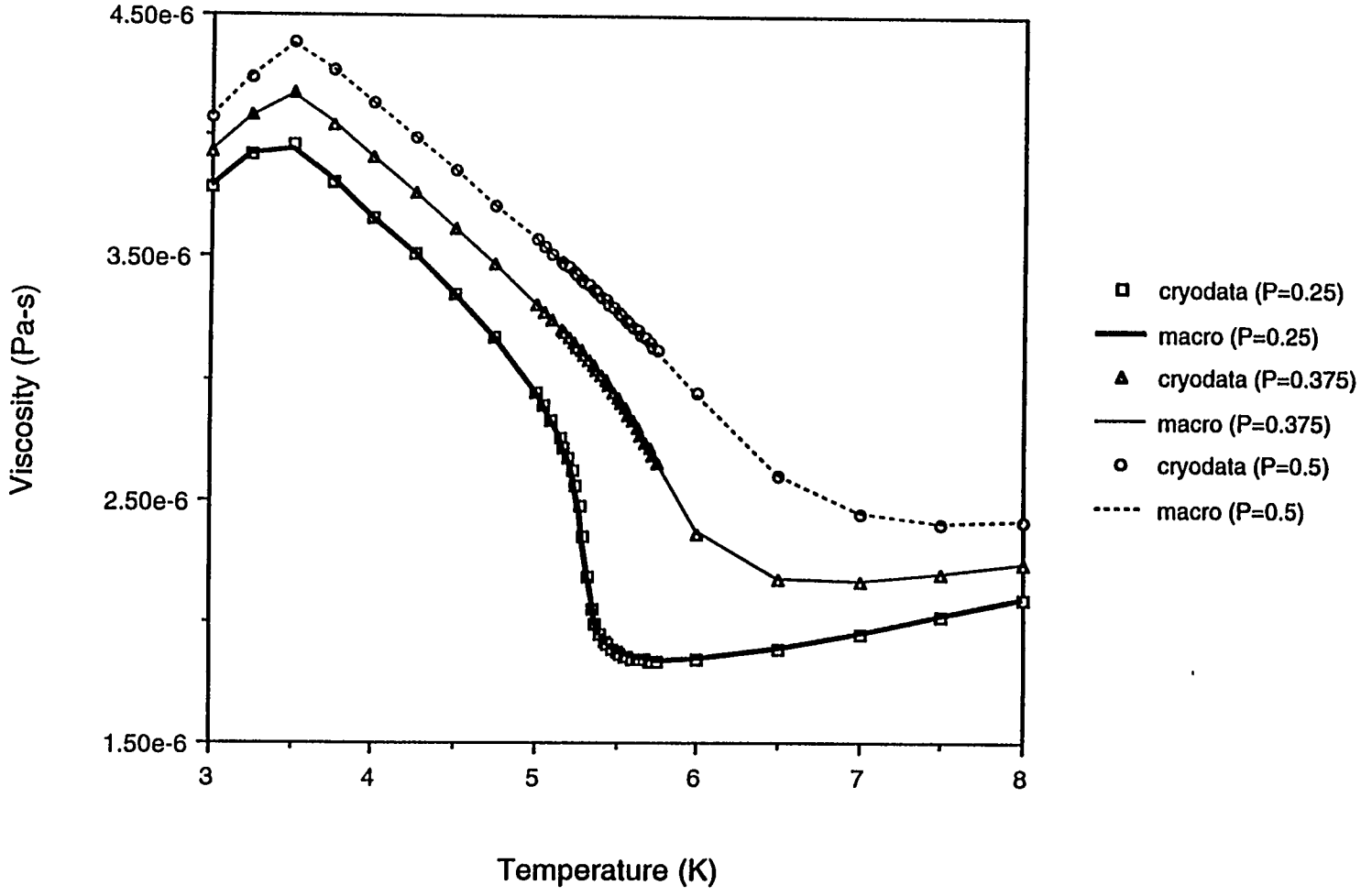


Excel Macro "JTCOEFhe" vs. Cryodata near Critical Point for Various Isobars (MPa)

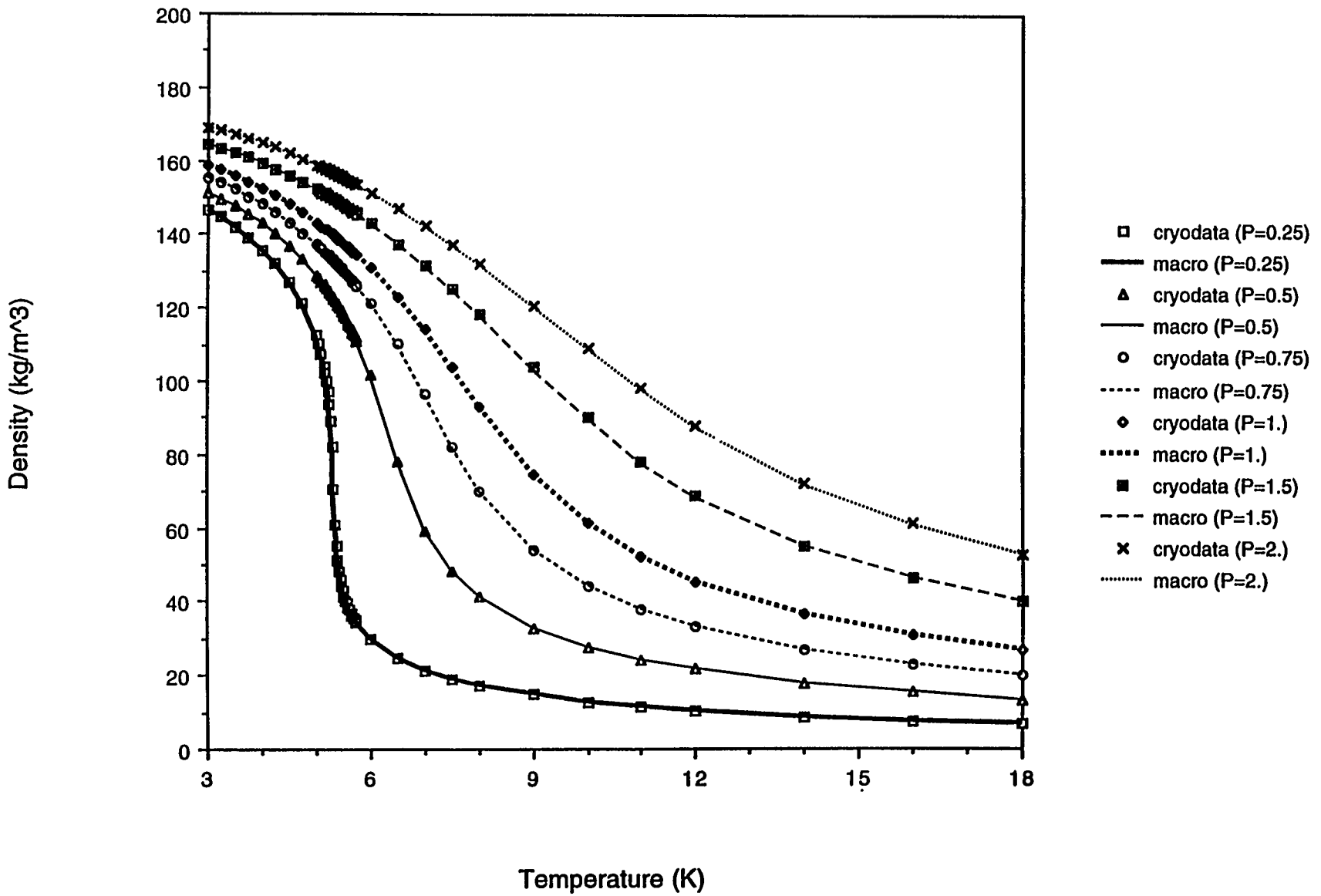



Comparison of Excel Macro "VISChe" versus Cryodata for Various Isobars (MPa)
7.00000e-6
6.00000e-6
5.00000e-6
4.00000e-6
3.00000e-6
2.00000e-6
1.00000e-6
Viscosity (Pa-s)
3
6
9
12
15
18
Temperature (K)
cryodata (P=0.25)
macro (P=0.25)
cryodata (P=0.5)
macro (P=0.5)
cryodata (P=0.75)
macro (P=0.75)
cryodata (P=1.)
macro (P=1.)
cryodata (P=1.5)
macro (P=1.5)
cryodata (P=2.)
macro (P=2.)

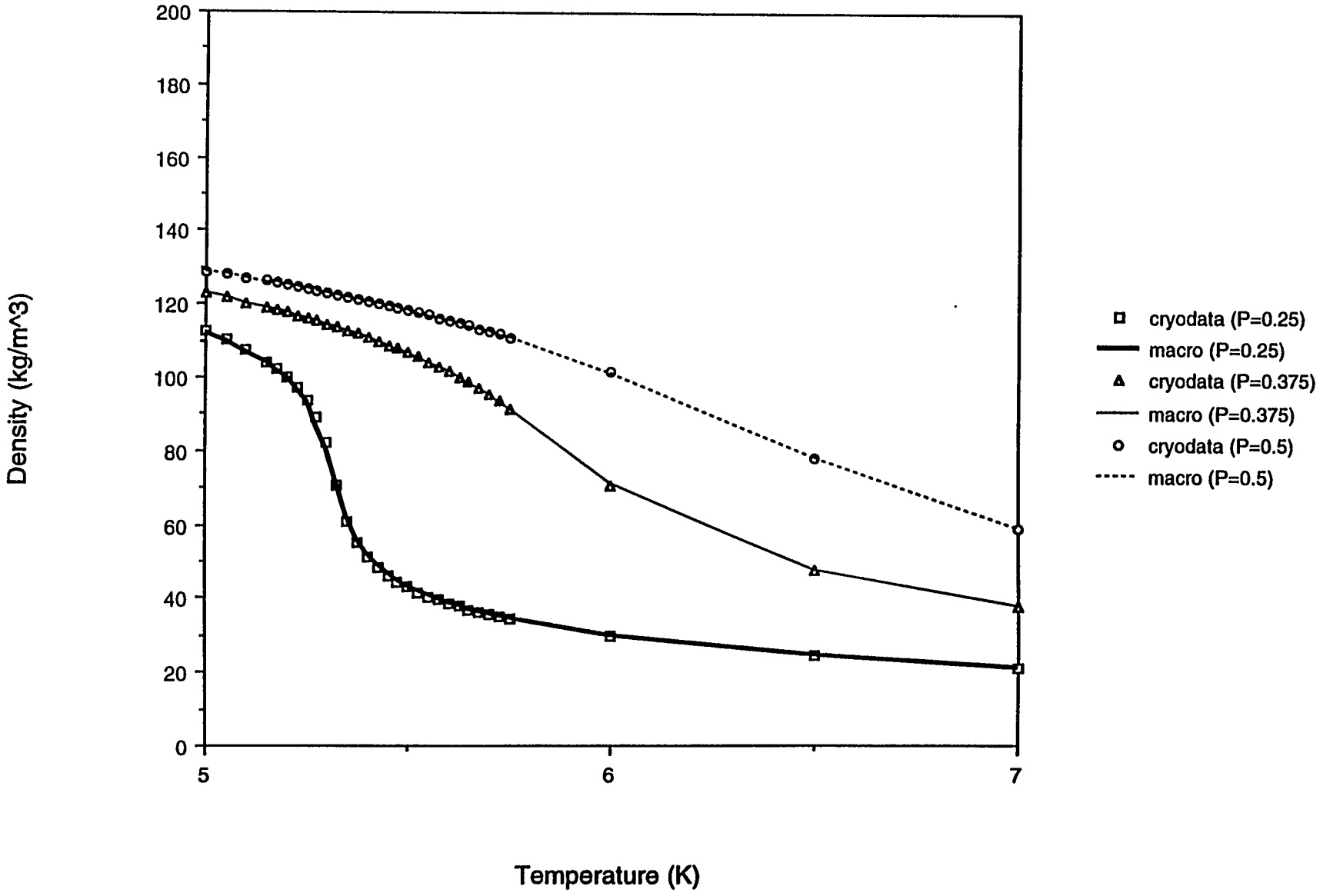
Excel Macro "VISChe" versus Cryodata near Critical Point for Various Isobars (MPa)

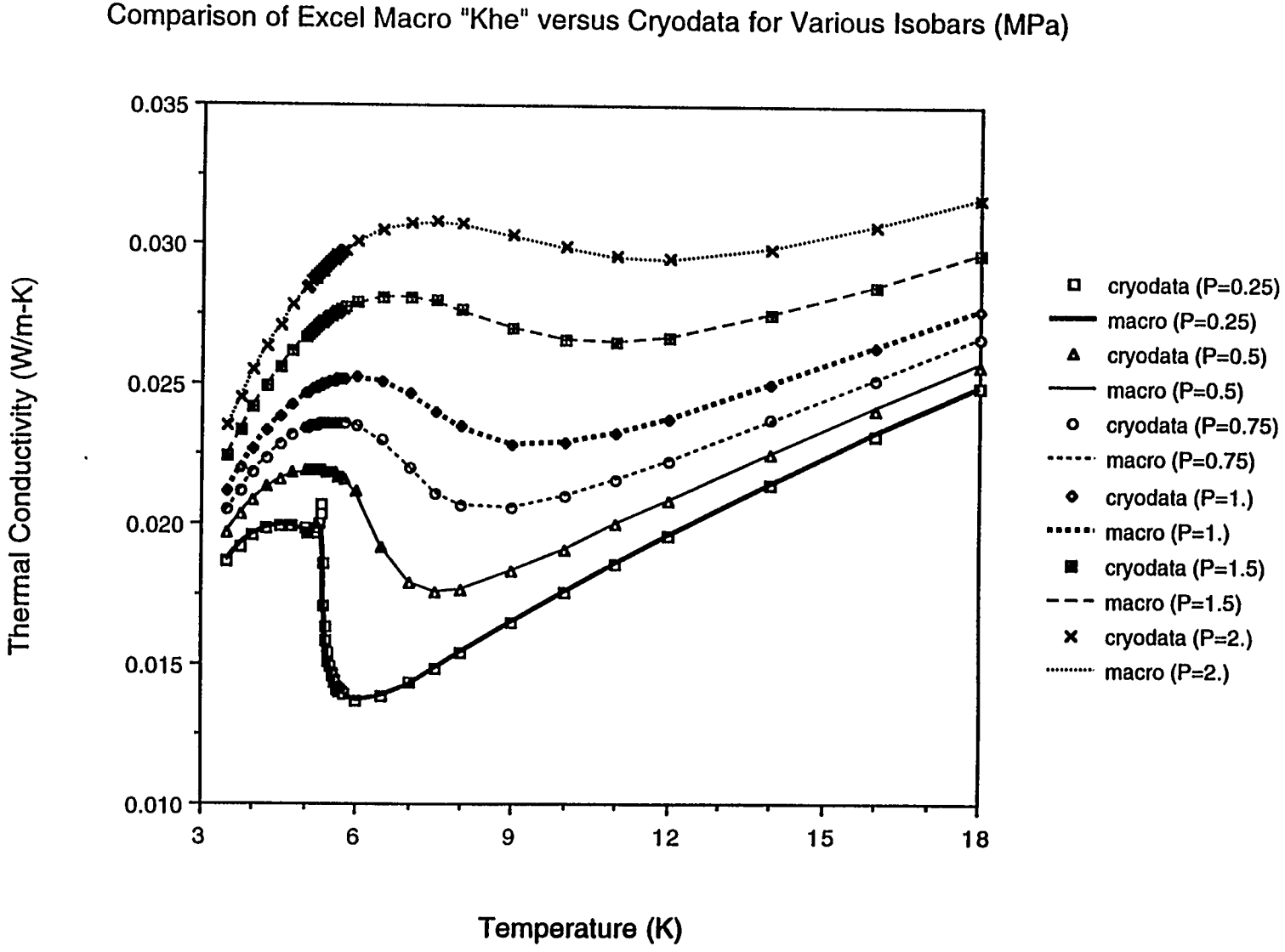


Comparison of Excel Macro "DENShe" versus Cryodata for Various Isobars (MPa)

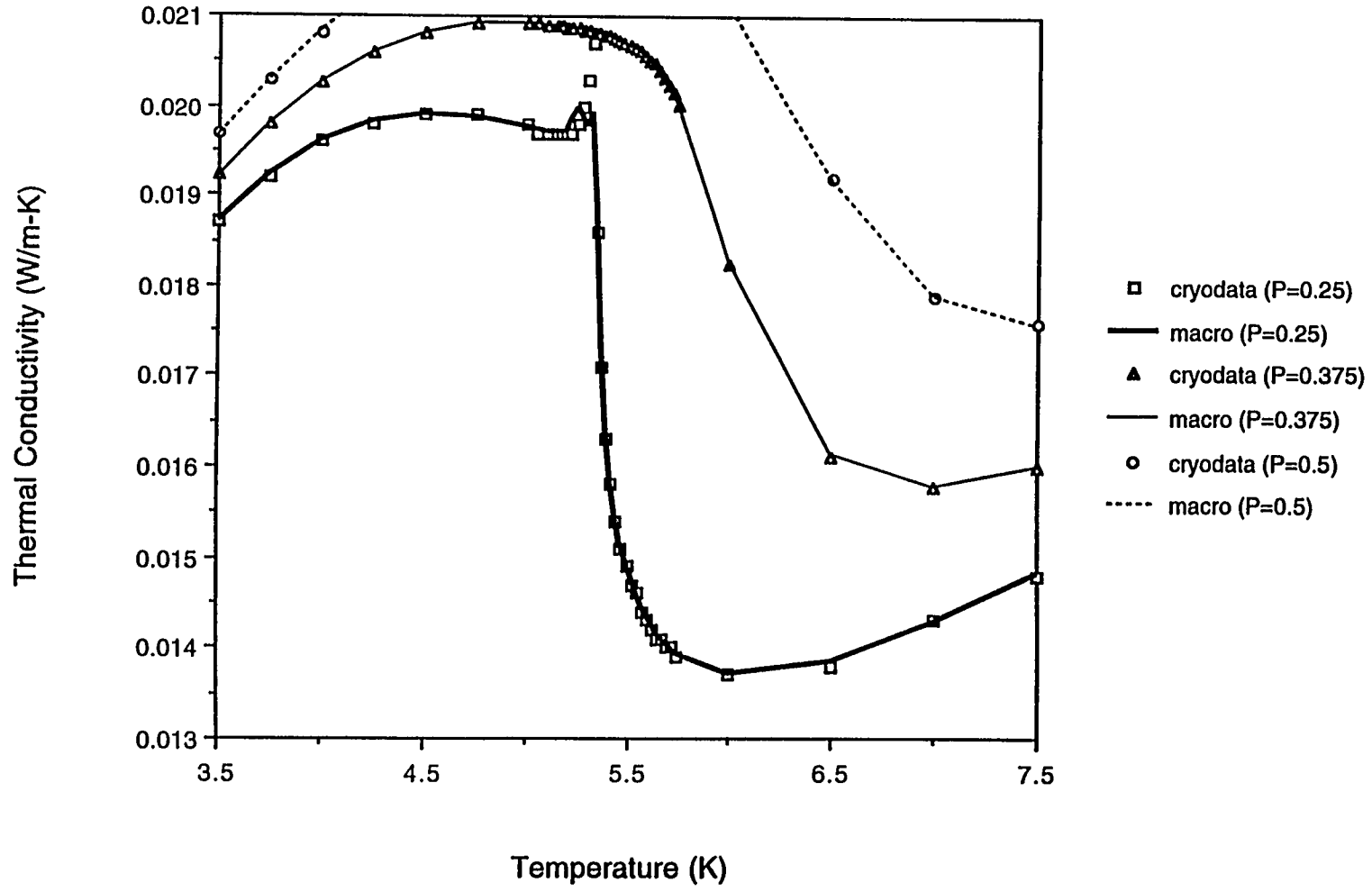


Comparison of Excel Macro "DENShe" versus Cryodata near Critical Point for Various Isobars (MPa)

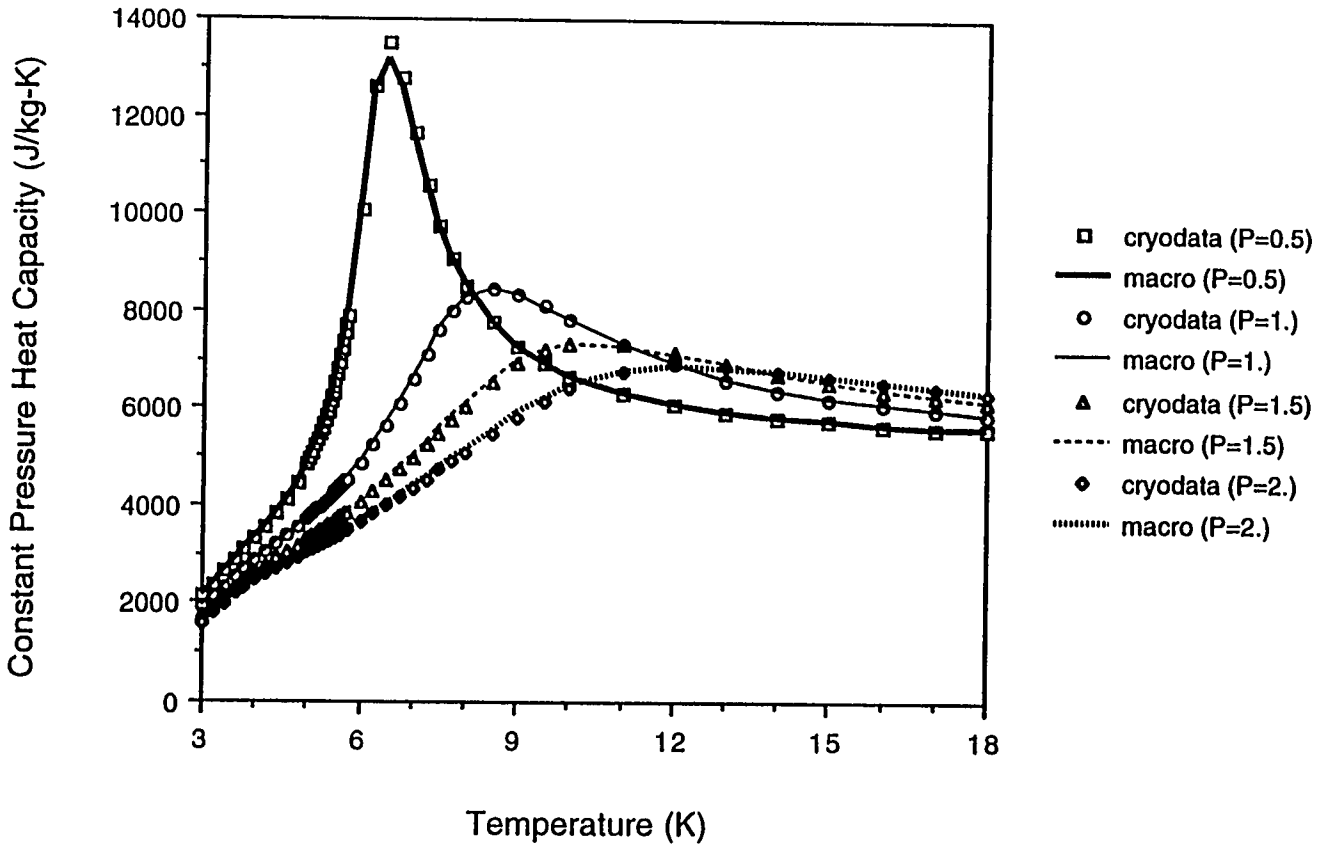



Comparison of Excel Macro "Khe" versus Cryodata for Various Isobars (MPa)
Thermal Conductivity (W/m-K)
0.035
0.030
0.025
0.020
0.015
0.010
3
6
9
12
15
18
Temperature (K)
cryodata (P=0.25)
macro (P=0.25)
cryodata (P=0.5)
macro (P=0.5)
cryodata (P=0.75)
macro (P=0.75)
cryodata (P=1.)
macro (P=1.)
cryodata (P=1.5)
macro (P=1.5)
cryodata (P=2.)
macro (P=2.)

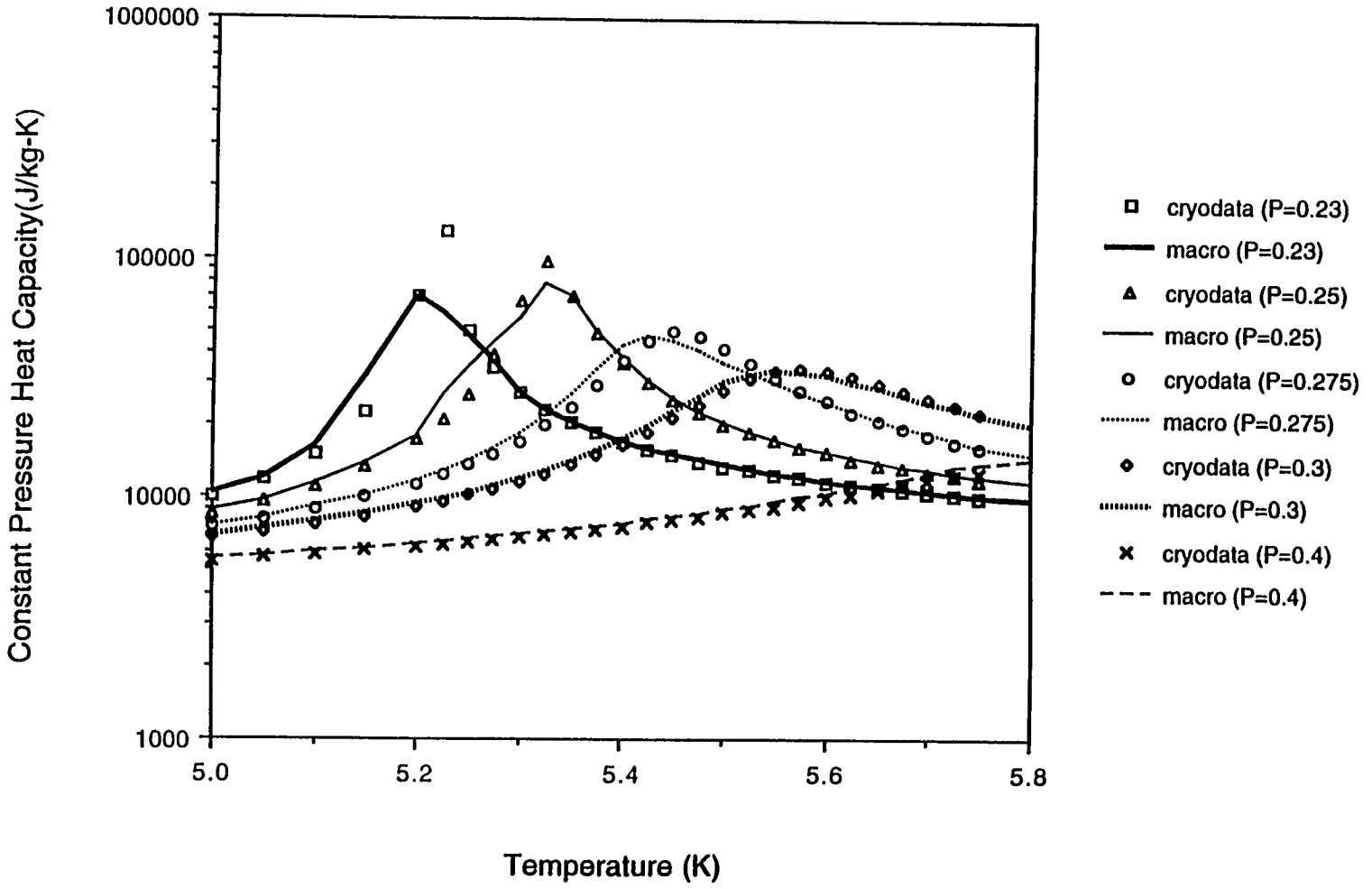
Comparison of Excel Macro "Khe" versus Cryodata near Critical Point for Various Isobars (MPa)



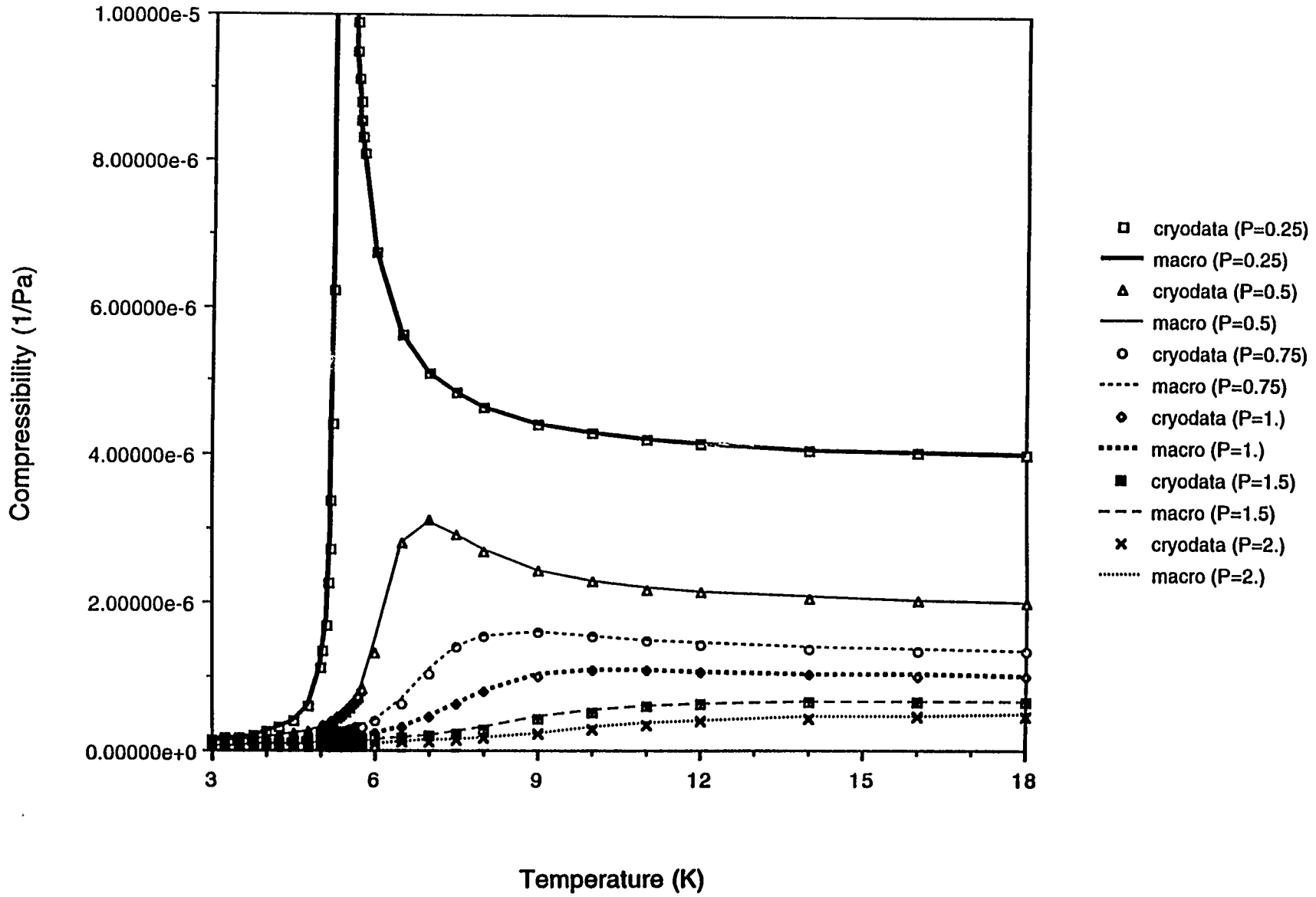
Comparison of Excel Macro "CPhe" versus Cryodata for Various Isobars(MPa)



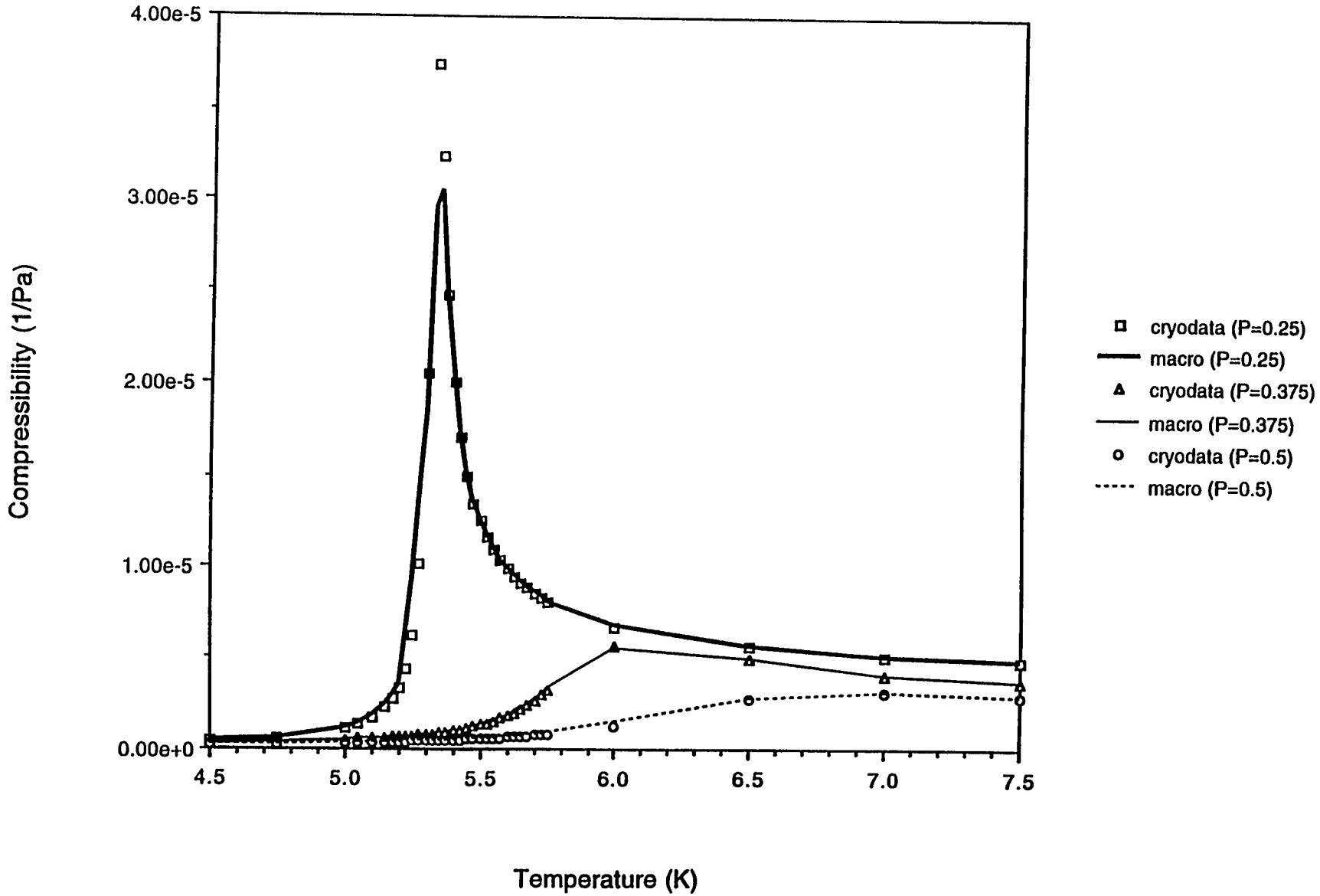
Comparison of Excel Macro "CPhe" versus Cryodata near Critical Point for Various Isobars(MPa)



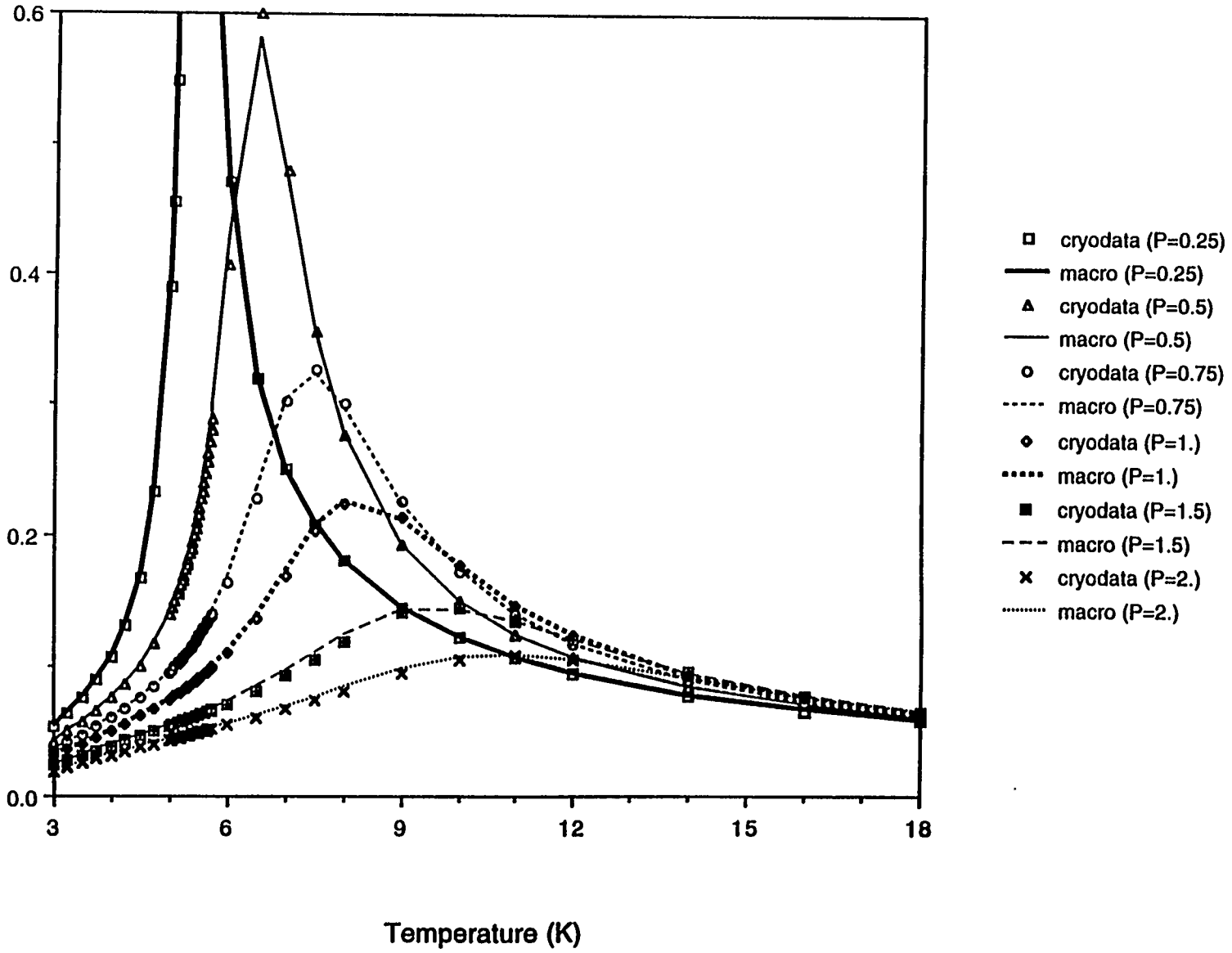
Comparison of Excel Macro "KAPAhe" versus Cryodata for Various Isobars (MPa)



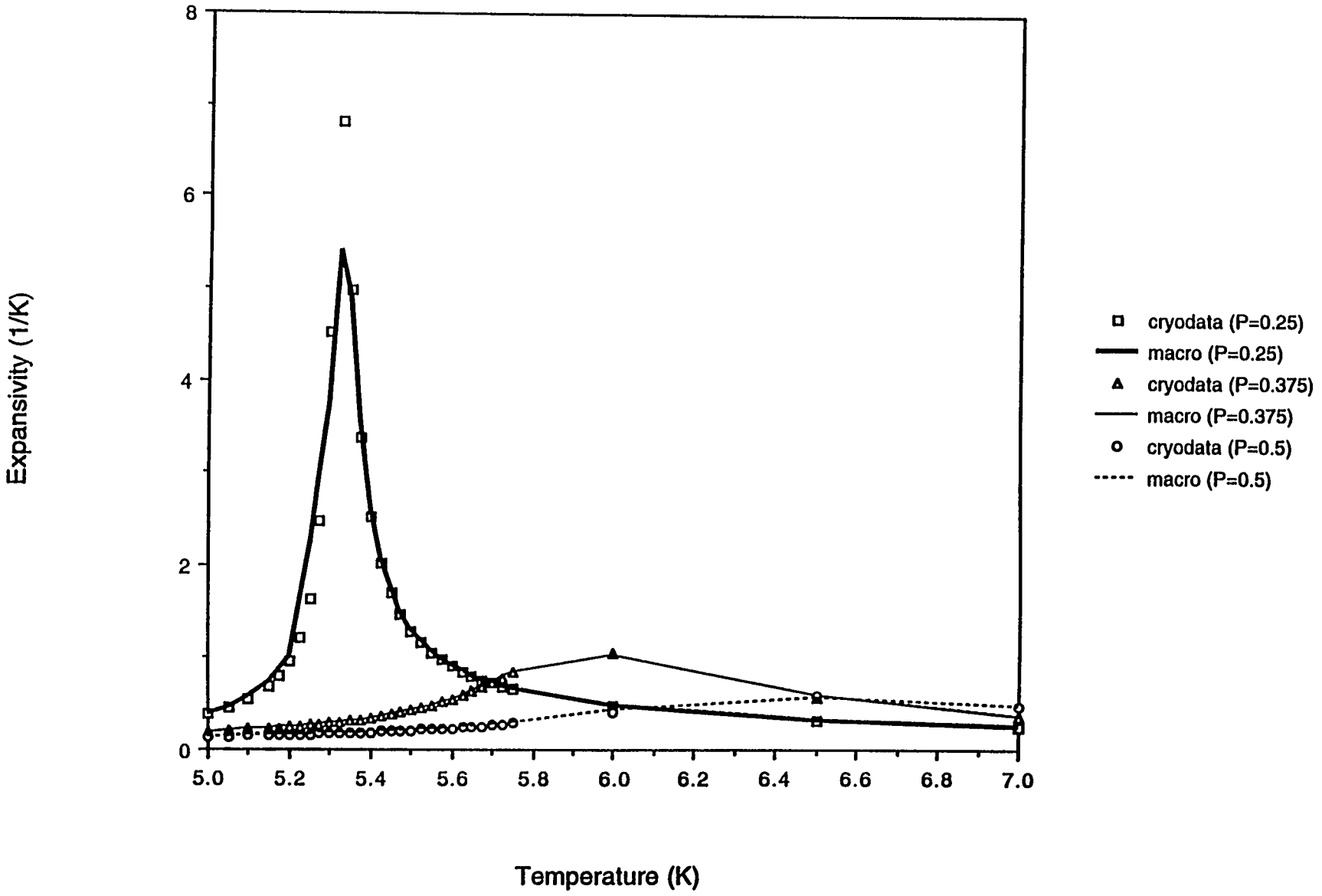
Comparison of Excel Macro "KAPAhe" versus Cryodata near Critical Point for Various Isobars (MPa)



Comparison of Excel Macro "BETAhe" versus Cryodata for Various Isobars (MPa)



Comparison of Excel Macro "BETAhe" versus Cryodata near Critical Point for Various Isobars (MPa)

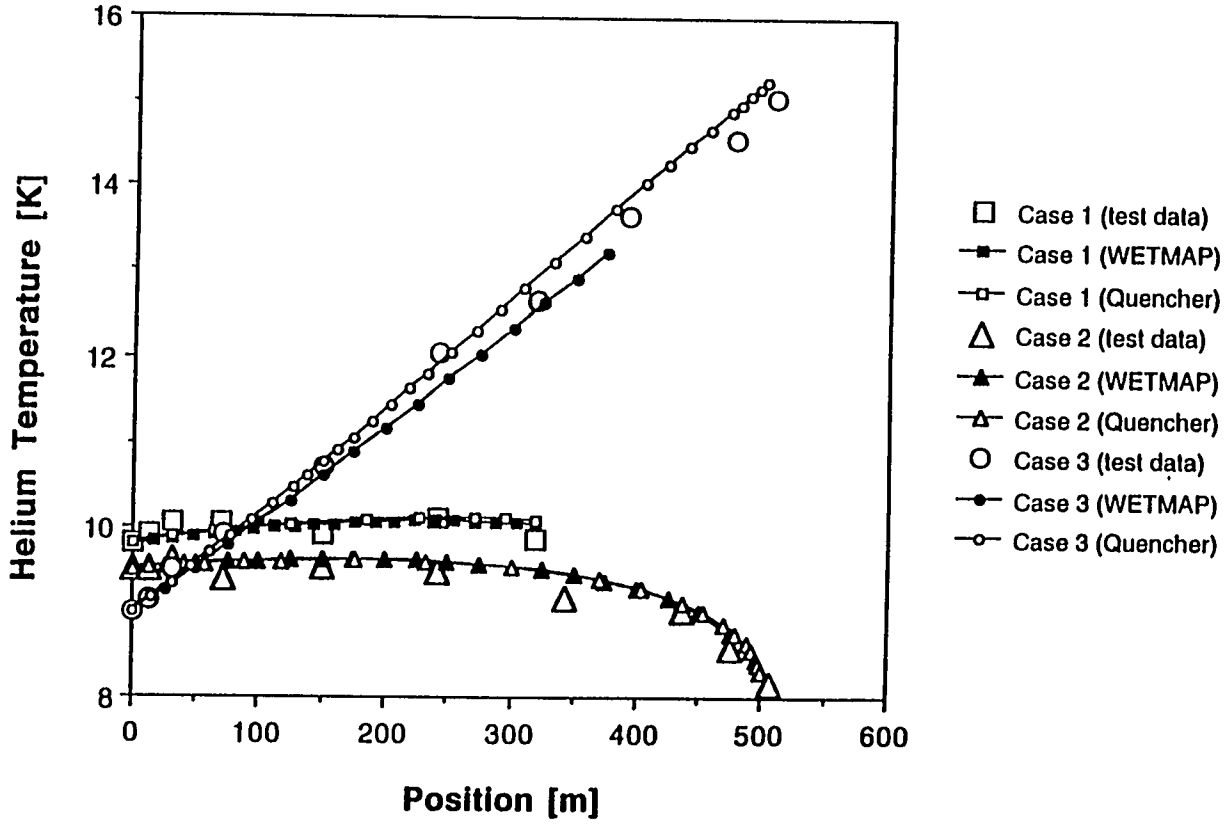


APPENDIX F

Validation of WETMAP Computer Model

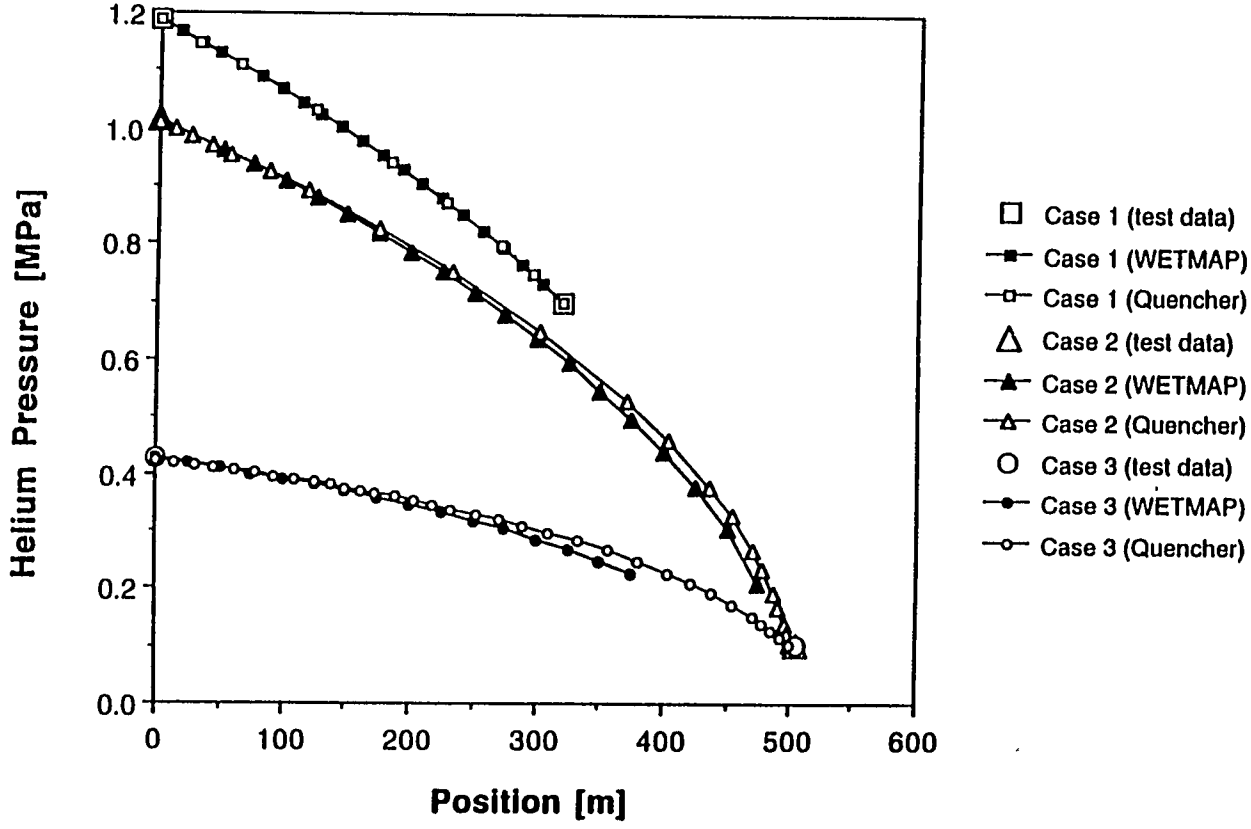
Thermal Analysis

Comparison of Software Tools versus Experiments



Thermal Analysis

Comparison of Software Tools versus Experiments (cont'd)



Comparison of Software Tools versus Experiments (reference information)

	Heat Input [Watt per m]			Helium Mass Flow [gm/sec]			Fanning Friction Factor		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
Experiment	0.09	0.062	0.074	3.55	3.0	0.98	unknown	unknown	unknown
WETMAP	0.09	0.062	0.074	3.55	3.0	0.98	0.0055	0.006	0.007
Quencher	0.09	0.062	0.074	3.3	3.1	0.917	see Note (2)		

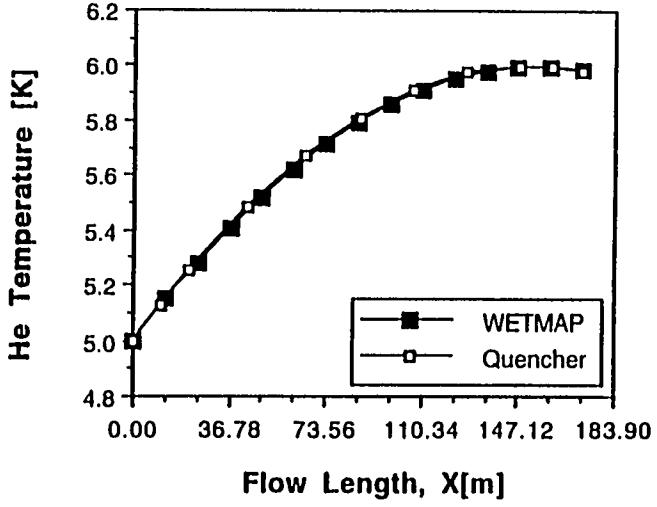
NOTE:
(1) Test data reported in "Temperature Profiles in a Long Gaseous-Helium-Cooled Tube" by J. W. Dean, W. Stewart, and J. K. Hoffer, Adv. in Cryo. Eng., Vol. 23, 1978, pg 250.
(2) Quencher Darcy friction factor = 1.8 to 2.3 x 0.184 / Re^0.2 for rough tube w/ turbulent flow.
(3) WETMAP correlations for CICC friction factors were disabled & replaced w/ constant values.
(4) Test hydraulic diameter = 4.8 mm.
(5) Case 1 Reynolds number = 1E5; Case 2 & Case 3 Reynolds numbers were in range of 3E6 to 4E6.

TPX

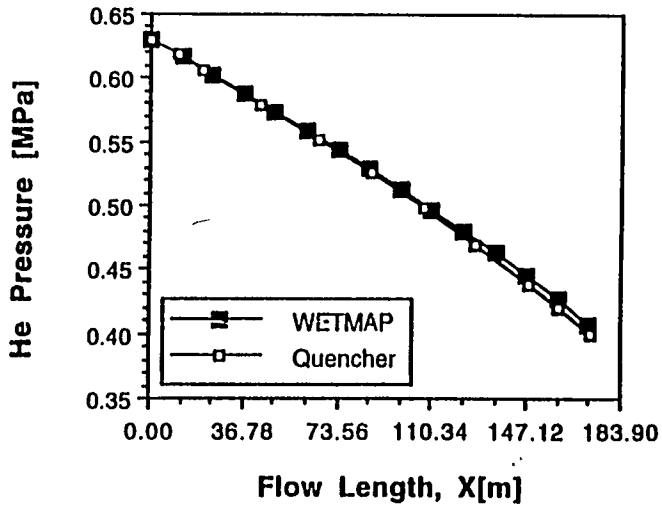
MARINE DIVISION

Thermal Analysis

Temperature Profile Comparison
(uniform heat input; no interturn heat flow)



Pressure Profile Comparison
(uniform heat input; no interturn heat flow)



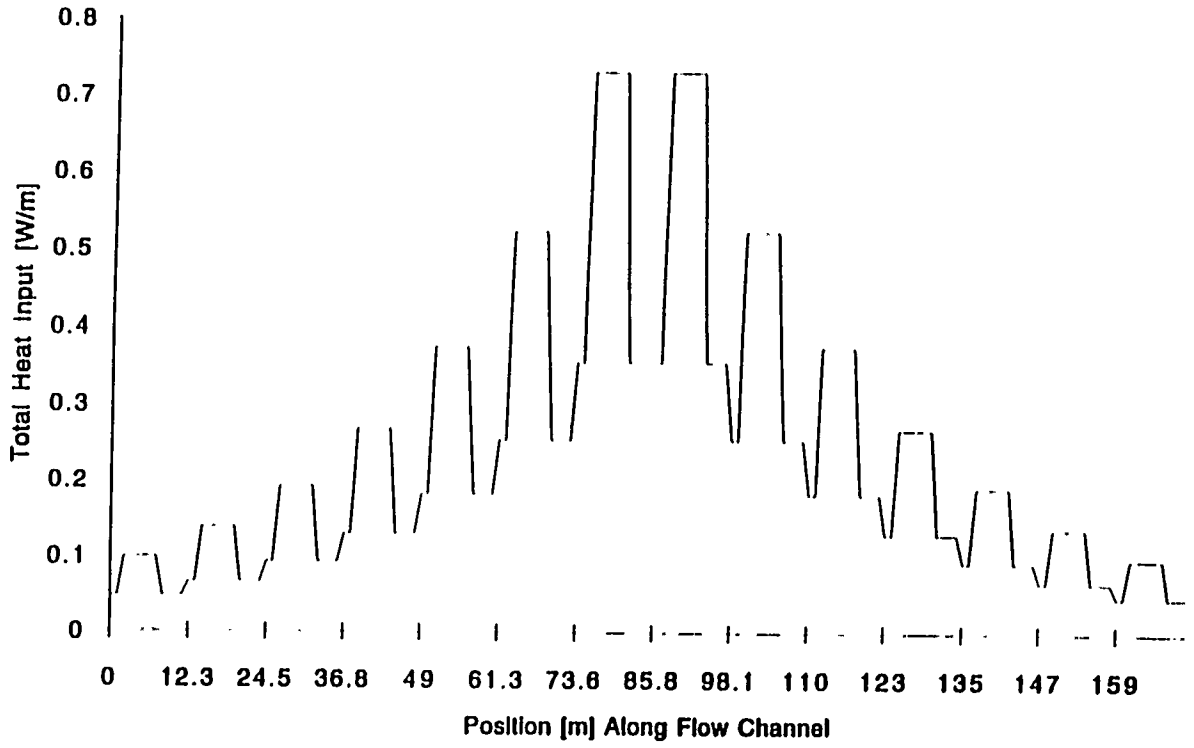
Software	He Inlet Conditions			He Outlet Conditions			Flow [kg/sec]	Power Balance [W]	
	P[MPa]	T[K]	H[J/kg]	P[MPa]	T[K]	H[J/kg]		Input Heat	(Flow x ΔH)
WETMAP	0.63	5	15,035.	0.4065	5.986	23,851.	0.004167	37.5	36.74
Quencher	0.63	5	15,035.	0.4	5.974	23,979.	0.00418	37.5	37.39

TPX

MARINE DIVISION

Thermal Analysis

TF Coil Heat Generation Profile (5kW nuclear + 3kW eddy heating scenario)

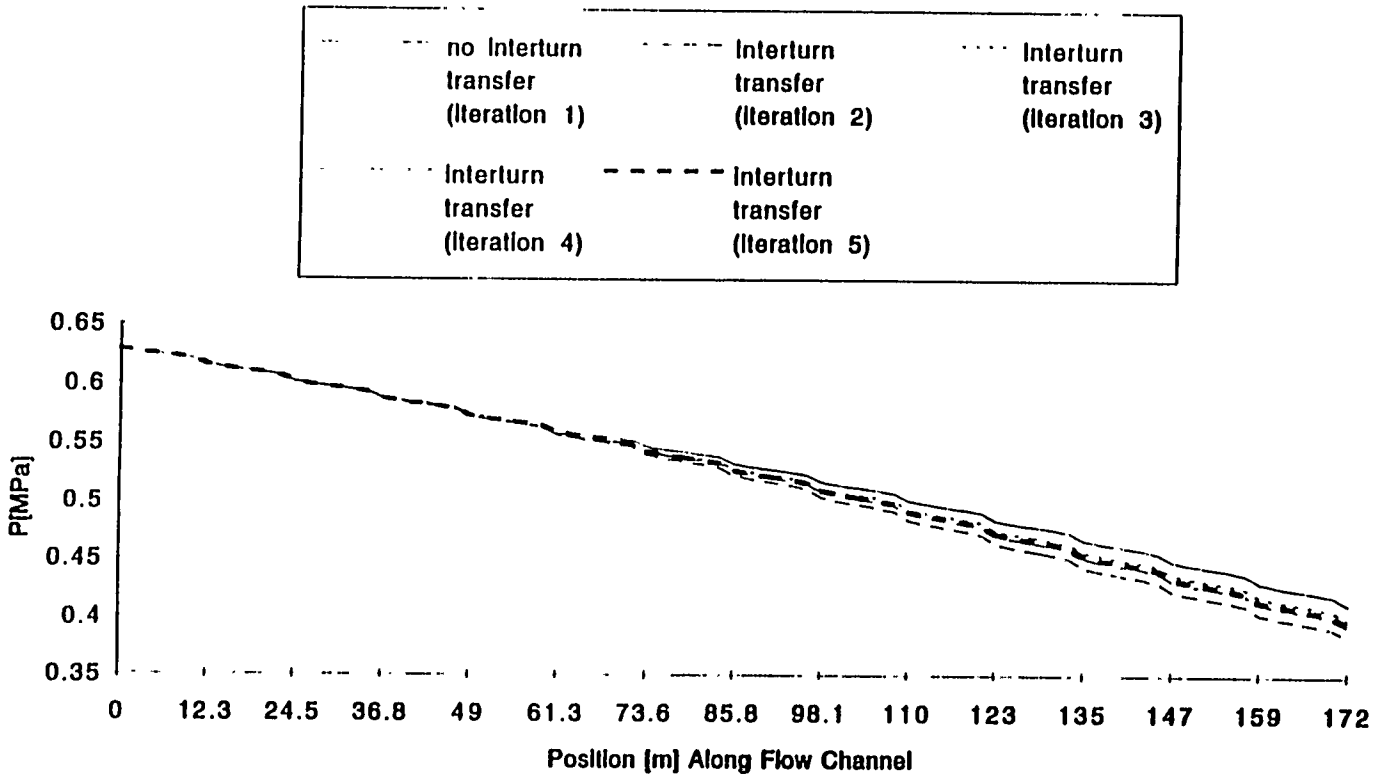


TPX

MARINE DIVISION

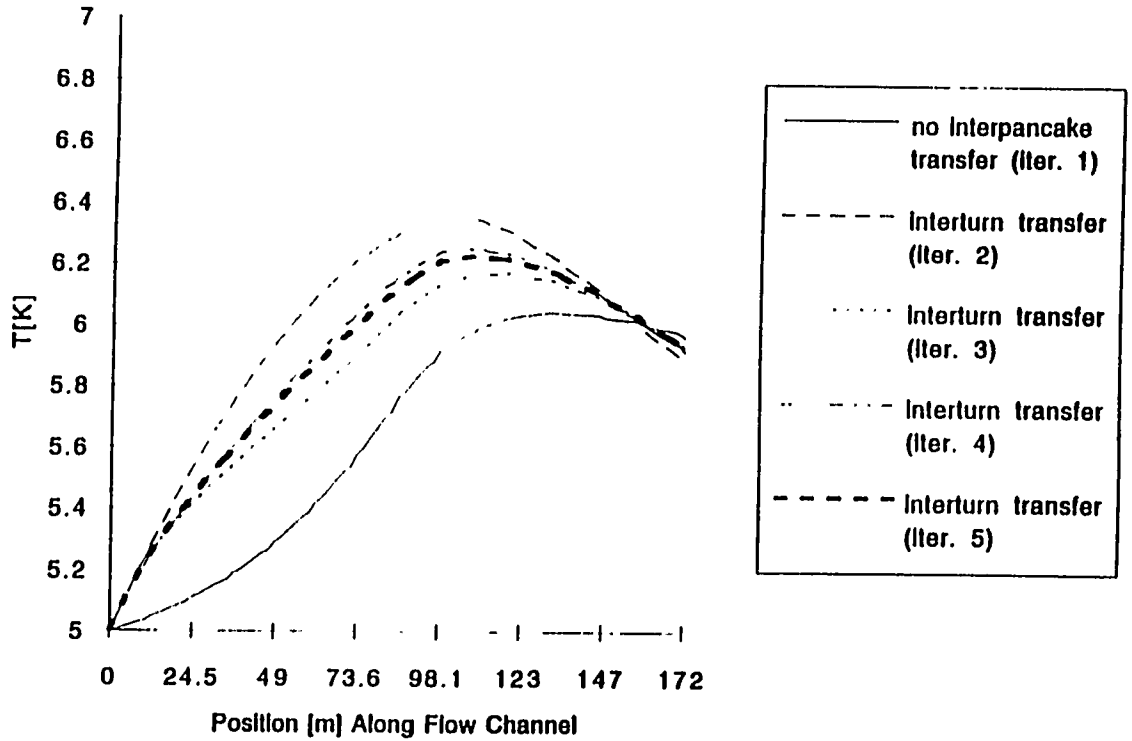
Thermal Analysis

TF Coil Helium Pressure Profile Comparison (Validation vs. CICC)



Thermal Analysis

TF Coil Helium Temperature Profile Comparison (Validation vs. CICC)

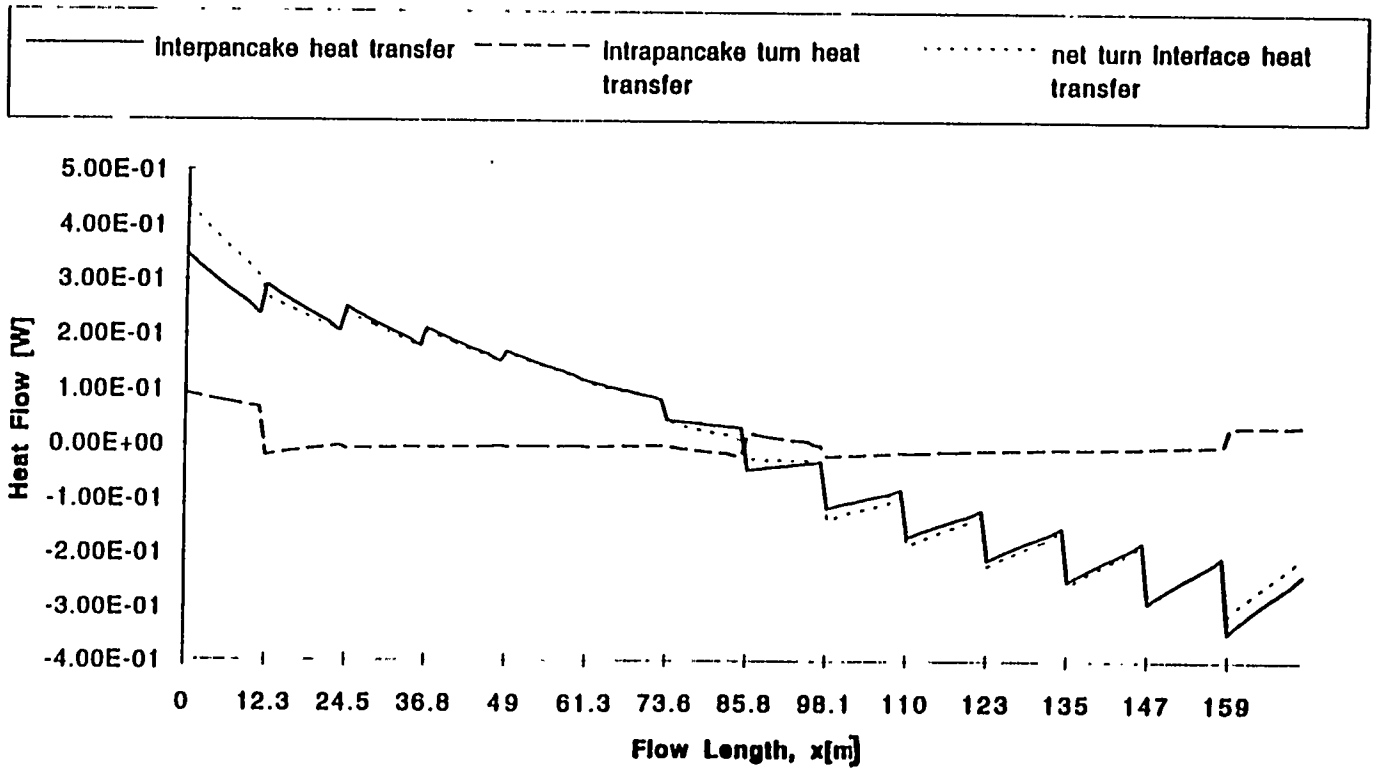


TPX

MARINE DIVISION

Thermal Analysis

Comparison of Turn Interface Heat Flows (conduit-to-conduit; Iteration 5)



Thermal-hydraulic Software Conservation of Energy Check

T. Kupiszewski
2/7/95

PRESSURE [MPa]	TEMP [K]	ENTHALPY* [J/Kg]	ENERGY* [J/Kg]	MASS FLOW [kg/sec]	Comment
0.6284	5.00	15030.	10329.	0.004167	inlet He state
0.2857	5.53	23902.	19756.	0.004167	outlet He state (WETMAP)
0.4054**	5.9**	22476.	17937.	0.004167	outlet He state (CICC-LLNL)
	6.0**	24148.	19209.	0.004167	outlet He state (CICC-LLNL)

ENTHALPY	Change (outlet - inlet)	= +8,872.	[J/kg]	WETMAP
		= +7,446.	[J/kg]	CICC-LLNL @ He outlet T = 5.9K
		= +9,118.	[J/kg]	CICC-LLNL @ He outlet T = 6.0K
ENERGY	Change (outlet - inlet)	= +9,427.	[J/kg]	WETMAP
		= +7,608.	[J/kg]	CICC-LLNL @ He outlet T = 5.9K
		= +8,880.	[J/kg]	CICC-LLNL @ He outlet T = 6.0K

WETMAP Heat Input (via enthalpy change) = 8,872.[J/kg] x 0.004167[kg/sec] = 36.97 [Watt]
CICC Heat Input (via enthalpy change) = 31.03 to 38. [Watt]
WETMAP Heat Input (via energy increase) = 9,427.[J/kg] x 0.004167[kg/sec] = 39.28 [Watt]
CICC Heat Input (via energy change) = 31.7 to 37. [Watt]

WETMAP discrepancy wrt. 37.5 Watt Heat Input Actual = -1.41% to +4.75% < +/- 5%
CICC discrepancy wrt. 37.5 Watt Heat Input Actual = -17.3% to +1.01% < +/- 20%

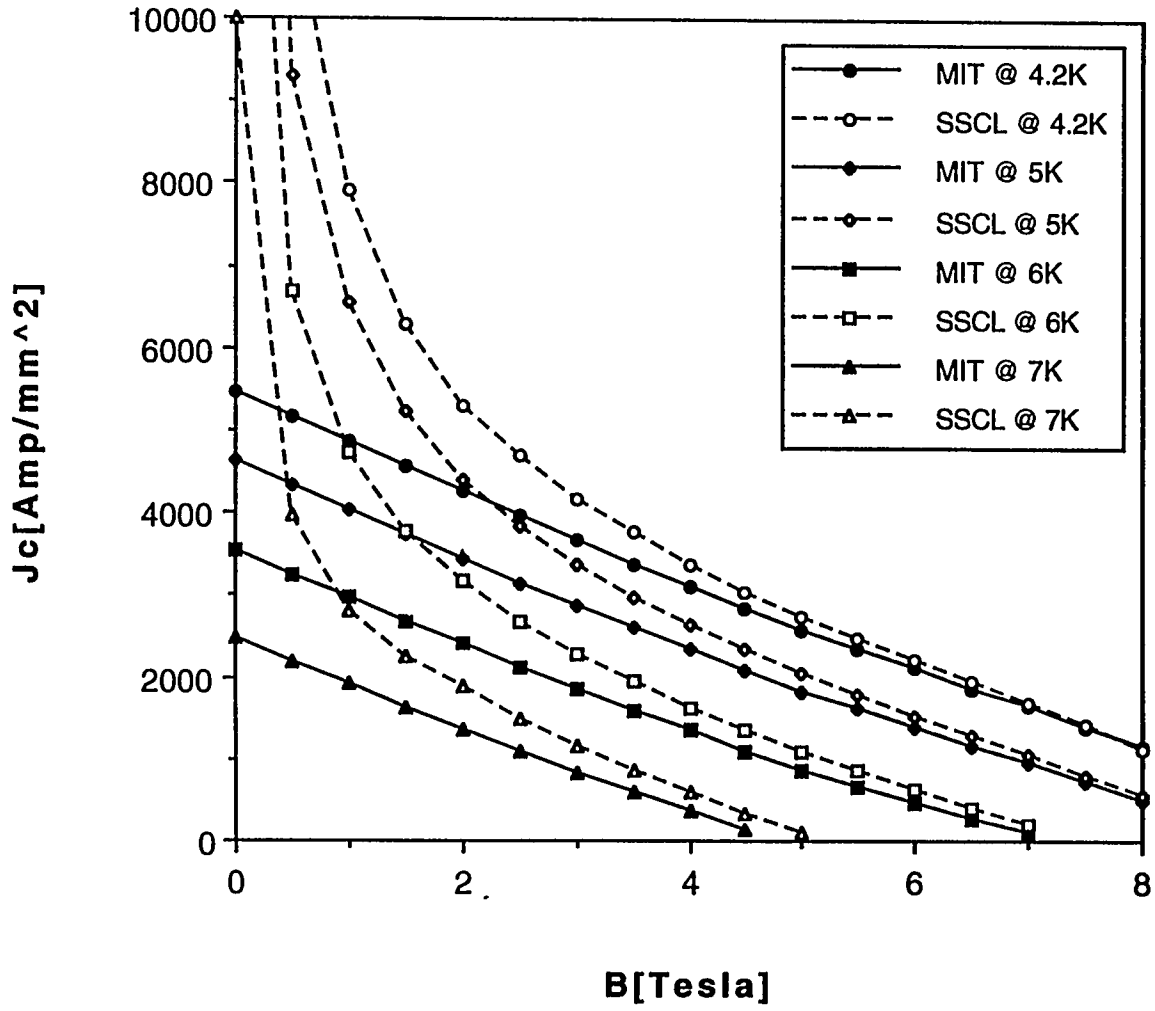
NOTES:
* Helium property values calculated by Cryodata, Inc. HEPAK Software (i.e., NIST/NBS correlations).
** Data obtained from CEC paper preprint UCRL-JC-112762 by LLNL's R.L. Wong, dated 7/9/93.

APPENDIX G

Current Sharing Temperature Calculations

5/24/95

Critical Current Density versus Magnetic Field Correlation Comparison for NbTi

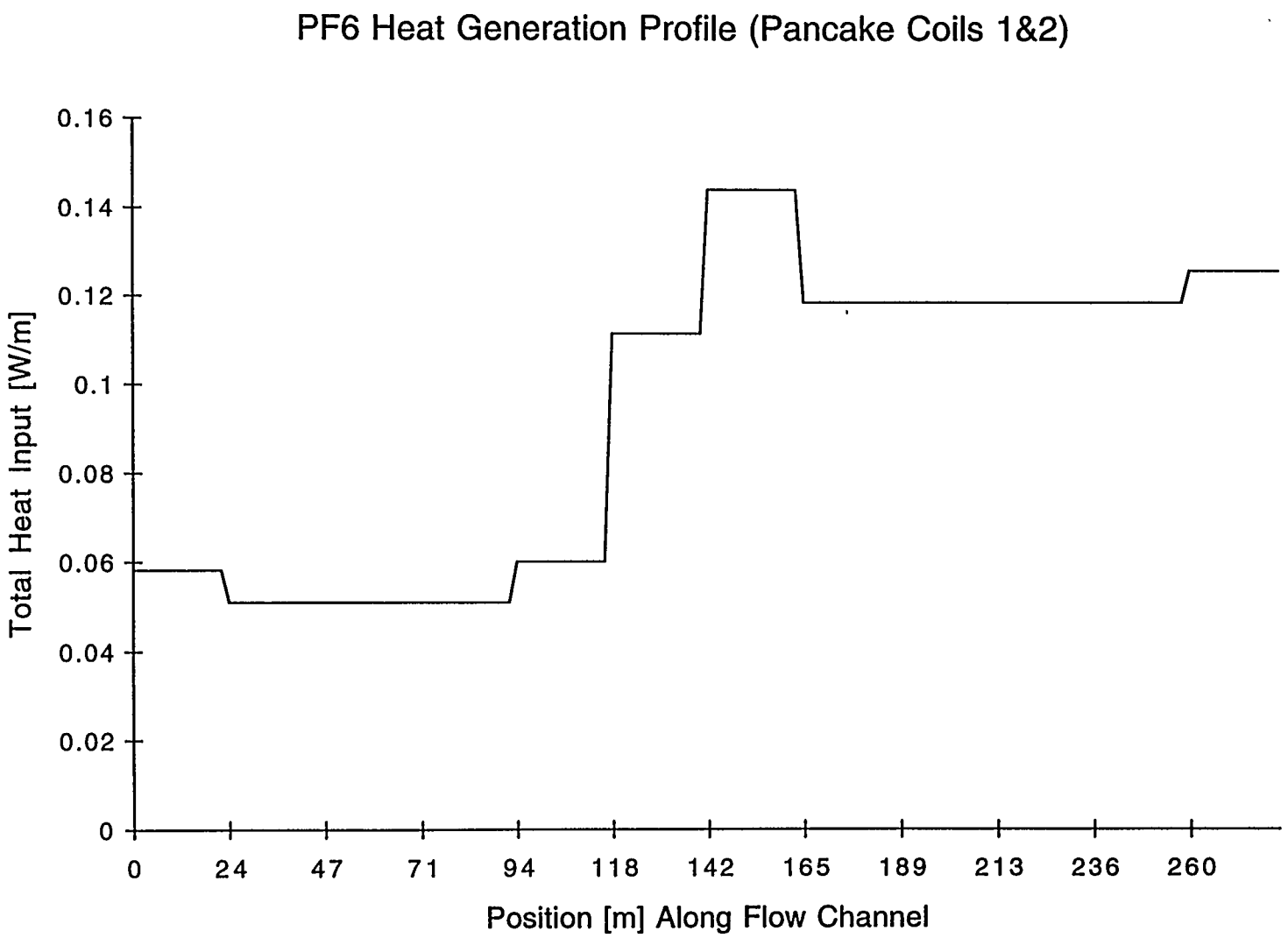


Parameter	Definition	Value	Units		Magnet	Iop *	Bop *	Temp.	Ic	Current
Dwire	sc wire diameter	0.78	mm			[Amp]	[Tesla]	[K]	[Amp]	Sharing ?
Nwire	no. of sc wires in cable	240	-		PF6	19775	3.28	6	55846.03	no
gamma	Cu:SC	2.5	-		PF6	19775	3.28	6.1	52509.95	no
Atot	total sc x-section area	114.68	mm^2		PF6	19775	3.28	6.2	49173.86	no
Ke	Jc degradation factor	1			PF6	19775	3.28	6.3	45837.78	no
					PF6	19775	3.28	6.4	42501.70	no
					PF6	19775	3.28	6.5	39165.61	no
* 14-950607-MIT-RPillsbury-01					PF6	19775	3.28	6.6	35829.53	no
					PF6	19775	3.28	6.7	32493.45	no
					PF6	19775	3.28	6.8	29157.37	no
					PF6	19775	3.28	6.9	25821.28	no
					PF6	19775	3.28	7	22485.20	no
					PF6	19775	3.28	7.01	22151.59	no
					PF6	19775	3.28	7.02	21817.98	no
					PF6	19775	3.28	7.03	21484.37	no
					PF6	19775	3.28	7.04	21150.77	no
					PF6	19775	3.28	7.05	20817.16	no
					PF6	19775	3.28	7.06	20483.55	no
					PF6	19775	3.28	7.07	20149.94	no
					PF6	19775	3.28	7.08	19816.33	no
					PF6	19775	3.28	7.081	19782.97	no
					PF6	19775	3.28	7.0811	19779.64	no
					PF6	19775	3.28	7.0812	19776.30	no
					PF6	19775	3.28	7.0813	19772.96	yes

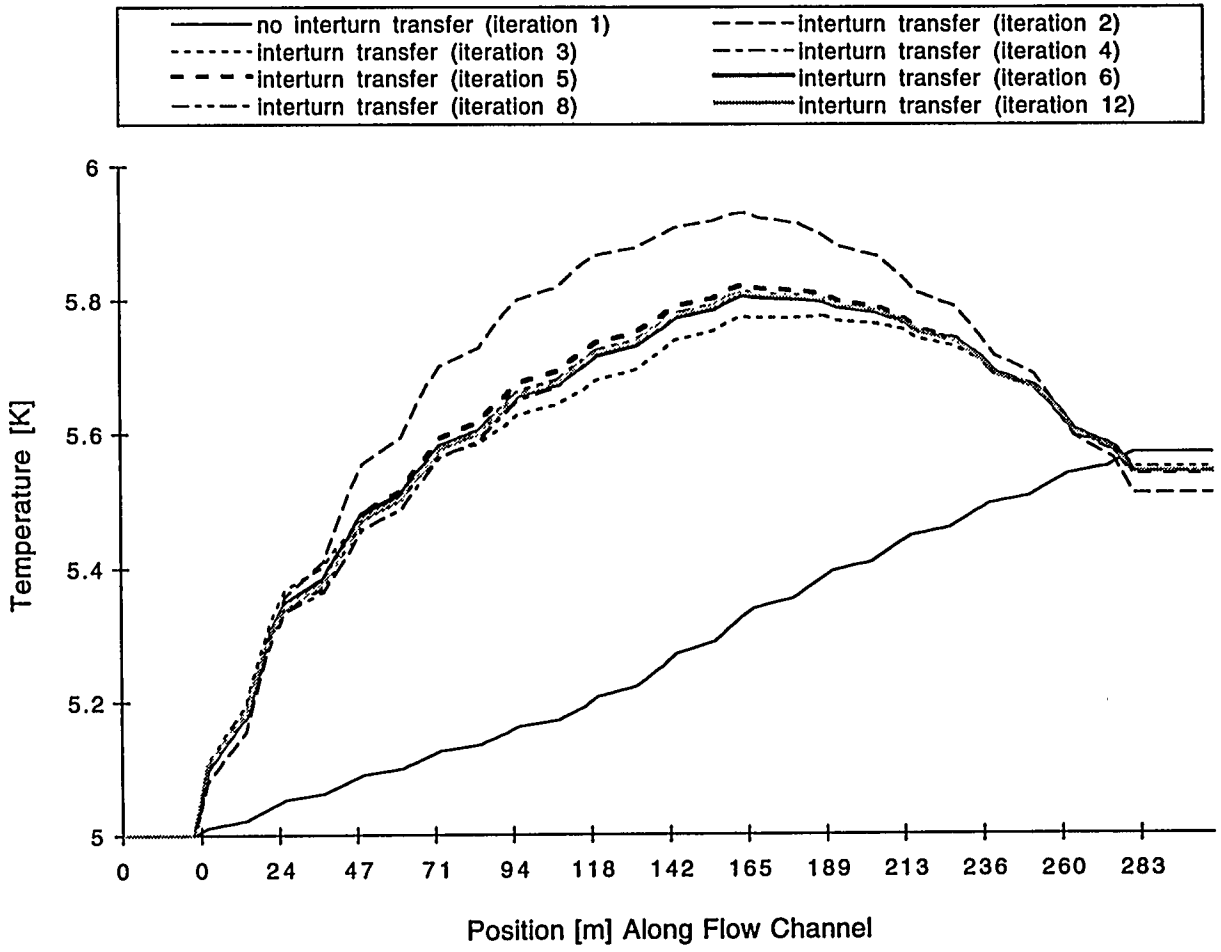
Parameter	Definition	Value	Units		Magnet	Iop *	Bop *	Temp.	Ic	Current
Dwire	sc wire diameter	0.78	mm			[Amp]	[Tesla]	[K]	[Amp]	Sharing ?
Nwire	no. of sc wires in cable	240	-		PF7	15655	2.31	6	73001.01	no
gamma	Cu:SC	2.5	-		PF7	15655	2.31	6.1	69597.70	no
Atot	total sc x-section area	114.68	mm^2		PF7	15655	2.31	6.2	66194.39	no
Ke	Jc degradation factor	1			PF7	15655	2.31	6.3	62791.08	no
					PF7	15655	2.31	6.4	59387.77	no
					PF7	15655	2.31	6.5	55984.46	no
* 14-950607-MIT-RPillsbury-01					PF7	15655	2.31	6.6	52581.15	no
					PF7	15655	2.31	6.7	49177.84	no
					PF7	15655	2.31	6.8	45774.52	no
					PF7	15655	2.31	6.9	42371.21	no
					PF7	15655	2.31	7	38967.90	no
					PF7	15655	2.31	7.1	35564.59	no
					PF7	15655	2.31	7.2	32161.28	no
					PF7	15655	2.31	7.3	28757.97	no
					PF7	15655	2.31	7.4	25354.66	no
					PF7	15655	2.31	7.5	21951.35	no
					PF7	15655	2.31	7.6	18548.04	no
					PF7	15655	2.31	7.61	18207.71	no
					PF7	15655	2.31	7.62	17867.38	no
					PF7	15655	2.31	7.63	17527.05	no
					PF7	15655	2.31	7.64	17186.72	no
					PF7	15655	2.31	7.65	16846.39	no
					PF7	15655	2.31	7.66	16506.06	no
					PF7	15655	2.31	7.67	16165.72	no
					PF7	15655	2.31	7.68	15825.39	no
					PF7	15655	2.31	7.681	15791.36	no
					PF7	15655	2.31	7.682	15757.33	no
					PF7	15655	2.31	7.683	15723.29	no
					PF7	15655	2.31	7.684	15689.26	no
					PF7	15655	2.31	7.685	15655.23	yes

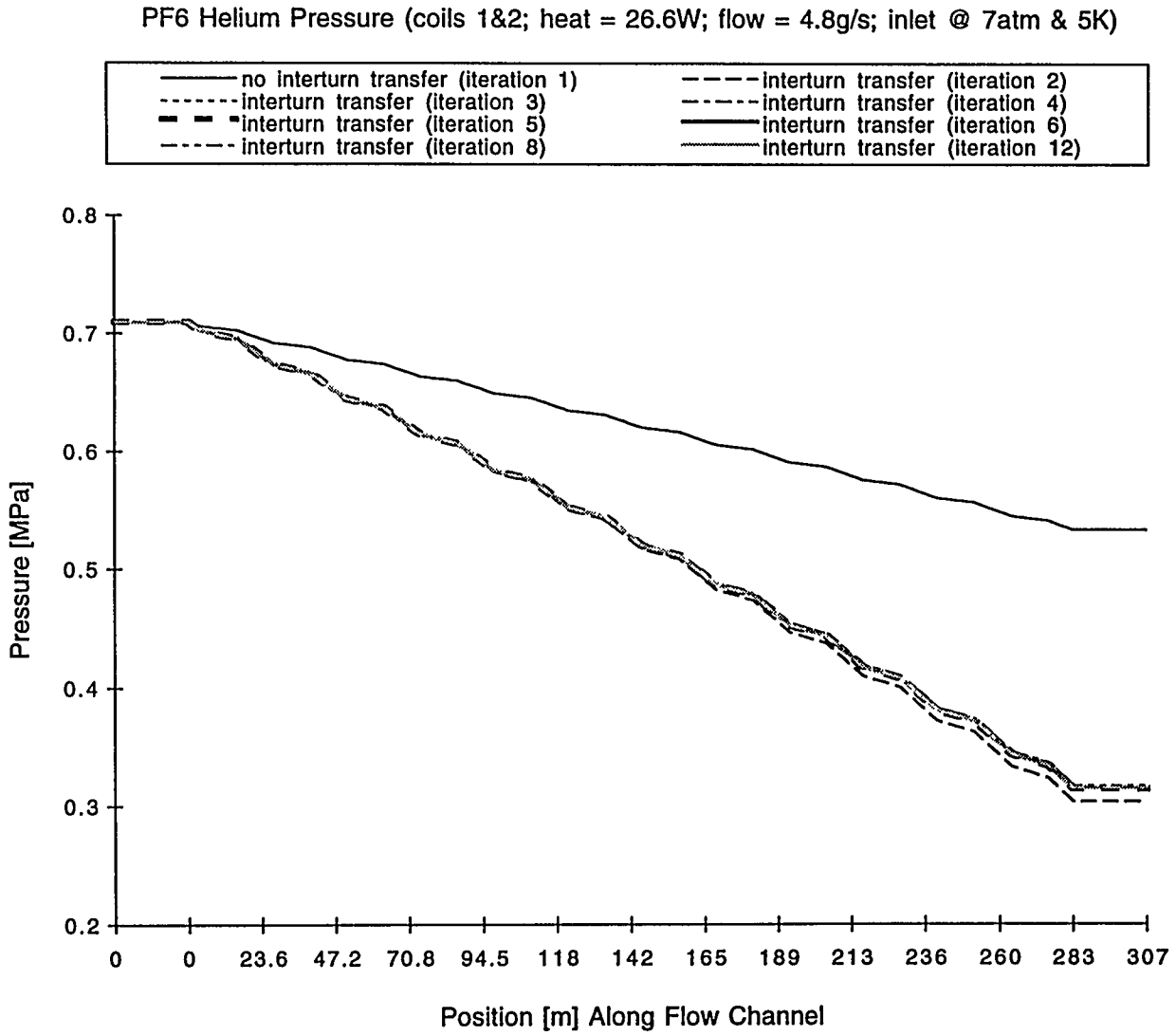
APPENDIX H

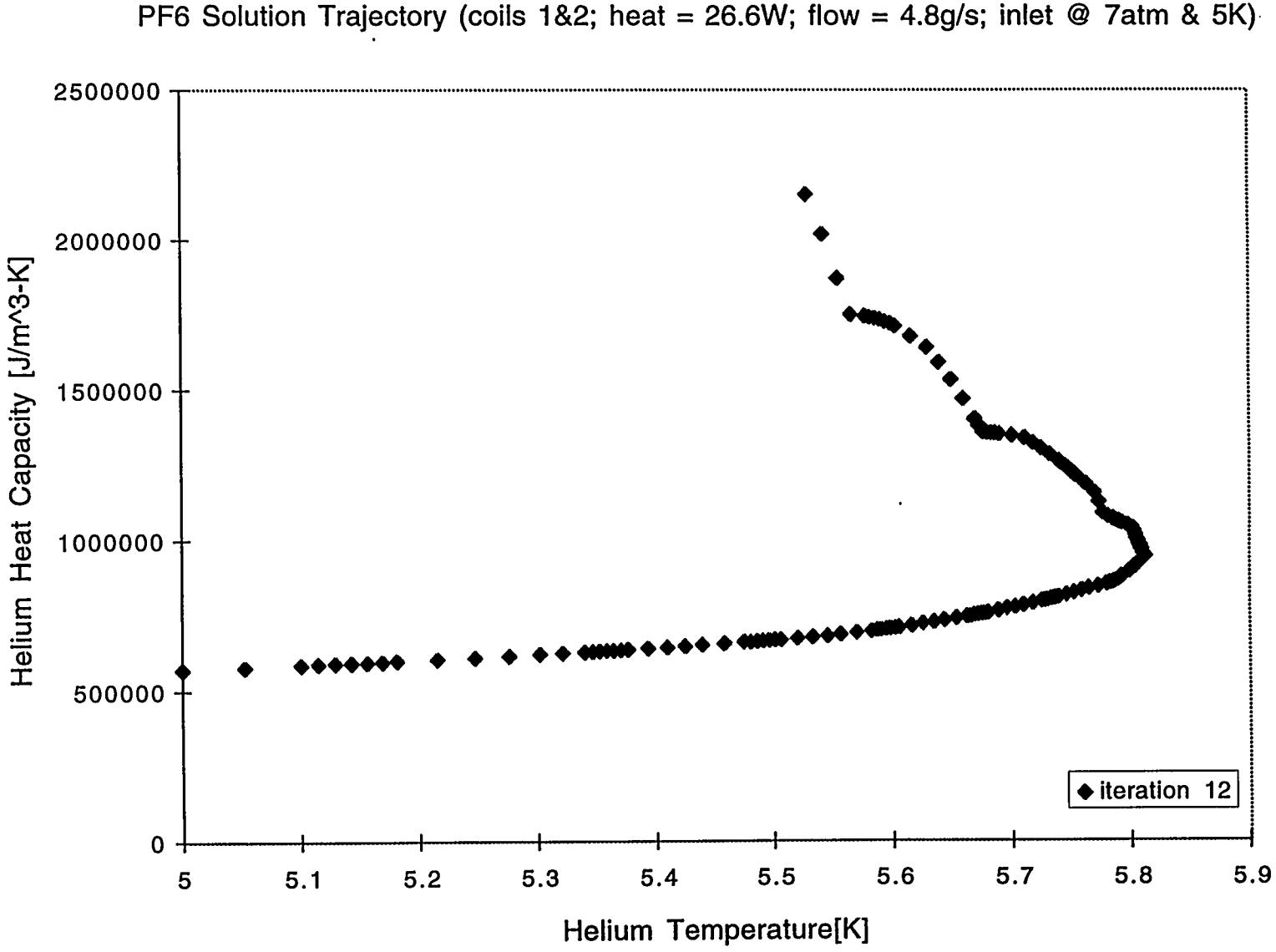
WETMAP Output Plots for Worst Case PF6 Coil


PF6 Heat Generation Profile (Pancake Coils 1&2)
Total Heat Input [W/m]
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
24
47
71
94
118
142
165
189
213
236
260
Position [m] Along Flow Channel

PF6 Wire Temperature (coils 1&2; heat = 26.6W; flow = 4.8g/s; inlet @ 7atm & 5K)



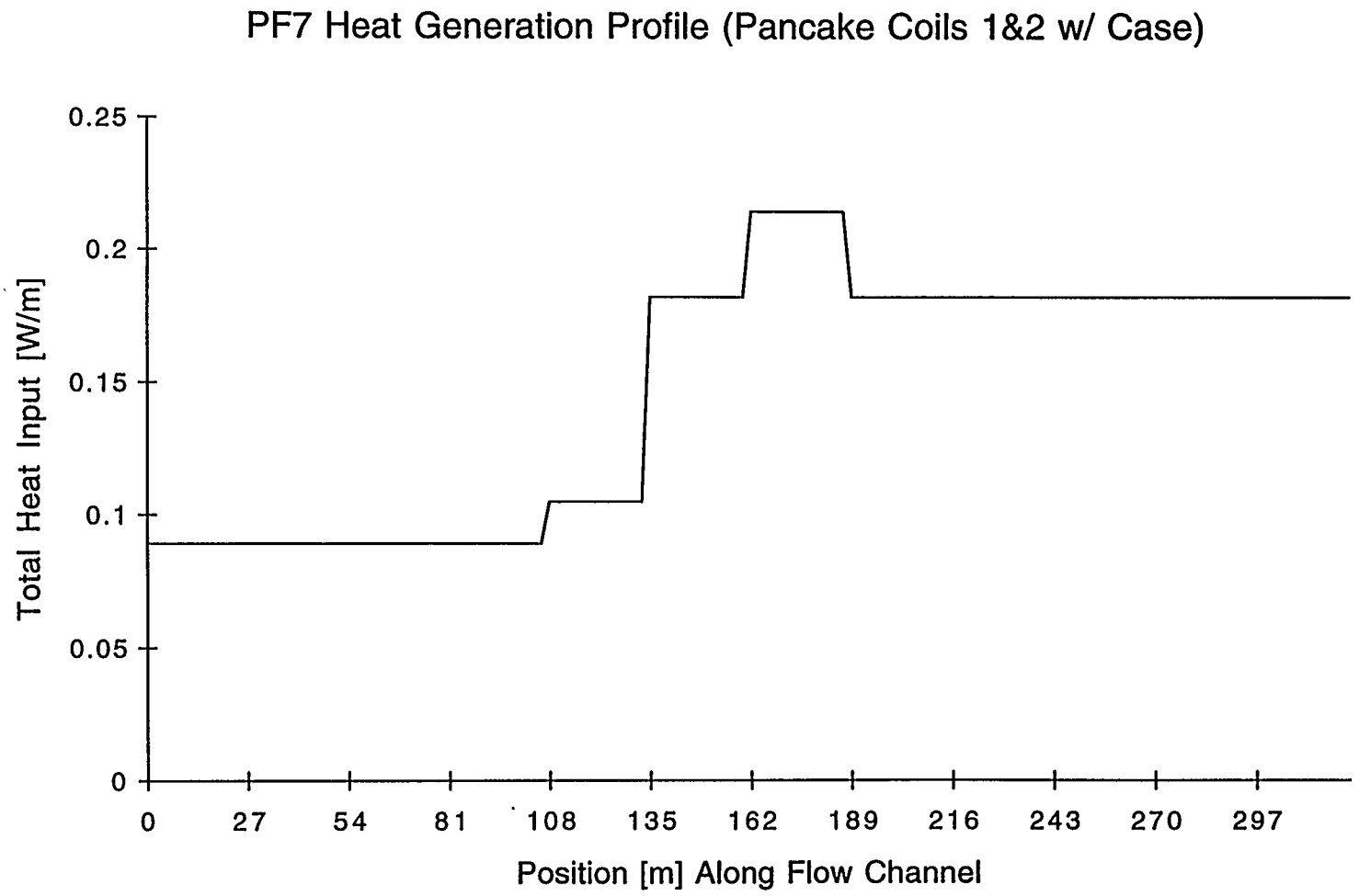

PF6 Helium Pressure (coils 1&2; heat = 26.6W; flow = 4.8g/s; inlet @ 7atm & 5K)
no interturn transfer (iteration 1)
interturn transfer (iteration 2)
interturn transfer (iteration 3)
interturn transfer (iteration 4)
interturn transfer (iteration 5)
interturn transfer (iteration 6)
interturn transfer (iteration 8)
interturn transfer (iteration 12)
Pressure [MPa]
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
0
23.6
47.2
70.8
94.5
118
142
165
189
213
236
260
283
307
Position [m] Along Flow Channel

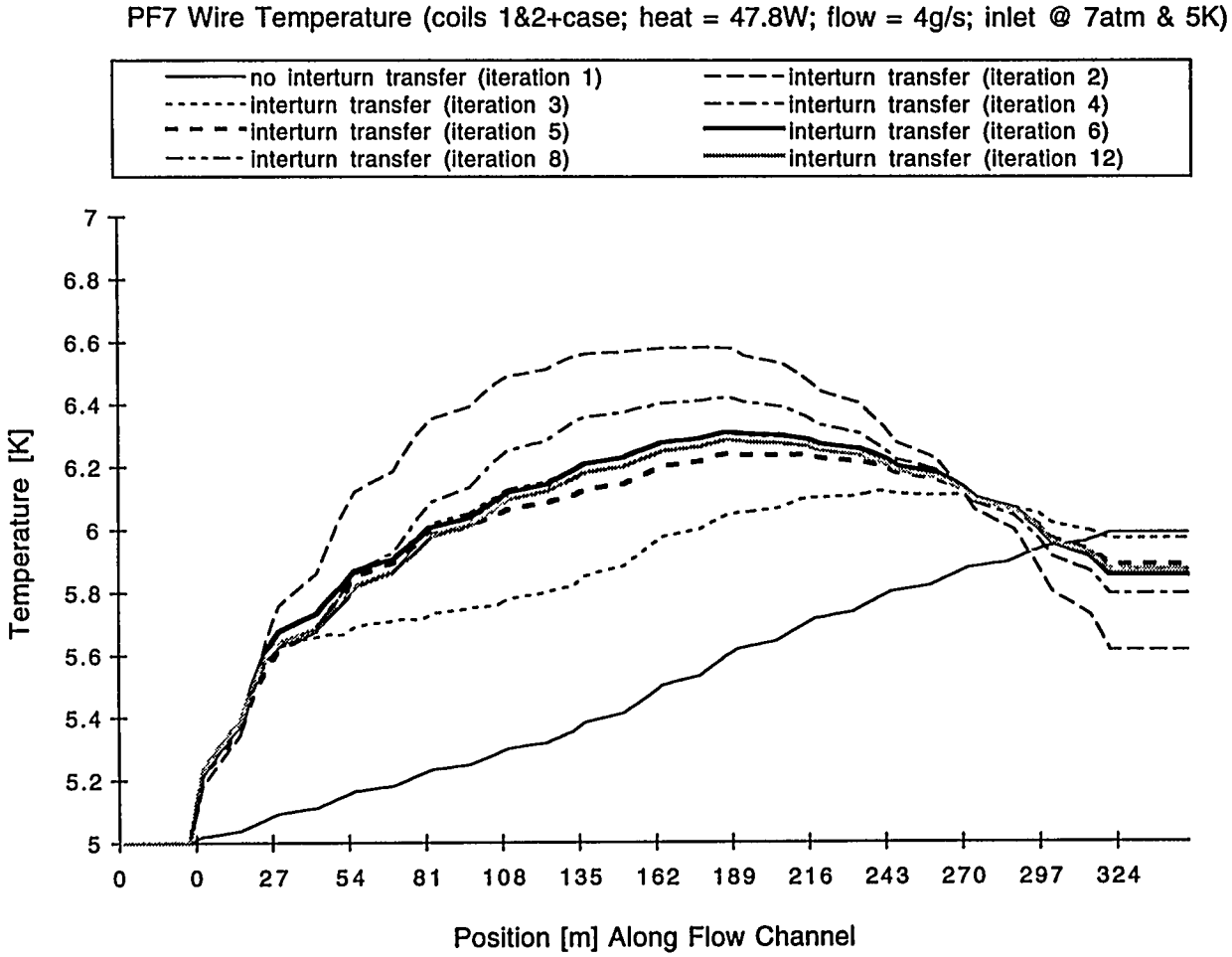

PF6 Solution Trajectory (coils 1&2; heat = 26.6W; flow = 4.8g/s; inlet @ 7atm & 5K)
Helium Heat Capacity [J/m^3-K]
2500000
2000000
1500000
1000000
500000
0
5
5.1
5.2
5.3
5.4
5.5
5.6
5.7
5.8
5.9
Helium Temperature[K]
iteration 12

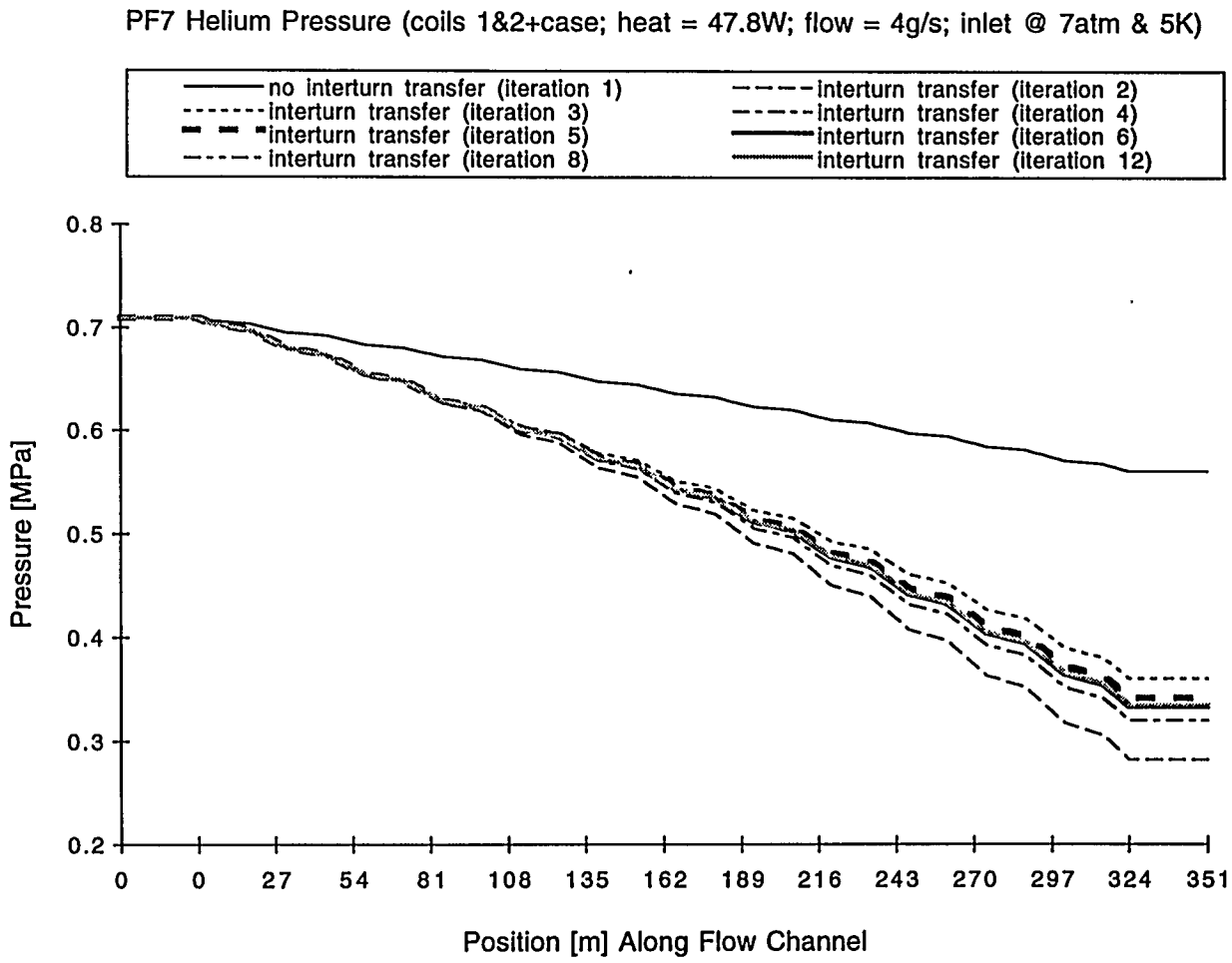
PF6 (pancakes 1&2; heat = 26.6W; flow = 4.8g/s; Phe_in = 7 atm: The_in = 5K)							
iteration	Helium Outlet Temperature [K]	The_out Residual [%]	Helium Outlet Pressure [MPa]	Phe_out Residual [%]	Cable Hot Spot Temperature [K]	Tcab_max Residual [%]	He Residence Time [s]
1	5.57		0.53		5.57		
2	5.49	-1.44	0.30	-43.14	5.93	6.43	
3	5.54	0.85	0.32	4.47	5.78	-2.61	
4	5.53	-0.14	0.32	-0.48	5.81	0.59	
5	5.53	-0.06	0.31	-0.35	5.82	0.20	
6	5.53	0.05	0.32	0.28	5.81	-0.26	
7	5.53	0.00	0.32	-0.02	5.81	0.07	
8	5.53	-0.01	0.32	-0.07	5.81	0.04	
9	5.53	0.01	0.32	0.04	5.81	-0.04	
10	5.53	-0.01	0.32	-0.04	5.81	0.00	
11	5.53	0.00	0.32	0.01	5.81	0.00	
12	5.53	0.00	0.32	-0.01	5.81	0.00	711

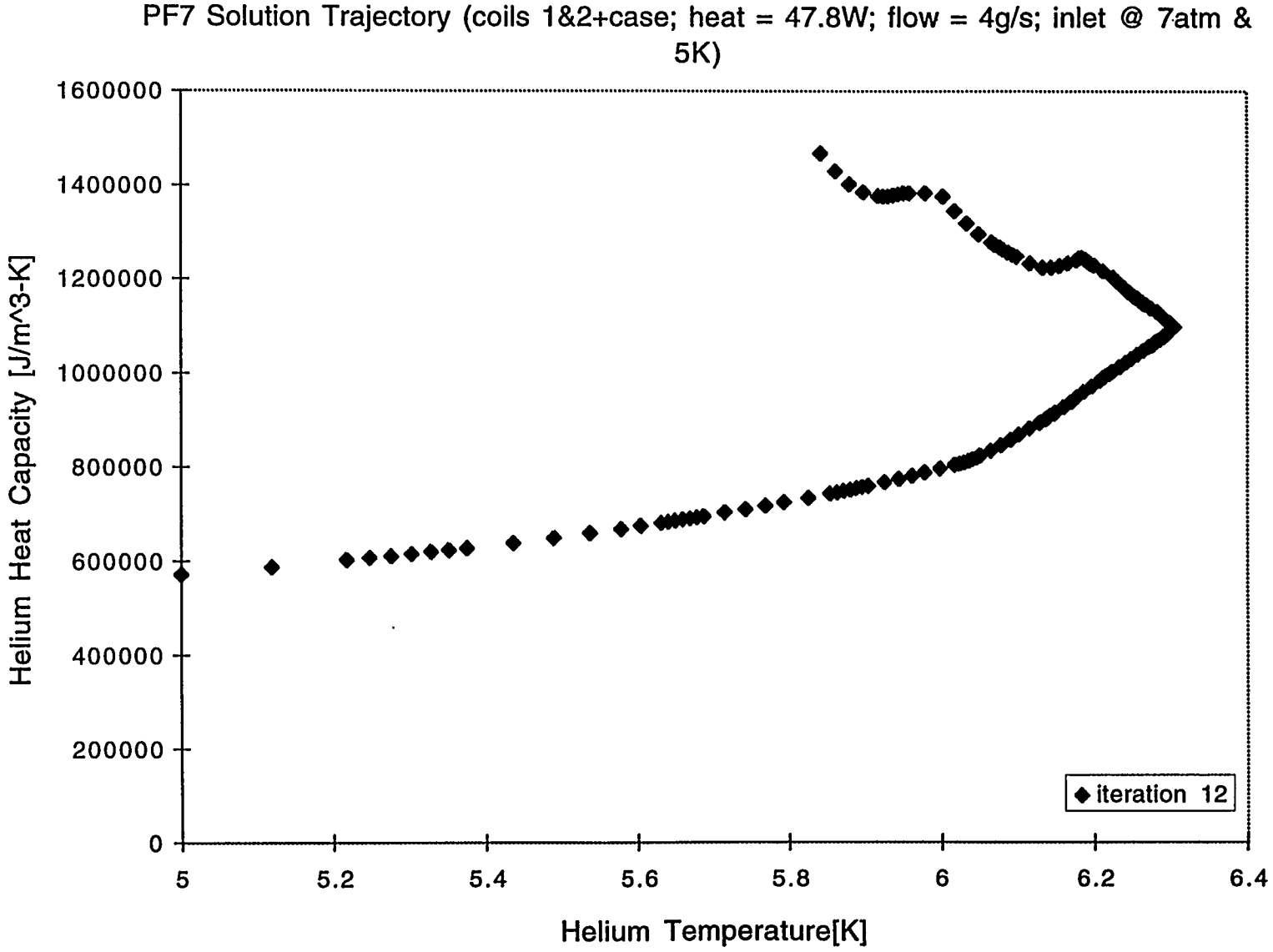
APPENDIX I

WETMAP Output Plots for Worst Case PF7 Coil w/ Case

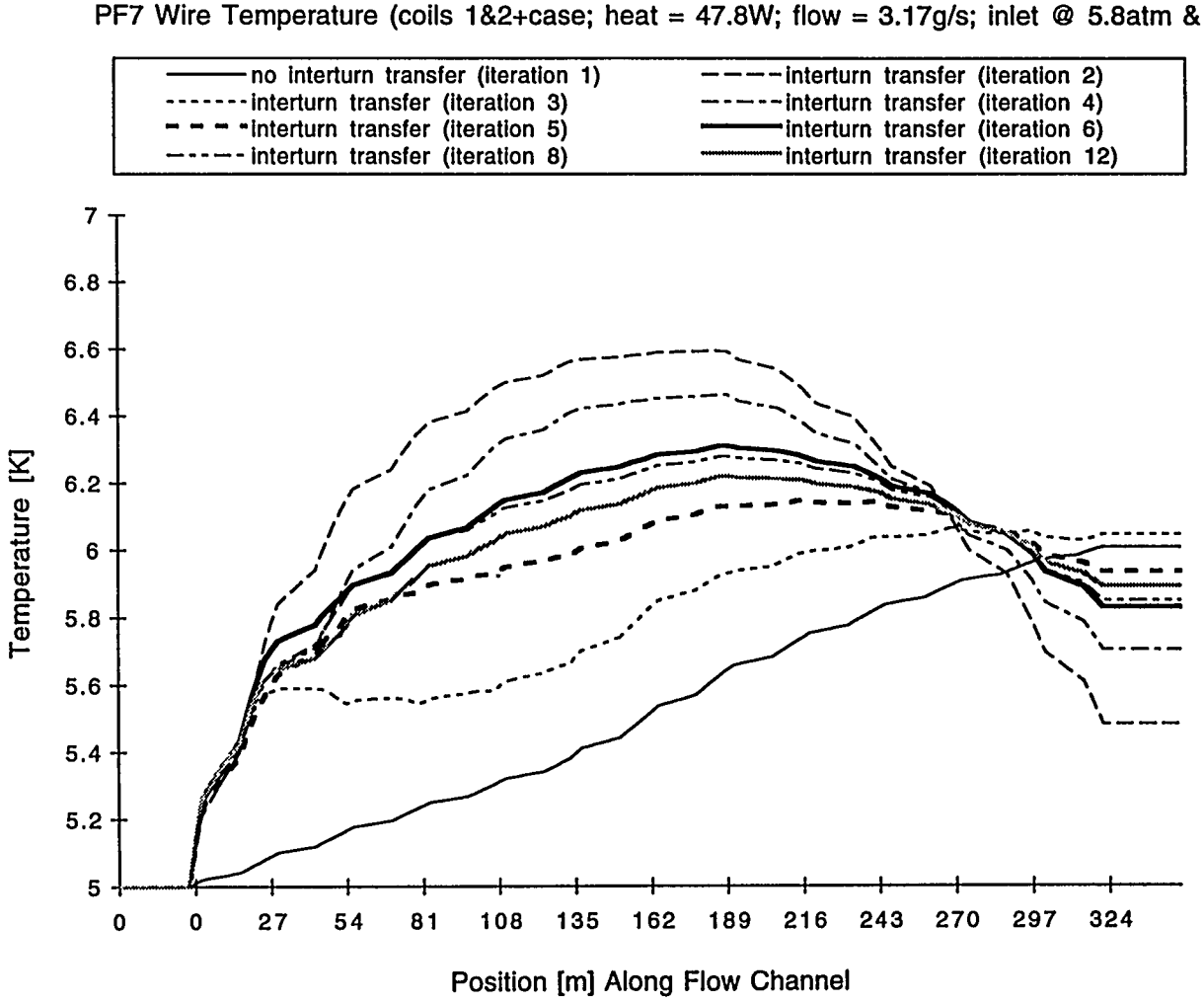

PF7 Heat Generation Profile (Pancake Coils 1&2 w/ Case)
Total Heat Input [W/m]
0.25
0.2
0.15
0.1
0.05
0
0
27
54
81
108
135
162
189
216
243
270
297
Position [m] Along Flow Channel

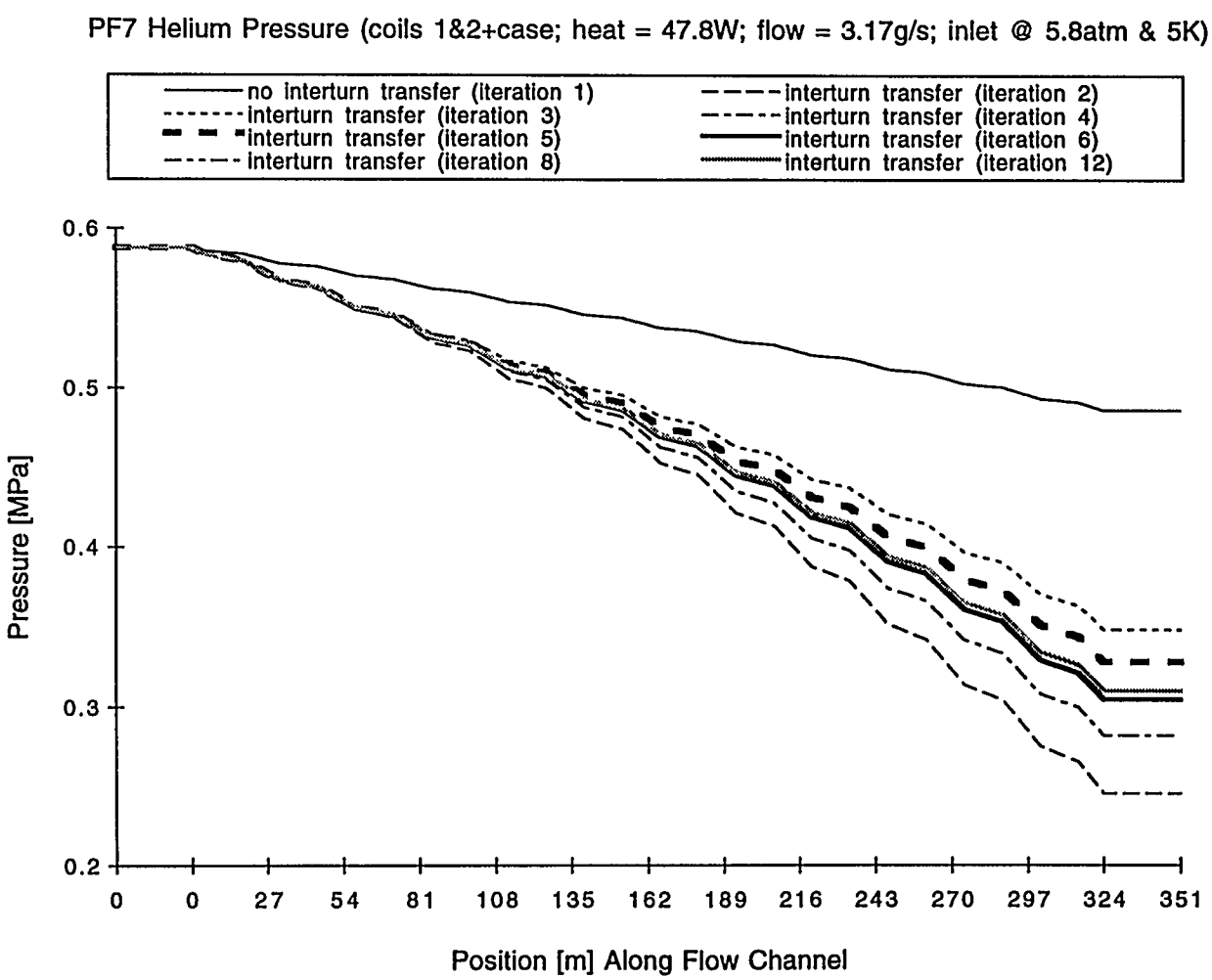

PF7 Wire Temperature (coils 1&2+case; heat = 47.8W; flow = 4g/s; inlet @ 7atm & 5K)
no interturn transfer (iteration 1)
interturn transfer (iteration 2)
interturn transfer (iteration 3)
interturn transfer (iteration 4)
interturn transfer (iteration 5)
interturn transfer (iteration 6)
interturn transfer (iteration 8)
interturn transfer (iteration 12)
Temperature [K]
7
6.8
6.6
6.4
6.2
6
5.8
5.6
5.4
5.2
5
0
0
27
54
81
108
135
162
189
216
243
270
297
324
Position [m] Along Flow Channel

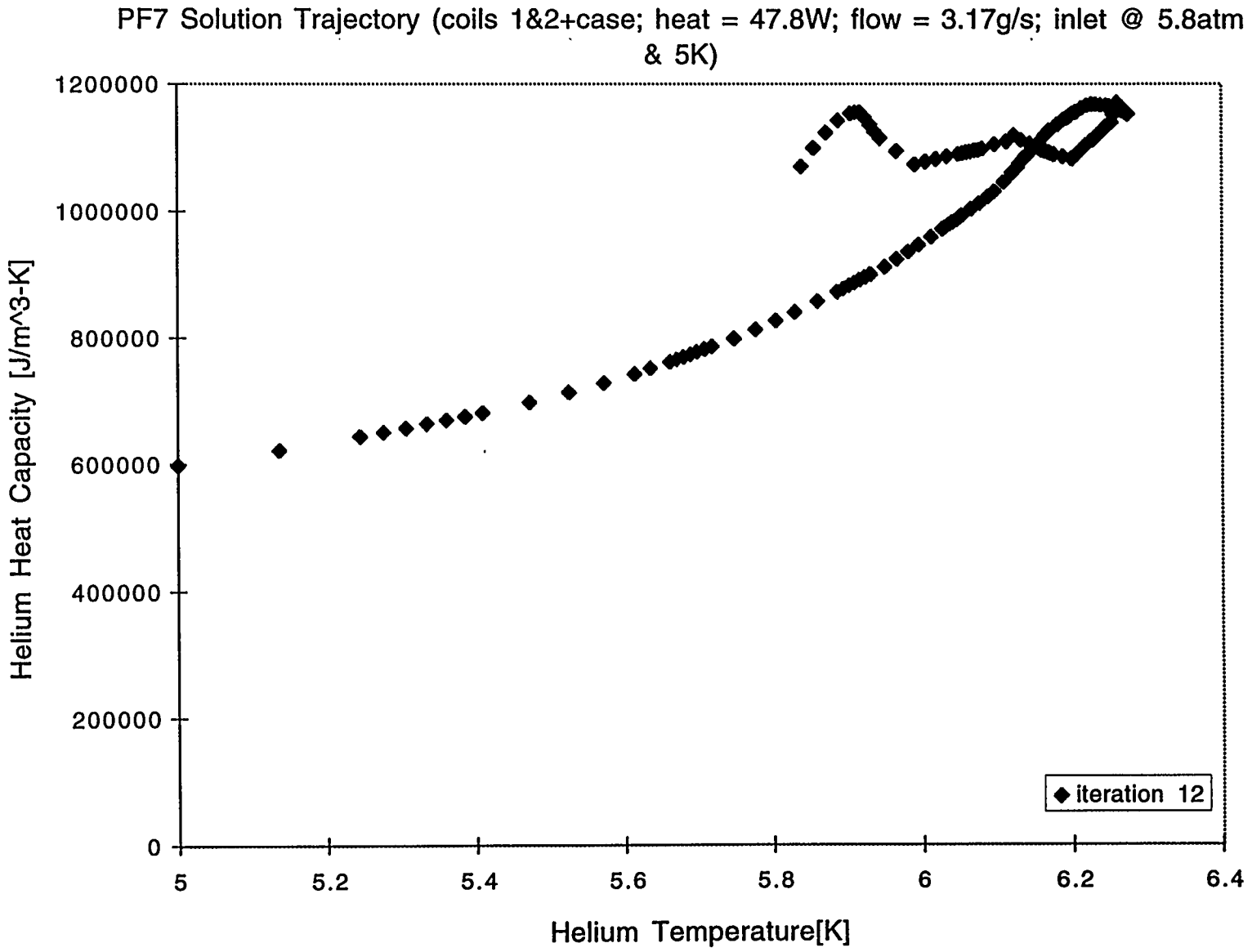

PF7 Helium Pressure (coils 1&2+case; heat = 47.8W; flow = 4g/s; inlet @ 7atm & 5K)
no interturn transfer (iteration 1)
interturn transfer (iteration 2)
interturn transfer (iteration 3)
interturn transfer (iteration 4)
interturn transfer (iteration 5)
interturn transfer (iteration 6)
interturn transfer (iteration 8)
interturn transfer (iteration 12)
Pressure [MPa]
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
0
27
54
81
108
135
162
189
216
243
270
297
324
351
Position [m] Along Flow Channel


PF7 Solution Trajectory (coils 1&2+case; heat = 47.8W; flow = 4g/s; inlet @ 7atm & 5K)
Helium Heat Capacity [J/m^3-K]
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
5
5.2
5.4
5.6
5.8
6
6.2
6.4
Helium Temperature[K]
iteration 12

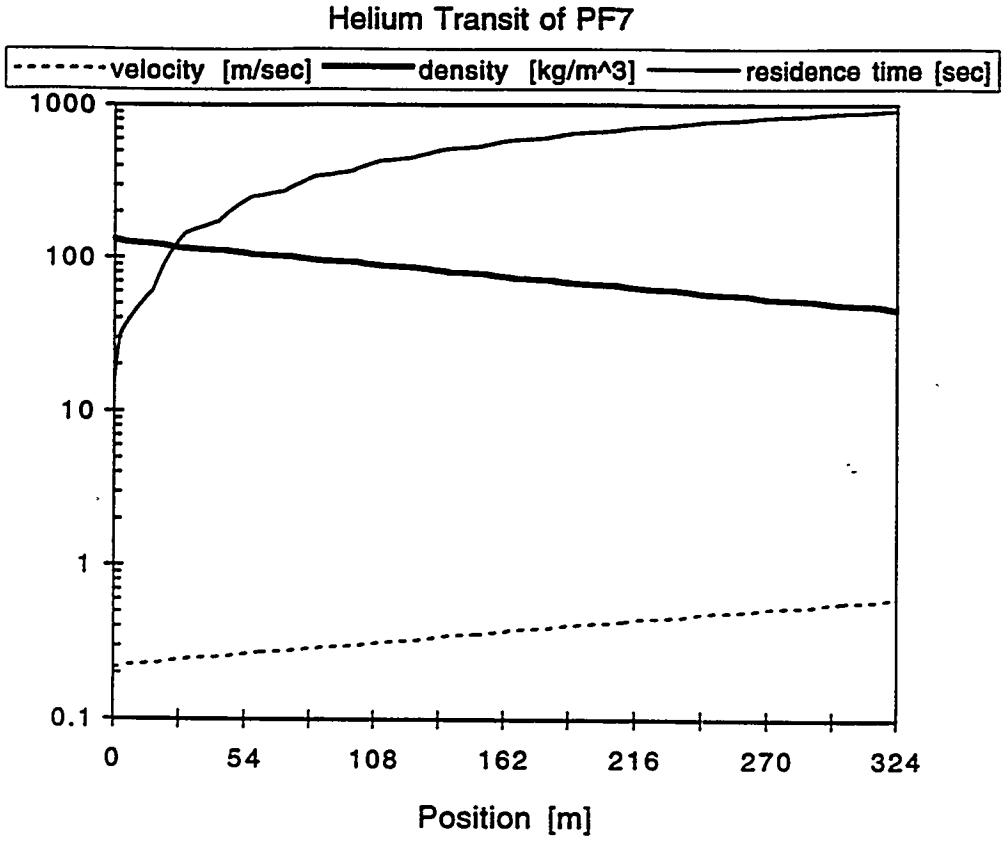
PF7 (pancakes 1&2+case; heat = 47.8W; flow = 4g/s; Phe_in = 7 atm: The_in = 5K)							
iteration	Helium Outlet Temperature [K]	The_out Residual [%]	Helium Outlet Pressure [MPa]	Phe_out Residual [%]	Cable Hot Spot Temperature [K]	Tcab_max Residual [%]	He Residence Time[s]
1	5.99		0.56		5.99		
2	5.58	-6.86	0.28	-49.66	6.58	9.87	
3	5.97	6.91	0.36	27.83	6.12	-6.96	
4	5.77	-3.23	0.32	-11.24	6.42	4.86	
5	5.87	1.72	0.34	6.75	6.24	-2.81	
6	5.84	-0.64	0.33	-2.44	6.31	1.11	
7	5.85	0.34	0.34	1.28	6.29	-0.39	
8	5.84	-0.26	0.33	-0.98	6.31	0.32	
9	5.85	0.16	0.34	0.61	6.29	-0.32	
10	5.84	-0.15	0.33	-0.60	6.29	0.00	
11	5.84	0.02	0.33	0.09	6.29	0.00	
12	5.84	0.00	0.33	-0.01	6.29	0.00	850.7


PF7 Wire Temperature (coils 1&2+case; heat = 47.8W; flow = 3.17g/s; inlet @ 5.8atm & 5K)
no interturn transfer (iteration 1)
interturn transfer (iteration 2)
interturn transfer (iteration 3)
interturn transfer (iteration 4)
interturn transfer (iteration 5)
interturn transfer (iteration 6)
interturn transfer (iteration 8)
interturn transfer (iteration 12)
Temperature [K]
7
6.8
6.6
6.4
6.2
6
5.8
5.6
5.4
5.2
5
0
0
27
54
81
108
135
162
189
216
243
270
297
324
Position [m] Along Flow Channel


PF7 Helium Pressure (coils 1&2+case; heat = 47.8W; flow = 3.17g/s; inlet @ 5.8atm & 5K)
no interturn transfer (iteration 1)
interturn transfer (iteration 2)
interturn transfer (iteration 3)
interturn transfer (iteration 4)
interturn transfer (iteration 5)
interturn transfer (iteration 6)
interturn transfer (iteration 8)
interturn transfer (iteration 12)
Pressure [MPa]
0.6
0.5
0.4
0.3
0.2
0
0
27
54
81
108
135
162
189
216
243
270
297
324
351
Position [m] Along Flow Channel


PF7 Solution Trajectory (coils 1&2+case; heat = 47.8W; flow = 3.17g/s; inlet @ 5.8atm & 5K)
Helium Heat Capacity [J/m^3-K]
1200000
1000000
800000
600000
400000
200000
0
5
5.2
5.4
5.6
5.8
6
6.2
6.4
Helium Temperature[K]
iteration 12

PF7 (pancakes 1&2+case; heat = 47.8W; flow = 3.17g/s; Phe_in = 5.8 atm: The_in = 5K)						
iteration	Helium Outlet Temperature [K]	The_out Residual [%]	Helium Outlet Pressure [MPa]	Phe_out Residual [%]	Cable Hot Spot Temperature [K]	Tcab_max Residual [%]
1	6.01		0.49		6.01	
2	5.44	-9.50	0.25	-49.54	6.59	9.71
3	6.05	11.19	0.35	42.14	6.07	-8.01
4	5.68	-6.09	0.28	-19.12	6.46	6.55
5	5.93	4.43	0.33	16.50	6.15	-4.90
6	5.81	-2.02	0.30	-7.17	6.31	2.66
7	5.88	1.25	0.32	4.67	6.22	-1.43
8	5.83	-0.83	0.31	-2.97	6.28	0.96
9	5.87	0.53	0.32	1.95	6.22	-0.95
10	5.84	-0.50	0.31	-1.83	6.22	0.00
11	5.84	0.04	0.31	0.16	6.22	0.00
12	5.84	0.00	0.31	0.00	6.22	0.00


Helium Transit of PF7
velocity [m/sec]
density [kg/m^3]
residence time [sec]
1000
100
10
1
0.1
0
54
108
162
216
270
324
Position [m]

Distribution List

Science & Technology Center

*A. Melissaratos, 801-3C54
S. D. Harkness, 801-3C54C
C. J. Heyne, 501-3Y56A
D. T. Hackworth, 501-3Y56B
O. S. Taylor, 501-3Y56C
J. R. Repp, 501-3Y56D
S. K. Singh, 501-3Y56E
J. L. Wu, 501-3Y56H
*W. F. Hannan, 501-3Y59
M. P. Krefta, 501-3D24
D. C. Johnson, 501-3D30
D. J. Hall, 501-3E25
T. Kupiszewski, 501-3E29
O. R. Christianson, 501-3D34
T. J. Fagan, 501-2Y29
J. F. Lowry, 501-3Y31
J. F. Roach, 501-3Y25
P. A. Sanger, 501-3D22
J. H. Parker, Jr., 501-3D28
W. J. Carr, Jr., 401-3A13
Library (3)

Sunnyvale, CA - MARD

C. B. Armstrong
*R. Ryan

Orlando, FL - PGBU

*D. A. Bartol
*F. .P. Bevc

Pittsburgh, PA - PGSD

*P. J. Craig

* TDS Page Only

TPX Pulsed Coil System Instrumentation

P. L. Walstrom Ph.D.
Northrop Grumman Corporation

August 10, 1995

TPX-14-950810-WEC-PWalstrom-01

APPROVED:

P.A. Sanger
Westinghouse TPX Chief Scientist

APPROVED:

D. R. Potter
Westinghouse TPX Engineering Manager

Westinghouse Electric Corporation
Electronic Systems Group

401 East Hendy Avenue, Sunnyvale, California 94088-3499

Introduction

Instrumentation is required in the PF coils to monitor and control cooldown and normal operation, and to detect quenches. The instrumentation installation task includes mounting of flowmeters, absolute pressure sensors, and temperature sensors, installation of strain gauges, etc., and routing and protection of lead wires for these sensors, including voltage tap wires and fiber-optics temperature sensors, which are critical for quench detection. Many of these sensors are under development and final dimensions and installation details are not presently available. Exact numbers and types of sensors will be specified in the final design phase. In many cases (e.g., sensors in the helium lines), the sensors will be installed during installation of the coils in the facility. The main exceptions are the co-wound voltage taps and fiber-optics temperature sensors, which must be installed in the cable-in-conduit conductor during its manufacture.

Use of instrumentation in addition to that in the specifications is proposed here, but the sensors are not included in the sensor table, which contains only the required sensors.

Voltage Taps

Wherever a lead termination or conductor splice occurs, voltage-tap connections will be made. The detailed procedure for the connections will be part of the lead termination process specification, which is under development and which will apply to all of the coils in the system. Making the connection to the internal voltage taps will involve extracting six coaxial cables from the conductor cable after the conduit has been removed prior to installation in the terminal block. At least two approaches for the coaxial cables inside the conduit have been considered. One approach is to use a copper or Constantan center wire insulated with Mg0 and surrounded by a coaxial stainless-steel sheath. Cables of this type are widely used in high-temperature thermocouple and heater installations. The problem with this approach is availability of sufficiently long continuous lengths. For this reason, the present approach is to use S-glass braid insulation instead of MgO[1,2]. A copper braid is applied over the S-glass layer, and then the entire cable is encased in a stainless-steel tube. The differential voltage between the sheath and center wire is the raw quench signal that is input to the quench-detection signal-conditioning system. As the coaxes leave the conductor cable, a transition will be made to a single cable with six insulated inner conductors, surrounded by a single conducting sheath that is connected to one of the coax sheaths or the cable. When the coax is stripped, the local glass insulation will also be removed, and this area must be reinsulated. This insulation, the glass insulation of the coax, and the insulation of the wires that are connected to the center wire of the coax must be able to withstand the peak differential voltages, which are mainly due to resistive voltages developed in normal zones in the conductor. An insulation rating of a few hundred volts is sufficient to withstand these voltages with an adequate margin of safety. The connection must also provide mechanical support for the wires. The outer sheath of the six-wire cable will be surrounded by solid high-voltage insulation, a grounded sheath, and an outer protective insulation layer. The inner wires

will be twisted and the cable routed to the vacuum interface in such a way as to minimize inductive pickup, and connected to high-voltage vacuum feedthroughs either with a removable connector, or with direct connections. Since this is a critical instrumentation channel, redundant lead connections should be considered. The installation will probably also include a break in the high-voltage cable with a mating high-voltage connector pair near the terminations.

One possible alternative to coaxial cables installed within the conductor cable inside the conduit is to co-wind a Kapton-insulated metal ribbon with the conduit. The signal-to-noise performance of this would not be as good as that of the internal coax, but would be much better than that of conventional direct taps.

The fiber-optics temperature-sensing cables require a fiber-optics interface and do not involve high-voltage cabling. Details of the interface are under development. The fiber-optics lead cables would probably be routed separately from the voltage-tap cables to the vacuum wall and would be brought out through the ground screen layer in the vicinity of the lead termination region. At this point, the ground screen would be extended approximately ten diameters of the fiber-optics cable bundle to form a ground-screen tee with negligible electric field strength inside the end where the fiber-optics cable exits it.

Flow Rate and Pressure Measurements

The other methods of quench detection involve sensing sudden increases in helium flow rate that are caused by a resistive zone in the channel. Flowmeter measurements are also required to monitor normal operation and cooldown flows. A final flowmeter approach has not yet been selected. Venturi tubes with differential pressure gauges have been used for precision liquid helium flow measurement. In the Large Coil Program in Oak Ridge, capillary tubes were used to transmit the pressure signals from Venturi tubes in the liquid helium inlets and outlets to warm differential pressure transducers. Commercially available variable-reluctance type differential pressure transducers, intended for room temperature use, were successfully tested at helium temperature for use in LCP, but were not used in the final LCP installation because of questions of reliability (helium leak tightness) and magnetic-field sensitivity. The potential leak problem came about from the use of magnetic stainless steels in the transducers. These steels are brittle at low temperature.

The capillary lengths were approximately four meters. The pressure transducers actually used were of the strain-gauge type, were mounted outside of the vacuum vessel in ambient air, and were magnetically shielded with soft iron and mu metal. The time delay for flow-rate transients incurred by using capillary tubes was not directly measured, but was on the order of a few tenths of a second. The flow measurements were used mostly for monitoring operating flow rates, but were also inputs to the quench detection system.

The differential pressure from Venturi tubes, for constant fluid density, varies as the square of the mass flow rate (or velocity). As a result, it is difficult to find differential pressure transducers with sufficient dynamic range to measure nominal flow rates but also withstand the quench transients, and be capable of operating at low temperature and in a magnetic field.[3] Flowmeters that use other operating principles, such as measuring flow-induced acoustic and optical Doppler shifts, and have outputs that are directly

proportional to velocity instead of its square, are also being considered for use in TPX. At the present level of design, locations, but not specific types of flowmeters are given. The flowmeters are assumed for the present to be cooled to near liquid helium temperature during use.

One absolute pressure transducer will be installed on the inlet manifold of each coil and one on each outlet manifold. The present concept calls for a cold installation. Use of more than one outlet manifold for a coil or set of coils, with flow-control orifices between them and a single common return manifold, has been considered in trade studies. The nominal number at present is two per coil– one on the inlet, and one on the outlet.

Temperature Measurements

For monitoring helium temperature, one or two temperature sensors on the inlet manifolds and at least one sensor on each outlet (helium stub or lead termination) will be used. The installations will be "wet" (i.e., the sensor and some length of lead wires will be immersed in the helium) to ensure accurate readings. This requires use of a multipin liquid helium/vacuum feedthrough with a high pressure rating. The installation will be made on the ground side of the insulating breaks. For long-term reliability, a combination of a germanium resistance thermometer (GRT) and a carbon glass resistance thermometer (CGRT) should be considered. The GRT has a long-term temperature stability, even after repeated temperature cycling, of better than 10 mK, but is field sensitive. The CGRT is less field sensitive, but has poorer stability with thermal cycling. For monitoring the helium temperature during cooldown, other thermometers, e.g., thermocouples or platinum resistance thermometers, must be used to cover the 300-20K range, since the CGRT and GRT lose sensitivity at higher temperatures.

A number of additional temperature sensors should also be used to monitor temperatures of various items during cooldown. These include the coil case (for PF6 and 7), outer epoxy temperatures for PF1-5, and the temperatures of the CS supports and intercoil support structures. Temperatures of only grounded structures would be measured. A relatively inexpensive approach that covers the most critical portion of the cooldown cycle (300-50K) with adequate accuracy is to use type E (chromel-constantan) thermocouples . They are connected to multichannel scanners for recording the temperatures and do not require expensive signal conditioning.

Strain Gauges

Strain gauges will be mounted on the case of PF6 and PF7 and on the structural mounts of all of the PF coils in critical areas. As in the LCP, these will be installed in active/dummy compensating pairs, and read out with ac carrier amplifiers to eliminate spurious thermal voltages[4,5]. The exact number required is to be determined. Use of strain gauges on the epoxy surface of PF coils 1–5 can also be considered, but problems may arise due to the poor conductivity of the epoxy, which leaves the gauges at an undetermined temperature.

Displacement Transducers

With the coil support concepts proposed, strain-gauge measurements cannot be used to infer the shifts in coil positions that may occur during load cycling. Use of displacement transducers to monitor the position of the coils with respect to the TF mounts is therefore recommended. At a minimum, this should be done at four locations on each of PF5, 6, and 7, and at four places on the top and bottom of the CS. This could be done by use of optical interferometry, but it is difficult to maintain light paths through the cryostat, multilayer insulation, etc. A moving-coil differential transformer (MCDT) that behaves in much the same as the LVDT, but has no ferromagnetic parts, was developed and used successfully in the LCP program in Oak Ridge for displacement measurements on the superconducting test coils inside the test cryostat[6]. In the LCP tests, the change in inside horizontal and vertical coil bore dimensions during magnetic loading was measured. Signal conditioning for the MCDT is a standard ac carrier amplifier of the type used with, for example, LVDTs. The device is has a resolution of better than a microinch (at high amplifier gain) and a range of inch or more (at lower gain), depending upon its physical length.

Sensor Summary Tables

CS Sensors.

Sensor	*Number*	*Location*	*Remarks*
Strain Gages	8	CS vertical supports	
	16	CS preload structure	
	24	CS coils	Measure hoop stress
Internal Fiber Optic Temperature Sensors	2 Fibers x 2 magnet terminations x 8 magnets = 32 sensors	Co-wound, exiting at the magnet terminations.	Inside CICC
Voltage Taps external	2 pairs (one redundant pair) per joint x 2 terminations x 8 magnets=16 sensors (twisted pairs)	Across magnet terminations	Monitors voltage drop across joints
Voltage Taps Co-wound (Non-Inductive)	6 sensors(twisted pairs) x 2 terminations x 8 magnets = 96 sensors (twisted pairs)	@ Magnet Terminations	Inside CICC
Flowmeters	PF1 5 x 2 = 10 PF2 5 x 2 = 10 PF3 3 x 2 = 6 PF4 3 x 2 = 6 Total = 32	@ all double-pancake helium inlet & outlet lines (& terminations)	
Pressure transducers	2	Inlet / Outlet manifolds	
Temperature Sensors (CGR or Cernox)	PF1 3 x 2 = 6 PF2 3 x 2 = 6 PF3 2 x 2 = 4 PF4 2 x 2 = 4	@ pancake (& terminations) He outlet lines	
	2	@ He inlet manifold	
	8+16+24 = 48 TOTAL = 70	@ each strain gage location	
Hall Probes	1 x 8 magnets = 8	@ centerline of I.D. for each magnet	

PF5 Sensors.

Sensor	*Number*	*Location*	*Remarks*
Strain Gages	24	Mounts, PF5U	8 mounts x 3/mount
	6	Mounts, PF5L	2 mounts x 3/mount
	6	PF5 coils	Measure hoop stress
Internal Fiber Optic Temperature Sensors	2 Fibers x 2 magnet terminations x 2 magnets = 8 sensors	Co-wound, exiting at the magnet terminations.	Inside CICC
Voltage Taps external	2 pairs (one redundant pair) per joint x 2 terminations x 2 magnets=8 sensors (twisted pairs)	Across magnet terminations	Monitors voltage drop across joint
Voltage Taps Co-wound (Non-Inductive)	6 sensors(twisted pairs) x 2 terminations x 2 magnets = 24 sensors (twisted pairs)	@ Magnet Terminations	Inside CICC
Flowmeters	5 x 2 magnets = 10	@ all double-pancake helium inlet & outlet lines (& terminations)	
Pressure Transducers	2	Inlet / Outlet manifolds	
Temperature Sensors (CGR or Cernox)	3 x 2 magnets = 6	@ pancake (& termination) He outlet lines	
	2	@ He inlet manifold	
	6+6+24 = 36 TOTAL = 44	@ each strain gage location	
Hall Probes	1 x 2 magnets = 2	@ centerline of I.D. for each magnet	

PF6&7 Sensors

Sensor	*Number*	*Location*	*Remarks*
Strain Gages	48	Mounts, PF6U	16 mounts x 3/mount
	18	Mounts, PF6&7L, PF7U	2 mounts x 3/mount x 3
	12	Coils (3 per coil)	Measure hoop/bending stress
Internal Fiber Optic Temperature Sensors	2 Fibers x (2 magnet terminations +4 splice ends) x 2 magnets +2 Fibers x (2 magnet terminations +2 splice ends)x 2 magnets = 40 sensors	Co-wound, exiting at the magnet terminations and conductor splices.	Inside CICC
Voltage Taps external	2 pairs (one redundant pair) per joint x (2 magnet terminations +2 splices) x 2 magnets +2 pairs per joint x (2 magnet terminations +1 splice)x 2 magnets = 28 sensors (twisted pairs)	Across magnet terminations and splice joints	Monitors voltage drop across joint
Voltage Taps Co-wound (Non-Inductive)	6 sensors(twisted pairs) x (2 terminations+4 splice ends) x 2 magnets+ 6 sensors(twisted pairs) x (2 terminations+2 splice ends) x 2 magnets = 120 sensors (twisted pairs)	@ Magnet terminations and conductor splices	Inside CICC
Flowmeters	PF6 11 x 2 = 22 PF7 8 x 2 = 16 TOTAL = 38	@ all double-pancake helium inlet & outlet lines (& terminations)	
Pressure Transducers	2	Inlet / Outlet manifolds	
Temperature Sensors (CGR or Cernox)	PF6 6 x 2 = 12 PF7 4 x 2 = 8	@ pancake (& termination) He outlet lines	
	2	@ He inlet manifold	
	48+18+12 = 78 TOTAL = 98	@ each strain gage location	
Hall Probes	1 x 4 magnets = 4	@ centerline of I.D. for each magnet	

References

1. Memo of Stephen P. Smith to Joel Schultz, June 30, 1995, "Preliminary Quench Detection System Design Parts Count and Cost", TPX no. 1314-950628-MIT-SSmith-01.

2. Joel E. Schultz, "Quench Detection Status Report", presentation at the July 7-11 TPX Technical Interchange Meeting, LIvermore, CA.

3. Michael R. Chaplin, "Quench Detection Design and R&D– TF and PF Magnet Systems", presentation at the July 7-11 TPX Technical Interchange Meeting, Livermore, CA.

4. P. L. Walstrom, "Strain Gauges for Superconducting Magnet Testing", **Cryogenics 20**, no. 9, p. 509 (1979).

5. P. L. Walstrom, "The Effect of High Magnetic Fields on Metal-Foil Strain Gauges at 4.2 K", **Cryogenics 15**, p. 270 (1975).

6. J. F. Ellis and P. L. Walstrom, "Moving-Coil Linear Variable Differential Transformer", **Review of Scientific Instruments 49,** no. 3, Mar. 1978.
End of document

DISCLAIMER

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

This report has been reproduced
directly from the best available copy.

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information
P.O. Box 62, Oak Ridge, TN 37831
Prices available from (615) 576-8401, FTS 626-8401

Available to the public from the
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Rd.,
Springfield, VA 22161

Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.