17

ESG-DOE-13404
VOLUME III, BOOK 3

DO NOT MICROFILM
COVER

PRELIMINARY DESIGN OF THE CARRISA PLAINS SOLAR CENTRAL RECEIVER POWER PLANT

VOLUME III, BOOK 3 — APPENDICES

PART 1

Prepared for the Department of Energy,
San Francisco Operations Office,
under Contract DE-FC03-82SF11674

Rockwell International
Energy Systems Group

PG and E

ARCO Solar Industries

DISCLAIMER

DISCLAIMER

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, nor any of their contractors, subcontractors, or 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.

DOE/SF/11674--1-Vol.3-Bk.3-Pt.1

DE84 005780

PRELIMINARY DESIGN OF THE CARRISA PLAINS SOLAR CENTRAL RECEIVER POWER PLANT

VOLUME III, BOOK 3 — APPENDICES

PART 1

Rockwell International
Energy Systems Group

PG and E

ARCO Solar Industries

CONTRACT: DE-FC03-82SF11674

ISSUED: 31 DECEMBER 1983

This report, Preliminary Design of the Carrisa Plains Solar Central Receiver Power Plant, ESG-DOE-13404, consists of three volumes, one of which is further subdivided. These are:

Volume I. Executive Summary

Volume II. Plant Specifications

Volume III. Plant Design

- Book 1. Design Description
- Book 2. Design Drawings
- Book 3. Appendices

Books 1, 2, and 3 in Volume III, Plant Design, are a single document, separated for reasons of format and readability. Book 1, Design Description, contains narrative material, tables, and figures suited to an 8½-in. by 11-in. format. Book 2, Design Drawings, is a 17-in. by 22-in. volume containing material whose readability is benefitted by a larger format. Graphic material cited in Book 1 is referenced as a figure if it appears in Book 1, or as a drawing if it appears in Book 2. Material appearing in Books 2 and 3 is assigned a number in accordance with the section of Book 1 in which it is referenced. Consequently, the numbering in Books 2 and 3 may appear to leave gaps.

INDEX

Rockwell International
Energy Systems Group

SUPPORTING DOCUMENT

GO NO.	S/A NO.	PAGE 1 OF	TOTAL PAGES	REV LTR/CHG NO (SEE SUMMARY OF CHG)	NUMBER
09479	13120	203	204	A	079TI000002

PROGRAM TITLE

Carrizo Plains 30 MWt Solar Power Plant

DOCUMENT TITLE

Thermal Analysis of Central Receiver for Preliminary Design Phase

DOCUMENT TYPE	KEY NOUNS
Technical Information	Solar Central Receiver, Thermal Analysis

ORIGINAL ISSUE DATE	REL. DATE	APPROVALS	DATE
	6-9-83 RK	L. G. Rico	3-16-83

PREPARED BY/DATE	DEPT	MAIL ADDR
Edward M. Mouradian	731	LB-30

Edward M. Mouradian

IR&D PROGRAM? YES ☐ NO ☒
IF YES, ENTER TPA NO.

DISTRIBUTION

*	NAME	MAIL ADDR
*	W R Castle	LB30
*	L E Glasgow	LA19
	J K Ives	LA19
**	T L Johnson	LA19
*	B Katz	LA19
	J A Miller	LA19
**	E M Mouradian	LB30
*	L G Rico	LB30
*	T H Springer	LA24
*	A Z Ullman	LA19
	W Veljovich	LB30
*	C K Wahnsiedler	LB30
	J H Walter	LB07

** Complete Document

* Title Page/Summary of Change and Addendum (Pg 66 - 203) Only

NO ASTERISK, TITLE PAGE/SUMMARY OF CHANGE PAGE ONLY

ABSTRACT

Thermal analyses for the preliminary design phase of the Receiver of the Carrizo Plains Solar Power Plant are presented. The sodium reference operating conditions (T_{in} = 610°F, T_{out} = 1050°F) have been considered. Included are:

- Nominal flux distribution on receiver panel
- Energy input to tubes
- Axial temperature distribution; sodium and tubes
- Sodium flow distribution,
- Sodium pressure drop, orifice calculations
- Temperature distribution in tube cut (R-θ)
- Backface structure
- Nonuniform sodium outlet temperature.

Transient conditions and panel front face heat losses are not considered. These are to be addressed in a subsequent design phase. Also to be considered later are the design conditions as variations from the nominal reference (operating) condition.

An addendum, designated Appendix C, has been included describing panel heat losses, panel temperature distribution, and tube-manifold joint thermal model.

FORM 734-C REV. 12-79

REV	SUMMARY OF CHANGE	APPROVALS AND DATE
A	1) Added sentence to Abstract; cover page. 2) Added to Table of Contents; page 2. 3) Addendum included, Appendix C; pgs. 66 - 203.	June 9, 1983 E. M. Mouradian 6-9-83

CONTENTS

APPENDICES

I. INTRODUCTION

The Carrizo Plains Plant, Unit 1 is a 30-MWt Central Solar Receiver Power Plant currently under design. In this report, presentation is made of the thermal and hydraulic analyses of the Receiver Subsystem for the Preliminary Design Phase (as laid out in IL 640-82-53, Reference 1). The design specifications are N10046 and N10048, References 2a and 2b.

The nominal operating condition is for receiver sodium inlet and outlet temperatures of 610°F and 1050°F, respectively. This is considered the "reference condition." In later analysis, deviations from this reference condition (e.g., design limits) will be investigated.

The receiver design calls for a panel (in plane form, facing north) consisting of eight subpanels. The vertical length of an individual tube is 50 ft (manifold-to-manifold) with a 40-ft active length (exposed to solar flux). Each subpanel consists of 102 tubes; 3/4-in. OD, 0.049-in. wall, 316 stainless steel. Each subpanel has a nominal width of 77.51 in. (including a 10-mil thermal expansion clearance between tubes). The overall width of the panel is approximately 52 ft. See the receiver drawings, Reference 4.

Calculations in this report are based on each tube intercepting a 0.75-in. width of the solar flux field. It has been assumed that all solar energy intercepted by the tube is absorbed by the internal sodium flow. Heat loss from the tube surface (by reflection, reradiation, and convection) has been neglected. This means that the results are conservative from a stress analysis viewpoint, but would overestimate the overall energy performance of the receiver. This is considered acceptable as these results are intended as support for the stress analysis effort. Heat loss calculations are planned for a later analysis.

The analyses presented in this report are based on the nominal solar flux distribution on the panel as shown in the receiver design specification (Reference 2b, Pages 13 and 14). In the following sections, the calculations made are presented and explained. All calculations performed are for steady-state conditions.

II. ANALYSIS AND RESULTS

A. HEAT FLUX DISTRIBUTION ON PANEL - SODIUM TEMPERATURE DISTRIBUTION TUBE (Z)

Figures A-1 and A-2 show the nominal solar flux distribution on the receiver from the Receiver Design Specification (Reference 2b).

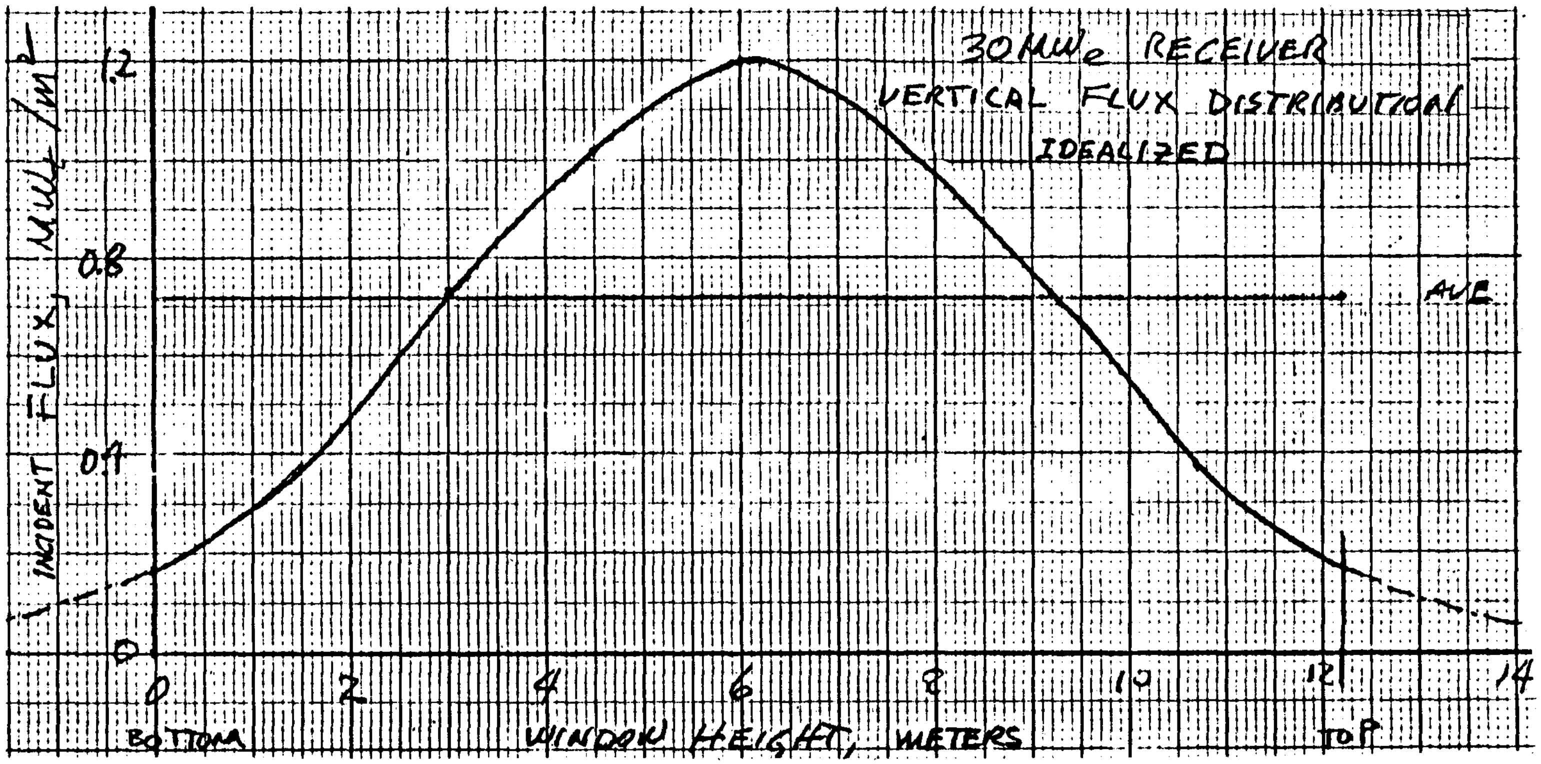
Figure A-1 shows the vertical flux distribution for tubes in the central region of the receiver. The shape of the curve is taken to be a "normal" distribution, with a standard deviation of 10 ft. Thus, the 40-ft-high tube sees a normal distribution from -2 to +2 standard deviations, with a peak flux at mid-height of 1.20 MW/m^2.

Figure A-2 shows the lateral flux distribution on the panel at mid-height. The central subpanels (3, 4, 5, and 6) show mid-height flux of 1.20 MW/m^2 across the entire subpanel. Subpanels 2 and 7 show a partial tapering of incident flux at the outer edges of these subpanels. But the outermost subpanels (1 and 8) show a severe variation of solar flux across the subpanel width; from 0.97 MW/m^2 to 0.225 MW/m^2.

In those tubes which have a mid-height flux less than 1.20 MW/m^2, it is still assumed that the vertical flux distribution is "normal," as shown in Figure A-1 with a reduction in magnitude proportionate to that of the mid-height flux.

Table A-I shows characteristics of a normal distribution curve; $-2 \leq \sigma \leq +2$. As indicated, the axially averaged flux is 0.59814 of the peak mid-height flux.

$$\underset{\text{axial average}}{\left(\frac{\overline{Q}}{A}\right)} = 0.59814 \left(\frac{Q}{A}\right)_{\mathbb{C}}$$



Z → 0 FT — 10 FT — ℄ 20 FT — 30 FT — 40 FT.

← L = ACTIVE TUBE LENGTH →

$\chi = \frac{Z-20}{S.D}$ -2, -1, 0, +1, +2

FIGURE A-1

VERTICAL FLUX DISTRIBUTION (From Ref. 2b)
FOR "FULL THERMAL LOAD" TUBES; $(Q/A)_{℄} = 1.20\ MW/m^2$

NORMAL DISTRIBUTION { LENGTH = 40 FT. ; STD. DEV = σ = 10 FT }

For tubes with lower peak flux, $(Q/A)_{℄}$, the normal distribution curve applies with proportionally lower amplitudes.

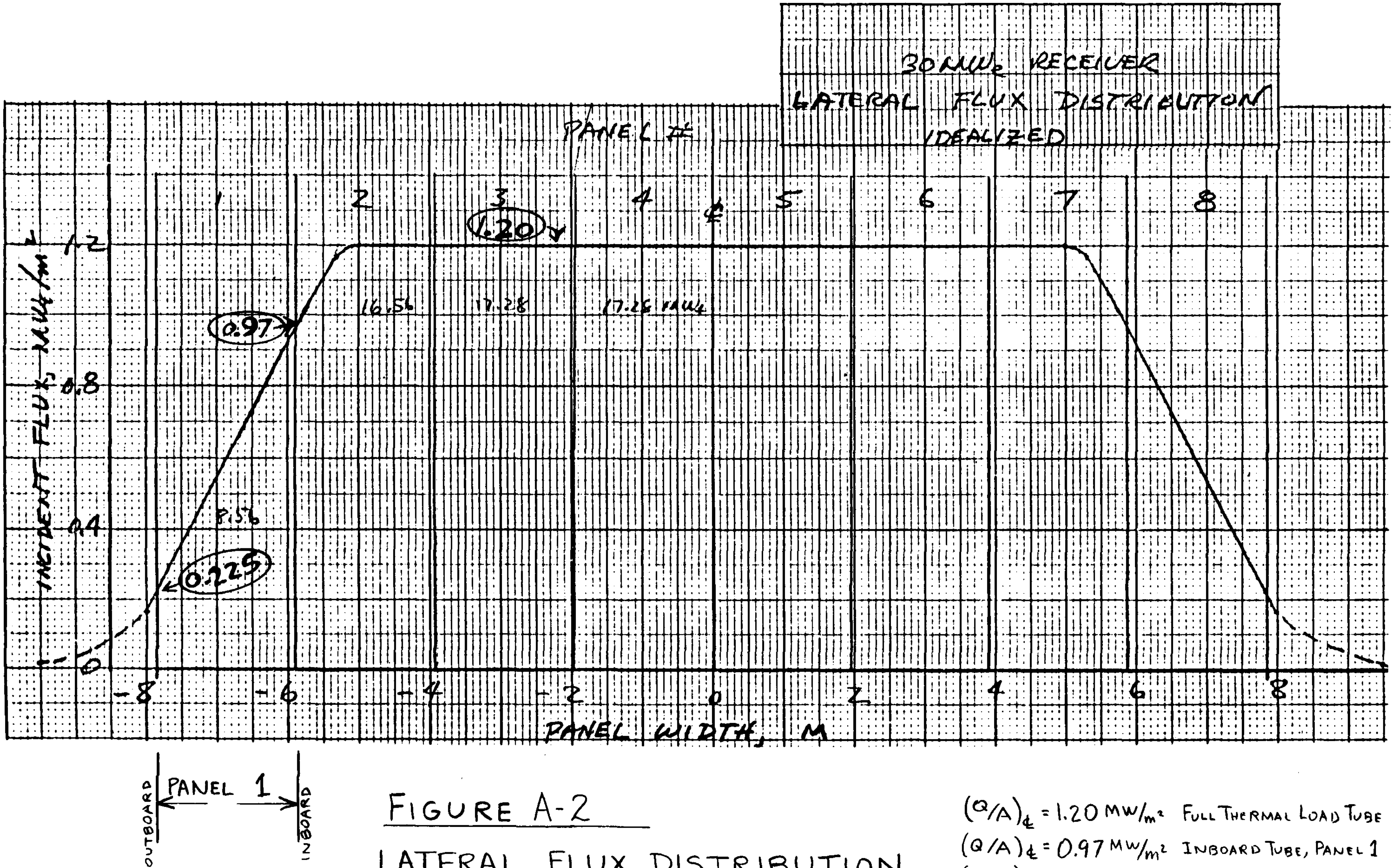


FIGURE A-2

LATERAL FLUX DISTRIBUTION

AT PANEL MID-HEIGHT, Z = 20 FT.

From Ref. 2b

$(Q/A)_{℄} = 1.20\ MW/m^2$ FULL THERMAL LOAD TUBE

$(Q/A)_{℄} = 0.97\ MW/m^2$ INBOARD TUBE, PANEL 1

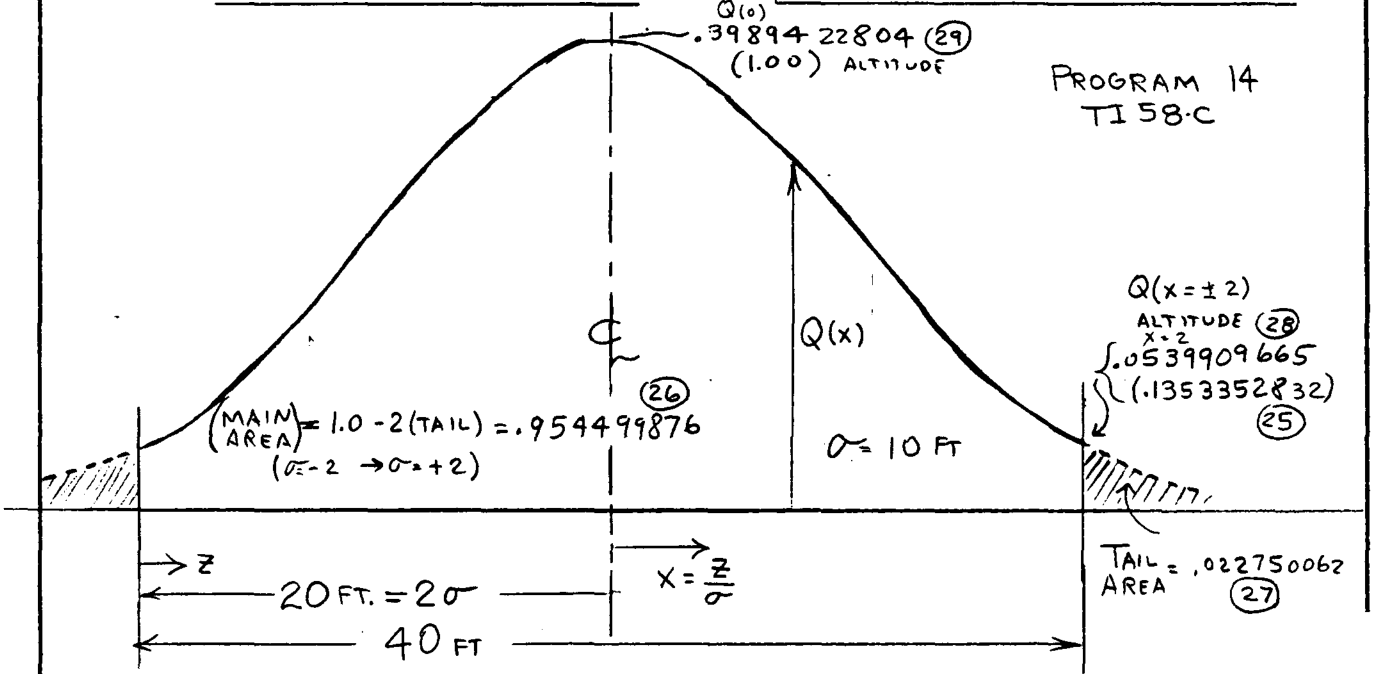
$(Q/A)_{℄} = 0.225\ MW/m^2$ OUTBOARD TUBE, PANEL 1

0079T10000002

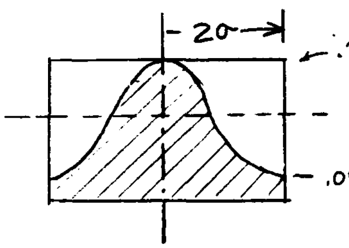
TABLE A-I

"NORMAL DISTRIBUTION" VERTICAL FLUX DISTRIBUTION

PROGRAM 14
TI 58·C



NORMALIZED:



1.0

$.5981440943 = \dfrac{(26)}{4((29))}$

.1353352832

$$\left\{\begin{matrix}\text{AVERAGE HEIGHT} \\ \text{IN BAND: } (-2\sigma \to +2\sigma)\end{matrix}\right\} = \frac{\text{SHADED}}{\text{TOTAL RECT}} = \frac{1.0 - 2(\text{TAILS})}{(.398942 * 4\sigma)} = \frac{(26)}{4 * (29)}$$

$$\left\{\begin{matrix}\text{AVERAGE} \\ \text{HEIGHT}\end{matrix}\right\} = 0.5981440943 \quad (24)$$

FOR AXIALLY AVERAGED POWER ALONG ONE TUBE:

$$\left(\frac{\overline{Q}}{A}\right)_{\text{AXIAL AVERAGE}} = 0.5981440943 * \left(\frac{Q}{A}\right)_{℄ \text{ (MID-HEIGHT)}}$$

STORAGE TI-58C

(29)	.3989422804	℄ HEIGHT
(28)	.0539909665	σ = 2 HEIGHT
(27)	.022750062	AREA, ONE TAIL (σ = 2)
(26)	.954499876	AREA (σ = -2 → σ = +2) 1 - 2 * TAIL
(25)	.1353352832	NORMALIZED HEIGHT @ σ = 2
(24)	.5981440943	NORMALIZED AVERAGE HEIGHT, BETWEEN σ = -2 → σ = +2

In Table A-II, calculations are made for energy deposition distribution on the panel, and sodium temperature in the tube. It is assumed that no heat losses occur from the panel. This means that all incident energy goes to the sodium (without the bias of higher heat loss from the upper, higher temperature, portion of the panel). The inlet and outlet temperatures of the sodium are taken at the nominal operating temperatures of 610°F and 1050°F, respectively. (This presumes the appropriate sodium flow rate.) The fracion of the total energy which is incident on the tube up to a given point is determined, and the corresponding sodium temperature calculated assuming constant sodium specific heat.

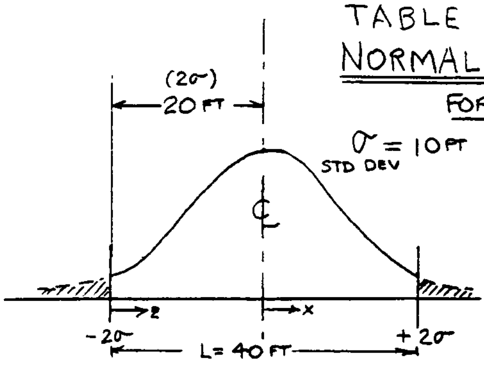
In Table A-II, Column a is z, the axial location on the tube, measured from the bottom of the 40-ft active zone, and Column b is the axial location, x, measured in standard deviations from the mid-height ($-2 \leq x \leq +2$ std. div.) Columns c and d are the height of the normal distribution curve; raw and normalized, respectively. Columns e and f are the areas under the normal distribution curves from $x = -\infty$ and $x = -2$, respectively. Column g is the ratio of the normal distribution curve area from $x = -2$ to x to the total area from $x = -2$ to $x = +2$. Thus, the value in Column g represents the fraction of the total energy incident on the tube which strikes in the region from $x = -2$ (tube bottom) to x (the point in question). For instance, 83.1% of the total energy is intercepted by the tube in the lower 29 ft of the tube. Thus, it is taken that 83.1% of the sodium temperature rise has occurred in the first 29 ft. Hence, the sodium temperature at Z = 29 ft is:

$$T(z = 29\ \text{ft}) = 610 + 0.831\ (1050 - 610) = 975.64°\text{F}.$$

This sodium temperature distribution is shown in Column h, as well as Figures E1a, b, and c.

8 mm 12/82

TABLE A-II
NORMAL DISTRIBUTION CURVE
FOR VERTICAL FLUX DISTRIBUTION



Q(x) = ALTITUDE

P(x) = AREA (TOTAL AREA = 1.0)

PROGRAM 14
TEXAS INSTRUMENTS
TI-58C

NOTE: $\left(\frac{dQ(x)}{dx}\right)_{MAX} = 0.24197075$ at $\sigma = \pm 1.0$ CRC Pg 258-262

(29) .3989422804 Q(x=0); ¢ ALTITUDE
(28) .0539909665 Q(x=±2σ) EDGE ALTITUDES
(27) .0227500620 P(σ=2 → ∞) AREA; ONE TAIL
(26) .9544998760 P(σ=-2 → σ=+2) NON TAIL AREA
(25) .1353352832 NORMALIZED HEIGHT; σ=±2
(24) .5981440943 NORMALIZED MEAN HEIGHT BETWEEN σ=-2 → σ=+2.

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Z LOCATION FROM BOTTOM OF PANEL	χ LOCATION IN STANDARD DEVIATIONS FROM ¢. σ=10 χ = (20-z)/10	Q(x) ALTITUDE OF NORMAL DISTRB CURVE PRGM 14 (A) TI58C	Q(x)/Q(x=0) ¢ = Q(x)/(29) ¢ .39894 NORMALIZED ALTITUDE OF NORMAL DISTRB CURVE Φ(z)	P(x) AREA OF CURVE: FROM: (σ=-∞) TO: χ PRGM 14 (B) TI58C	P(x) - P(x=2) TAIL AREA OF CURVE: FROM: (σ=-2) TO: χ (e) - (27) .022750	FRACTION OF EFFECTIVE ENERGY FROM: Z=0 (σ=-2) TO: z (χ) ENERGY (z=0 → z_i) / ENERGY (z=0 → z=40) (P(x) - TAIL) / (1.0 - 2*TAIL) = (f)/(26) .95449 → (26)	SODIUM TEMP FOR: 610° → 1050° T_{Na} °F 610 + 440 * FRAC 610 + 440 (g) (Constant Cp, No Losses)
0.	2.0	.053991	.135335	.022750	0.0	0.0	610
1.	1.9	.065616	.164474	.028716	.005966	.006251	612.75
2.	1.8	.078950	.197899	.035930	.013180	.013808	616.08
3.	1.7	.094049	.235746	.044565	.021815	.022855	620.06
4.	1.6	.110921	.278037	.054799	.032049	.033577	624.77
5.	1.5	.129518	.324652	.066807	.044057	.046157	630.31
6.	1.4	.149727	.375311	.080757	.058007	.060772	636.74
7	1.3	.171369	.429557	.096801	.074050	.077580	644.14
8	1.2	.194186	.486752	.115070	.092320	.096720	652.56
9	1.1	.217852	.546074	.135666	.112916	.118299	662.05
10.	1.0	.241971	.606531	.158655	.135905	.142384	672.65
11	.9	.266085	.666977	.184060	.161310	.169000	684.36
12	.8	.289692	.726149	.211855	.189105	.198120	697.17
13	.7	.312254	.782705	.241964	.219214	.229663	711.05
14	.6	.333225	.835270	.274253	.251503	.263492	725.94
15.	.5	.352065	.882497	.308538	.285787	.299411	741.74
16	.4	.368270	.923116	.344578	.321828	.337169	758.35
17	.3	.381388	.955997	.382089	.359339	.376468	775.65
18	.2	.391043	.980199	.420740	.397990	.416962	793.46
19	0.1	.396953	.995012	.460172	.437422	.458274	811.64
20	0	.398942	1.000	.500000	.477250	.500000	830.00
21	-.1	.396953	.995012	.539828	.517078	.541726	848.36
22	-.2	.391043	.980199	.579260	.556510	.583038	866.54
23	-.3	.381388	.955997	.617911	.595161	.623532	884.35
24	-.4	.368270	.923116	.655422	.632672	.662831	901.65
25	-.5	.352065	.882497	.691462	.668712	.700589	918.26
26	-.6	.333225	.835270	.725747	.702997	.736508	934.06
27	-.7	.312254	.782705	.758036	.735286	.770337	948.95
28	-.8	.289692	.726149	.788145	.765395	.801880	962.83
29	-.9	.266085	.666977	.815940	.793190	.831000	975.64
30	-1.0	.241971	.606531	.841345	.818595	.857616	987.35
31	-1.1	.217852	.546074	.864334	.841584	.881701	997.95
32	-1.2	.194186	.486752	.884930	.862180	.903280	1007.44
33	-1.3	.171369	.429557	.903199	.880449	.922420	1015.86
34	-1.4	.149727	.375311	.919243	.896493	.939228	1023.26
35	-1.5	.129518	.324652	.933193	.910443	.953843	1029.69
36	-1.6	.110921	.278037	.945201	.922451	.966423	1035.23
37	-1.7	.094049	.235746	.955435	.932685	.977145	1039.94
38	-1.8	.078950	.197899	.964070	.941320	.986192	1043.92
39	-1.9	.065616	.164474	.971283	.948533	.993749	1047.25
40	-2.0	.053991	.135335	.977250	.954500	1.0	1050.0

$\left(\frac{dQ(x)}{dx}\right)_{Max} = .24197$ @ z = 10 ft 30 ft

Max $\frac{dT}{dx} = 1.53\ \frac{°F}{inch}$ @ z = 20 ft

B. ENERGY INPUT TO TUBE - SODIUM FLOW PARAMETERS

In Table B-I, the total energy input to an individual tube is calculated based on the mid-height solar heat flux and the properties of the axial normal distribution function. Three representative tubes are considered: full thermal load tube, inboard tube of Panel 1, and outboard tube of Panel 1. These have mid-height solar heat fluxes of 1.20 MW/m^2, 0.97 MW/m^2, and 0.225 MW/m^2, respectively (see Figures A-1 and A-2).

It is assumed that all energy incident on the tube is absorbed by the internal sodium. That is, no heat losses occur from the tube. This assumption is conservative from a stress analysis standpoint, as it maximizes (mathematically) the temperature gradients and differentials in the tube metal. However, the no-loss assumption is not conservative from a performance (energy delivery) standpoint. Heat losses are to be investigated in a later phase of this work. The primary emphasis in this report is support of stress analysis.

The energy input to a tube is calculated on the basis of the projected area of 0.75-in. width * 40-ft length. The 0.01 gap between tubes (or the thermally expanded tube diameter) is not taken into account.

The energy input is used to determine the sodium flow rate within individual tubes required to maintain the sodium temperature increase from 610°F to 1050°F. Table B-II shows sodium property values (from References 5a and 5b). Table B-III is a calculation sheet for the evaluation of the sodium heat transfer coefficient within the tube. Among the parameters determined are: axially averaged heat flux, total heat input to one tube, sodium flow rate $\dot{w}$, Reynolds number Re, Peclet number Pe, Nusselt number Nu, and heat transfer coefficient h. Notice that of the "high" and "low" sodium heat transfer coefficients calculated, the lower one is chosen for conservatism. In the calculations that follow, the lower h value yields higher tube wall temperature differentials; hence, higher thermal stresses. (A lower h value results in a larger metal surface to liquid sodium temperature drop. Since the heat flux is set, the result is a higher metal temperature on the front half of the tube; hence, a greater front-to-back temperature differential across the tube diameter.)

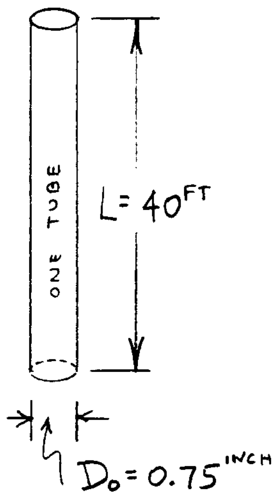
Table B-IV shows the calculation of sodium flow velocity and related parameters, some of which are used in subsequent calculations. These include gpm flow rate, transit time, velocity head, and Reynolds number. Where appropriate, these parameters are determined for: tube entrance (bottom), lower quarter, middle half, upper quarter, and exit (top).

Table B-V shows the calculation of the sodium flow pressure drop in the tubes. The calculation for each tube is in five segments, as shown. For each segment, the parameters determined are: Reynolds number Re, friction factor f, loss coefficient K, velocity head H, and pressure loss ΔP. For each segment, sodium property values are based on the local mean sodium temperature. The segmental pressure drops are summed to determine the total pressure drop in the tube, from lower manifold to upper manifold. The three tubes considered are: full thermal load, inboard panel 1, and outboard panel 1. These calculations are based on the assumption that each tube has exactly the flow rate required to maintain the 1050°F outlet sodium temperature (for inlet of 610°F) for the idealized nominal solar flux of Figures A-1 and A-2. How to bring about this proper sodium flow distribution is investigated in following calculations.

Figure B-1 is the friction factor versus Reynolds number plot (based on data from Reference 9a). For this analysis, a roughness factor of ϵ/D = .0001 (based on Reference 9b) as indicated in Table B-V.

TABLE B-I

ENERGY INCIDENT ON TUBE



PROJECTED AREA OF ONE TUBE:

$$A_{PROJ} = L * D_o = (40*12)*(.75) = 360 \text{ in}^2 \quad (2.5 \text{ ft}^2)$$

FLOW AREA OF ONE TUBE:

0023185 82 65 $$A_{FLOW} = \frac{\pi}{4} D_i^2 = \frac{\pi}{4}\left(\frac{.652}{12}\right)^2 = .0023186 \text{ ft}^2$$

$$1.0 \frac{MW}{m^2} = 1.0 \frac{MW}{m^2} * 3413000 \frac{BTU}{hr\ MW} * \frac{hr}{3600 sec} * \left(\frac{2.54}{100}\right)^2 \left(\frac{cm}{in}\frac{m}{cm}\right)^2$$

$$1.0 \frac{MW}{m^2} = \begin{cases} 0.61165 \frac{BTU}{sec\ in^2} \\ 317078 \frac{BTU}{hr\ ft^2} \end{cases}$$

.5981440943 $$\left(\frac{\overline{Q}}{A}\right)_{\substack{AXIAL \\ AVERAGE}} = .598144 * \left(\frac{Q}{A}\right)_{℄\ PEAK} \quad ; \quad Q_{ONE\ TUBE} = \left(\frac{\overline{Q}}{A}\right) * A \quad (A = 360 \text{ in}^2)$$

TUBE	$(Q/A)_{℄\ PEAK}$ MW/m² (BTU/in² sec)	$(\overline{Q}/A) = .59814 (Q/A)_{Pk}$ AXIAL AVG MW/m² (BTU/in² sec)	Q (ONE TUBE) $Q = A \times (\overline{Q}/A) = 360\ \overline{Q}/A$ BTU/sec
FULL THERMAL LOAD	1.20 (.73398)	0.71777 (.43903)	– 158.049 BTU/SEC
INBOARD: PANEL 1	0.97 (.59330)	0.58020 (.35488)	– 127.757 BTU/SEC
OUTBOARD: PANEL 1	0.225 (.13762)	0.13458 (.08232)	29.634 BTU/SEC

TABLE B-II

SODIUM PROPERTIES

GOLDEN & TOKAR
REF. 5a

SPECIFIC HEAT:

T °F	Cp BTU/lbm °F	h BTU/lbm
1050	0.3001	471.88
(830)	(0.3034)	(405.54)
610	0.3100	338.11
ΔT = 440°		Δh = 133.77

$$\bar{C}_p = \frac{\Delta h}{\Delta T} = \frac{133.77}{440} = 0.30402 \ \text{BTU/lbm °F}$$

T °F TEMP	k BTU/hr ft °F THERMAL CONDUC	ρ lbm/ft3 DENSITY		μ lbm/ft hr VISCOSITY		Cp BTU/lbm °F SPECIFIC HEAT	$Pr = \frac{\mu C_p}{k}$ PRANDTL NO.
1050	36.89	50.971		.5221		.3001	.004247
			51.430 [4] TOP QUAR		.5452 [4] TOP QUAR		
940	38.50	51.889		.5683		.3013	.004449
830	40.15	52.804	52.803 [5] MID HALF	.6256	.6295 [5] MID HALF	.3034	.004727
720	41.86	53.715		.6984		.3063	.005110
			54.169 [6] BOT QUAR		.7461 [6] BOT QUAR		
610	43.62	54.623		.7937		.3100	.005641
AVERAGE VALUES: FULL LENGTH	40.1913 [1] $\bar{k}$	52.8013 [1] $\bar{\rho}$		0.63755 [1] $\bar{\mu}$		.30402 [2] $\bar{C}_p$	.004823 [3] $\bar{Pr}$

1) $\bar{k} = \frac{1}{4}\left(\frac{k}{2} + k + k + k + \frac{k}{2}\right)$
   $\bar{\rho} = \sim$
   $\bar{\mu} = \sim$
2) $\bar{C}_p = \frac{\Delta h}{\Delta T}$
3) $\bar{Pr} = \frac{\bar{\mu}\bar{C}_p}{\bar{k}}$
4) Top $\frac{1}{4}$ Tube:
   $\rho = \frac{1}{2}\rho + \frac{1}{2}\rho$
   $\mu = \frac{1}{2}\mu + \frac{1}{2}\mu$
5) Mid $\frac{1}{2}$ Tube
   $\rho = \frac{1}{2}\left(\frac{1}{2}\rho + \rho + \frac{1}{2}\rho\right)$
6) Bottom 1/4 Tube
   $\rho = \frac{1}{2}\rho + \frac{1}{2}\rho$

TABLE B-III

SODIUM HEAT TRANSFER COEFFICIENT, h_{Na}

TUBE:	FULL THERMAL LOAD	INBOARD, PANEL 1	OUTBOARD, PANEL 1
PEAK FLUX @ MID-HEIGHT $(Q/A)_{℄}$ MW/m²	1.20	0.97	0.225
AXIALLY AVERAGED FLUX $\overline{\left(\frac{Q}{A}\right)} = 0.598144 * \left(\frac{Q}{A}\right)_{℄}$ (24) MW/m²	.717773	.580200	.134582
TOTAL HEAT; ONE TUBE $Q_{\text{ONE TUBE}} = \left(\frac{Q}{A}\right)_{MW/m^2} * .61165_{\frac{BTU/sec\ in^2}{MW/m^2}} * 360_{in^2}$ (A_{PROJ}) BTU/sec	158.049	127.757	29.634
SODIUM FLOW RATE; ONE TUBE $\dot{W}_{lb_m/sec} = \frac{Q\ BTU/sec}{C_p \Delta T} = \frac{Q\ BTU/sec}{(.30402)(440)}$	1.18151	0.95505	0.22153
AVERAGE REYNOLDS NUMBER $\bar{Re} = \frac{4}{\pi}\frac{W}{D\mu}$ D = .652/12 ft; μ = .63755/3600 lbm/sec ft; $Re = W \frac{4}{\pi} \frac{12}{.652} \frac{3600}{.63755}$; Re = 132322 W	156344	126375	29314
AVERAGE PECLET NUMBER $\bar{Pe} = \bar{Re}\,\bar{Pr}$; $\bar{Pe} = .004823\,\bar{Re}$	754.05	609.50	141.38
$\frac{1}{40}(\bar{Pe})^{0.8}$	5.0102	4.2259	1.3130
AVERAGE NUSSELT NUMBER: LOW: $\bar{Nu} = 5 + \frac{1}{40}\bar{Pe}^{0.8}$ (Reference 8a)	10.0102	9.2259	6.3130
HIGH: $\bar{Nu} = 7 + \frac{1}{40}\bar{Pe}^{0.8}$	12.0102	11.2259	8.3130
AVERAGE SODIUM HEAT TRANSFER COEFFICIENT $\bar{h} = \bar{Nu}\frac{\bar{k}}{D} = \bar{Nu}\frac{40.1913}{.652/12} = 739.7172\ Nu$ (LOW)	7407.7	6824.6	4669.8
(HIGH)	8884.2	8304.0	6149.2
SODIUM HEAT TRANSFER COEFFICIENT FOR USE IN CALCULATIONS $\frac{BTU}{hr\ ft^2\ °F}$	7400	6800	4700

PREPARED BY: EMM	Rockwell International Energy Systems Group	PAGE NO. 16 OF
CHECKED BY:		REPORT NO. 079TI000002
DATE: 12/82		MODEL NO.

TABLE B-IV

SODIUM FLOW VELOCITIES

TUBE:		FULL THERMAL LOAD	INBOARD, PANEL 1	OUTBOARD, PANEL 1
PEAK FLUX @ MID-HEIGHT $(Q/A)_{℄}$ MW/m²		1.20	0.97	0.225
SODIUM FLOW RATE; ONE TUBE, $\dot{W}$ lbm/sec		1.18151	0.95505	0.22153
SODIUM FLOW VELOCITY: $V = \frac{W}{\rho A}$ ft/sec	ρ (EXIT) = 50.971	10.00	8.08	1.87
	$\bar{\rho}$ (TOP ¼) = 51.430	9.91	8.01	1.86
	$\bar{\rho}$ (MID ½) = 52.803	9.65	7.80	1.81
	$\bar{\rho}$ (BOT ¼) = 54.169	9.41	7.60	1.76
	ρ (ENTR) = 54.623	9.33	7.54	1.75
SODIUM FLOW, GPM $GPM = \frac{W}{\rho}\frac{1728}{231}60$ gal./min	EXIT	10.40	8.41	1.95
	TOP ¼	10.31	8.33	1.93
	MID ½	10.04	8.12	1.88
	BOT ¼	9.79	7.91	1.83
	ENTR	9.71	7.85	1.82
TRANSIT TIME (SECONDS) $L = 40_{FT};\ \tau = \left\{\frac{10}{V_{BOT\,1/4}} + \frac{20}{V_{MID\,1/2}} + \frac{10}{V_{TOP\,1/4}}\right\}$		4.14	5.13	22.11
$L = 50_{FT}$ (600"); $\tau = \left\{\frac{15}{V_{BOT\,1/4}} + \frac{20}{V_{MID\,1/2}} + \frac{15}{V_{TOP\,1/4}}\right\}$		5.18	6.41	27.64
VELOCITY HEAD; H (psi) $H = \frac{\rho V^2}{2g_c} = \frac{1}{2g_c}\frac{1}{\rho}\frac{W^2}{A^2}$ $H = \frac{1}{(2)(32.1739)}\frac{1}{\rho}\frac{W^2}{\left(\left(\frac{\pi}{4}\right)\left(\frac{.652}{12}\right)^2\right)^2}\frac{1}{144}$ $H_{psi} \approx 20.075143\,\frac{W^2}{\rho}$	EXIT	0.5498	0.3592	0.01933
	TOP ¼	0.5449	0.3560	0.01916
	MID ½	0.5307	0.3468	0.01865
	BOT ¼	0.5173	0.3380	0.01819
	ENTR	0.5130	0.3352	0.01804
REYNOLDS NUMBER; Re $Re = \frac{4}{\pi D}\frac{W}{\mu} = \frac{4(12)3600}{\pi(.652)}\frac{W}{\mu}$ $Re = 84361.9\,\frac{W}{\mu}$	$\bar{\mu}$ (EXIT) .5221	1.909×10^5	1.543×10^5	3.580×10^4
	$\bar{\mu}$ (TOP ¼) .5452	1.828×10^5	1.478×10^5	3.428×10^4
	$\bar{\mu}$ (MID ½) .6295	1.583×10^5	1.280×10^5	2.969×10^4
	$\bar{\mu}$ (BOT ¼) .7461	1.336×10^5	1.080×10^5	2.505×10^4
	$\bar{\mu}$ (ENTR) .7937	1.256×10^5	1.015×10^5	2.355×10^4

0023185826

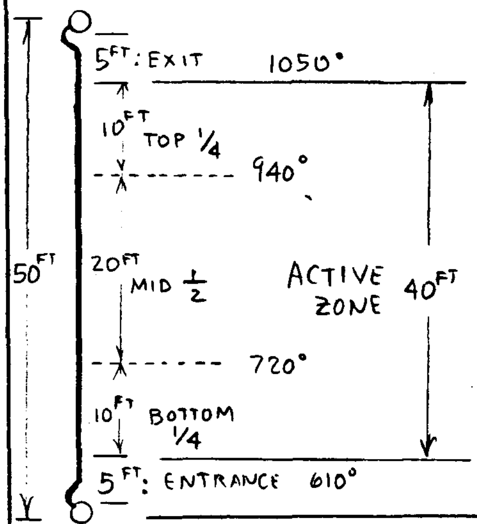
448.3311688

20.0751428

8434.884

TABLE B-V

PRESSURE DROP:
- FULL THERMAL LOAD TUBES
- INBOARD TUBE; PANEL 1
- OUTBOARD TUBE; PANEL 1



DRAWN TUBING $\epsilon = .000\,005$ FT (Reference 8b Page A.23)

$$\frac{\epsilon}{D} = \frac{.000\,005}{\frac{.652}{12}} = .000092 \rightarrow .0001 = \frac{\epsilon}{D}$$

$$\Sigma K = K_{EXIT\ OR\ ENT} + f\left(\frac{L}{D}\right)$$

$$H = \frac{\rho V^2}{2g_c} = \frac{1}{2g_c\rho}\left(\frac{W}{A}\right)^2$$

$$\Delta p = \Sigma K * H \text{ psi}$$

TUBE	FULL THERMAL LOAD: $(Q/A)_{℄} = 1.20$	INBOARD $(Q/A)_{℄} = 0.97$	OUTBOARD $(Q/A)_{℄} = 0.225$
EXIT: UPPER 5 FT T=1050 $K_{EXIT} = 1.0$ $\frac{L}{D} = \frac{5(12)+.7}{.652} = 93$	$Re = 1.91 \times 10^5$ $f = .0165$ (f ↙ curve, ↙ L/D) $\Sigma K = 1 + .0165(93) = 2.5345$ $H = .5498$ psi $\Delta p = 1.3935$ psi	$Re = 1.54 \times 10^5$ $f = .0171$ $\Sigma K = 1 + .0171(93) = 2.5903$ $H = .3592$ $\Delta p = 0.9304$ psi	$Re = 3.58 \times 10^4$ $f = .0222$ $\Sigma K = 1 + .0222(93) = 3.0646$ $H = .01933$ $\Delta p = .0592$
UPPER 1/4: 10 FT $\frac{L}{D} = \frac{10(12)}{.652} = 184$ T= 940→1050	$Re = 1.83 \times 10^5$ $f = .0166$ $\Sigma K = .0166(184) = 3.0544$ $H = .5449$ psi $\Delta p = 1.6643$ psi	$Re = 1.48 \times 10^5$ $f = .0172$ $\Sigma K = .0172(184) = 3.1648$ $H = .3560$ $\Delta p = 1.1267$	$Re = 3.43 \times 10^4$ $f = .0225$ $\Sigma K = .0225(184) = 4.14$ $H = .01916$ $\Delta p = .0793$
MID 1/2: 20 FT $\frac{L}{D} = \frac{20(12)}{.652} = 368$ T=720→940	$Re = 1.58 \times 10^5$ $f = .0170$ $\Sigma K = f\frac{L}{D} = .0170(368) = 6.256$ $H = .5307$ $\Delta p = 3.3201$	$Re = 1.28 \times 10^5$ $f = .0178$ $\Sigma K = .0178(368) = 6.5504$ $H = .3468$ $\Delta p = 2.2717$	$Re = 2.97 \times 10^4$ $f = .0235$ $\Sigma K = .0235(368) = 8.648$ $H = .01865$ $\Delta p = .1613$
LOWER 1/4: 10 FT $\frac{L}{D} = \frac{10(12)}{.652} = 184$ T= 610→720	$Re = 1.34 \times 10^5$ $f = .0175$ $\Sigma K = .0175(184) = 3.22$ $H = .5173$ $\Delta p = 1.6657$	$Re = 1.08 \times 10^5$ $f = .0182$ $\Sigma K = .0182(184) = 3.3488$ $H = .3380$ $\Delta p = 1.1319$	$Re = 2.51 \times 10^4$ $f = .0243$ $\Sigma K = .0243(184) = 4.4712$ $H = .01819$ $\Delta p = .0813$
ENTRANCE: LOWEST 5 FT $K_{ENTR} = 0.25$ (curve) $\frac{L}{D} = \frac{5(12)+.7}{.652} = 93$ T=610	$Re = 1.26 \times 10^5$ $f = .0179$ $\Sigma K = .25 + .0179(93) = 1.9147$ $H = .5130$ $\Delta p = 0.9822$	$Re = 1.02 \times 10^5$ $f = .0190$ $\Sigma K = .25 + .0190(93) = 2.017$ $H = .3352$ $\Delta p = 0.6761$	$Re = 2.36 \times 10^4$ $f = .0247$ $\Sigma K = .25 + (.0247)(93) = 2.5471$ $H = .01804$ $\Delta p = .0459$
TOTAL: PSI	$\Sigma\Delta p = 9.0258$	$\Sigma\Delta p = 6.1368$	$\Sigma\Delta p = 0.4270$

$$\Delta(\Sigma\Delta p) = 6.1368 - 0.4270 = 5.7098 \text{ PSI}$$

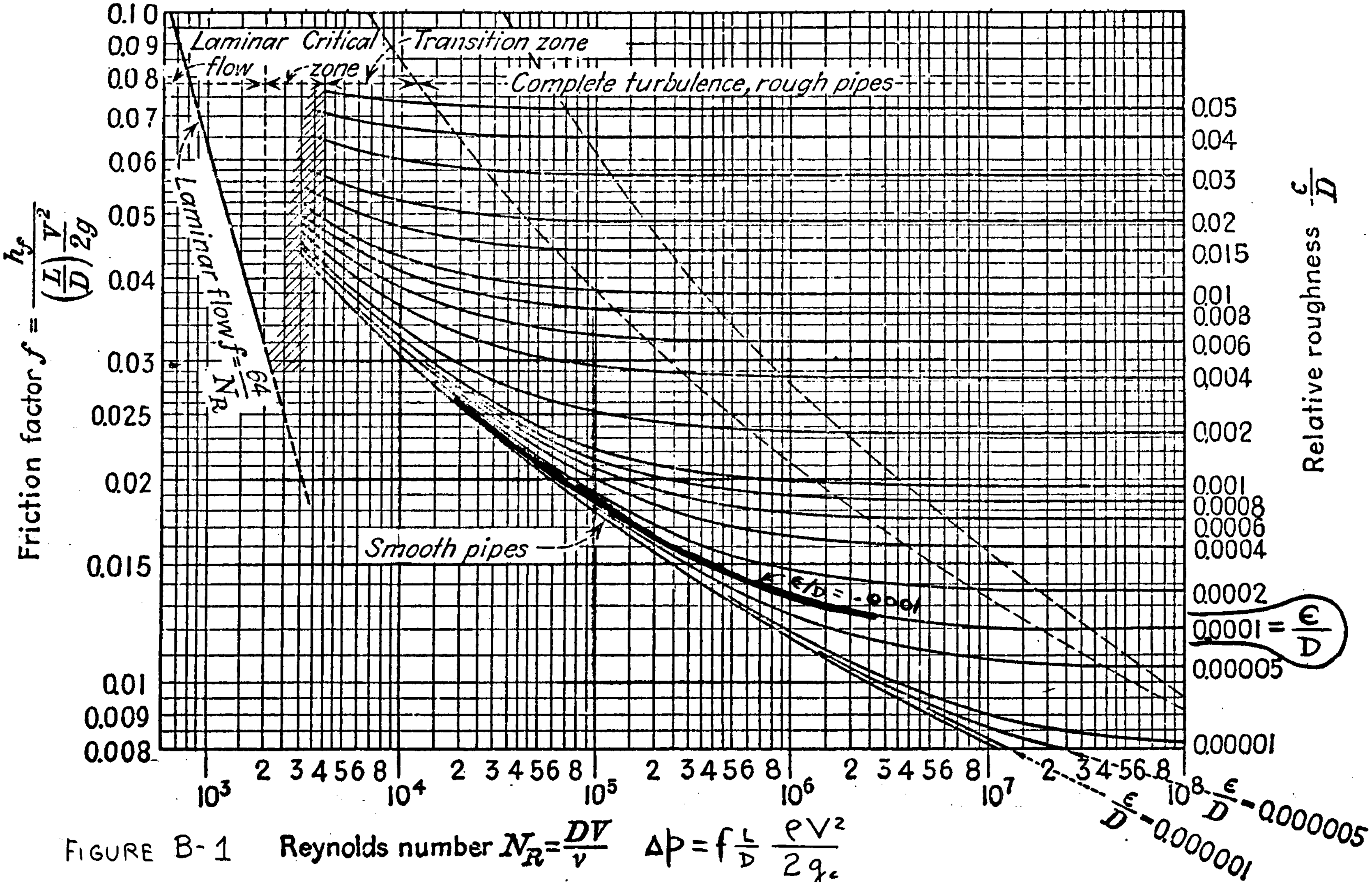


FIGURE B-1 Reynolds number $N_R = \frac{DV}{\nu}$ $\Delta p = f\frac{L}{D}\frac{\rho V^2}{2g_c}$

FRICTION FACTOR FOR PIPES

C. ORIFICE CALCULATIONS

In the preceding calculations, it has been assumed that sodium enters the tubes (at the bottom) at 610°F and exits (at the top) at 1050°F. This requires that the sodium flow rate to each subpanel must be maintained at just the proper amount to match the heat input to that subpanel. Each of the eight subpanels has an independently controlled valve for this purpose.

Having a flow control valve may be satisfactory for those subpanels with uniform heat flux laterally (identical heat load to each tube). However, as shown in Figure A-2, the end subpanels are expected to have a substantial lateral variation of solar heat flux. Thus, some control of flow to the individual tubes in the subpanel is necessary so that the sodium flow in each tube can match the heat load on the tube. Otherwise, there would be a substantial variation of tube outlet temperatures across the subpanel.

In order to minimize the variation of sodium outlet temperatures (and hence, lateral variation of tube temperatures), it is proposed that orifices (or similar devices) be incorporated in the tube inlets of the end subpanels. These orifices would be designed such as to distribute the sodium flow among the tubes of the two end subpanels to match the nominal solar flux distribution of Figure A-2.

Table C-I is based on the pressure drop data of Table B-V of Section II-B. Notice that the extreme tubes (inboard and outboard) of the end panels have a nominal mid-height heat flux of 0.97 MW/m^2 and 0.225 MW/m^2. Assume that the sodium flow rate is somehow adjusted so that both tubes have inlet-to-outlet temperatures of 610°F to 1050°F. The required sodium flow rates result in tube pressure drops of 6.137 psi and 0.427 psi, respectively. Thus, the difference in pressure drop (5.710 psi, Table B-V) must be created in the outboard tube to match pressure drops for the desired flow distribution.

In Table C-II, the equations used to calculate the orifice flow pressure drops are shown. (Table C-III is the calculational listing for the TI58C calculator.) The method shown is expected to give reasonably close results. However, some adjustment may be necessary in the velocity-of-approach factor and the sharp-edged orifice factor.

Table C-IV shows an estimate of the required orifice sizes in the outboard tube with one orifice, or with multiple orifices in series. The series calculation is presented only as a rough estimate since the calculational method is, rigorously, not valid for multiple orifices in series unless they are separated by sufficient distance to make them independent of one another. (The flow pattern must be able to recover to its original "far upstream" condition, so that each successive orifice is independent of its predecessor.)

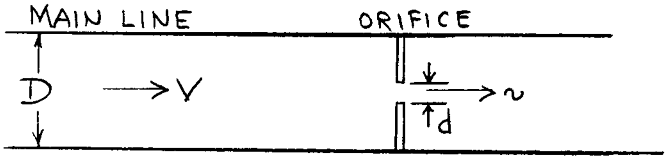
It is recommended that the methods shown here be used to establish approximate orifice sizes, to be followed by a water test to establish the final design.

The above discussed calculation is for the orifice of the outboard tube, with no orifice in the inboard tube. The intermediate tubes of the subpanel will also require orifices; but each one somewhat larger in diameter than that of the outboard tube since a smaller orifice pressure drop is required. In Tables C-V, C-VI, and C-VII, calculations and results are shown for orifices for tubes at intermediate locations in the end subpanels.

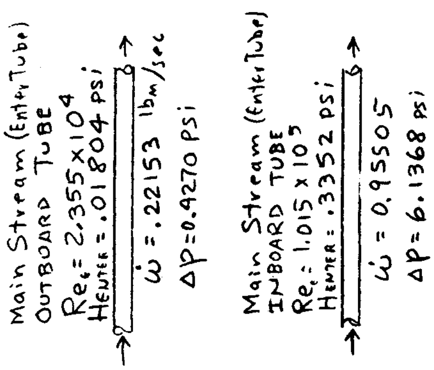
TABLE C-I ORIFICE CALCULATIONS

Consider orifices (or similar flow restrictor) to match sodium flow to solar heat flux in tubes of end panels.

$$\beta = \frac{d}{D}$$



D	$d = \beta D$
$A = \frac{\pi}{4} D^2$	$a = \frac{\pi}{4} d^2 = \frac{\pi}{4} D^2 \beta^2 = A \beta^2$
V	$\nu = V \frac{A}{a} = V \left(\frac{D}{d}\right)^2 = V \beta^2$
$H = \frac{\rho V^2}{2 g_c}$	$h = \frac{\rho \nu^2}{2 g_c} = \frac{\rho V^2}{2 g_c \beta^4} = \frac{H}{\beta^4}$
$Re = V D \frac{\rho}{\mu}$	$re = \nu d \frac{\rho}{\mu} = \frac{V}{\beta^2} \beta D \frac{\rho}{\mu} = \frac{Re}{\beta}$



$$\Delta p \binom{\text{INBOARD}}{\text{No Orifice}} = 6.1368$$

$$\Delta p \binom{\text{OUTBOARD}}{\text{No Orifice}} = 0.4270$$

$$\Delta p \binom{\text{Required}}{\text{Orifice}} = 5.7098 \text{ psi}$$

Orifice Drop is required in outboard tube to make total pressure drop equal to pressure drop in inboard tube.

TABLE C-II ORIFICE LOSS COEFFICIENT

FOR OUTBOARD TUBE:

$$\Delta p_{\text{ORIFICE LOSS}} = K(\beta)\frac{\rho v^2}{2g_c} = K(\beta)\frac{\rho V^2}{2g_c}\left(\frac{D}{d}\right)^4 = K(\beta)\frac{H}{\beta^4}$$

$$H = \frac{\rho V^2}{2g_c} \quad \left(\begin{array}{c}\text{Main Stream Flow}\\ \text{Velocity Head}\end{array}\right)$$

$$K = \left(\frac{\pi+2}{\pi}\right)^2\left[(1-\beta^4)(1-\beta^2)\right] = 2.6785\left[(1-\beta^4)(1-\beta^2)\right]$$

References 6a & 6b

$\left(\frac{1}{c'}\right)^2$ For SharpEdge Orifice

$\left[(1-\beta^4)(1-\beta^2)\right]$: Velocity of Approach Correction

$$d_{\text{ORIFICE I.D.}} = \beta D_{\text{TUBE I.D}}$$

FOR OUTBOARD TUBE (COMPARED TO INBOARD TUBE)

$$H = \frac{\rho V^2}{2g_c} = 0.01804 \text{ psi}$$

$$\Delta p_{\text{REQUIRED ORIFICE}} = 5.7098 \text{ psi}$$

$$D = 0.652 \text{ inch}$$

Find β (and $d = \beta D$)
by Trial & Error.

(See Program for TI-58C)

SOLAR

TABLE C-III

PROGRAM FOR TI58C
ORIFICE DIAMETER

PRIOR TO RUN:

STORE:

29 $\left(\frac{1}{c'}\right)^2 = \left(\frac{\pi+2}{\pi}\right)^2 = 2.67852428$

28 $H\left(\text{FREE STREAM}\right) = \frac{\rho V^2}{2g_c}$ psi

27 N (NUMBER OF ORIFICES IN SERIES)

26 $\Sigma\Delta p$ (TOTAL REQUIRED ORIFICE DROP) psi

DURING RUN:

STORAGE:

00 $\beta = d/D$

01 $(1-\beta^4)$

02 $(1-\beta^2)$

03 $K = 2.6785(1-\beta^4)(1-\beta^2)$
29 * 01 * 02

04 $\Delta P_{\text{CALCULATED}} = \frac{KH}{\beta^4} = \frac{03 * 28}{(00)^4}$

05 $\frac{\Delta p(\text{CALC})}{\Delta p(\text{TARGET})} \overset{?}{=} 1.0 = \frac{04}{06}$

06 $\Delta P_{\text{TARGET}} = \frac{\Sigma\Delta P}{N}$

101	76	Lbl	} B
102	12	B	
103	91	R/S	INPUT β
104	42	STO	} β
105	00	00	
106	33	x^2	β^2
107	33	x^2	β^4
108	94	+/-	$-\beta^4$
109	85	+	
110	01	1.0	
111	95	=	} $1-\beta^4$
112	42	STO	} $(1-\beta^4)$
113	01	01	
114	43	RCL	} β
115	00	00	
116	33	x^2	β^2
117	94	+/-	$-\beta^2$
118	85	+	
119	01	1.0	
120	95	=	} $1-\beta^2$
121	42	STO	} $(1-\beta^2)$
122	02	02	
123	65	*	
124	43	RCL	} $(1-\beta^4)$
125	01	01	
126	65	*	
127	43	RCL	} $\left(\frac{1}{c'}\right)^2$
128	29	29	
129	95	=	} $K = \left(\frac{1}{c'}\right)^2(1-\beta^4)(1-\beta^2)$
130	42	STO	} K
131	03	03	
132	65	*	
133	43	RCL	} H
134	28	28	
135	95	=	KH
136	55	÷	
137	53	(	
138	43	RCL	} β
139	00	00	
140	33	x^2	
141	33	x^2	
142	54	)	
143	95	=	} $\Delta P_{\text{CALC}} = \frac{KH}{\beta^4}$
144	42	STO	} ΔP_{CALC}
145	04	04	
146	43	RCL	} $\Sigma\Delta P$
147	26	26	
148	55	÷	
149	43	RCL	} N
150	27	27	
151	95	=	} $\frac{\Sigma\Delta P}{N} = \Delta P_{\text{TARGET}}$
152	42	STO	} ΔP_{TARGET} ONE ORIFICE
153	06	06	
154	55	÷	
155	43	RCL	} ΔP_{CALC}
156	04	04	
157	95	=	
158	35	1/x	
159	42	STO	} $\frac{\Delta P_{\text{CALC}}}{\Delta P_{\text{TARGET}}} \overset{?}{=} 1.0$
160	05	05	
161	91	END.	

1) INPUT TRIAL VALUE OF β
2) RUN: CALCULATE ΔP_{CALC}.
3) RCL 05: $\frac{\Delta P_{\text{CALC}}}{\Delta P_{\text{TARGET}}}$
4) IF 05 = 1.0; β = Correct
   IF 05 ≠ 1.0;
   Modify β and Try Again
   $\beta' \cong \beta_0 (\text{RCL } 05)^{.22 \text{ approx}}$
   USE THIS FOR NEXT TRY
5) WHEN 05 = 1.0,
   $\Delta P_{\text{CALC}} = \Delta P_{\text{TARGET}}$.

   Then: $d = \beta D$

TABLE C-IV

ORIFICE DIAMETER: OUTBOARD TUBE

FOR OUTBOARD TUBE

29 $\left(\frac{1}{C}\right)^2 = 2.67852$

28 $0.01804 = H$

27 N = 1, 2, 3, etc (ORIFICE IN SERIES)

26 5.7098 = Δp REQUIRED

.192905234

N (27)	β	d INCH	Δp psi CALC	$\Delta p_{TARGET} = \frac{\Sigma \Delta p}{N}$
1	.295867	0.1929	5.7098	5.7098
2 *	.347953	0.2269	2.8549	2.8549
3 *	.381708	0.2489	1.903267	1.903267
4 *	.407095	0.2654	1.42745	1.42745
5 *	.427572	0.2788	1.14196	1.14196
6 *	.444782	0.2900	0.95163	0.95163

* Assumes same coefficient applies for orifices in series.

ONE ORIFICE AT ENTRANCE OF OUTBOARD TUBE:

d = 0.1929" SHARP-EDGED

D = 0.652"

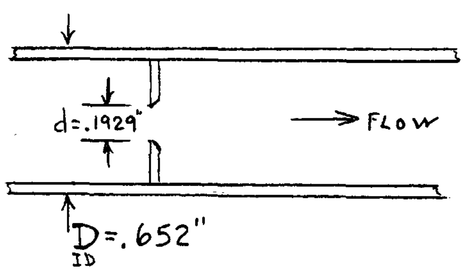
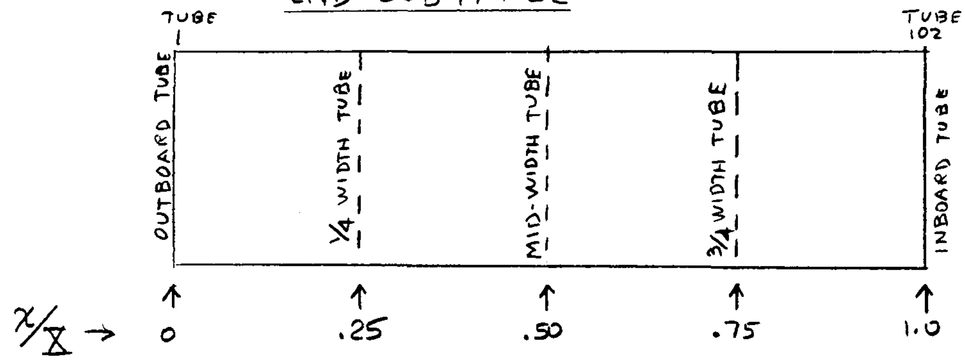


TABLE C-V
END SUB-PANEL



$$\frac{x}{X} = \frac{(\text{TUBE No.} - 1)}{\left(\text{TOTAL TUBES} - 1\right)} = \left(\frac{\text{TUBE No.} - 1}{101}\right)$$

$$(Q/A)_{\text{¢}_i} = 0.225 + (.970 - .225)\left(\frac{x}{X}\right) \; ; \quad \frac{(Q/A)_{\text{¢}\,i}}{(Q/A)_{\text{¢ INBOARD}}} = \frac{.225 + \overbrace{(.970 - .225)}^{.745}\left(\frac{x}{X}\right)}{.97}$$

$$\frac{\dot{\omega}_i}{\dot{\omega}_{INBOARD}} = \frac{(Q/A)_{\text{¢}\,i}}{(Q/A)_{\text{¢ INBOARD}}} \qquad \underset{\text{lbm/sec}}{\dot{\omega}_i} = 0.95505\left\{\frac{.225 + .745\left(\frac{x}{X}\right)}{.97}\right\}$$

$$\frac{H_i}{H_{INBOARD}} = \left(\frac{\dot{\omega}_i}{\dot{\omega}_{INBOARD}}\right)^2 = \left\{\frac{.225 + .745\left(\frac{x}{X}\right)}{.970}\right\}^2 = \left\{\frac{(Q/A)_{\text{¢}\,i}}{(Q/A)_{\text{¢ INBOARD}}}\right\}^2$$

.3467756
.3352242

$$\underset{\text{MID-HEIGHT psi}}{H_i} = H_{\text{MID INBOARD}}\left(\frac{\dot{\omega}_i}{\dot{\omega}_{INBRD}}\right)^2 = (.3468)\left(\frac{\dot{\omega}_i}{\dot{\omega}_{IN}}\right)^2 ; \quad \underset{\text{ENTER}}{H_i} = H_{\text{ENTER INBOARD}}\left(\frac{\dot{\omega}_i}{\dot{\omega}_{INBRD}}\right)^2 = (.3352)\left(\frac{\dot{\omega}_i}{\dot{\omega}}\right)^2$$

SEE CALCULATIONS ON NEXT SHEET FOR TUBES AT OUTBOARD EDGE, 1/4 WIDTH, MID-WIDTH, 3/4 WIDTH AT INBOARD EDGE OF END PANEL.

SIMILAR CALCULATIONS CAN BE MADE FOR EACH INDIVIDUAL TUBE OF END PANEL TO DETERMINE ORIFICE REQUIREMENT.

PREPARED BY: Emm	Rockwell International Energy Systems Group	PAGE NO. 26 OF
CHECKED BY:		REPORT NO. 079TI000002
DATE: 2/83		MODEL NO.

TABLE C-VI
INTERMEDIATE FLOW PARAMETERS

	$(x/X)_i$	0	0.25	0.50	0.75	1.0
00	$(Q/A)_{℄ i} = .225 + .745(x/X)$	.225	.41125	.5975	.78375	0.970
01	$\frac{\dot{\omega}_i}{\dot{\omega}_{INBRD}} = \frac{(Q/A)_{℄ i}}{0.970}$	.23196	.42397	.61598	.80800	1.00
02	$\dot{\omega}_i = 0.95505 \left(\frac{\dot{\omega}_i}{\dot{\omega}_{INBRD}}\right)$ $\frac{lb_m}{sec}$	.22153	.40491	.58829	.77167	.95505
03	$\frac{H}{H_{INBRD}} = \left(\frac{\dot{\omega}_i}{\dot{\omega}_{IN}}\right)^2$	.053805	.17975	.37943	.65285	1.00
04	$H_{MID\ HEIGHT\ i} = .3468 \left(\frac{\dot{\omega}_i}{\dot{\omega}_{IN}}\right)^2$ psi	.01866	.06233	.13158	.22639	.3468
05	$H_{ENTER\ i} = .3352 \left(\frac{\dot{\omega}_i}{\dot{\omega}_{IN}}\right)^2$ psi	.01804	.06026	.12719	.21885	.3352
06	Δp (CALC) psi	0.4270	–	–	–	6.1368
	$\bar{f}_{EFFECTIVE} = \frac{\Delta p}{H_{MID} \left(\frac{L}{D}\right)_{\leq 922}}$ Based on Mid Height Properties	0.024819	–	–	–	0.019193
07	$\bar{f}_{EFF} = \bar{f}_{x/X=0} + (f_{x/X=1} - f_{x/X=0}) \frac{x}{X}$	0.024819	0.023413	0.022006	0.020600	0.019193
08	$\Delta p = \bar{f}_{EFF} \left(\frac{L}{D}\right) H_{MID}$ psi	0.4270	1.3456	2.6697	4.2999	6.1368
	Δp (ORIFICE REQUIRED) psi $(6.1368 - \Delta p)$ * 26	5.7098	4.7912	3.4671	1.8369	0.00
	$H_{i\ ENTER}$ psi ** 28	0.01804	0.06026	.12719	.21885	.3352

FOR ORIFICE PROGRAM,

* STØ 26

** STØ 28

TABLE C-VII
ORIFICE DIAMETERS: INTERMEDIATE TUBES

For the indicated values of Δp_i (TOTAL REQUIRED ORIFICE LOSS) and H_i (MAIN STREAM HEAD, ENTRANCE), $\beta = \frac{d}{D}$ and d(ORIFICE) values are obtained using program on TI58C. N=1 is for one orifice only in each tube. Calculations also have been made for N=2 and N=3 (orifices in series, assuming no hydraulic effect of successive orifices on one another).

N SUCESSIVE ORIFICES IN EACH TUBE	TUBE LOCATION	OUTBOARD	¼ WIDTH	MID-WIDTH	¾ WIDTH	INBOARD
	$(x/X) \rightarrow$	0	0.25	0.50	0.75	1.0
	Δp psi REQUIRED ORIFICE LOSS (26)	5.7098	4.7912	3.4671	1.8369	0.00
	H_i ENTER psi (28)	0.01804	0.06026	0.12719	0.21885	0.3352
1 (27)	$\beta = \frac{d}{D}$	.295867	.406661	.510201	.632997	1.0
	d ORIFICE inch	.1929"	.2651"	.3327"	.4127"	.652" NO ORIFICE
2	β	.347953	.472267	.582285	.702893	–
	d ORIFICE	.2269"	.3079"	.3796"	.4583"	–
3	β	.381708	.513078	.624751	.741016	–
	d ORIFICE	.2489	.3345	.4073	.4831	–

$D = 0.625"$ $d = \beta * D$

D. TEMPERATURE DISTRIBUTION IN TUBES: R,θ; RADIAL AND CIRCUMFERENTIAL

The tubes of the receiver panel experience an unusual thermal environment. A very intense solar heat flux impinges on one side of the tube. For the analysis of this report, this heat flux is as high as 1.20 MW/m^2 (almost 1000 times the sun's normal intensity). The heat is carried away by the sodium coolant flowing within the tube. A severe temperature gradient is set up in the tube wall. Thermal stresses are indiced including both T_1 and T_2 type stresses; that is, both bowing moment producing and surface peaking (see Appendix A).

The two-dimensional (radial-circumferential) temperature distributions in tube cuts have been calculated by means of the "TAP" computer program (Reference 7) nodal model shown in Figure D-1. Additional details of the model used are in Reference 3, and a listing in Appendix B. The calculation is carried out at tube mid-height, which represents the highest heat flux location. Thus, this is where the highest temperature gradients and differentials (though not the highest temperatures) occur. The sodium temperature is set at 830°F (the average of the inlet and outlet temperatures). The incident solar heat fluxes are taken as 1.20 MW/m^2, 0.97 MW/m^2, and 0.225 MW/m^2, representing the full thermal load tubes, inboard tube of an end panel, and the outboard tube of an end panel (see Figure A-2). The sodium side heat transfer coefficient is calculated and tabulated in Table B-III. The incident heat flux is assumed to have a cosine distribution (which results in a slightly more front loaded condition than the actual solar flux distribution coming from a mirror field). No heat losses are taken into consideration; not reflection, radiation, or convection. This assumption yields results that are conservative from a stress viewpoint since the neglect of losses means that all the heat is to be transferred through the tube wall, giving slightly exaggerated temperature gradients and differentials. On the other hand, the neglect of heat losses will yield somewhat higher than actual thermal power performance values. The matter of heat losses and panel thermal performance will be investigated in subsequent analyses.

Figures D-2a, D-2b, and D-2c show the results of the temperature distribution calculations for the three cases indicated. Tables D-Ia, D-Ib, and D-Ic show the numerical results from the computer printout. The terms ΔT_1 and ΔT_2 are defined and explained in Appendix A.

Table D-II summarizes parameters of interest from the results of these three cases.

FIGURE D-1
THERMAL NODAL MAP

See 004TI000002, Pg. 4 & 5
Reference 3

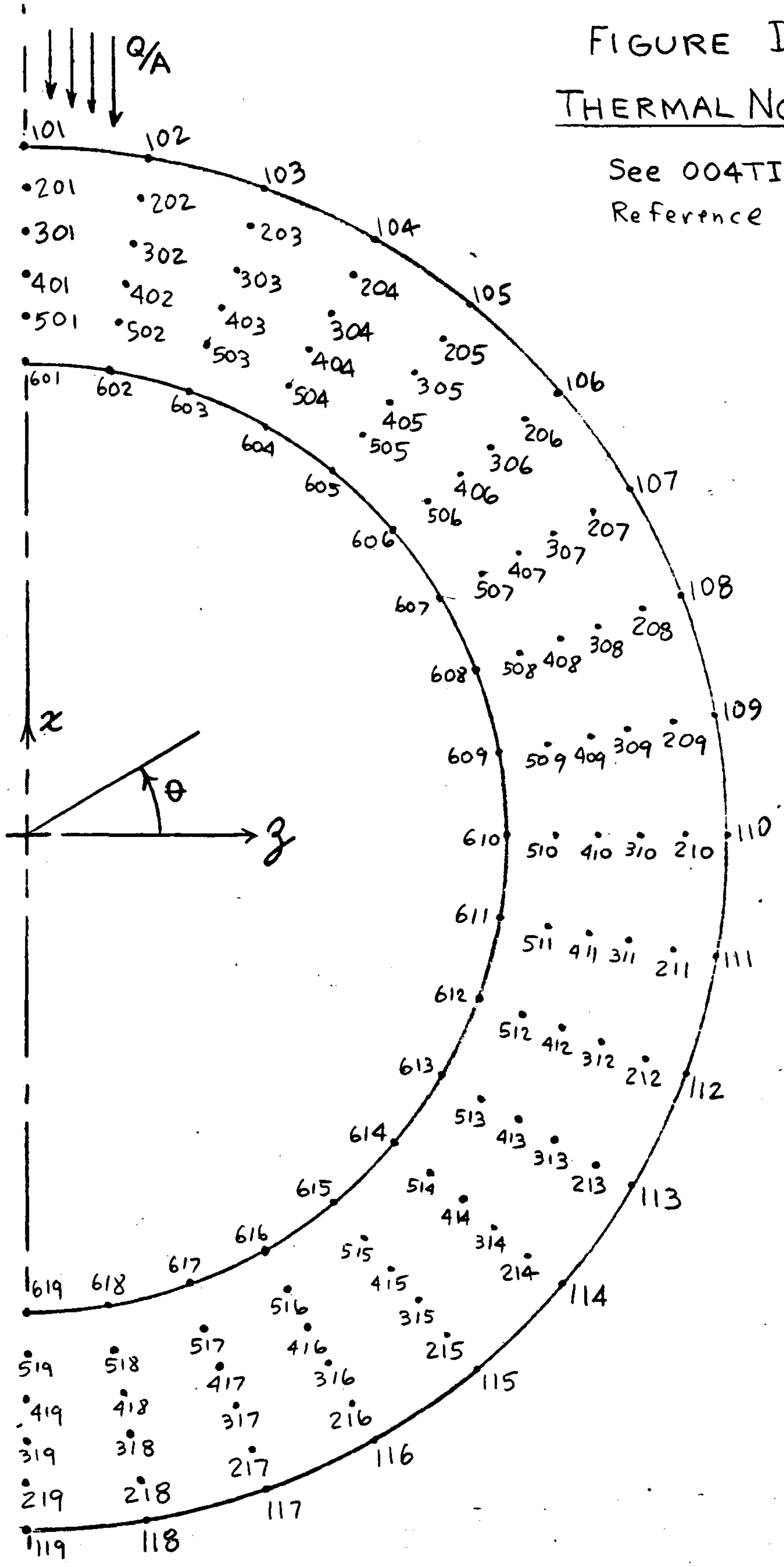
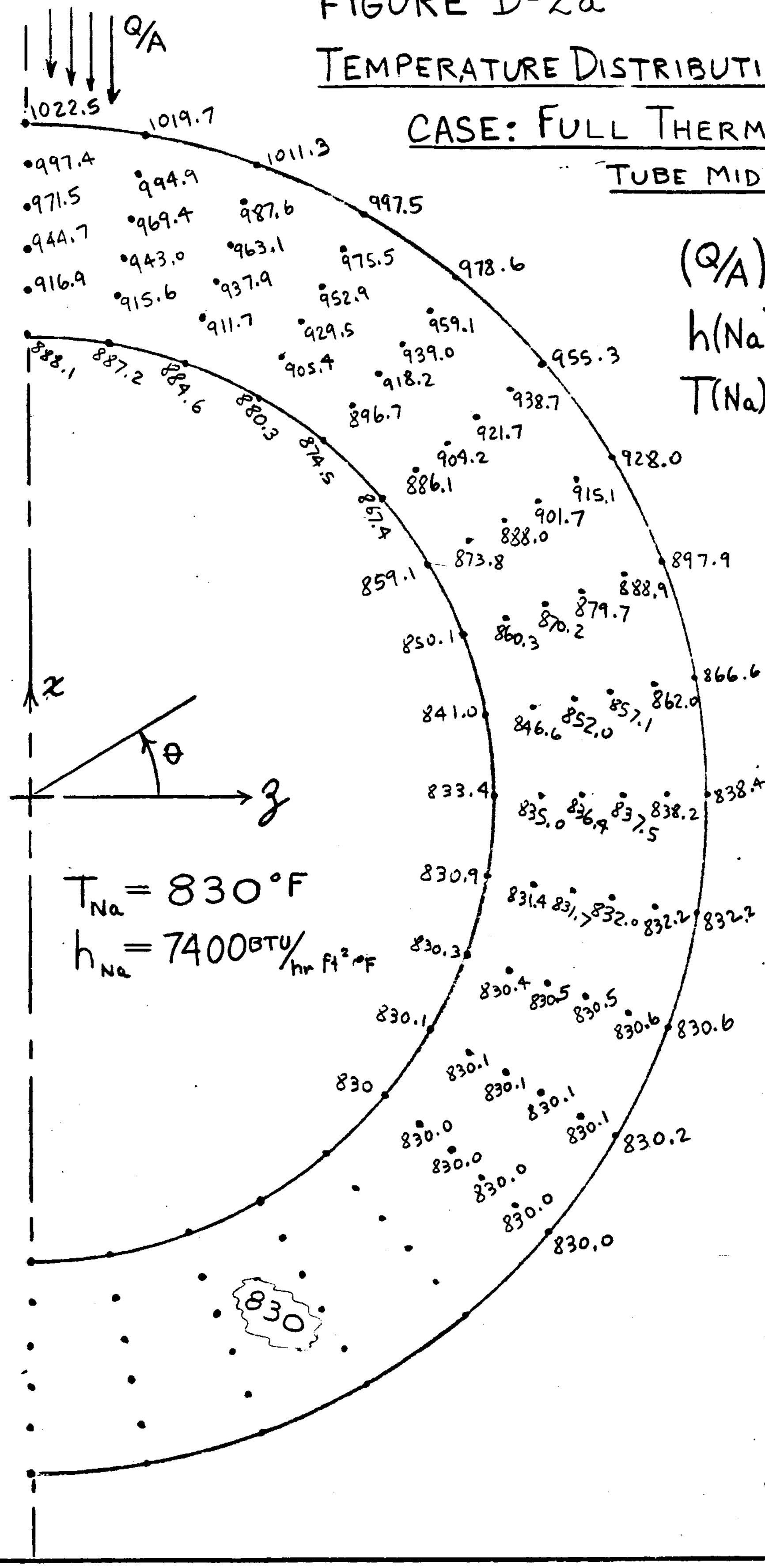


FIGURE D-2a

TEMPERATURE DISTRIBUTION MAP

CASE: FULL THERMAL LOAD

TUBE MID-HEIGHT (Z = 20 FT)



$(Q/A)_o = 1.20\ \frac{MW}{m^2}$ (COSINE LOADING)

$h(Na) = 7400\ BTU/hr\ ft^2\ °F$

$T(Na) = 830°F$

$T_{PEAK} = 1022.5°$

$\overline{\overline{T}}_{MET} = 871.74°$

$\Delta T_1 = 139.66°$

$\Delta T_2 = 80.98°$

$T_{PK} - \overline{\overline{T}}_{MET} = \frac{\Delta T_1}{2} + \Delta T_2 = 150.81°$

$T_{PK} - T_{Na} = 192.5°$

$T_{\text{"FRONT"}} = \overline{\overline{T}} + \frac{\Delta T_1}{2} = 941.57°$

$T_{\text{"BACK"}} = \overline{\overline{T}} - \frac{\Delta T_2}{2} = 801.91°$

$S_1 = \frac{E\alpha\Delta T_1}{2} = 18{,}575\ PSI$

$S_2 = E\alpha\Delta T_2 = 21{,}541\ PSI$

$S_{TOT} = S_1 + S_2 = 40{,}116\ PSI$

$D_o = 3/4''$ SS: 316

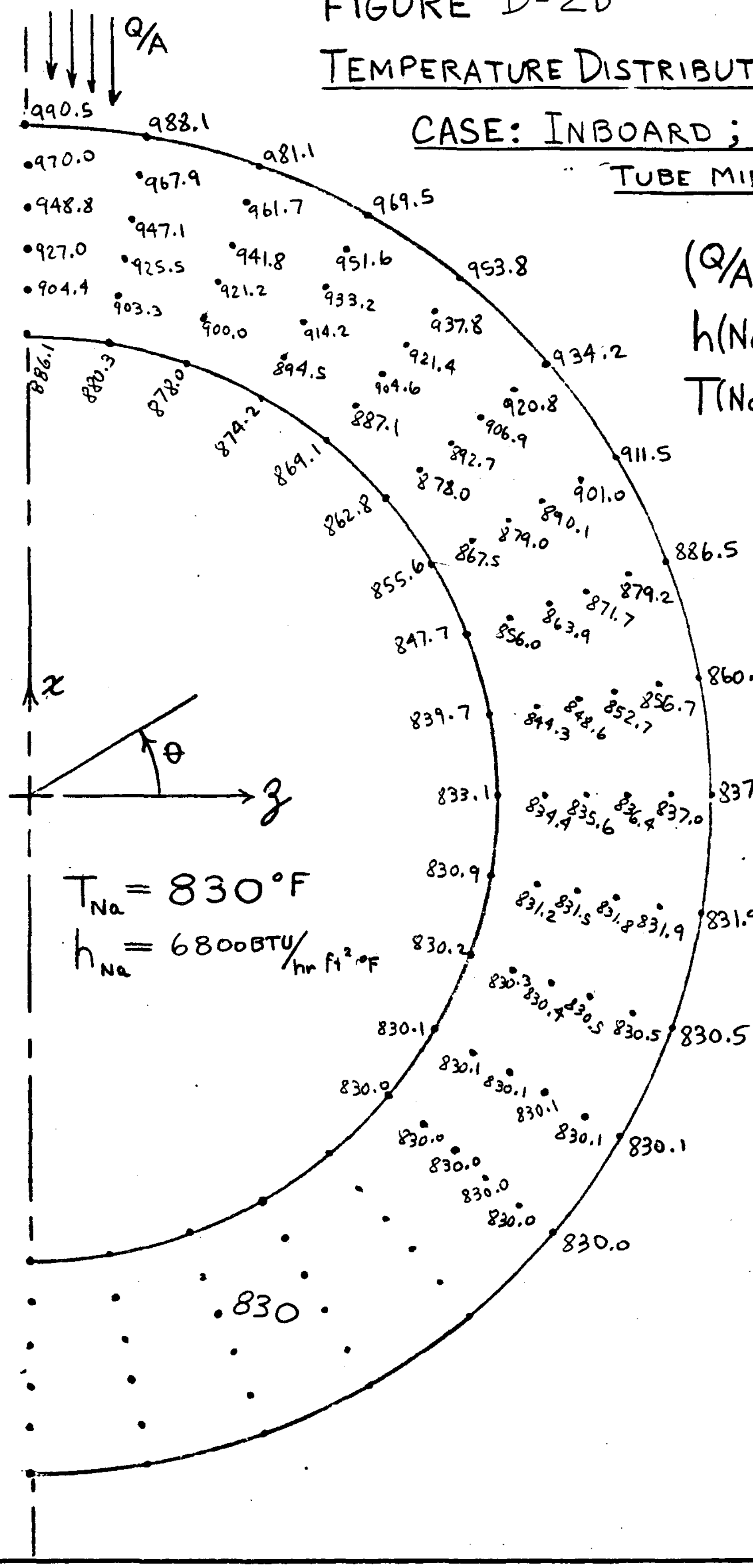
$t_{WALL} = 0.049''$ $E\alpha = 266\ \frac{PSI}{°F}$

FIGURE D-2b

TEMPERATURE DISTRIBUTION MAP

CASE: INBOARD; PANEL 1

TUBE MID-HEIGHT (Z = 20 FT)



$(Q/A)_o = 0.97 \ \frac{MW}{m^2}$ (COSINE LOADING)

$h(Na) = 6800 \ BTU/hr \ ft^2 \ °F$

$T(Na) = 830°F$

$T_{PEAK} = 990.50°$

$\bar{\bar{T}}_{MET} = 865.16°$

$\Delta T_1 = 117.57°$

$\Delta T_2 = 66.56°$

$T_{PK} - \bar{\bar{T}}_{MET} = \frac{\Delta T_1}{2} + \Delta T_2 = 125.34°$

$T_{PK} - T_{Na} = 160.50°$

$T_{\text{"FRONT"}} = \bar{\bar{T}} + \frac{\Delta T_1}{2} = 923.95°$

$T_{\text{"BACK"}} = \bar{\bar{T}} - \frac{\Delta T_2}{2} = 806.38°$

$S_1 = \frac{E\alpha \Delta T_1}{2} = 15,637 \ PSI$

$S_2 = E\alpha \Delta T_2 = 17705 \ PSI$

$S_{TOT} = S_1 + S_2 = 33,342 \ PSI$

$D_o = 3/4''$ SS: 316

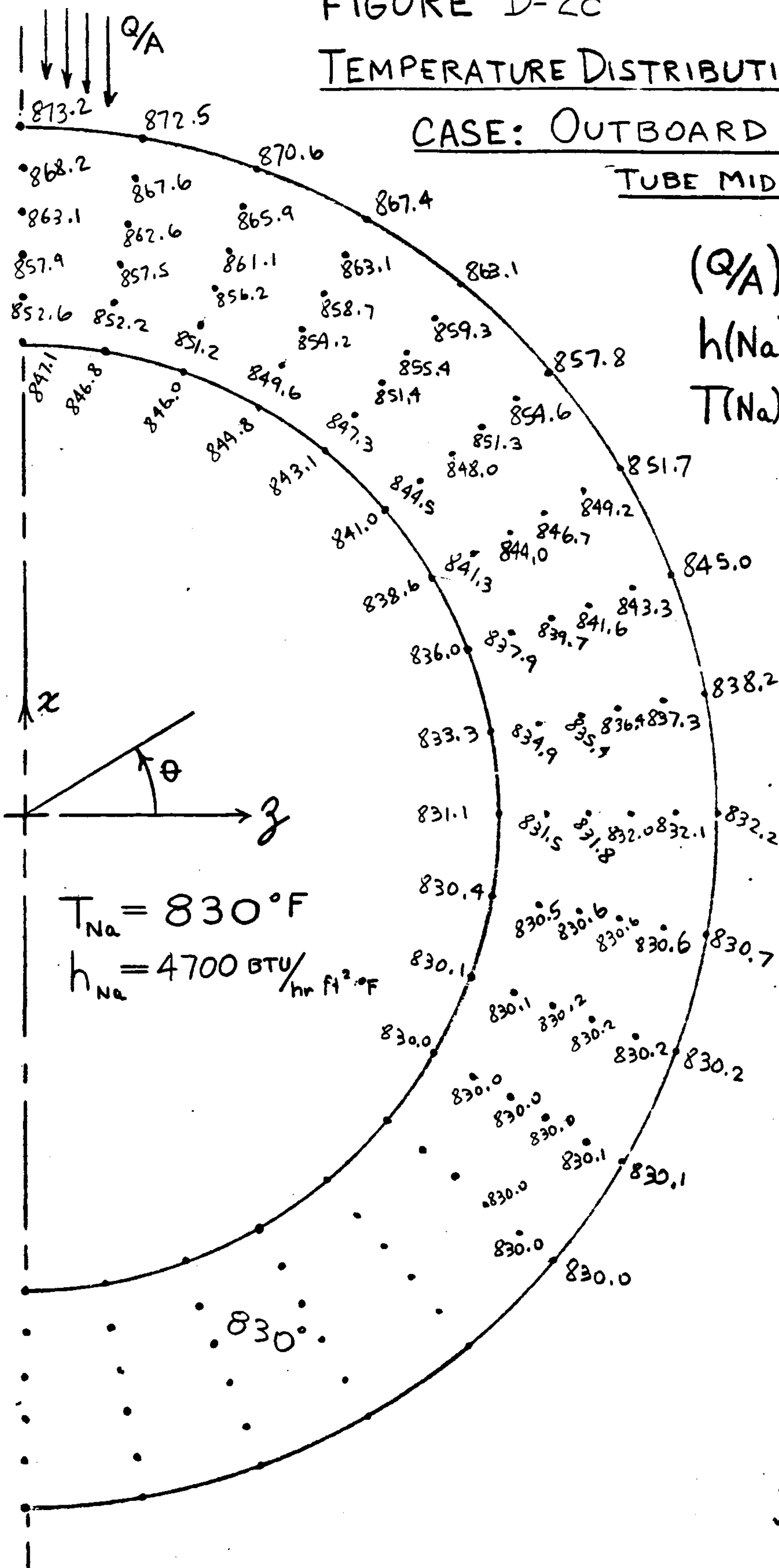
$t_{WALL} = 0.049''$ $E\alpha = 266 \ \frac{PSI}{°F}$

FIGURE D-2c

TEMPERATURE DISTRIBUTION MAP

CASE: OUTBOARD; PANEL 1

TUBE MID-HEIGHT (Z = 20 FT)



$(Q/A)_o = 0.225 \frac{MW}{m^2}$ (COSINE LOADING)

$h(Na) = 4700$ BTU/hr ft² °F

$T(Na) = 830°F$

$T_{PEAK} = 873.17°$

$\bar{T}_{MET} = 839.94°$

$\Delta T_1 = 33.13°$

$\Delta T_2 = 16.66°$

$T_{PK} - \bar{T}_{MET} = \frac{\Delta T_1}{2} + \Delta T_2 = 33.23°$

$T_{PK} - T_{Na} = 43.17°$

$T_{\text{"FRONT"}} = \bar{T} + \frac{\Delta T_1}{2} = 856.51°$

$T_{\text{"BACK"}} = \bar{T} - \frac{\Delta T_2}{2} = 823.37°$

$S_1 = \frac{E\alpha\Delta T_1}{2} = 4406$ PSI

$S_2 = E\alpha\Delta T_2 = 4432$ PSI

$S_{TOT} = S_1 + S_2 = 8838$ PSI

$D_o = 3/4''$ SS:316

$t_{WALL} = 0.049''$ $E\alpha = 266 \frac{PSI}{°F}$

TABLE D-Ia

TUBE CROSS-SECTION TEMPERATURE DISTRIBUTION AT TUBE MID-HEIGHT

(See Plot: Figure D2a)
(See Nodal Map: Figure D1)

FULL THERMAL LOAD TUBE

$(Q/A)_o = 1.20\ MW/m^2$

DEL R = 49 MILS   O.D. = 0.75 INCH   T:NA=830F   COSINE LOADING   FULL THERMAL LOAD
Q/A = 1.20 MW/M2   H:NA=7400   SS:316   MODEL 2

ITER NO. 240.   GREATEST TEMPERATURE CHANGE PER ITERATION = 2.4414E-04   CRITICAL NODE = 313

DT(1) =	139.66	DT(2) =	80.980	T:PK-BAR=	150.81	T:PEAK =	1022.5	T:BAR =	871.74
DT:FT WL=	134.46	DT:TUBE =	192.56	T:NA =	830.00	T:SINK =	60.000	MODEL 2 =	2.0000
I IN4 =	6.6632E-03	AREA IN2=	.10791	R:OUTER =	.37500	R:INNER =	.32600	DEL R =	4.9000E-02
(Q/A)0 =	1.2000	ALPHA =	1.0000	EMISS =	1.0000E-07	H:NA =	7400.0	K:STL	
HT TO NA=	.54884	HT TO SK=	1.4820E-09	HT OUT =	.54884	HT IN =	.54905	CT/IN=17=	.99963
STRESS 1=	18575.	STRESS 2=	21541.	STRS TOT=	40115.	STRS TOT=	40115.	E*A =	266.00

T 101 =	1022.5	T 102 =	1019.7	T 103 =	1011.3	T 104 =	997.48	T 105 =	978.64
T 106 =	955.27	T 107 =	928.04	T 108 =	897.93	T 109 =	866.61	T 110 =	838.43
T 111 =	832.21	T 112 =	830.58	T 113 =	830.15	T 114 =	830.03	T 115 =	830.00
T 116 =	829.99	T 117 =	829.99	T 118 =	829.99	T 119 =	829.99	T 120 =	829.99
T 121 =	829.99	T 122 =	829.99	T 123 =	830.00	T 124 =	830.03	T 125 =	830.14
T 126 =	830.58	T 127 =	832.21	T 128 =	838.43	T 129 =	866.61	T 130 =	897.93
T 131 =	928.04	T 132 =	955.27	T 133 =	978.64	T 134 =	997.48	T 135 =	1011.3
T 136 =	1019.7								

T 201 =	997.42	T 202 =	994.94	T 203 =	987.58	T 204 =	975.53	T 205 =	959.09
T 206 =	938.74	T 207 =	915.06	T 208 =	888.94	T 209 =	861.95	T 210 =	838.18
T 211 =	832.16	T 212 =	830.57	T 213 =	830.14	T 214 =	830.03	T 215 =	830.00
T 216 =	829.99	T 217 =	829.99	T 218 =	829.99	T 219 =	829.99	T 220 =	829.99
T 221 =	829.99	T 222 =	829.99	T 223 =	830.00	T 224 =	830.03	T 225 =	830.14
T 226 =	830.57	T 227 =	832.16	T 228 =	838.18	T 229 =	861.95	T 230 =	888.94
T 231 =	915.06	T 232 =	938.74	T 233 =	959.09	T 234 =	975.53	T 235 =	987.58
T 236 =	994.94	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
T 301 =	971.48	T 302 =	969.38	T 303 =	963.13	T 304 =	952.90	T 305 =	938.97
T 306 =	921.73	T 307 =	901.71	T 308 =	879.69	T 309 =	857.06	T 310 =	837.49
T 311 =	832.00	T 312 =	830.53	T 313 =	830.13	T 314 =	830.02	T 315 =	830.00
T 316 =	829.99	T 317 =	829.99	T 318 =	829.99	T 319 =	829.99	T 320 =	829.99
T 321 =	829.99	T 322 =	829.99	T 323 =	830.00	T 324 =	830.02	T 325 =	830.13
T 326 =	830.53	T 327 =	832.00	T 328 =	837.49	T 329 =	857.06	T 330 =	879.69
T 331 =	901.71	T 332 =	921.73	T 333 =	938.97	T 334 =	952.90	T 335 =	963.13
T 336 =	969.38								

T 401 =	944.67	T 402 =	942.96	T 403 =	937.86	T 404 =	929.53	T 405 =	918.20
T 406 =	904.20	T 407 =	887.97	T 408 =	870.15	T 409 =	851.95	T 410 =	836.43
T 411 =	831.74	T 412 =	830.46	T 413 =	830.11	T 414 =	830.02	T 415 =	830.00
T 416 =	829.99	T 417 =	829.99	T 418 =	829.99	T 419 =	829.99	T 420 =	829.99
T 421 =	829.99	T 422 =	829.99	T 423 =	830.00	T 424 =	830.02	T 425 =	830.11
T 426 =	830.46	T 427 =	831.74	T 428 =	836.43	T 429 =	851.95	T 430 =	870.15
T 431 =	887.97	T 432 =	904.20	T 433 =	918.20	T 434 =	929.53	T 435 =	937.86
T 436 =	942.96								

1.20 " Q/A

T 501 =	916.90	T 502 =	915.60	T 503 =	911.71	T 504 =	905.37	T 505 =	896.74
T 506 =	886.10	T 507 =	873.78	T 508 =	860.30	T 509 =	846.60	T 510 =	835.04
T 511 =	831.38	T 512 =	830.36	T 513 =	830.09	T 514 =	830.02	T 515 =	830.00
T 516 =	829.99	T 517 =	829.99	T 518 =	829.99	T 519 =	829.99	T 520 =	829.99
T 521 =	829.99	T 522 =	829.99	T 523 =	830.00	T 524 =	830.02	T 525 =	830.09
T 526 =	830.36	T 527 =	831.38	T 528 =	835.04	T 529 =	846.60	T 530 =	860.30
T 531 =	873.78	T 532 =	886.10	T 533 =	896.74	T 534 =	905.37	T 535 =	911.71
T 536 =	915.60								

T 601 =	888.09	T 602 =	887.20	T 603 =	884.59	T 604 =	880.31	T 605 =	874.51
T 606 =	867.36	T 607 =	859.12	T 608 =	850.13	T 609 =	841.02	T 610 =	833.39
T 611 =	830.93	T 612 =	830.25	T 613 =	830.06	T 614 =	830.01	T 615 =	830.00
T 616 =	830.00	T 617 =	829.99	T 618 =	829.99	T 619 =	829.99	T 620 =	829.99
T 621 =	829.99	T 622 =	830.00	T 623 =	830.00	T 624 =	830.01	T 625 =	830.06
T 626 =	830.25	T 627 =	830.93	T 628 =	833.39	T 629 =	841.02	T 630 =	850.13
T 631 =	859.12	T 632 =	867.36	T 633 =	874.51	T 634 =	880.31	T 635 =	884.59
T 636 =	887.20								

TABLE D-I b

TUBE CROSS-SECTION TEMPERATURE
DISTRIBUTION AT TUBE MID-HEIGHT

(See Plot: Figure D2b)
(See Nodal Map: Figure D1)

INBOARD TUBE; PANEL 1

$(Q/A)_o = 0.97\ MW/m^2$

DEL R = 49 MILS   O.D. = 0.75 INCH   T:NA=830F   COSINE LOADING
Q/A = 0.97 MW/M2   H:NA=6800   SS:316

INBOARD: PANEL 1

ITER NO. 191. GREATEST TEMPERATURE CHANGE PER ITERATION = 2.4414E-04 CRITICAL NODE = 101

DT(1) =	117.57	DT(2) =	66.558	T:PK-BAR=	125.34	T:PEAK =	990.50	T:BAR =	865.16
DT:FT WL=	109.44	DT:TUBE =	169.52	T:NA =	830.00	T:SINK =	60.000	MODEL 2 =	2.0000
I IN4 =	6.6632E-03	AREA IN2=	.10791	R:OUTER =	.37500	R:INNER =	.32600	DEL R =	4.9000E-02
(Q/A)0 =	.97000	ALPHA =	1.0000	EMISS =	1.0000E-07	H:NA =	6800.0	K:STL	
HT TO NA=	.44362	HT TO SK=	1.3880E-09	HT OUT =	.44362	HT IN =	.44381	CT/IN=1?=	.99956
STRESS 1=	15637.	STRESS 2=	17704.	STRS TOT=	33341.	STRS TOT=	33341.	E*A =	266.00

T 101 =	990.50	T 102 =	988.13	T 103 =	981.07	T 104 =	969.50	T 105 =	953.75
T 106 =	934.23	T 107 =	911.53	T 108 =	886.47	T 109 =	860.48	T 110 =	837.20
T 111 =	831.94	T 112 =	830.52	T 113 =	830.13	T 114 =	830.03	T 115 =	830.00
T 116 =	829.99	T 117 =	829.99	T 118 =	829.99	T 119 =	829.99	T 120 =	829.99
T 121 =	829.99	T 122 =	829.99	T 123 =	830.00	T 124 =	830.03	T 125 =	830.13
T 126 =	830.52	T 127 =	831.94	T 128 =	837.20	T 129 =	860.48	T 130 =	886.47
T 131 =	911.53	T 132 =	934.23	T 133 =	953.75	T 134 =	969.50	T 135 =	981.07
T 136 =	988.13								
T 201 =	969.97	T 202 =	967.89	T 203 =	961.71	T 204 =	951.59	T 205 =	937.82
T 206 =	920.77	T 207 =	900.97	T 208 =	879.17	T 209 =	856.70	T 210 =	837.00
T 211 =	831.90	T 212 =	830.51	T 213 =	830.13	T 214 =	830.03	T 215 =	830.00
T 216 =	829.99	T 217 =	829.99	T 218 =	829.99	T 219 =	829.99	T 220 =	829.99
T 221 =	829.99	T 222 =	829.99	T 223 =	830.00	T 224 =	830.03	T 225 =	830.13
T 226 =	830.51	T 227 =	831.90	T 228 =	837.00	T 229 =	856.70	T 230 =	879.17
T 231 =	900.97	T 232 =	920.77	T 233 =	937.82	T 234 =	951.59	T 235 =	961.71
T 236 =	967.89								
T 301 =	948.82	T 302 =	947.05	T 303 =	941.78	T 304 =	933.16	T 305 =	921.43
T 306 =	906.94	T 307 =	890.13	T 308 =	871.66	T 309 =	852.74	T 310 =	836.43
T 311 =	831.76	T 312 =	830.48	T 313 =	830.12	T 314 =	830.02	T 315 =	830.00
T 316 =	829.99	T 317 =	829.99	T 318 =	829.99	T 319 =	829.99	T 320 =	829.99
T 321 =	829.99	T 322 =	829.99	T 323 =	830.00	T 324 =	830.02	T 325 =	830.12
T 326 =	830.48	T 327 =	831.76	T 328 =	836.43	T 329 =	852.74	T 330 =	871.66
T 331 =	890.13	T 332 =	906.94	T 333 =	921.43	T 334 =	933.16	T 335 =	941.78
T 336 =	947.05								
T 401 =	926.99	T 402 =	925.54	T 403 =	921.22	T 404 =	914.16	T 405 =	904.56
T 406 =	892.70	T 407 =	878.97	T 408 =	863.93	T 409 =	848.60	T 410 =	835.56
T 411 =	831.54	T 412 =	830.42	T 413 =	830.11	T 414 =	830.02	T 415 =	830.00
T 416 =	829.99	T 417 =	829.99	T 418 =	829.99	T 419 =	829.99	T 420 =	829.99
T 421 =	829.99	T 422 =	829.99	T 423 =	830.00	T 424 =	830.02	T 425 =	830.11
T 426 =	830.42	T 427 =	831.54	T 428 =	835.56	T 429 =	848.60	T 430 =	863.93
T 431 =	878.97	T 432 =	892.70	T 433 =	904.56	T 434 =	914.16	T 435 =	921.22
T 436 =	925.54								
T 501 =	904.43	T 502 =	903.31	T 503 =	899.98	T 504 =	894.54	T 505 =	887.14
T 506 =	878.02	T 507 =	867.47	T 508 =	855.95	T 509 =	844.26	T 510 =	834.42
T 511 =	831.23	T 512 =	830.33	T 513 =	830.09	T 514 =	830.02	T 515 =	830.00
T 516 =	829.99	T 517 =	829.99	T 518 =	829.99	T 519 =	829.99	T 520 =	829.99
T 521 =	829.99	T 522 =	829.99	T 523 =	830.00	T 524 =	830.02	T 525 =	830.09
T 526 =	830.33	T 527 =	831.23	T 528 =	834.42	T 529 =	844.26	T 530 =	855.95
T 531 =	867.47	T 532 =	878.02	T 533 =	887.14	T 534 =	894.54	T 535 =	899.98
T 536 =	903.31								
T 601 =	881.36	T 602 =	880.28	T 603 =	877.98	T 604 =	874.22	T 605 =	869.12
T 606 =	862.84	T 607 =	855.60	T 608 =	847.71	T 609 =	839.73	T 610 =	833.05
T 611 =	830.86	T 612 =	830.23	T 613 =	830.06	T 614 =	830.01	T 615 =	830.00
T 616 =	829.99	T 617 =	829.99	T 618 =	829.99	T 619 =	829.99	T 620 =	829.99
T 621 =	829.99	T 622 =	829.99	T 623 =	830.00	T 624 =	830.01	T 625 =	830.06
T 626 =	830.23	T 627 =	830.86	T 628 =	833.05	T 629 =	839.73	T 630 =	847.71
T 631 =	855.60	T 632 =	862.84	T 633 =	869.12	T 634 =	874.22	T 635 =	877.98
T 636 =	880.28								

TABLE D-Ic

TUBE CROSS-SECTION TEMPERATURE DISTRIBUTION AT TUBE MID-HEIGHT

(See Plot: Figure D2c)
(See Nodal Map: Figure D1)
OUTBOARD TUBE; PANEL 1

$(Q/A)_o = 0.225\ MW/m^2$

DEL R = 49 MILS   O.D. = 0.75 INCH   T:NA=830F   COSINE LOADING
Q/A = 0.225 MW/M2   H:NA=4700   SS:316

OUTBOARD: PANEL 1

ITER NO. 269.   GREATEST TEMPERATURE CHANGE PER ITERATION = 2.4414E-04   CRITICAL NODE = 231

DT(1) =	33.133	DT(2) =	16.662	T:PK-BAR=	33.229	T:PEAK =	873.17	T:BAR =	839.94
DT:FT WL=	26.105	DT:TUBE =	43.187	T:NA =	830.00	T:SINK =	60.000	MODEL 2 =	2.0000
I IN4 =	6.6632E-03	AREA IN2=	.10751	R:OUTER =	.37500	R:INNER =	.32600	DEL R =	4.9000E-02
(Q/A)0 =	.22500	ALPHA =	1.0000	EMISS =	1.0000E-07	H:NA =	4700.0	K:STL	
HT TO NA=	.10275	HT TO SK=	1.0861E-09	HT OUT =	.10275	HT IN =	.10295	CT/IN=1?=	.99808
STRESS 1=	4406.7	STRESS 2=	4432.2	STRS TOT=	8838.9	STRS TOT=	8838.9	E*A =	266.00

T 101 =	873.17	T 102 =	872.52	T 103 =	870.58	T 104 =	867.42	T 105 =	863.13
T 106 =	857.84	T 107 =	851.72	T 108 =	845.04	T 109 =	838.20	T 110 =	832.19
T 111 =	830.66	T 112 =	830.19	T 113 =	830.05	T 114 =	830.01	T 115 =	829.99
T 116 =	829.98	T 117 =	829.98	T 118 =	829.98	T 119 =	829.98	T 120 =	829.98
T 121 =	829.98	T 122 =	829.98	T 123 =	829.99	T 124 =	830.00	T 125 =	830.05
T 126 =	830.19	T 127 =	830.66	T 128 =	832.19	T 129 =	838.20	T 130 =	845.04
T 131 =	851.73	T 132 =	857.84	T 133 =	863.13	T 134 =	867.42	T 135 =	870.58
T 136 =	872.52								
T 201 =	868.20	T 202 =	867.63	T 203 =	865.91	T 204 =	863.11	T 205 =	859.31
T 206 =	854.63	T 207 =	849.22	T 208 =	843.32	T 209 =	837.32	T 210 =	832.14
T 211 =	830.64	T 212 =	830.19	T 213 =	830.05	T 214 =	830.00	T 215 =	829.99
T 216 =	829.98	T 217 =	829.98	T 218 =	829.98	T 219 =	829.98	T 220 =	829.98
T 221 =	829.98	T 222 =	829.98	T 223 =	829.99	T 224 =	830.00	T 225 =	830.05
T 226 =	830.19	T 227 =	830.64	T 228 =	832.14	T 229 =	837.32	T 230 =	843.32
T 231 =	849.22	T 232 =	854.63	T 233 =	859.31	T 234 =	863.12	T 235 =	865.91
T 236 =	867.63								
T 301 =	863.12	T 302 =	862.62	T 303 =	861.13	T 304 =	858.70	T 305 =	855.41
T 306 =	851.34	T 307 =	846.66	T 308 =	841.55	T 309 =	836.39	T 310 =	832.00
T 311 =	830.61	T 312 =	830.18	T 313 =	830.04	T 314 =	830.00	T 315 =	829.99
T 316 =	829.98	T 317 =	829.98	T 318 =	829.98	T 319 =	829.98	T 320 =	829.98
T 321 =	829.98	T 322 =	829.98	T 323 =	829.99	T 324 =	830.00	T 325 =	830.04
T 326 =	830.18	T 327 =	830.61	T 328 =	832.00	T 329 =	836.39	T 330 =	841.55
T 331 =	846.66	T 332 =	851.34	T 333 =	855.41	T 334 =	858.71	T 335 =	861.13
T 336 =	862.62								
T 401 =	857.91	T 402 =	857.49	T 403 =	856.23	T 404 =	854.18	T 405 =	851.40
T 406 =	847.98	T 407 =	844.03	T 408 =	839.74	T 409 =	835.41	T 410 =	831.78
T 411 =	830.55	T 412 =	830.16	T 413 =	830.04	T 414 =	830.00	T 415 =	829.99
T 416 =	829.99	T 417 =	829.99	T 418 =	829.99	T 419 =	829.99	T 420 =	829.99
T 421 =	829.99	T 422 =	829.99	T 423 =	829.99	T 424 =	830.00	T 425 =	830.04
T 426 =	830.16	T 427 =	830.55	T 428 =	831.78	T 429 =	835.41	T 430 =	839.74
T 431 =	844.03	T 432 =	847.98	T 433 =	851.40	T 434 =	854.19	T 435 =	856.23
T 436 =	857.49								
T 501 =	852.56	T 502 =	852.22	T 503 =	851.20	T 504 =	849.55	T 505 =	847.29
T 506 =	844.53	T 507 =	841.33	T 508 =	837.87	T 509 =	834.39	T 510 =	831.49
T 511 =	830.46	T 512 =	830.14	T 513 =	830.03	T 514 =	830.00	T 515 =	829.99
T 516 =	829.99	T 517 =	829.99	T 518 =	829.99	T 519 =	829.99	T 520 =	829.99
T 521 =	829.99	T 522 =	829.99	T 523 =	829.99	T 524 =	830.00	T 525 =	830.03
T 526 =	830.13	T 527 =	830.46	T 528 =	831.49	T 529 =	834.39	T 530 =	837.87
T 531 =	841.33	T 532 =	844.53	T 533 =	847.30	T 534 =	849.55	T 535 =	851.20
T 536 =	852.22								
T 601 =	847.06	T 602 =	846.80	T 603 =	846.03	T 604 =	844.78	T 605 =	843.07
T 606 =	840.98	T 607 =	838.56	T 608 =	835.94	T 609 =	833.32	T 610 =	831.14
T 611 =	830.35	T 612 =	830.10	T 613 =	830.03	T 614 =	830.00	T 615 =	829.99
T 616 =	829.99	T 617 =	829.99	T 618 =	829.99	T 619 =	829.99	T 620 =	829.99
T 621 =	829.99	T 622 =	829.99	T 623 =	829.99	T 624 =	830.00	T 625 =	830.02
T 626 =	830.10	T 627 =	830.35	T 628 =	831.14	T 629 =	833.32	T 630 =	835.94
T 631 =	838.56	T 632 =	840.98	T 633 =	843.07	T 634 =	844.78	T 635 =	846.03
T 636 =	846.80								

Q/A = .225

PREPARED BY: EMM	Rockwell International Energy Systems Group	PAGE NO. 37 OF
CHECKED BY:		REPORT NO. 079TI000002
DATE: 12/82		MODEL NO.

TABLE D-II
TUBE TEMPERATURE PARAMETERS
TUBE MID-HEIGHT (℄)

SS: 316
OD = 3/4"
t_w = 0.049"

RUN 6903-07

MID-HEIGHT (℄)

$(Q/A)_o = 1.20$ MW/m²

$h(Na) = 7400$ BTU/hr ft² °F

$T_{Na} = 830.°$

$\bar{T}_{MET} = 871.74$

$T_{PEAK} = 1022.5$

$\Delta T_1 = 139.66$

$\Delta T_2 = 80.98$

CASE: "FULL" THERMAL LOAD

(21) $(\bar{T}_{MET} - T_{Na})_℄ = (871.74 - 830.0) = 41.74$

(22) $(\Delta T_1)_℄ = 139.66$

(23) $(T_{Pk} - T_{Na})_℄ = (1022.5 - 830)_℄ = 192.5$

(24) $(T_{Pk} - \bar{T}_{MET})_℄ = (1022.5 - 871.74)_℄ = 150.76$

(25) $(\Delta T_2)_℄ = 80.98$

MID-HEIGHT (℄)

$(Q/A)_o = 0.97$ MW/m²

$h(Na) = 6800$ BTU/hr ft² °F

$T_{Na} = 830.°$

$\bar{T}_{MET} = 865.16$

$T_{PEAK} = 990.50$

$\Delta T_1 = 117.57$

$\Delta T_2 = 66.558$

CASE: INBOARD, PANEL 1

(21) $(\bar{T}_{MET} - T_{Na})_℄ = (865.16 - 830.0) = 35.16$

(22) $(\Delta T_1)_℄ = 117.57$

(23) $(T_{Pk} - T_{Na})_℄ = (990.50 - 830)_℄ = 160.50$

(24) $(T_{Pk} - \bar{T}_{MET})_℄ = (990.50 - 865.16)_℄ = 125.34$

(25) $(\Delta T_2)_℄ = 66.558$

MID-HEIGHT (℄)

$(Q/A)_o = 0.225$ MW/m²

$h(Na) = 4700$ BTU/hr ft² °F

$T_{Na} = 830.°$

$\bar{T}_{MET} = 839.94$

$T_{PEAK} = 873.17$

$\Delta T_1 = 33.133$

$\Delta T_2 = 16.662$

CASE: OUTBOARD, PANEL 1

(21) $(\bar{T}_{MET} - T_{Na})_℄ = (839.94 - 830) = 9.94$

(22) $(\Delta T_1)_℄ = 33.133$

(23) $(T_{Pk} - T_{Na})_℄ = (873.17 - 830)_℄ = 43.17$

(24) $(T_{Pk} - \bar{T}_{MET})_℄ = (873.17 - 839.94)_℄ = 33.23$

(25) $(\Delta T_2)_℄ = 16.662$

E. TEMPERATURE DISTRIBUTION IN TUBES; Z; AXIAL

The axial variation of sodium temperature in the tubes has been determined in Section II-A, and shown in Table A-II (as well as being shown in Figures E-1a, b, and c). The temperature differentials and gradients that occur in a tube (in a cut normal to the tube axis) due to the heat flux at tube mid-height (peak flux location) have been determined in Section II-D, and shown in Tables D-Ia, b, and c and Figures D-2a, b, and c.

The temperature distributions for cuts of the tubes other than at mid-height (peak flux) have not been separately calculated by the methods of Section II-D. Instead, it has been assumed that the local temperature distribution (R, θ) is similar to that at mid-height, and proportional to the local heat flux. The local heat flux is taken to vary according to the "normal" distribution curve of Section II-A, on Figure A-1 and Tables A-I and A-II.

Thus, at any axial tube location, the temperature distribution (r, o) is taken to be the local sodium temperature PLUS the proportionate amount of the peak flux location temperature differentials.

$$T_i(z) = T_{Na}(z) + \Phi(z) * T_{i_{\mathbb{C}}(z=20)}$$

These calculations are laid out on Table E-I, and presented in Tables E-IIa, b, and c for the three cases of interest: "Full Thermal Load Tube," "Inboard Tube, Subpanel 1," and "Outboard Tube, Subpanel 1." Table E-III shows the computational program used with the TI58C calculator.

The axial temperature profiles thus determined are shown in Figures E-1a, b, and c. Each of these figures show five temperature curves. T(Na) is the sodium temperature from Section II-A, Table A-II. T(peak) is the highest temperature of the tube metal, occurring on the front-center of the tube outer surface. $\bar{T}$(met) is the mean metal temperature at the entire 360° cut at location z.

T(front) and T(back) are the fictitious temperatures that create the appropriate "Moment Generating Equivalent Linear Temperature Difference," ΔT_1, as discussed in Appendix A. That is, if it is assumed that the tube, acting as a beam, has a linear temperature profile across a diameter (front-to-back) with the magnitude of the differential ΔT_1, then the beam would have the same tendency to bow or generate internal moments as the tube with the actual complex temperature distribution.

$$T(\text{front}) = \bar{T}(\text{met}) + \Delta T_1/2$$
$$T(\text{back}) = \bar{T}(\text{met}) - \Delta T_1/2$$

The values of T(front) and T(back) are useful as input data for the tube thermal stress-deflection analysis.

The net axial thermal expansion of the tube is based on the axially averaged temperature. This calculation and results are shown in Table E-IV. Notice that the axially averaged metal temperature is close to, but somewhat greater than, the mean sodium temperature.

The temperature distributions (including the appropriate temperature differentials) at tube mid-height are shown in Figures D-2a, b, and c and Tables D-Ia, b, and c. These are based on the peak solar heat flux at the three reference tubes. At axial locations between Z = 0 (bottom) to Z = 40 ft (top), the increment of temperature above the local sodium temperature is assumed to vary as $\phi(Z)$; (the normalized altitude of the normal distribution curve, Column d of Table A-III).

The calculations shown in the following Tables E-IIa, b, and c are made by the equations shown in Table E-I, of the form:

$$T_i(z) = T_{Na}(z) + \phi(z) * \Delta T_{i\,\mathbb{C}}(z=20')$$

See Table A-II Col. h   See Table A-II Col. d   See Table D-II

TABLE E-I

AXIAL TEMPERATURE VARIATION

FOR CALCULATIONS OF TABLES E-IIa, b, c
FROM DATA OF TABLES A-II & D-II

COLUMN	
0	$Z(ft)$ Location from bottom of panel $(0 \le Z \le 40)$
1	$T_{Na}(Z)$, Sodium Temperature; See Table A-II, Col. h $(610 \le T_{Na} \le 1050)$
2	$\phi(Z) = \frac{Q(x)}{Q_{℄}}$, Normalized Altitude of Curve, See Table A-II, Col. d $(.1353 \le \phi \le 1)$
3	$\bar{T}_{MET}(Z) = T_{Na}(Z)$ ① $+ (\phi)$ ② $* (\bar{T}_{MET} - T_{Na})_{℄}$ Table D-II; Mean Metal Temperature.
4	$\Delta T_1(Z) = (\Delta T_1)_{℄}$ Table D-II $* (\phi)$ ②; Equivalent Moment Generating ΔT
5	$\frac{\Delta T_1(Z)}{2} = \frac{[\Delta T_1(Z)]}{2}$ ④
6	$T_{\text{"FRONT"}}(Z) = \bar{T}_{MET}(Z)$ ③ $+ \left(\frac{\Delta T_1(Z)}{2}\right)$ ④ — $T_{\text{"FRONT"}}$ FOR STRESS MODEL
7	$T_{\text{"BACK"}}(Z) = \bar{T}(Z)$ ③ $- \left(\frac{\Delta T_1(Z)}{2}\right)$ ④ — $T_{\text{"BACK"}}$ FOR STRESS MODEL
8	$T_{PEAK}(Z) = T_{Na}(Z)$ ① $+ (\phi)$ ② $* [T_{PK} - T_{Na}]_{℄}$ Table D-II — PEAK METAL TEMPERATURE AT Z
9	$(T_{PEAK} - \bar{T}_{MET})(Z) = (\phi)$ ② $* [T_{PK} - \bar{T}_{MET}]_{℄}$ Table D-II — $T_{MAX} - \bar{T} = \frac{\Delta T_1}{2} + \Delta T_2$
10	$\Delta T_2(Z) = (\phi)$ ② $* (\Delta T_2)_{℄}$ Table D-II

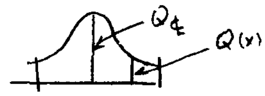


TABLE E-IIa
AXIAL TEMPERATURE DISTRIBUTION

CASE: "FULL LOAD" TUBE

$(Q/A)_0 = 1.20\ MW/m^2$

(21) $(\bar{T}_{MET} - T_{Na})_{\mathcal{C}} = 41.74$
(22) $(\Delta T_1)_{\mathcal{C}} = 139.66$
(23) $(T_{PK} - T_{Na})_{\mathcal{C}} = 192.50$
(24) $(T_{PK} - \bar{T}_{MET})_{\mathcal{C}} = 150.76$
(25) $(\Delta T_2)_{\mathcal{C}} = 80.98$

(0) Z LOCATION (FT)	(1) $T_{Na}(z)$ SODIUM	(2) $\phi(z)$ NORMALIZED ALTITUDE OF CURVE	(3) $\bar{T}_{MET}(z)$ MEAN METAL TEMP	(4) $\Delta T_1(z)$	(5) $\frac{\Delta T_1}{2}$	(6) $T(z)$ "FRONT"	(7) $T(z)$ "BACK"	(8) $T_{PK}(z)$ PEAK	(9) $(T_{PK} - \bar{T}_{MET})(z)$	(10) $\Delta T_2(z)$
0	610.00	.135335	615.65	18.90	9.45	625.10	606.20	636.05	20.40	10.96
1	612.75	.164474	619.62	22.97	11.49	631.10	608.13	644.41	24.80	13.32
2	616.08	.197899	624.34	27.64	13.82	638.16	610.52	654.18	29.84	16.03
3	620.06	.235746	629.90	32.92	16.46	646.36	613.44	665.44	35.55	19.09
4	624.77	.278037	636.38	38.83	19.42	655.79	616.96	678.29	41.93	22.52
5	630.31	.324652	643.86	45.34	22.67	666.53	621.19	692.81	48.96	26.29
6	636.74	.375311	652.41	52.42	26.21	678.61	626.20	708.99	56.60	30.39
7	644.14	.429557	662.07	59.99	30.00	692.07	632.07	726.83	64.78	34.79
8	652.56	.486752	672.88	67.98	33.99	706.87	638.89	746.26	73.40	39.42
9	662.05	.546074	684.84	76.26	38.13	722.98	646.71	767.17	82.35	44.22
10	672.65	.606531	697.97	84.71	42.35	740.32	655.61	789.91	91.46	49.12
11	684.36	.666977	712.20	93.15	46.58	758.77	665.62	812.75	100.58	54.01
12	697.17	.726149	727.48	101.41	50.71	778.19	676.77	836.95	109.50	58.80
13	711.05	.782705	743.72	109.31	54.66	798.38	689.06	861.72	118.03	63.38
14	725.94	.835270	760.80	116.65	58.33	819.13	702.48	886.73	125.96	67.64
15	741.74	.882497	778.57	123.25	61.62	840.20	716.95	911.62	133.08	71.46
16	758.35	.923116	796.88	128.92	64.46	861.34	732.42	936.05	139.21	74.75
17	775.65	.955997	815.55	133.51	66.76	882.31	748.80	959.68	144.16	77.42
18	793.46	.980199	834.37	136.89	68.45	902.82	765.93	982.15	147.81	79.38
19	811.64	.995012	853.17	138.96	69.48	922.65	783.69	1003.18	150.05	80.58
20	830.00	1.00	871.74	139.66	69.83	941.57	801.91	1022.50	150.76	80.98
21	848.36	.995012	889.89	138.96	69.48	959.37	820.41	1039.90	150.05	80.58
22	866.54	.980199	907.45	136.89	68.45	975.90	839.01	1055.23	147.81	79.38
23	884.35	.955997	924.25	133.51	66.76	991.01	857.50	1068.38	144.16	77.42
24	901.65	.923116	940.18	128.92	64.46	1004.64	875.72	1079.35	139.21	74.75
25	918.26	.882497	955.10	123.25	61.62	1016.72	893.47	1088.14	133.08	71.46
26	934.06	.835270	968.92	116.65	58.33	1027.25	910.60	1094.85	125.96	67.64
27	948.95	.782705	981.62	109.31	54.66	1036.28	926.96	1099.62	118.03	63.38
28	962.83	.726149	993.14	101.41	50.71	1043.85	942.93	1102.61	109.50	58.80
29	975.64	.666977	1003.48	93.15	46.58	1050.05	956.90	1104.03	100.58	54.01
30	987.35	.606531	1012.67	84.71	42.35	1055.02	970.31	1104.11	91.46	49.12
31	997.95	.546074	1020.74	76.26	38.13	1058.88	982.61	1103.07	82.35	44.22
32	1007.44	.486752	1027.76	67.98	33.99	1061.75	993.77	1101.14	73.40	39.42
33	1015.86	.429557	1033.79	59.99	30.00	1063.79	1003.79	1098.55	64.78	34.79
34	1023.26	.375311	1038.93	52.42	26.21	1065.13	1012.72	1095.51	56.60	30.39
35	1029.69	.324652	1043.24	45.34	22.67	1065.91	1020.57	1092.19	48.96	26.29
36	1035.23	.278037	1046.84	38.83	19.42	1066.25	1027.42	1088.75	41.93	22.52
37	1039.94	.235746	1049.78	32.92	16.46	1066.24	1033.32	1085.32	35.55	19.09
38	1043.92	.197899	1052.18	27.64	13.82	1066.00	1038.36	1082.02	29.84	16.03
39	1047.25	.164474	1054.12	22.97	11.49	1065.60	1042.63	1078.91	24.80	13.32
40	1050.00	.135335	1055.65	18.90	9.45	1065.10	1046.20	1076.05	20.40	10.96

TABLE E-IIb
AXIAL TEMPERATURE DISTRIBUTION

CASE: INBOARD: PANEL 1

$(Q/A)_0 = 0.97\ MW/m^2$

(21) $(\bar{T}_{MET} - T_{Na})_{℄} = 35.16°$
(22) $(\Delta T_1)_{℄} = 117.57°$
(23) $(T_{PK} - T_{Na})_{℄} = 160.50°$
(24) $(T_{PK} - \bar{T}_{MET})_{℄} = 125.34°$
(25) $(\Delta T_2)_{℄} = 66.558°$

z	(1) $T_{Na}(z)$ SODIUM	(2) $\phi(z)$	(3) $\bar{T}_{MET}(z)$	(4) $\Delta T_1(z)$	(5) $\frac{\Delta T_1}{2}$	(6) $T(z)$ "FRONT"	(7) $T(z)$ "BACK"	(8) $T_{PEAK}(z)$	(9) $(T_{PK} - \bar{T}_{MET})$	(10) $\Delta T_2(z)$
0	610.0	.135335	614.76	15.91	7.96	622.71	606.80	631.72	16.96	9.01
1	612.75	.164474	618.53	19.34	9.67	628.20	608.86	639.15	20.62	10.95
2	616.08	.197899	623.04	23.27	11.63	634.67	611.40	647.84	24.80	13.17
3	620.06	.235746	628.35	27.72	13.86	642.21	614.49	657.90	29.55	15.69
4	624.77	.278037	634.55	32.69	16.34	650.89	618.20	669.39	34.85	18.51
5	630.31	.324652	641.72	38.17	19.08	660.81	622.64	682.42	40.69	21.61
6	636.74	.375311	649.94	44.13	22.06	672.00	627.87	696.98	47.04	24.98
7	644.14	.429557	659.24	50.50	25.25	684.49	633.99	713.08	53.84	28.59
8	652.56	.486752	669.67	57.23	28.61	698.29	641.06	730.68	61.01	32.40
9	662.05	.546074	681.25	64.20	32.10	713.35	649.15	749.69	68.44	36.35
10	672.65	.606531	693.98	71.31	35.65	729.63	658.32	770.00	76.02	40.37
11	684.36	.666977	707.81	78.42	39.21	747.02	668.60	791.41	83.60	44.39
12	697.17	.726149	722.71	85.37	42.69	765.40	680.02	813.73	91.02	48.33
13	711.05	.782705	738.57	92.02	46.01	784.58	692.56	836.67	98.10	52.10
14	725.94	.835270	755.31	98.20	49.10	804.41	706.21	860.00	104.69	55.59
15	741.74	.882497	772.77	103.76	51.88	824.65	720.89	883.38	110.61	58.74
16	758.35	.923116	790.81	108.53	54.27	845.07	736.54	906.51	115.70	61.44
17	775.65	.955997	809.26	112.40	56.20	865.46	753.06	929.09	119.82	63.63
18	793.46	.980199	827.92	115.24	57.62	885.54	770.30	950.78	122.86	65.24
19	811.64	.995012	846.62	116.98	58.49	905.12	788.13	971.34	124.71	66.23
20	830.00	1.00	865.16	117.57	58.79	923.95	806.38	990.50	125.34	66.56
21	848.36	.995012	883.34	116.98	58.49	941.84	824.85	1008.06	124.71	66.23
22	866.54	.980199	901.00	115.24	57.62	958.62	843.38	1023.86	122.86	65.24
23	884.35	.955997	917.96	112.40	56.20	974.16	861.76	1037.79	119.82	63.63
24	901.65	.923116	934.11	108.53	54.27	988.37	879.84	1049.81	115.70	61.44
25	918.26	.882497	949.29	103.76	51.88	1001.17	897.41	1059.90	110.61	58.74
26	934.06	.835270	963.43	98.20	49.10	1012.53	914.33	1068.12	104.69	55.59
27	948.95	.782705	976.47	92.02	46.01	1022.48	930.46	1074.57	98.10	52.10
28	962.83	.726149	988.36	85.37	42.69	1031.05	945.67	1079.38	91.02	48.33
29	975.64	.666977	999.09	78.42	39.21	1038.30	959.88	1082.69	83.60	44.39
30	987.35	.606531	1008.68	71.31	35.65	1044.33	973.02	1084.70	76.02	40.37
31	997.95	.546074	1017.15	64.20	32.10	1049.25	985.05	1085.59	68.44	36.35
32	1007.44	.486752	1024.55	57.23	28.61	1053.17	995.94	1085.56	61.01	32.40
33	1015.86	.429557	1030.96	50.50	25.25	1056.21	1005.71	1084.80	53.84	28.59
34	1023.26	.375311	1036.46	44.13	22.06	1058.52	1014.39	1083.50	47.04	24.98
35	1029.69	.324652	1041.10	38.17	19.08	1060.19	1022.02	1081.80	40.69	21.61
36	1035.23	.278037	1045.00	32.69	16.34	1061.35	1028.66	1079.85	34.85	18.51
37	1039.94	.235746	1048.23	27.72	13.86	1062.09	1034.37	1077.78	29.55	15.69
38	1043.92	.197899	1050.88	23.27	11.63	1062.51	1039.24	1075.68	24.80	13.17
39	1047.25	.164474	1053.03	19.34	9.67	1062.70	1043.36	1073.65	20.62	10.95
40	1050.00	.135335	1054.76	15.91	7.96	1062.71	1046.80	1071.72	16.96	9.01

TABLE E-IIc

AXIAL TEMPERATURE DISTRIBUTION

CASE: OUTBOARD: PANEL 1

$(Q/A)_o = 0.225 \frac{MW}{m^2}$

(21) $(\bar{T}_{MET} - T_{Na})_{℄} = 9.94°$
(22) $(\Delta T_1)_{℄} = 33.133°$
(23) $(T_{PK} - T_{Na})_{℄} = 43.17°$
(24) $(T_{PK} - \bar{T}_{MET})_{℄} = 33.23°$
(25) $(\Delta T_2)_{℄} = 16.662°$

(0) Z	(1) $T_{Na}(z)$ SODIUM	(2) $\Phi(z)$	(3) $\bar{T}_{MET}(z)$	(4) $\Delta T_1(z)$	(5) $\frac{\Delta T_1}{2}$	(6) $T(z)$ "FRONT"	(7) $T(z)$ "BACK"	(8) $T_{PEAK}(z)$	(9) $(T_{PK} - \bar{T}_{MET})(z)$	(10) $\Delta T_2(z)$
0	610.00	.135335	611.35	4.48	2.24	613.59	609.10	615.84	4.50	2.25
1	612.75	.164474	614.38	5.45	2.72	617.11	611.66	619.85	5.47	2.74
2	616.08	.197899	618.05	6.56	3.28	621.33	614.77	624.62	6.58	3.30
3	620.06	.235746	622.40	7.81	3.91	626.31	618.50	630.24	7.83	3.93
4	624.77	.278037	627.53	9.21	4.61	632.14	622.93	636.77	9.24	4.63
5	630.31	.324652	633.54	10.76	5.38	638.92	628.16	644.33	10.79	5.41
6	636.74	.375311	640.47	12.44	6.22	646.69	634.25	652.94	12.47	6.25
7	644.14	.429557	648.41	14.23	7.12	655.53	641.29	662.68	14.27	7.16
8	652.56	.486752	657.40	16.13	8.06	665.46	649.33	673.57	16.17	8.11
9	662.05	.546074	667.48	18.09	9.05	676.52	658.43	685.62	18.15	9.10
10	672.65	.606531	678.68	20.10	10.05	688.73	668.63	698.83	20.16	10.11
11	684.36	.666977	690.99	22.10	11.05	702.04	679.94	713.15	22.16	11.11
12	697.17	.726149	704.39	24.06	12.03	716.42	692.36	728.52	24.13	12.10
13	711.05	.782705	718.83	25.93	12.97	731.80	705.86	744.84	26.01	13.04
14	725.94	.835270	734.24	27.68	13.84	748.08	720.41	762.00	27.76	13.92
15	741.74	.882497	750.51	29.24	14.62	765.13	735.89	779.84	29.33	14.70
16	758.35	.923116	767.53	30.59	15.29	782.82	752.23	798.20	30.68	15.38
17	775.65	.955997	785.15	31.68	15.84	800.99	769.32	816.92	31.77	15.93
18	793.46	.980199	803.20	32.48	16.24	819.44	786.96	835.78	32.57	16.33
19	811.64	.995012	821.53	32.97	16.48	838.01	805.05	854.59	33.06	16.58
20	830.00	1.00	839.94	33.13	16.57	856.51	823.37	873.17	33.23	16.66
21	848.36	.995012	858.27	32.97	16.48	874.75	841.79	891.33	33.06	16.58
22	866.54	.980199	876.28	32.48	16.24	892.52	860.04	908.86	32.57	16.33
23	884.35	.955997	893.85	31.68	15.84	909.69	878.02	925.62	31.77	15.93
24	901.65	.923116	910.83	30.59	15.29	926.12	895.53	941.50	30.68	15.38
25	918.26	.882497	927.03	29.24	14.62	941.65	912.41	956.36	29.33	14.70
26	934.06	.835270	942.36	27.68	13.84	956.20	928.53	970.12	27.76	13.92
27	948.95	.782705	956.73	25.93	12.97	969.70	943.76	982.74	26.01	13.04
28	962.83	.726149	970.05	24.06	12.03	982.08	958.02	994.18	24.13	12.10
29	975.64	.666977	982.27	22.10	11.05	993.32	971.22	1004.43	22.16	11.11
30	987.35	.606531	993.38	20.10	10.05	1003.43	983.33	1013.53	20.16	10.11
31	997.95	.546074	1003.38	18.09	9.05	1012.42	994.33	1021.52	18.15	9.10
32	1007.44	.486752	1012.28	16.13	8.06	1020.34	1004.21	1028.45	16.17	8.11
33	1015.86	.429557	1020.13	14.23	7.12	1027.25	1013.01	1034.40	14.27	7.16
34	1023.26	.375311	1026.99	12.44	6.22	1033.21	1020.77	1039.46	12.47	6.25
35	1029.69	.324652	1032.92	10.76	5.38	1038.30	1027.54	1043.71	10.79	5.41
36	1035.23	.278037	1037.99	9.21	4.61	1042.60	1033.39	1047.23	9.24	4.63
37	1039.94	.235746	1042.28	7.81	3.91	1046.19	1038.38	1050.12	7.83	3.93
38	1043.92	.197899	1045.89	6.56	3.28	1049.17	1042.61	1052.46	6.58	3.30
39	1047.25	.164474	1048.88	5.45	2.72	1051.61	1046.16	1054.35	5.47	2.74
40	1050.00	.135335	1051.35	4.48	2.24	1053.59	1049.10	1055.84	4.50	2.25

SOLAR

TABLE E-III

PROGRAM FOR TI58C

PRIOR TO RUN:

STORE:

21 $(\bar{T}_{MET} - T_{Na})_{℄}$

22 $(\Delta T_1)_{℄}$

23 $(T_{PK} - T_{Na})_{℄}$

24 $(T_{PK} - \bar{T}_{MET})_{℄}$

25 $(\Delta T_2)_{℄}$

DURING RUN:

STORAGE:

01	T_{Na} (z)
02	ϕ (z)
03	$\bar{T}_{MET}$ (z)
04	ΔT_1 (z)
05	$\Delta T_1/2$ (z)
06	T_{FRONT} (z)
07	T_{BACK} (z)
08	T_{PEAK} (z)
09	$(T_{PK} - \bar{T}_{MET})$ (z)
10	ΔT_2 (z)

RUN (LBL C)

Code	Key	Comment
76	Lbl	C
13	C	
91	R/S	INPUT T_{Na}(z)
42	STΦ	T_{Na}
01	01	
91	R/S	INPUT ϕ (z)
42	STΦ	ϕ
02	02	
43	RCL	ϕ
02	02	
65	*	
43	RCL	$(\bar{T}_{MET} - T_{Na})_{℄}$
21	21	
95	=	$\phi(\bar{T}_m - T_{Na})_{℄}$
85	+	
43	RCL	T_{Na}
01	01	
95	=	$\bar{T}_{MET}$ (z)
42	STΦ	
03	03	
43	RCL	ϕ
02	02	
65	*	
43	RCL	$\Delta T_{1℄}$
22	22	
95	=	ΔT_1(z)
42	STΦ	
04	04	
55	÷	
02	2.	
95	=	$\frac{\Delta T_1(z)}{2}$
42	STΦ	
05	05	
43	RCL	$\bar{T}_{MET}$ (z)
03	03	
85	+	
43	RCL	$\frac{\Delta T_1(z)}{2}$
05	05	
95	=	T_{FRONT} (z)
42	STΦ	
06	06	
43	RCL	$\bar{T}_{MET}$ (z)
03	03	
75	−	
43	RCL	$\frac{\Delta T_1}{2}$ (z)
05	05	
95	=	T_{BACK} (z)
42	STΦ	
07	07	
43	RCL	ϕ
02	02	
65	*	
43	RCL	$(T_{PK} - T_{Na})_{℄}$
23	23	
95	=	$\phi(T_{PK} - T_{Na})_{℄}$
85	+	
43	RCL	T_{Na} (z)
01	01	
95	=	T_{PEAK} (z)
42	STΦ	
08	08	
43	RCL	ϕ
02	02	
65	*	
43	RCL	$(T_{PK} - \bar{T}_{MET})_{℄}$
24	24	
95	=	$(T_{PK} - \bar{T}_{MET})$ (z)
42	STΦ	
09	09	
43	RCL	ϕ
02	02	
65	*	
43	RCL	$\Delta T_{2℄}$
25	25	
95	=	ΔT_2 (z)
42	STΦ	
10	10	
91	END	

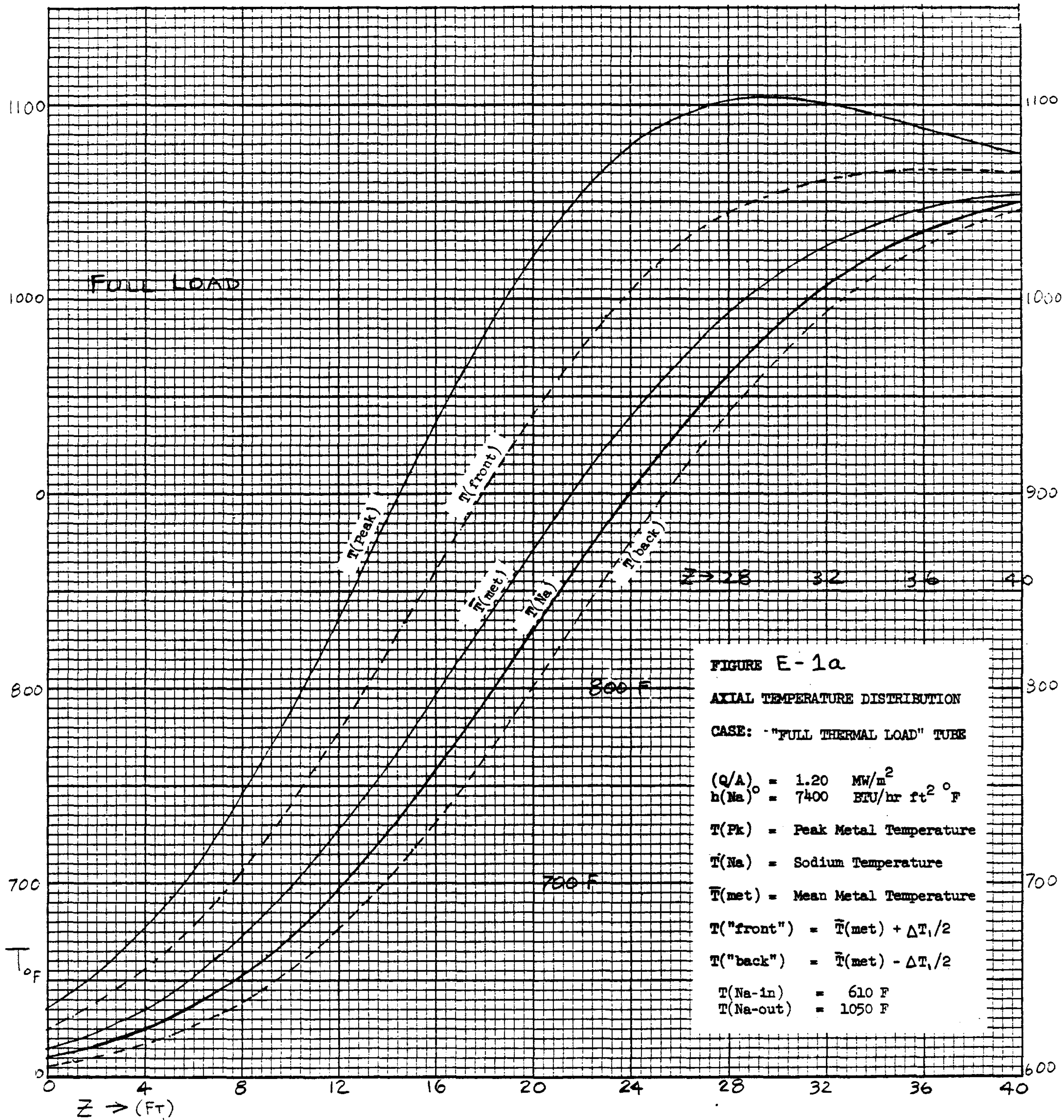


FIGURE E-1a

AXIAL TEMPERATURE DISTRIBUTION

CASE: "FULL THERMAL LOAD" TUBE

$(Q/A)_o$ = 1.20 MW/m^2
$h(Na)^o$ = 7400 BTU/hr ft^2 °F

T(Pk) = Peak Metal Temperature

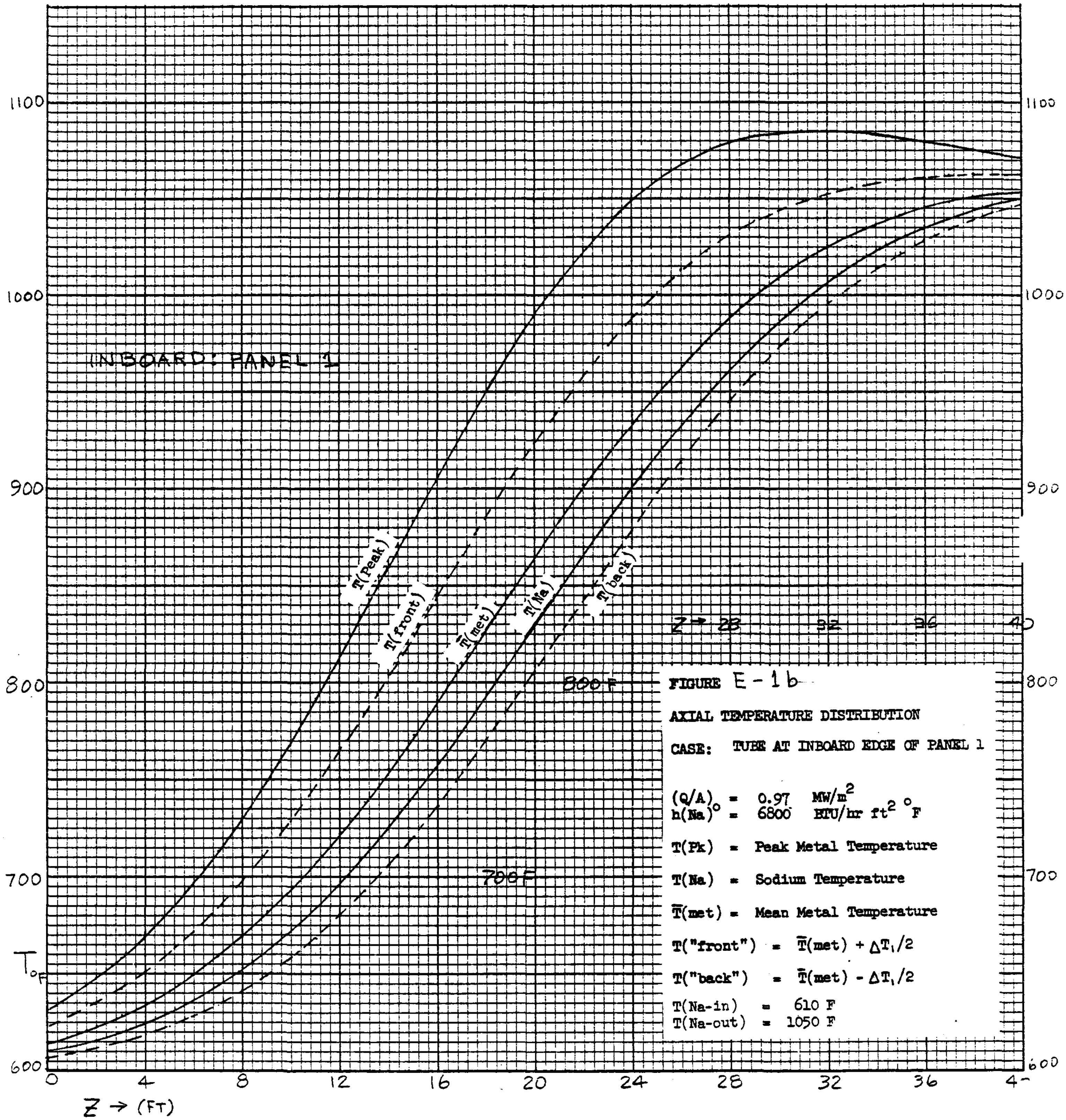
T(Na) = Sodium Temperature

$\bar{T}$(met) = Mean Metal Temperature

T("front") = $\bar{T}(met) + \Delta T_1/2$

T("back") = $\bar{T}(met) - \Delta T_1/2$

T(Na-in) = 610 F
T(Na-out) = 1050 F


1100
1000
900
800
700
600
INBOARD: PANEL 1
T(Peak)
T(front)
T̄(met)
T(Na)
T(back)
800 F
700 F
$T_{°F}$
0
4
8
12
16
20
24
28
32
36
40
Z → (FT)
Z → 28
FIGURE E - 1 b
AXIAL TEMPERATURE DISTRIBUTION
CASE: TUBE AT INBOARD EDGE OF PANEL 1
$(Q/A)_o$ = 0.97 MW/m^2
h(Na) = 6800 BTU/hr ft^2 °F
T(Pk) = Peak Metal Temperature
T(Na) = Sodium Temperature
$\bar{T}$(met) = Mean Metal Temperature
T("front") = $\bar{T}$(met) + $\Delta T_1/2$
T("back") = $\bar{T}$(met) - $\Delta T_1/2$
T(Na-in) = 610 F
T(Na-out) = 1050 F

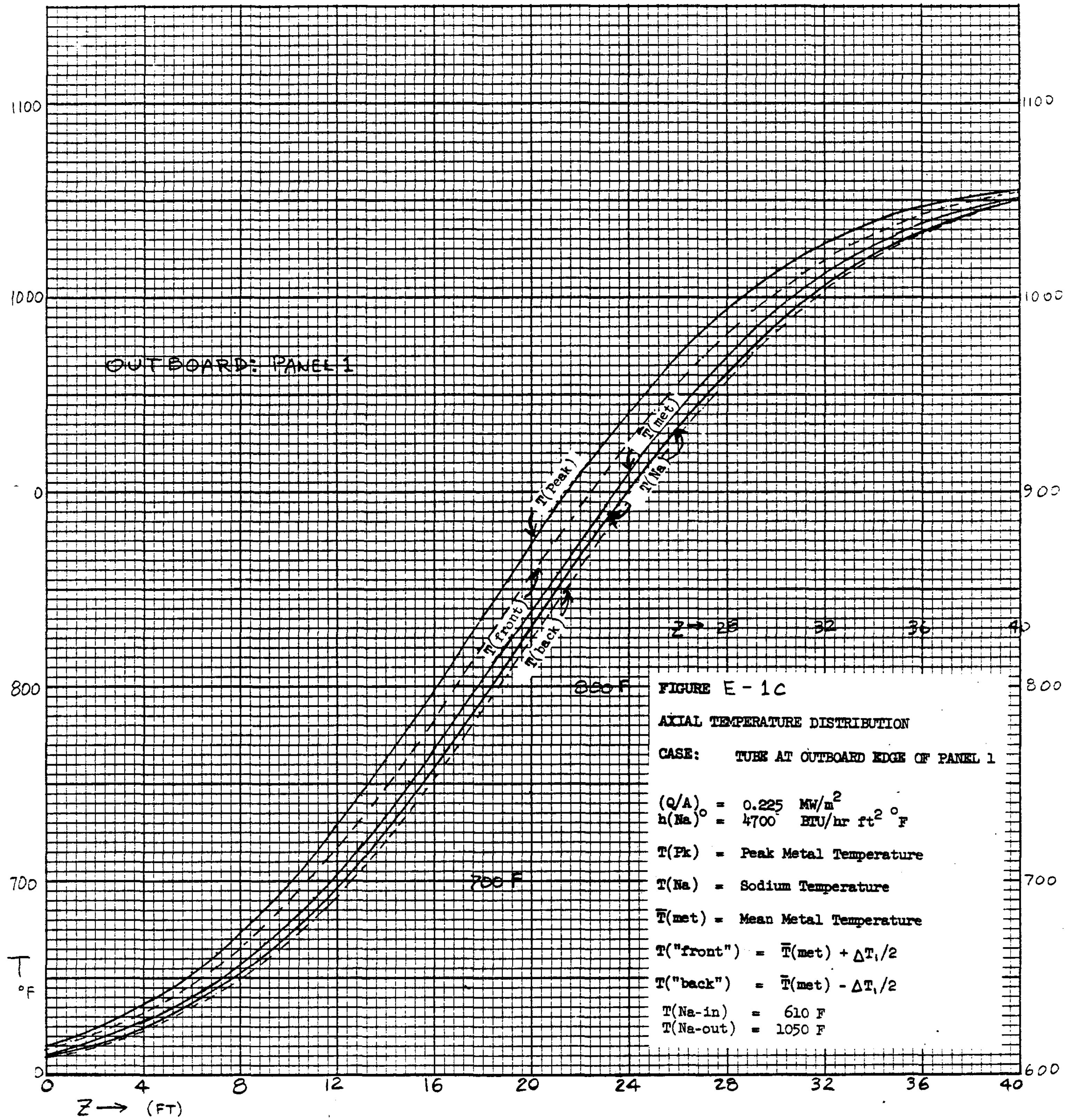


FIGURE E - 1c

AXIAL TEMPERATURE DISTRIBUTION

CASE: TUBE AT OUTBOARD EDGE OF PANEL 1

$(Q/A)_o$ = 0.225 MW/m^2
$h(Na)^o$ = 4700 $BTU/hr\ ft^2\ ^oF$

T(Pk) = Peak Metal Temperature

T(Na) = Sodium Temperature

$\bar{T}$(met) = Mean Metal Temperature

T("front") = $\bar{T}(met) + \Delta T_1/2$

T("back") = $\bar{T}(met) - \Delta T_1/2$

T(Na-in) = 610 F
T(Na-out) = 1050 F

TABLE E - IV

AXIALLY AVERAGED METAL TEMPERATURE, $\overline{\overline{T}}_{MET}$

The value $\overline{T}_{MET}$ is the average metal temperature at a particular cross-section (θ, r average). The value of $(\overline{T}_{MET} - T_{Na})_{℄}$ is the maximum differential between local average metal temperature and local sodium temperature. The axially averaged value of $(\overline{T}_{MET} - T_{Na}) = .59814 * (\overline{T}_{MET} - T_{Na})_{℄}$ based on the Normal Distribution Curve of Table A-I. (The axially averaged value of $(\overline{T}_{MET} - T_{Na})$ is marked "AXIALL AVERAGE".) The axially averaged sodium temperature is 830°F, based on the symmetry of the axial sodium temperature profile. Thus, the axially averaged metal temperature (actually averaged in z, θ and r) is given by:

59814409431

$$\overline{\overline{T}}_{MET} = \overline{T}_{Na} + (\overline{T}_{MET} - T_{Na})_{℄} * .598144$$

- $\overline{\overline{T}}_{MET}$: AXIAL AVERAGE
- $\overline{T}_{Na}$: AXIAL AVERAGE (830°F)
- $\overline{T}_{MET}$: CROSS-SECTION AVERAGE, Table D-II
- .598144: AVERAGE HEIGHT; NORMAL DISTRIBUTION, Table A-I

TUBE	$(Q/A)_{℄}$ MW/m²	$(\overline{T}_{MET} - T_{Na})_{℄}$ z = 0 TUBE MID-HEIGHT Table D-II	$.598144 * (\overline{T}_{MET} - T_{Na})_{℄} = (\overline{T}_{MET} - \overline{T}_{Na})$ AXIAL AVG	$\overline{\overline{T}}_{MET}$ AXIAL AVERAGE (use for Thermal Expansion)
FULL THERMAL LOAD	1.20	41.74	24.967	854.97°
INBOARD; PANEL 1	0.97	35.16	21.031	851.03°
OUTBOARD PANEL 1	0.225	9.94	5.946	835.95°

ALTERNATIVE: To determine $\overline{\overline{T}}_{MET}$; Go to Tables E-II, Column 3:

$$\overline{\overline{T}}_{MET} = \frac{1}{40}\left[\frac{T(z=0) + T(z=40)}{2} + \sum_{z=1}^{39} T(z)\right]$$

F. BACK FACE STRUCTURE

Calculations have been made to determine temperatures on the back face structure of the receiver panel: "hat bands," "tangs," and the panel back face.

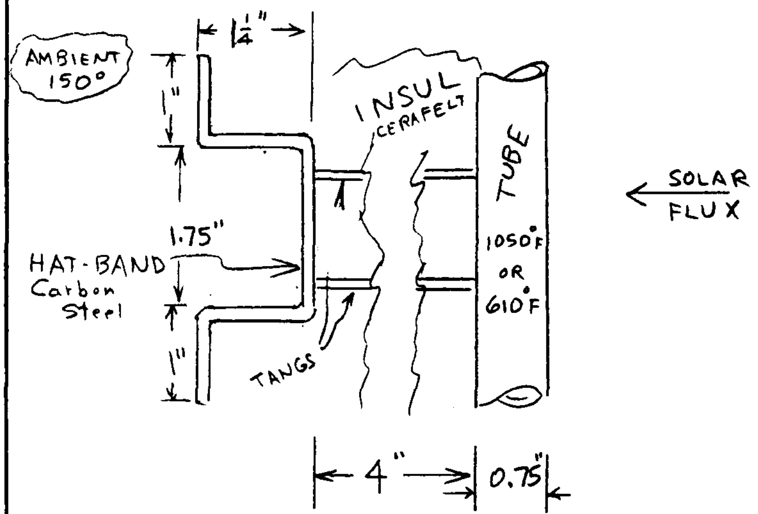
The calculations indicate panel back face temperatures of approximately 220°F at the top (T_{Na} = 1050°F) and 190°F at the bottom (T_{Na} = 610°F) for an ambient temperature of 150°F. The calculations show hat band temperatures of approximately 230°F and 195°F at the panel top and bottom, respectively.

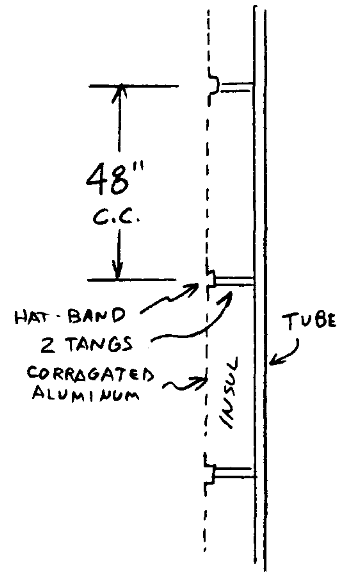
Overall heat loss from the back face of the panel is equal to or less than 0.6 KW/m_2, which is considerably less than the 3.0 KW/m^2 maximum allowable by the Receiver Specification (Reference 2b, Section 3.3.2.8).

The tang configuration has not been established yet. The calculations take into account both tang configurations under consideration, and the calculated results reflect the behavior of the configuration with the more adverse thermal effect.

CALCULATION SHEET F-1

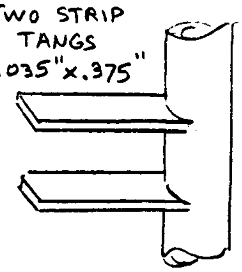
HAT-BAND, TANGS & PANEL BACK FACE





GEOMETRIC PARAMETERS ASSUMED FOR THERMAL CALCULATIONS.

Two STRIP TANGS @ .035"x.375"



(INSULATION THICKNESS) = 4 INCH (or more) CERAFELT

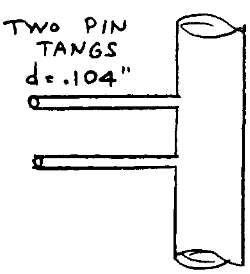
(HAT BAND WIDTH (ONE TUBE WIDTH)) = 0.75"

(CELL HEIGHT (C.C. HAT BANDS)) = 48"

OR:

(INSULATION AREA (UNIT CELL; ONE TANG SET)) = (.75)(48) = 36 in²

Two PIN TANGS d = .104"



(GROSS EXPOSED HAT-BAND AREA (ONE TANG SET)) = (6)(.75) = 4.5 in²

(EFFECTIVE EXPOSED HAT-BAND SURFACE AREA (ONE TANG SET)) ≅ 4.0 in²

TUBE & TANGS: STAINLESS STEEL

(TANG CROSS-SECTION AREA (ONE TANG SET (2)))

a) Two Strips: $2(.035)(.375) = .02625 \text{ in}^2$

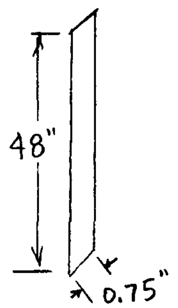
b) Two Pins: $2\left(\frac{\pi}{4}\right)(.104)^2 = .0170 \text{ in}^2$

CALC SHEET F-2

HOW MUCH HEAT IS LOST THROUGH BACK OF PANEL?
(Through insulation and tangs.)

$$\dot{q} = kA\frac{\Delta T}{\Delta x}$$

Consider one "cell" near top of panel, (Max heat loss location).



$\Delta T \leqq T_{HOT} - T_{AMB} = 1050° - 150° = 900°F$

$\Delta x \geqq 4^{INCH}$

k_{INSUL} (CERAFELT) $\leqq 0.75 \frac{BTU\ in}{ft^2\ °F\ hr} \longrightarrow 0.0625 \frac{BTU}{hr\ ft\ °F}$
(Johns-Manville Bulletin) Ref. 10a

$A_{INSUL} = 36\ in^2$

k_{TANGS} (SS) $\cong 11.0 \frac{BTU}{hr\ ft\ °F}$ Ref. 10b

$a_{2\ TANGS} = \begin{cases} .02625\ in^2 \\ .0170\ in^2 \end{cases}$ Use Larger Value

$$Q_{LOSS} = kA_{INSUL}\frac{\Delta T}{\Delta x} + ka_{TANG}\frac{\Delta T}{\Delta x} = A\frac{\Delta T}{\Delta x}\left(k_{INSUL} + k_{SS}\frac{a}{A}\right)$$

$$\frac{Q}{A} \leqq \frac{\Delta T}{\Delta x}\left(k_{INSUL} + k_{SS}\frac{a}{A}\right) = \frac{900}{\frac{4}{12}}\left(.0625 + \underbrace{11.0\left(\frac{.02625}{36}\right)}_{.008021}\right)$$

$$\frac{Q}{A} = 190.4 \frac{BTU}{hr\ ft^2}$$

$$190.4 \frac{BTU}{hr\ ft^2} \times \frac{1}{3413}\frac{hr\ kw}{BTU}\ \frac{1}{(.3048)^2}\frac{ft^2}{m^2} = 0.60 \frac{kw}{m^2}$$

$$\left(\frac{Q}{A}\right) \leqq 190 \frac{BTU}{hr\ ft^2} \cong 0.60 \frac{kw}{m^2}$$

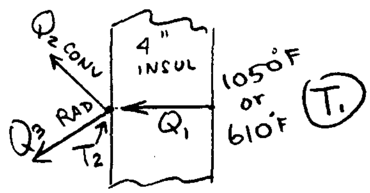
HEAT LOSS FROM BACK OF PANEL

THIS IS SUBSTANTIALLY LESS THAN THE $3.0 \frac{kw}{m^2}$ WHICH IS THE MAXIMUM ALLOWABLE ¶ 3.3.2.8 OF SPECIFICATION

CALC SHEET F-3

$T_3 = 150°F$

DETERMINE TEMPERATURE AT BACK FACE OF PANEL



$$Q_1 = Q_2 + Q_3$$

(IN COND) (OUT CONV) (OUT RAD)

$(A = 1.0\,ft^2)$

$$Q_1 = kA\frac{\Delta T}{\Delta x} = .0625\,\frac{BTU}{hr\,ft^2\,°F}\;\frac{1.0\,ft^2\,(T_1 - T_2)\,°F}{\frac{4}{12}\,ft} : \quad Q_1 = .1875\,(T_1 - T_2)$$

(IN COND; T_1 = 1050 or 610)

$$Q_2 = Ah\Delta T = 1.0\,ft^2\;0.2\,\Delta T^{1/3}\,\Delta T = 0.2\,(T_2 - T_3)^{4/3} : \quad Q_2 = 0.2\,(T_2 - 150)^{4/3}$$

(OUT CONV)

$$Q_3 = A\epsilon\sigma 4\,(\bar{T}_R)^3\Delta T = (1)(.75)(1.713)(4)\left(\frac{\bar{T}_R}{1000}\right)^3\Delta T : \quad Q_3 = 5.14\left(\frac{\bar{T}_R}{1000}\right)^3(T_2 - 150)$$

(OUT RAD)

$\epsilon = 0.75$
$\sigma = 1.713 \times 10^{-9}$
$A = 1\,ft^2$

$\Delta T = (T_2 - T_3)$

$$\bar{T}_R = \left(\frac{T_2 + T_3}{2} + 460\right)$$

SOLVE FOR T_2 BY TRIAL & ERROR: $Q_1 = Q_2 + Q_3$

FOR $T_1 = 1050°F$

TRY $T_2 = 221°F$

$T_2 - T_3 = 221 - 150 = 71$

$\bar{T}_R = \frac{221 + 150}{2} + 460 = 645.5$

$Q_1 = .1875\,(1050 - 221) = 155.44_{IN}$

$Q_2 = .2\,(71)^{4/3} = 58.80_{OUT}$ } 156.95

$Q_3 = 5.14\left(\frac{645.5}{1000}\right)^3(71) = 98.15_{OUT}$

IN = OUT, $155.44 \approx 156.95$

$T_2 = 221°F$ FOR $T_1 = 1050°F$

FOR $T_1 = 610°F$

SIMILAR CALCULATION GIVES $T_2 = 190°F$

BACK FACE OF PANEL

AT TOP; $T_2 = 221°F$ $(T_{TUBE} = 1050°F)$

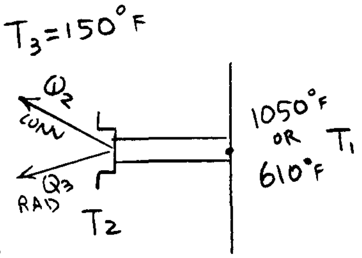
AT BOTTOM; $T_2 = 190°F$ $(T_{TUBE} = 610°F)$

(EXCLUSIVE OF HAT BANDS)

FOR $T_{AMB} = 150°F$

CALC SHEET F-4

DETERMINE HAT BAND TEMPERATURE



$$\underset{\text{IN COND}}{Q_1} = \underset{\text{OUT CONV}}{Q_2} + \underset{\text{OUT RAD}}{Q_3}$$

$$\underset{\text{IN COND}}{Q_1} = kA\frac{\Delta T}{\Delta x} = 11\,\frac{BTU}{hr\,ft\,°F}\left(\begin{matrix}\text{STRIP}\\ .02625\ in^2\\ \text{OR}\\ .0170\ in^2\\ \text{PIN}\end{matrix}\right)\frac{1}{144}\frac{ft^2}{in^2}\ \frac{(T_1 - T_2)}{\frac{4}{12}\ ft} \qquad Q_1 = \begin{cases} .0060\,(T_1 - T_2) & \text{STRIP} \\ .0039\,(T_1 - T_2) & \text{PIN} \end{cases}$$

$$\underset{\text{OUT CONV}}{Q_2} = Ah\Delta T = \frac{4}{144}\,ft^2\,(.2)(T_2 - T_3)^{4/3} : \qquad Q_2 = .0056\,(T_2 - 150)^{4/3}$$

$$\underset{\text{OUT RAD}}{Q_3} = A\epsilon\sigma\,4(\bar{T}_R)^3\Delta T = \frac{4}{144}\,ft^2\,(.75)(1.713)(4)\left(\frac{\bar{T}_R}{1000}\right)^3\Delta T : \qquad Q_3 = .143\left(\frac{\bar{T}_R}{1000}\right)^3(T_2 - 150)$$

$\epsilon = .75$

SOLVE BY TRIAL & ERROR PREVIOUS PAGE:

STRIP TANGS:		PIN TANGS	
$A = .02625\ in^2$		$A = .0170\ in^2$	
FOR $T_1 = 1050°F$	$T_2 = 230°F$	FOR $T_1 = 1050°F$	$T_2 = 206°F$
FOR $T_1 = 610°F$	$T_2 = 195°F$	FOR $T_1 = 610°F$	$T_2 = 182°F$

HAT BAND TEMPERATURES:

AT TOP OF PANEL $T \leq 230°F$ $(T_{TUBE} = 1050°F)$

AT BOTTOM OF PANEL $T \leq 195°F$ $(T_{TUBE} = 610°F)$

$T_{AMBIENT} = 150°F$

G. PANEL WITH NONUNIFORM SODIUM DISCHARGE TEMPERATURE

In the preceding sections of this report, calculations have been made for three tubes of the subpanel (full thermal load tube, inboard tube of Panel 1, and outboard tube of Panel 1) for the idealized nominal solar heat flux distribution. Sodium flow has been assumed to be appropriately distributed among the tubes to result in a uniform discharge temperature (T_{out} = 1050°F).

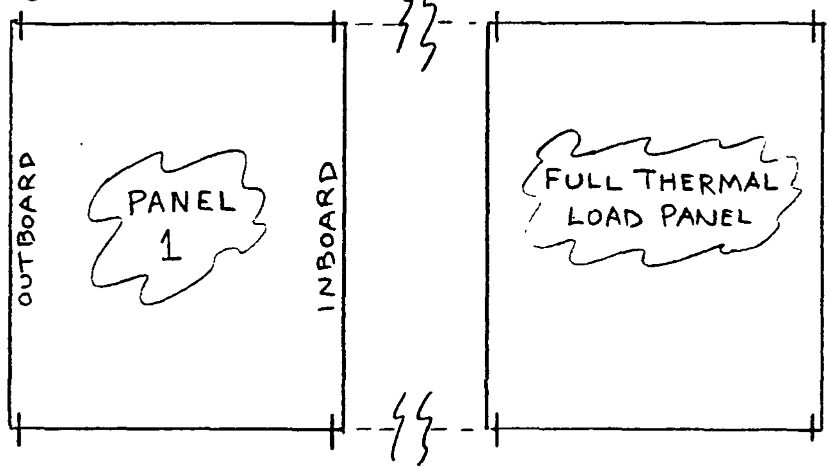
However, the Receiver Specification (Reference 2b, Section 3.3.2.2) indicates a maximum allowable "tube-to-tube outlet temperature variation" not to exceed 2°F. This means a possible 200°F variation of tube outlet temperature across a subpanel.

Tables G-Ia, and b show a method of estimating the tube temperature distribution factors for the three tubes for the indicated outlet temperature maldistribution as a modification of the calculated temperatures for the nominal cases.

In Tables G-Ia and b, the o subscripted terms indicate the nominal idealized conditions; the primed terms indicate the maldistribution case conditions.

TABLE G-Ia
NON-UNIFORM DISCHARGE TEMPERATURE

$(T_{OUT})'_{MAL\ DIST}$ =	900F	1100F	900F	1100F
$(T_{OUT})_o$ NOMINAL =	1050F	1050F	1050F	1050F



$(T_{IN})_o$ =	610F	610F	610F	610F
$(T_{IN})'$ =	610F	610F	610F	610F
$(\Delta T_{OUT-IN})_o$ =	440F	440F	440F	440F
$(\Delta T_{OUT-IN})'$ =	290F	490F	290F	490F
$\mathcal{F} = \frac{\Delta T'}{\Delta T_o}$	$\frac{290}{440} = .6591$	$\frac{490}{440} = 1.11364$	$\frac{290}{440} = .6591$	$\frac{490}{440} = 1.11364$
(APPLY TO PLOT:)	PANEL 1 "OUTBOARD"	PANEL 1 "INBOARD"	FULL THERMAL LOAD	FULL THERMAL LOAD
$(Q/A)_{¢\ NOM}$	0.225	0.97	1.20	1.20
$\left(\frac{Q}{A}\right)' = \mathcal{F}\left(\frac{Q}{A}\right)_o$	0.1483	1.0802	0.7909	1.3364

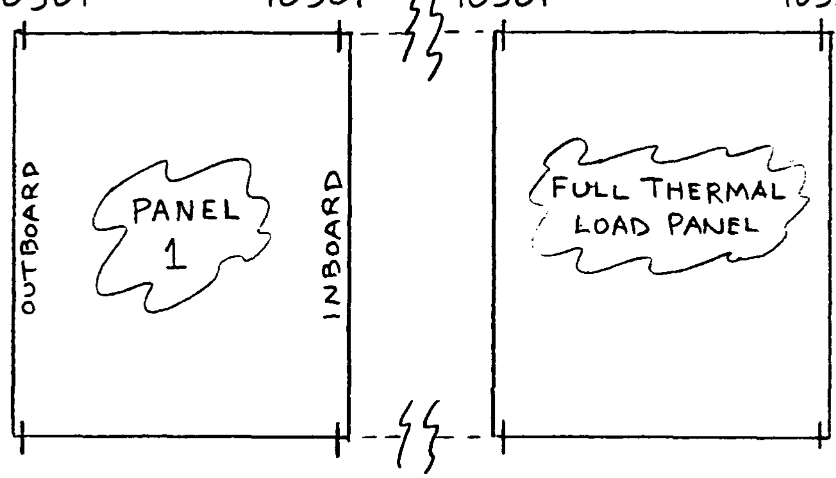
MODIFICATION FORMULA

$$T_i'(z) = \left[T_{io}(z) - 610^\circ\right] * (\mathcal{F}) + 610^\circ$$

PREPARED BY: E MM	Rockwell International Energy Systems Group	PAGE NO. 56 OF
CHECKED BY:		REPORT NO. 079TI000002
DATE: 2/83		MODEL NO.

TABLE G-Ib
NON-UNIFORM DISCHARGE TEMPERATURE

$(T_{OUT})'_{MAL\ DIST}$ =	1100F	900F	1100F	900F
$(T_{OUT})_0$ NOMINAL =	1050F	1050F	1050F	1050F



$(T_{IN})_0$ =	610F	610F	610F	610F
$(T_{IN})'$ =	610F	610F	610F	610F
$(\Delta T_{OUT-IN})_0$ =	440F	440F	440F	440F
$(\Delta T_{OUT-IN})'$ =	490F	290F	490F	290F
$\mathcal{F} = \frac{\Delta T'}{\Delta T_0}$	$\frac{490}{440} = 1.11364$	$\frac{290}{440} = 0.6591$	$\frac{490}{440} = 1.11364$	$\frac{290}{440} = 0.6591$
(APPLY TO PLOT:)	PANEL 1 "OUTBOARD"	PANEL 1 "INBOARD"	FULL THERMAL LOAD	FULL THERMAL LOAD
$(Q/A)_{NOM}$ ℄ D	0.225	0.97	1.20	1.20
$\left(\frac{Q}{A}\right)' = \mathcal{F}\left(\frac{Q}{A}\right)_0$	0.2506	0.6393	1.3364	0.7909

MODIFICATION FORMULA

$$T_i'(z) = \left[T_{i0}(z) - 610^\circ\right] * (\mathcal{F}) + 610^\circ$$

III. REFERENCES

1. E. M. Mouradian, "Proposed Thermal Analysis for Receiver of 30 MW Solar Power Plant," I. to G. H. Skopp, IL: 640-82-53, Energy Systems Group, Rockwell International, October 19, 1982

2. Design Specifications: Solar Central Power Plant, Unit 1, Energy Systems Group, Rockwell International:

   2a. Overall Specification N10046, Rev. D-1, January 6, 1983

   2b. Receiver Subsystem Specification N10048, October 22, 1983

3. E. M. Mouradian, "Solar Receiver Panel: Tube Wall Temperature Distribution," 004TI000002, Energy Systems Group, Rockwell International, April 1980

4. Solar Receiver Panel; Drawings: Energy System Group, Rockwell International, December 1982 and January 1983

   Drawing Numbers: 079R000001 (2 sheets)
   079R000002
   079R000003
   079R000005
   079R000021
   079R000025

5. Sodium Properties:

   5a. G. H. Golden and J. V. Tokar, "Thermophysical Properties of Sodium," ANL-7323, Argonne National Laboratory, August 1967

   5b. Nuclear Systems Materials Handbook - Design Data, Volume 1, Book 5, TID-26666, Hanford Engineering Development Laboratory

6. Orifice Pressure Loss Characteristics:

   6a. E. M. Mouradian, Personal Notes

   6b. H. Rouse, Elementary Mechanics of Fluids, John Wiley, Inc., 1962, Pages 56-60

   6c. R. H. Perry and C. H. Chilton, Chemical Engineers' Handbook, 5th Edition, McGraw-Hill, 1973, Pages 5.10, 5.11, 5.34

   6d. Fluid Meters - Their Theory and Application, 5th Edition, American Society of Mechanical Engineers

7. A. V. von Arx, "Thermal Analyzer Program (TAP-4S) Description and User's Manual," N036CPM620006, Energy Systems Group, Rockwell International, January 1979

8. Sodium Heat Transfer Coefficient

   8a. J. G. Knudsen and D. L. Katz, Fluid Dynamics and Heat Transfer, McGraw-Hill, 1958, Page 463

   8b. O. E. Dwyer, "Manuscript for Chapter 5 of the 1970 Edition of the Sodium and NaK Supplement to the Liquid Metals Handbook," BNL-11936, Brookhaven National Laboratory, January 1969, Page 4

9. Pipe Flow Friction:

   9a. L. F. Moody, "Friction Factors for Pipe Flow," Transactions of the American Society of Mechanical Engineers, Volume 66, November 1944, Pages 671-678

   9b. Flow of Fluids, Crane Technical Paper No. 410, Crane Co. 1965, Pages A.23 and A.24

10. Insulative Conductivities:

   10a. Cerafelt - Refractory Fiber Insulation, Johns-Manville Bulletin

   10b. Stainless Steel (316) - ASME Boiler and Pressure Vessel Code, 1980 Section III, Division 1, Appendix I, Page 88

11. W. R. Castle, "Preliminary Design Structural Analysis - Carrizo Plains Solar Receiver Subsystem," 079TI000001, Rockwell International, Energy Systems Group, March 1983

APPENDICES

Appendix App - A

DETERMINE ΔT_1 and ΔT_2

For this analysis, ΔT_1 and ΔT_2 are used in a different (though conceptually similar) manner than in the ASME B&PV Code.

The ASME definitions are based on a slab of a given thickness, assuming it acts as the wall of a thin-walled tube with only radial temperature variation (no circumferential variation).

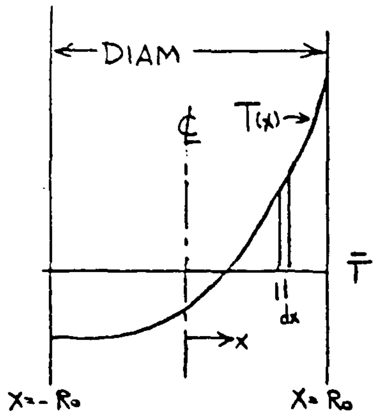
For the analysis of this report, ΔT_1 and ΔT_2 are defined on the basis of a tube acting as a beam.

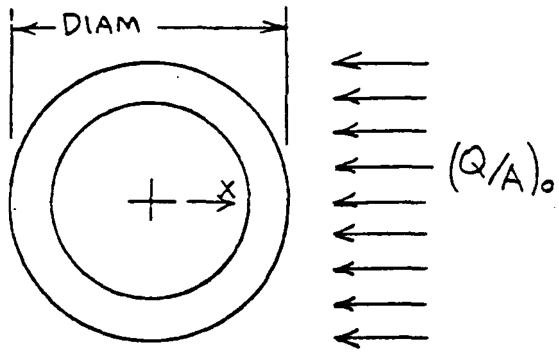
In both cases:

ΔT_1 = Moment Generating Equivalent Linear Temperature Difference,
ΔT_2 = Peaking (non-linear portion) component.

The difference between the two methods of defining ΔT_1 and ΔT_2 is somewhat analogous to the difference between polar moment of inertia $J = \int r^2 dA$, and regular moment of inertia $I = \int x^2 dA$.

The derivation of ΔT_1 and ΔT_2 as used in this analysis is shown on the following two pages. These expressions have been incorporated into the TAP program for determination of tube wall temperature distribution. The TAP program listing is included in the Appendix. Also see Reference 3, 004TI000002.





DETERMINE INTERNAL MOMENT GENERATED BY T(x).

$$dF = \sigma\, dA$$

$$\sigma = E\alpha\left(T(x) - \bar{T}\right)$$

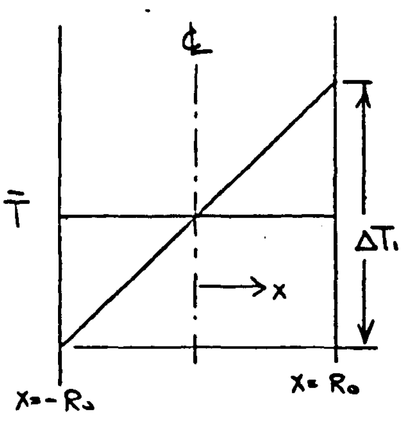
$$dF = E\alpha T(x)\, dA - (E\alpha \bar{T}\, dA)$$

$$dM = dF * X = E\alpha T(x)\, x\, dA - E\alpha \bar{T} x\, dA$$

$$M = \int_A E\alpha T(x)\, x\, dA - \int_A E\alpha \bar{T} x\, dA \quad (= 0)$$

$$M = \int_A E\alpha T(x)\, x\, dA \cong E\alpha \sum T_i x_i A_i$$

MOMENT DUE TO T(x) (A-1)



DETERMINE MOMENT GENERATED BY LINEAR PROFILE OF MAGNITUDE ΔT_1.

$$T(x) = \frac{\Delta T_1}{2}\left(\frac{x}{R_o}\right)$$

$$M = \int_A E\alpha \frac{\Delta T_1}{2} \frac{x}{R_o}\, x\, dA$$

$$M = \frac{E\alpha \Delta T_1}{2R_o} \int_A x^2\, dA \cong \frac{E\alpha \Delta T_1}{2R_o} \sum x_i^2 A_i$$

MOMENT DUE TO LINEAR PROFILE (A-2)

NOTE: $\underset{(BEAM)}{I} = \int_A x^2\, dA \cong \sum x_i^2 A_i$

WHAT IS ΔT_1?

Equate (A-1) & (A-2):

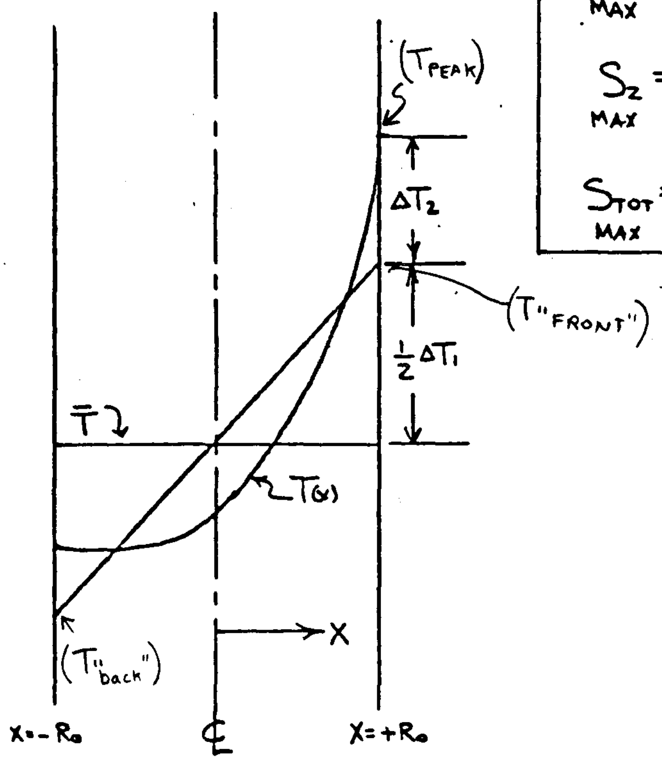
$$E\alpha \int_A T(x)\, x\, dA = \frac{E\alpha\, \Delta T_1}{2R_o} \int x^2\, dA$$

$$\Delta T_1 = \frac{2R_o \int_A T(x)\, x\, dA}{\int_A x^2\, dA} \cong \frac{2R_o \sum T_i X_i A_i}{\sum X_i^2 A_i}$$

$$\Delta T_1 = \frac{2R_o \sum T_i X_i A_i}{\sum (X_i^2 A_i)}$$

$$\Delta T_2 = (T_{SURF} - \bar{T}) - \frac{1}{2}\Delta T_1$$

(A-3)



$$S_{1\,MAX} = E\alpha \frac{\Delta T_1}{2}$$

$$S_{2\,MAX} = E\alpha\, \Delta T_2$$

$$S_{TOT\,MAX} = (S_{1\,MAX} + S_{2\,MAX}) = E\alpha (T_{MAX} - \bar{T})$$

(A-4)

Appendix App - B

TAP MODEL LISTING

Two-dimensional (r,θ) steady-state thermal analysis of a single tube. (See Section II-D.)

```
*0001                                                                      00010000
                         *** STAR 001 - TITLES & STORED COMMENTS

      E M MOURADIAN    EXT 3320   LB-30                            (1)     00010020
      67890123456789O                                                      00010028
                                                                           00010050
       TAP-4S    SUPER TAP                                                 00010080
          6903-(AB)   (500K)                                               00010120
                                                                           00010150
      MODEL 2    (ONE TUBE, 360 DEG.)                                      00010200
                                                                           00010220
      ONE TUBE MODEL                                                       00010260
                                                                           00199999
      DUMMIES:                                                             00200000
           A0101-A0636 = ANGULAR COORDINATE  (DEGREES)                     00201010
           B0101-B0636 = NODE CROSS-SECTIONAL AREA (IN2)                   00202010
           B0999 = TOTAL METAL AREA, ONE TUBE  (IN2)                       00202020
           C0101-C0636 = CAPACITANCE OF NODES, BTU/F                       00203010
           D0101-D0890 = Y/K = A/DX (INCH) FOR CONDUCTION PATHS            00204010
              D0101-D0636 = CIRCUMFERENTIAL                                00204020
              D0711-D0890 = RADIAL                                         00204030
           E0101-E0136 = Q/A FLUX FACTOR (E.G. E(I)=SIN(ANGLE).)           00205010
           F0101-F0636 = (T*X*A) FOR EACH NODE                             00206010
           G0101-G0636 = (AREA)*(X**2) FOR EACH NODE      IN4              00207010
           H0001 = H(NA) BTU/HR FT2 F                                      00208001
           I0001 = SUM(A*X**2) = MOMENT OF INERTIA, ONE TUBE   IN4         00209001
           I0005 = T:BAR, TUBE                                             00209005
           I0006 = DEL T ACROSS FRONT PART OF TUBE WALL                    00209006
           I0007 = DEL T ACROSS TUBE DIAMETER                              00209007
           I0010 = ALPHA (ABSORPTIVITY)                                    00209010
           I0011 = EMISSIVITY                                              00209011
           I0004 = DEL T(1) = 2*RO*SUM(T*X*A)/SUM(X*X*A)      (F)          00209040
           I0021 = T(PEAK) - T(BAR)          F                             00209210
           I0022 = (1/2)*(DEL T(1))          F                             00209220
           I0023 = DEL T(2) = I21-I22 = (T:PK-T:BAR)-(.5 DT:1)             00209230
           I0031 = MODEL NUMBER    (2)                                     00209310

           I0101 = STRESS 1 = (1/2)*EA*DT(1)                 PSI           00209511
           I0102 = STRESS 2 = EA*DT(2)                       PSI           00209512
           I0103 = TOT STRS = (1/2)*EA*DT(1) + EA*DT(2)      PSI    (2)    00209513
           I0104 = TOT STRS = (T:PEAK-T:BAR)*EA              PSI           00209514
           J0005 = SMALL NUMBER = 1.0 E-10                         2       00210005
           J0010 = Q/A: EXTERNAL HEAT FLUX, MW/M2                          00210010
           J0011 = Q/A: EXTERNAL HEAT FLUX, BTU/SEC IN2                    00210011
           J0012 = Q/A:NET = Q/A*ALPHA        BTU/SEC IN2                  00210012
           J0020 = E*A    (ELAS MOD * THERM EXPAN COEFF)   266.0 PSI/F     00210020
           J0021 = E*A/MU = 371.43                                         00210021
           J0031 = K:SS304   BTU/HR FT F                                   00210031
           J0032 = K:SS304   BTU/SEC IN F                                  00210032
           J0041 = RHO*CP    BTU/FT3 F                                     00210041
           J0042 = RHO*CP    BTU/IN3 F                                     00210042
           P0101-P0636 = T(LOCAL)-T(BAR)   =  T(OABC) - I(0005)            00216010
           Q0101-Q0136 = HEAT INPUT (SOLAR) ON SURFACE   BTU/SEC           00217010
           R0001 = R(OUTER), INCH                                          00218001
           R0002 = DEL R = WALL THICKNESS,   INCH                          00218002
           R0101-R0636 = RADIAL COORDINATE FOR EACH NODE (INCH)            00218020
           S0101-S0136 = EXTERNAL SURFACE AREA (IN2): FOR Q/A & RAD.       00219010
           S0601-S0636 = INTERNAL SURFACE AREA (IN2): FOR NA CONV.         00219020
           T0000 = DUMMY FOR USE IN CARD PUNCHING                          00220001
           T0101-T0636 = STEEL NODE TEMPERATURES                           00220101
           T0901= SODIUM TEMP                                              00220901
           T0902= SINK TEMP                                                00220902
           U0001 = TOTAL HEAT TO NA                     BTU/SEC            00221010
           U0002 = TOTAL HEAT RADIATED TO SINK          BTU/SEC            00221020
           U0003 = TOTAL HEAT OUT (U1+U2)               BTU/SEC            00221030
           U0004 = TOTAL HEAT IN  (Q0101 TO Q0136)      BTU/SEC            00221040
           U0005 = HEAT OUT/HEAT IN = 1.0?              BTU/SEC            00221050
           U0901-U0936 = HEAT FLOW TO NA    (BTU/SEC)                      00221100
           U0951-U0986 = HEAT FLOW TO SINK (BTU/SEC)                       00221110
           V0101-V0636 = NODAL VOLUMES    (L=1.0")       (IN3)             00222010
           W0101-W0636 = T(I)-T:BAR - (1/2)*(DT1)*X(I)/RO                  00223010
           X0101-X0636 = X COORDINATE.  X = N-S    N=+,  S=-               00224010
           Z0101-Z0636 = Z COORDINATE.  Z = E-W                            00226010
                                                                           00227999
      NODES:                                                               00300000
           T0101-T0636 = STEEL NODES.                                      00300100
                T0101-T0136 = RING 1      OUTER                            00300110
                T0201-T0236 = RING 2                                       00300120
                T0301-T0336 = RING 3                                       00300130
                T0401-T0436 = RING 4                                       00300140
                T0501-T0536 = RING 5                                       00300150
                T0601-T0636 = RING 6      INNER                            00300160
           T0901 = SODIUM                                                  00300901
           T0902 = SINK                                                    00300902
                                                                           00339999
      CAPACITANCES:        BTU/F                                   (3)     00340000
           NODAL VOLUMES:                                                  00340100
                   VOL = (2PI/36*R(I))*(.1OR.2*DEL R)*(L)        IN3       00340110
           C = (RHO*CP)*(VOLUME)                                           00340501
                                                                           00349999
      CONDUCTANCES:                                                        00350000
      CONDUCTANCES:        BTU/SEC F                                       00350001
           Y0101-Y0636 = CIRCUMFERENTIAL CONDUCTION                        00351004
                   Y/K = (L)*(.1OR.2)*(DEL R)/(2PI/36*R(I))     INCH       00351005
                Y0101-Y0136 = RING 1  (OUTER)                              00351010
                Y0201-Y0236 = RING 2                                       00351020
                Y0301-Y0336 = RING 3                                       00351030
                Y0401-Y0436 = RING 4                                       00351040
                Y0501-Y0536 = RING 5                                       00351050
                Y0601-Y0636 = RING 6  (INNER)                              00351060
           Y0711-Y0890 = RADIAL CONDUCTION                                 00352001
                   Y/K = (L)*(2PI/36*R:BAR)/(.2*DEL R)          INCH       00352003
                Y0711-Y0715 = @ ANGLE = +90 DEG                            00352010
                Y0716-Y0720 = @ ANGLE = +80 DEC                            00352020
                Y0886-Y0890 = @ ANGLE =+100 DEG                            00352360
           Y0901-Y0936 = SODIUM CONVECTION   (Y=HA)                        00353010
           Y0951-Y0986 = RADIATION TO SINK                                 00354010
                                                                           00579999
      TABLES:                                                              00580000
           1:  K:STEEL   BTU/SEC IN F    VS  TEMP                          00580100
           2:  RHO*CP(STEEL) BTU/IN3 F    RHO(T:100F)*CP(T:ACTUAL)         00580200
                                                                           00600000
      MATERIAL PROPERTIES:                                                 00600001
           FOR CONSTANT STEEL PROPERTIES:                                  00600005
                THERMAL CONDUCTIVITY:                                      00601001
                      T:BAR(F)     K(B/HR FT F)   K(B/SEC IN F)            00601010
                  SS-316   ASME B&PVC  1980                                00601020
                         0.0        7.4        0.0001713                   00602001
                        70.0        7.7        0.0001782                   00602007
                       100.0        7.9        0.0001829                   00602010
                       200.0        8.45       0.0001956                   00602020
                       300.0        9.0        0.0002083                   00602030
                       400.0        9.5        0.0002199                   00602040
                       500.0       10.0        0.0002315                   00602050
                       600.0       10.5        0.0002431                   00602060

                       700.0       11.0        0.0002546                   00602070
                       800.0       11.5        0.0002662                   00602080
                       900.0       12.0        0.0002778                   00602090
                      1000.0       12.45       0.0002882                   00602100
                      1100.0       12.9        0.0002986           (4)     00602110
                      1200.0       13.35       0.0003090                   00602120
                      1300.0       13.8        0.0003194                   00602130
                      1400.0       14.2        0.0003287                   00602140
                      1500.0       14.6        0.0003380                   00602150
                RHO CP:    (RHO T=100)*(CP T=LOCAL)                        00603001
                     J0041=BTU/FT3 F            J0042=BTU/IN3 F            00603002
                                                                           00799998
      UNITS:                                                               00800000
           LENGTHS, RADII = INCH                                           00800110
           UNIT LENGTH, (AXIAL) = 1.0 INCH                                 00800120
           AREA = IN2                                                      00800130
           I = MOMENT OF INERTIAL    IN4                                   00800200
           TIME = SECONDS                                                  00800300
           TEMP & DEL T = DEG F                                            00800400
           H(INPUT VALUE) = BTU/HR FT2 F                                   00800500
                1.0 BTU/HR FT2 F = 1.929 E-06 BTU/SEC IN2 F                00800505
           K = THERMAL CONDUCTIVITY (STEEL) = BTU/SEC IN F                 00800620
           RHO CP (STEEL) = BTU/IN3 F                                      00800640
           Y = CONDUCTANCE = BTU/SEC F                                     00800720
           C = CAPACITANCE = BTU/F                                         00800740
           HEAT FLOW = BTU/SEC                                             00800800
           Q/A = SOLAR HEAT FLUX = MW/M2 & BTU/SEC IN2                     00800900
                1.0 MW/M2 = 0.61160451 BTU/SEC IN2                         00800904
           STEPHAN-BOLTZMANN = 3.3044 E-15 BTU/IN2 SEC R4                  00801400
           EA = ELASTIC MOD * THERM EXPAN COEFF        PSI/F               00801610
           STRESS = PSI                                                    00801620
                                                                           00849999
      BOUNDARY CONDITIONS:                                                 00850000
           HEAT FLUX DISTRIBUTION = COSINE                                 00850100
           ALPHA = 1.0                                                     00850210
           EMISS = 0.9                                                     00850220
           T(SINK) = 60F                                                   00850310
           T(NA) = 900F                                                    00850320
           (Q/A)O = 1.20 MW/M2      (J0010)                                00850400
           EA = (ELAS MOD)*(THERM EXPAN COEFF) = 266.0 PSI/F               00850500
                                                                           00859999
      SPECIAL OPERATIONS:                                                  00860000
           CRT PLOTS:                                                      00861000
                ISOTHERM PLOT FOR TUBE CROSS-SECTION                       00861100
```

079TI000002

```
                                                                                   00900000
         PROBLEM CASE:                                                             00900001
              STEADY STATE.                                                        00900100
      1          DEL R = 49 MILS   O.D. = 0.75 INCH   T:NA=830F  COSINE LOADING    00990010
      2          Q/A = 1.20 MW/M2    H:NA=7400        SS:316    MODEL 2      (5)   00990020
                                                                                   00999999
   *0010                                                                           01000000
```

*** STAR 010 - STATIC NETWORK DESCRIPTION

```
   Y 101 Y 135    0   .0          .0        T 101 T 102    1     1     1           01000101
   Y 201 Y 235    0   .0          .0        T 201 T 202    1     1     1           01000102
   Y 301 Y 335    0   .0          .0        T 301 T 302    1     1     1           01000103
   Y 401 Y 435    0   .0          .0        T 401 T 402    1     1     1           01000104
   Y 501 Y 535    0   .0          .0        T 501 T 502    1     1     1           01000105
   Y 601 Y 635    0   .0          .0        T 601 T 602    1     1     1           01000106
   Y 136 Y 636    0   .0          .0        T 136 T 101  100   100   100           01000136
   Y 711 Y 886    0   .0          .0        T 101 T 201    1     1     5           01000711
   Y 712 Y 887    0   .0          .0        T 201 T 301    1     1     5           01000712
   Y 713 Y 888    0   .0          .0        T 301 T 401    1     1     5           01000713
   Y 714 Y 889    0   .0          .0        T 401 T 501    1     1     5           01000714
   Y 715 Y 890    0   .0          .0        T 501 T 601    1     1     5           01000715
   Y 901 Y 936    0   .0          .0        T 601 T 901    1     0     1           01000901
   Y 951 Y 959    0   .0          .0        T 101 T 902    1     0     1           01000951
   Y 978 Y 986    0   .0          .0        T 128 T 902    1     0     1           01000978
   *0020                                                                           02000000
```

*** STAR 020 - INITIALIZATION & CONSTANT DATA

```
   I  31      0    0   2.0000       .0          0     0     0     0   1 MODEL #2    (2)   02039001
   J   5      0    0   1.0000E-10   .0          0     0     0     0   1 SMALL NUMBER  2   02039010
   J  10      0    0   1.2000       .0          0     0     0     0   1 Q/A MW/M2         02040060
   I  10      0    0   1.0000       .0          0     0     0     0   1 ALPHA=1.0         02040072
   I  11      0    0   1.0000E-07   .0          0     0     0     0   1 EMISS = 0         02040074
   J  20      0    0   266.00       .0          0     0     0     0   1 EA     PSI/F      02041010
   J  21      0    0   380.00       .0          0     0     0     0   1 EA/1-M            02041020
   R   1      0    0   .37500       .0          0     0     0     0   1 R(OUT)            02050010
   R   2      0    0   4.9000E-02   .0          0     0     0     0   1 DEL R = 49 MILS   02050020
   H   1      0    0   7400.0       .0          0     0     0     0   1                   02060010
   J  41      0    0   65.590       .0          0     0     0     0   1 RHOCP: BTU/FT3 F  02060120
   T 901      0   -1   830.00       .0          0     0     0     0   1 T:NA=830F         02080100
   T 902      0   -1   60.000       .0          0     0     0     0   1                   02080200

   T 101 T 136    0    1000.0       .0          0     0     0     0   1                   02080310
   T 201 T 236    0    1000.0       .0          0     0     0     0   1                   02080320
   T 301 T 336    0    1000.0       .0          0     0     0     0   1                   02080330
   T 401 T 436    0    1000.0       .0          0     0     0     0   1                   02080340
   T 501 T 536    0    1000.0       .0          0     0     0     0   1           (6)     02080350
   T 601 T 636    0    1000.0       .0          0     0     0     0   1                   02080360
   A 101 A 601    0    90.000       .0          0     0     0     0 100                   02250010
   A 102 A 602    0    80.000       .0          0     0     0     0 100                   02250020
   A 103 A 603    0    70.000       .0          0     0     0     0 100                   02250030
   A 104 A 604    0    60.000       .0          0     0     0     0 100                   02250040
   A 105 A 605    0    50.000       .0          0     0     0     0 100                   02250050
   A 106 A 606    0    40.000       .0          0     0     0     0 100                   02250060
   A 107 A 607    0    30.000       .0          0     0     0     0 100                   02250070
   A 108 A 608    0    20.000       .0          0     0     0     0 100                   02250080
   A 109 A 609    0    10.000       .0          0     0     0     0 100                   02250090
   A 110 A 610    0    .0           .0          0     0     0     0 100                   02250100
   A 111 A 611    0   -10.000       .0          0     0     0     0 100                   02250110
   A 112 A 612    0   -20.000       .0          0     0     0     0 100                   02250120
   A 113 A 613    0   -30.000       .0          0     0     0     0 100                   02250130
   A 114 A 614    0   -40.000       .0          0     0     0     0 100                   02250140
   A 115 A 615    0   -50.000       .0          0     0     0     0 100                   02250150
   A 116 A 616    0   -60.000       .0          0     0     0     0 100                   02250160
   A 117 A 617    0   -70.000       .0          0     0     0     0 100                   02250170
   A 118 A 618    0   -80.000       .0          0     0     0     0 100                   02250180
   A 119 A 619    0   -90.000       .0          0     0     0     0 100                   02250190
   A 120 A 620    0   -100.00       .0          0     0     0     0 100                   02250200
   A 121 A 621    0   -110.00       .0          0     0     0     0 100                   02250210
   A 122 A 622    0   -120.00       .0          0     0     0     0 100                   02250220
   A 123 A 623    0   -130.00       .0          0     0     0     0 100                   02250230
   A 124 A 624    0   -140.00       .0          0     0     0     0 100                   02250240
   A 125 A 625    0   -150.00       .0          0     0     0     0 100                   02250250
   A 126 A 626    0   -160.00       .0          0     0     0     0 100                   02250260
   A 127 A 627    0   -170.00       .0          0     0     0     0 100                   02250270
   A 128 A 628    0    180.00       .0          0     0     0     0 100                   02250280
   A 129 A 629    0    170.00       .0          0     0     0     0 100                   02250290
   A 130 A 630    0    160.00       .0          0     0     0     0 100                   02250300
   A 131 A 631    0    150.00       .0          0     0     0     0 100                   02250310
   A 132 A 632    0    140.00       .0          0     0     0     0 100                   02250320
   A 133 A 633    0    130.00       .0          0     0     0     0 100                   02250330
   A 134 A 634    0    120.00       .0          0     0     0     0 100                   02250340
   A 135 A 635    0    110.00       .0          0     0     0     0 100                   02250350
   A 136 A 636    0    100.00       .0          0     0     0     0 100                   02250360
   *0030                                                                                 03000000
```

*** STAR 030 - FUNCTION STATEMENTS

```
  1 J  42       0  101  .0      5.7870E-04 J  41      0    0    0   1 RHOCP: BTU/IN3 F   03070042
  2 J  11       0  101  .0      .61160     J  10      0    0    0   1 Q/A BTU/SEC IN2    03070110
  3 J  12       0  101  .0      1.0000     J  11 I   10    0    0   1 (Q/A)*ALPHA        03070120
  4 R 101       0  101  .0      1.0000     R   1      0    0    0   1                    03100110
  5 R 102 R 136  101  .0        1.0000     R 101      0    0    0   1                    03100130
  6 R 201       0  101  .0      .20000     R   2      0    0    0   1                    03100210
  7 R 201       0  151  .0      1.0000     R   1 R  201    0    0   1                    03100220
  8 R 202 R 236  101  .0        1.0000     R 201      0    0    0   1             (7)    03100230
  9 R 301       0  101  .0      .40000     R   2      0    0    0   1                    03100310
 10 R 301       0  151  .0      1.0000     R   1 R  301    0    0   1                    03100320
 11 R 302 R 336  101  .0        1.0000     R 301      0    0    0   1                    03100330
 12 R 401       0  101  .0      .60000     R   2      0    0    0   1                    03100410
 13 R 401       0  151  .0      1.0000     R   1 R  401    0    0   1                    03100420
 14 R 402 R 436  101  .0        1.0000     R 401      0    0    0   1                    03100430
 15 R 501       0  101  .0      .80000     R   2      0    0    0   1                    03100510
 16 R 501       0  151  .0      1.0000     R   1 R  501    0    0   1                    03100520
 17 R 502 R 536  101  .0        1.0000     R 501      0    0    0   1                    03100530
 18 R 601       0  151  .0      1.0000     R   1 R    2    0    0   1 R(INNER)           03100610
 19 R 602 R 636  101  .0        1.0000     R 601      0    0    0   1                    03100630
 20 V 101       0  152  .0      1.7453E-02 R 101 R    2    0    0   1                    03200010
 21 V 102 V 136  101  .0        1.0000     V 101      0    0    0   1                    03200013
 22 V 201       0  152  .0      3.4907E-02 R 201 R    2    0    0   1                    03200020
 23 V 202 V 236  101  .0        1.0000     V 201      0    0    0   1                    03200023
 24 V 301       0  152  .0      3.4907E-02 R 301 R    2    0    0   1                    03200030
 25 V 302 V 336  101  .0        1.0000     V 301      0    0    0   1                    03200033
 26 V 401       0  152  .0      3.4907E-02 R 401 R    2    0    0   1                    03200040
 27 V 402 V 436  101  .0        1.0000     V 401      0    0    0   1                    03200043
 28 V 501       0  152  .0      3.4907E-02 R 501 R    2    0    0   1                    03200050
 29 V 502 V 536  101  .0        1.0000     V 501      0    0    0   1                    03200053
 30 V 601       0  152  .0      1.7453E-02 R 601 R    2    0    0   1                    03200060
 31 V 602 V 636  101  .0        1.0000     V 601      0    0    0   1                    03200063
 32 B   1 B 636  101  .0        1.0000     V   1      0    1    0   1                    03200090
 33 B 999       0  161  .0      1.0000     B 101 B  636    0    0   1 TOTAL AREA         03200099
 34 X 101 X 636  120  .0        1.0000     A 101      0    1    0   1                    03200510
 35 X 101 X 636  152  .0        1.0000     X 101 R  101    1    1   1 X=R*SIN(A)         03200512
 36 Z 101 Z 636  121  .0        1.0000     A 101      0    1    0   1                    03200520
 37 Z 101 Z 636  152  .0        1.0000     Z 101 R  101    1    1   1 Y=R*COS(A)         03200522
 38 D 101       0  153  .0      .57296     R   2 R  101    0    0   1                    03201010
 39 D 102 D 136  101  .0        1.0000     D 101      0    0    0   1                    03201013
 40 D 201       0  153  .0      1.1459     R   2 R  201    0    0   1                    03201020
 41 D 202 D 236  101  .0        1.0000     D 201      0    0    0   1                    03201023

 42 D 301       0  153  .0      1.1459     R   2 R  301    0    0   1                    03201030
 43 D 302 D 336  101  .0        1.0000     D 301      0    0    0   1                    03201033
 44 D 401       0  153  .0      1.1459     R   2 R  401    0    0   1                    03201040
 45 D 402 D 436  101  .0        1.0000     D 401      0    0    0   1                    03201043
 46 D 501       0  153  .0      1.1459     R   2 R  501    0    0   1             (8)    03201050
 47 D 502 D 536  101  .0        1.0000     D 501      0    0    0   1                    03201053
 48 D 601       0  153  .0      .57296     R   2 R  601    0    0   1                    03201060
 49 D 602 D 636  101  .0        1.0000     D 601      0    0    0   1                    03201063
 50 D 711       0  150  .0      .50000     R 101 R  201    0    0   1                    03202010
 51 D 711       0  153  .0      .87266     D 711 R    2    0    0   1                    03202012
 52 D 711 D 886  101  .0        1.0000     D 711      0    0    0   5                    03202014
 53 D 712       0  150  .0      .50000     R 201 R  301    0    0   1                    03202020
 54 D 712       0  153  .0      .87266     D 712 R    2    0    0   1                    03202022
 55 D 712 D 887  101  .0        1.0000     D 712      0    0    0   5                    03202024
 56 D 713       0  150  .0      .50000     R 301 R  401    0    0   1                    03202030
 57 D 713       0  153  .0      .87266     D 713 R    2    0    0   1                    03202032
 58 D 713 D 888  101  .0        1.0000     D 713      0    0    0   5                    03202034
 59 D 714       0  150  .0      .50000     R 401 R  501    0    0   1                    03202040
 60 D 714       0  153  .0      .87266     D 714 R    2    0    0   1                    03202042
 61 D 714 D 889  101  .0        1.0000     D 714      0    0    0   5                    03202044
 62 D 715       0  150  .0      .50000     R 501 R  601    0    0   1                    03202050
 63 D 715       0  153  .0      .87266     D 715 R    2    0    0   1                    03202052
 64 D 715 D 890  101  .0        1.0000     D 715      0    0    0   5                    03202054
 65 S 101       0  101  .0      .17453     R 101      0    0    0   1                    03203010
 66 S 102 S 136  101  .0        1.0000     S 101      0    0    0   1                    03203020
 67 S 601       0  101  .0      .17453     R 601      0    0    0   1                    03203030
 68 S 602 S 636  101  .0        1.0000     S 601      0    0    0   1                    03203040
 69 Y 101 Y 136   48  .0        1.0000         1 D  101    0    1   1 Y=(A/DX)*K: COND   03280101
 70 Y 201 Y 236   48  .0        1.0000         1 D  201    0    1   1 Y=(A/DX)*K: COND   03280201
 71 Y 301 Y 336   48  .0        1.0000         1 D  301    0    1   1 Y=(A/DX)*K: COND   03280301
 72 Y 401 Y 436   48  .0        1.0000         1 D  401    0    1   1 Y=(A/DX)*K: COND   03280401
 73 Y 501 Y 536   48  .0        1.0000         1 D  501    0    1   1 Y=(A/DX)*K: COND   03280501
 74 Y 601 Y 636   48  .0        1.0000         1 D  601    0    1   1 Y=(A/DX)*K: COND   03280601
 75 Y 711 Y 886   48  .0        1.0000         1 D  711    0    5   5 Y=(A/DX)*K: COND   03280711
 76 Y 712 Y 887   48  .0        1.0000         1 D  712    0    5   5 Y=(A/DX)*K: COND   03280712
 77 Y 713 Y 888   48  .0        1.0000         1 D  713    0    5   5 Y=(A/DX)*K: COND   03280713
 78 Y 714 Y 889   48  .0        1.0000         1 D  714    0    5   5 Y=(A/DX)*K: COND   03280714
 79 Y 715 Y 890   48  .0        1.0000         1 D  715    0    5   5 Y=(A/DX)*K: COND   03280715
 80 Y 901 Y 936  152  .0        1.9290E-06 S 601 H    1    1    0   1 Y=HA               03330090
 81 Y 951 Y 959   49  .0        1.0000         0 S  101    0    1   1                    03330110
 82 Y 979 Y 986   49  .0        1.0000         0 S  129    0    1   1                    03330112
 83 Y 951 Y 959   52  .0        1.0000     Y 951 I   11    1    0   1                    03330115
 84 Y 979 Y 986   52  .0        1.0000     Y 979 I   11    1    0   1                    03330117
 85 C 101 C 636  152  .0        1.0000     V 101 J   42    1    0   1 C=(VOL)*RHOCP      03333485
```

```
 86 E 101 E 136  120   .0          1.0000    A 101     0   1   0   1                     03350010
 87 Q 101 J 110  152   .0          1.0000    J  12 S 101   0   1   1                     03350110
 88 Q 101 Q 110  152   .0          1.0000    Q 101 E 101   1   1   1                     03350120
 89 Q 120 J 136  152   .0          1.0000    J  12 S 120   0   1   1                     03350210
 90 Q 120 Q 136  152   .0          1.0000    Q 120 E 120   1   1   1              (9)    03350220
 91 U 901 U 936   40   .0          1.0000    Y 901     0   1   0   1                     03600010
 92 U 951 U 986   40   .0          1.0000    Y 951     0   1   0   1                     03600020
 93 U   1     0   61   .0          1.0000    U 901 U 936   1   0   1 HT TO NA            03600110
 94 U   2     0   61   .0          1.0000    U 951 U 986   1   0   1 HT TO AMBIENT       03600120
 95 U   3     0   50   .0          1.0000    U   1 U   2   0   0   1 HT OUT              03600130
 96 U   4     0   61   .0          1.0000    Q 101 Q 136   1   0   1 HT IN               03600140
 97 U   4     0   50   .0          1.0000    U   4 J   5   0   0   1  U4*EPS         2   03600143
 98 U   5     0   53   .0          1.0000    U   3 U   4   0   0   1 HT OUT/HT IN        03600150
 99 I   5     0   59   .0          1.0000    T 101 T 636   0   0   1 T:BAR               03610050
100 I   6     0   51   .0          1.0000    T 101 T 601   0   0   1 DT:FRONT WALL       03610060
101 I   7     0   51   .0          1.0000    T 101 T 119   0   0   1 DT:TUBE             03610070
102 G 101 G 636  103   .0          1.0000    X 101     0   1   0   1 X**2                03620010
103 G 101 G 636  152   .0          1.0000    G 101 B 101   1   1   1 (X**2)*A            03620020
104 I   1     0  161   .0          1.0000    G 101 G 636   0   0   1 I=SUM(A*X*X)        03620030
105 F 101 F 636   52   .0          1.0000    T 101 X 101   1   1   1 T*X                 03620040
106 F 101 F 636   52   .0          1.0000    F 101 B 101   1   1   1 T*X*A               03620050
107 I   2     0   61   .0          1.0000    F 101 F 636   1   0   1 SUM(T*X*A)          03620060
108 I   3     0   52   .0          2.0000    I   2 R   1   0   0   1 2*RO*SUM(T*X*A)     03620070
109 I   4     0   53   .0          1.0000    I   3 I   1   0   0   1 DEL T(1)            03620080
110 I  21     0   51   .0          1.0000    T 101 I   5   0   0   1 T:PEAK - T:BAR      03628310
111 I  21     0    7   .0          1.0000    I  21     0   0   0   1                     03628312
112 I  22     0    1   .0           .50000   I   4     0   0   0   1 (1/2)(DEL T:1)      03628320
113 I  22     0    7   .0          1.0000    I  22     0   0   0   1                     03628322
114 I  23     0   51   .0          1.0000    I  21 I  22   0   0   1 DEL T(2)            03628330
115 W 101 W 136  152   .0          -.50000   I   4 X 101   0   1   1  -.5*DT1*K(1)   2   03650110
116 W 201 W 236  152   .0          -.50000   I   4 X 201   0   1   1                 2   03650120
117 W 301 W 336  152   .0          -.50000   I   4 X 301   0   1   1                 2   03650130
118 W 401 W 436  152   .0          -.50000   I   4 X 401   0   1   1                 2   03650140
119 W 501 W 536  152   .0          -.50000   I   4 X 501   0   1   1                 2   03650150
120 W 601 W 636  152   .0          -.50000   I   4 X 601   0   1   1                 2   03650160
121 W 101 W 136  153   .0          1.0000    W 101 R   1   1   0   1 -.5*DT1*K/RO    2   03650210
122 W 201 W 236  153   .0          1.0000    W 201 R   1   1   0   1                 2   03650220
123 W 301 W 336  153   .0          1.0000    W 301 R   1   1   0   1                 2   03650230
124 W 401 W 436  153   .0          1.0000    W 401 R   1   1   0   1                 2   03650240
125 W 501 W 536  153   .0          1.0000    W 501 R   1   1   0   1                 2   03650250
126 W 601 W 636  153   .0          1.0000    W 601 R   1   1   0   1                 2   03650260
127 W 101 W 136  150   .0          1.0000    W 101 T 101   1   1   1                 2   03650310
128 W 201 W 236  150   .0          1.0000    W 201 T 201   1   1   1                 2   03650320
129 W 301 W 336  150   .0          1.0000    W 301 T 301   1   1   1                 2   03650330

130 W 401 W 436  150   .0          1.0000    W 401 T 401   1   1   1                 2   03650340
131 W 501 W 536  150   .0          1.0000    W 501 T 501   1   1   1                 2   03650350
132 W 601 W 636  150   .0          1.0000    W 601 T 601   1   1   1                 2   03650360
133 W 101 W 136  151   .0          1.0000    W 101 I   5   1   0   1                 2   03650410
134 W 201 W 236  151   .0          1.0000    W 201 I   5   1   0   1           (10)  2   03650420
135 W 301 W 336  151   .0          1.0000    W 301 I   5   1   0   1                 2   03650430
136 W 401 W 436  151   .0          1.0000    W 401 I   5   1   0   1                 2   03650440
137 W 501 W 536  151   .0          1.0000    W 501 I   5   1   0   1                 2   03650450
138 W 601 W 636  151   .0          1.0000    W 601 I   5   1   0   1                 2   03650460
139 I 101     0  152   .0           .50000   J  20 I   4   0   0   1 .5EA*DT1  PSI       03660010
140 I 102     0  152   .0          1.0000    J  20 I  23   0   0   1   EA*DT2  PSI       03660020
141 I 103     0  150   .0          1.0000    I 101 I 102   0   0   1 PEAK STRESS  PSI    03660030
142 I 104     0  152   .0          1.0000    J  20 I  21   0   0   1 PEAK STRESS  PSI    03660040
143 P 101 P 136  151   .0          1.0000    T 101 I   5   1   0   1 T(I)-T:BAR          03690010
144 P 201 P 236  151   .0          1.0000    T 201 I   5   1   0   1                     03690020
145 P 301 P 336  151   .0          1.0000    T 301 I   5   1   0   1                     03690030
146 P 401 P 436  151   .0          1.0000    T 401 I   5   1   0   1                     03690040
147 P 501 P 536  151   .0          1.0000    T 501 I   5   1   0   1                     03690050
148 P 601 P 636  151   .0          1.0000    T 601 I   5   1   0   1                     03690060
149 Y 101 Y 890   89   .0          1.0000    X 101 Z 101   0   0   1                     03960010
    *0040                                                                                04000000
```

*** STAR 040 - TABULAR DATA

```
      1     0     0   .0          1.7130E-04    0     0     0     0    1 TABLE 1           04100000
      0     0     0   70.000      1.7820E-04    0     0     0     0    1 K:SS316           04100070
      0     0     0   100.00      1.8290E-04    0     0     0     0    1  BTU/SEC IN F     04100100
      0     0     0   300.00      2.0833E-04    0     0     0     0    1                   04100300
      0     0     0   900.00      2.7778E-04    0     0     0     0    1                   04100900
      0     0     0   1300.0      3.1944E-04    0     0     0     0    1                   04101300
      0     0     0   1500.0      3.3796E-04    0     0     0     0    1                   04101500
      0     0     0   10000.      3.3800E-04    0     0     0     0    1 1 1 1 1 1 1 1 1   04110000
   *0065                                                                                   06500000
```

*** STAR 065 - CONTOUR PLOT CRT DATA

```
      CURVE NO.  1 PLOTS THE  725.0 ISOTHERM                                               06500010
      CURVE NO.  2 PLOTS THE  750.0 ISOTHERM                                               06500020
      CURVE NO.  3 PLOTS THE  775.0 ISOTHERM                                               06500030
      CURVE NO.  4 PLOTS THE  800.0 ISOTHERM                                               06500040
      CURVE NO.  5 PLOTS THE  825.0 ISOTHERM                                               06500050
      CURVE NO.  6 PLOTS THE  850.0 ISOTHERM                                               06500060
```

```
      CURVE NO.  7 PLOTS THE  875.0 ISOTHERM                                               06500070
      CURVE NO.  8 PLOTS THE  900.0 ISOTHERM                                               06500080
      CURVE NO.  9 PLOTS THE  925.0 ISOTHERM                                               06500090
      PLOT  1, Y AXIS LABEL IS  NORTH-SOUTH       WITH LIMITS OF    -0.40    0.50          06500100
      CURVE NO. 10 PLOTS THE  950.0 ISOTHERM                                               06500100
      CURVE NO. 11 PLOTS THE  975.0 ISOTHERM                                         (11)  06500110
      CURVE NO. 12 PLOTS THE 1000.0 ISOTHERM                                               06500120
      CURVE NO. 13 PLOTS THE 1025.0 ISOTHERM                                               06500130
      CURVE NO. 14 PLOTS THE 1050.0 ISOTHERM                                               06500140
      CURVE NO. 15 PLOTS THE 1075.0 ISOTHERM                                               06500150
      CURVE NO. 16 PLOTS THE 1100.0 ISOTHERM                                               06500160
      CURVE NO. 17 PLOTS THE 1125.0 ISOTHERM                                               06500170
      CURVE NO. 18 PLOTS THE 1150.0 ISOTHERM                                               06500180
      CURVE NO. 19 PLOTS THE 1175.0 ISOTHERM                                               06500190
      PLOT  1, X AXIS LABEL IS  WEST-EAST         WITH LIMITS OF    -0.40    0.50          06500200
      CURVE NO. 20 PLOTS THE 1200.0 ISOTHERM                                               06500200
```

*** STAR 070 - SPECIAL CONTROL CONSTANTS

```
     4                2.5000E-04  CONVERGENCE TEST ON RATE OF TEMPERATURE CHANGE           07000040
     5                1.0000      0. = TRANSIENT; +1. = STEADY STATE                       07000050
     6                1.0000      +1=   DUMP Y,T,C,Q, & DUMMIES AT END OF CASE             07000060
     9                3.3044E-15  STEFAN-BOLTZMANN CONSTANT                                07000090
    13                5.0000      TIME STEP OR ITERS BETWEEN CALLING ARITH                 07000130
    14                1.0000      +1.0 PREVENTS KICKOFF ON EXCEEDING TABLE LIMITS          07000140
    15                1.0000      +1.0 FOR 100 SERIES EVAL. AT END OF RUNS                 07000150
    19                1.0000      +1.0 - TAPOUT ENTRIES ON SEPARATE TITLED PAGE            07000190
  *0080                                                                                    08000000
```

*** STAR 080 - PRINTOUT SPECIFICATIONS

```
  I   4     0   1  .0        .0           0    0    0    0    1 DT(1)                   08101010
  I  23     0   1  .0        .0           0    0    0    0    1 DT(2)                   08101020
  I  21     0   1  .0        .0           0    0    0    0    1 T:PK-BAR                08101030
  T 101     0   1  .0        .0           0    0    0    0    1 T:PEAK                  08101040
  I   5     0   1  .0        .0           0    0    0    0    1 T:BAR                   08101050
  I   6     0   1  .0        .0           0    0    0    0    1 DT:FT WL                08102010
  I   7     0   1  .0        .0           0    0    0    0    1 DT:TUBE                 08102020
  T 901     0   1  .0        .0           0    0    0    0    1 T:NA                    08102030
  T 902     0   1  .0        .0           0    0    0    0    1 T:SINK                  08102040
  I  31     0   1  .0        .0           0    0    0    0    1 MODEL 2                 08102051
  I   1     0   1  .0        .0           0    0    0    0    1 I IN4                   08103010

  B 999     0   1  .0        .0           0    0    0    0    1 AREA IN2                08103020
  R   1     0   1  .0        .0           0    0    0    0    1 R:OUTER                 08103030
  R 601     0   1  .0        .0           0    0    0    0    1 R:INNER      (12)       08103040
  R   2     0   1  .0        .0           0    0    0    0    1 DEL R                   08103050
  J  10     0   1  .0        .0           0    0    0    0    1 (Q/A)O                  08104010
  I  10     0   1  .0        .0           0    0    0    0    1 ALPHA                   08104020
  I  11     0   1  .0        .0           0    0    0    0    1 EMISS                   08104030
  H   1     0   1  .0        .0           0    0    0    0    1 H:NA                    08104040
  J  31     0   1  .0        .0           0    0    0    0    1 K:STL                   08104051
  U   1     0   1  .0        .0           0    0    0    0    1 HT TO NA                08150210
  U   2     0   1  .0        .0           0    0    0    0    1 HT TO SK                08150220
  U   3     0   1  .0        .0           0    0    0    0    1 HT OUT                  08150230
  U   4     0   1  .0        .0           0    0    0    0    1 HT IN                   08150240
  U   5     0   1  .0        .0           0    0    0    0    1 OT/IN=17                08150250
  I 101     0   1  .0        .0           0    0    0    0    1 STRESS 1                08150310
  I 102     0   1  .0        .0           0    0    0    0    1 STRESS 2                08150320
  I 103     0   1  .0        .0           0    0    0    0    1 STRS TOT                08150330
  I 104     0   1  .0        .0           0    0    0    0    1 STRS TOT                08150340
  J  20     0   1  .0        .0           0    0    0    0    1 E*A                     08150350
  T   1 T   5   1  .0        .0           0    0    0    0    1                         08200005
  T 101 T 136   0  .0        .0           0    0    0    0    1                         08200100
  T 137 T 145   1  .0        .0           0    0    0    0    1                         08200101
  T 201 T 236   0  .0        .0           0    0    0    0    1                         08200200
  T 237 T 245   1  .0        .0           0    0    0    0    1                         08200201
  T 301 T 336   0  .0        .0           0    0    0    0    1                         08200300
  T 337 T 345   1  .0        .0           0    0    0    0    1                         08200301
  T 401 T 436   0  .0        .0           0    0    0    0    1                         08200400
  T 437 T 445   1  .0        .0           0    0    0    0    1                         08200401
  T 501 T 536   0  .0        .0           0    0    0    0    1                         08200500
  T 537 T 545   1  .0        .0           0    0    0    0    1                         08200501
  T 601 T 636   0  .0        .0           0    0    0    0    1                         08200600
  T 637 T 645   1  .0        .0           0    0    0    0    1                         08200601
  *0090                                                                                 09000000
```

*** STAR 090 - PRINTOUT & STOP TIMES

```
      0     0    0  .0        200.00       0    0    0    0    1                         09000001
      0     0    0  600.0     .0           0    0    0    0    1                         09000002
  *0099                                                                                 09699999
```

APPENDIX C

ADDENDUM OF JUNE 1983

Thermal analysis of the central receiver of the Carrisa Plains 30-MWt solar power plant continued after the publication of 079TI000002 in March 1983. The continuing analysis, to date, is summarized in the addendum.

The subjects presented are:

5370F/sjh

ADD-1 PANEL HEAT LOSS

In order to determine the heat loss from the panel, the "effective" mean temperature is calculated for both convection and radiation. These are defined as:

$$\bar{\bar{T}}_{CONV} = \frac{\int^{A} T\,dA}{\int^{A} dA} \qquad \bar{\bar{T}}_{RAD} = \left[\frac{\int^{A} T^{4}\,dA}{\int^{A} dA} \right]^{1/4}$$

The integration proceeds in three steps: circumferential around the periphery of the individual tube surface, θ, axially along the tube (panel) height, Z; and laterally across the panel width, X.

The heat loss from the panel is then calculated based on these "effective" mean temperatures (as if the panel were isothermal). The reflection heat loss is taken to be 5% of the solar flux energy incident on the panel, ($\alpha = 0.95$). The radiation heat loss is based on an effective emissivity of 0.88. The convection heat loss is based on a combination of natural convection and forced (wind) convection. The receiver is approximated by a 43-ft-diameter cylinder.

The circumferential temperature distributions on panel tubes at panel mid-height are hown on Pages 30 through 36 (of 079TI000002, March 1983) for the "Reference" Solar Flux Distribution of Figure A-2, Page 7 of 079TI000002. The surface temperature varies approximately as the cosine expression shown in Table Add-I-1, and as verified in the table. In Table Add-I-2, the circumferentially averaged mean temperature (for convection) is determined for an individual tube. In Table A-I-3, the circumferentially averaged mean temperature (for radiation) is determined for an individual tube.

The second integration is carried out by assuming that the ΔT (Peak-Na) varies axially according to the normal distribution curve indicated on Pages 6, 8, and 10 (of 079TI000002, March 1983).

Table Add-I-4 lists the computer program used to carry out the first two steps of the integration. Step 1 evaluates the circumferential mean temperatures at tube mid-height based on the equations of Tables Add-I-2 and Add-I-3. Step 2 evaluates the axial mean temperatures based on the normal distribution factors of Page 10, Table A-II, Column d. The calculations are made for 1/8-in.-wide strips of the less-than-peak portion of Subpanel 2.

The computer output is summarized in Table Add-I-5 (circumferential and axially averaged temperatures).

The third step of the integration is the lateral integration. In Table Add-I-6, the lateral averaging across Subpanels 1 and 2 are shown. In Table Add-I-7, the lateral averaging across all eight subpanels is carried out. The final "overall" mean temperatures for the panel are:

Radiation: 1396.40°R (936.71°F)
Convection: 894.19°F

With these values, the heat loss calculations can be carried out. On Table Add-I-8a, the panel area and total incident thermal power is determined. On Table Add-I-8b, the reflection heat loss and radiation heat loss are calculated. On Table Add-I-8c, the natural convection heat loss is determined based on the assumption of still air. In order to account for the effect of wind, the rectangular cross section of the receiver structure is approximated by a cylinder 43 ft in diameter. The forced convection heat transfer correlation employed (Figure Add-I-1) was previously shown in 272TI000004, Page 38, of April 1978. Table Add-I-9 shows the forced convection heat transfer calculation, as well as the combined effect of forced and natural convection.

Table Add-I-10 summarizes the total heat losses from the panel under conditions of the "REFERENCE" solar flux distribution with sodium inlet/outlet temperatures of 610/1050°F.

TABLE Add-I-1

VERIFY: $T(\theta)_{SURFACE} = T_{Na} + (T_{PEAK} - T_{Na}) \cos\theta$

See: 079TI000002
Pages: 30-36

$(Q/A)_{℄}$ MW/m2	θ ANGULAR LOCATION	$T(\theta)$ SURFACE	$\Delta T = T_{SURF} - T_{Na}$ (830)	$\frac{(T_s - T_{Na})_\theta}{(T_s - T_{Na})_{\theta=0}}$	$\cos\theta$	$\frac{(T_s - T_{Na})_\theta / (T_s - T_{Na})_{\theta=0}}{\cos\theta} \overset{?}{=} 1$
1.20	0	10225	192.50	1.0	1.0	1.0
	10	1019.7	189.7	0.98545	0.98481	1.000657
	20	1011.3	181.3	0.94182	0.93969	1.00226
	30	997.48	167.48	0.87003	0.86603	1.00462
	40	978.64	148.64	0.77216	0.76604	1.00798
	50	955.27	125.27	0.65075	0.64279	1.01239
	60	928.04	98.04	0.50930	0.50000	1.01860
	70	897.93	67.93	0.35288	0.34202	1.03176
	80	866.61	36.61	0.19018	0.17365	1.09521
	90	838.43	8.43	0.04379	0.00	—
0.97	0	990.50	160.50	1.0	1.0	1.0
	10	988.13	158.13	0.98523	0.98481	1.000433
	20	981.07	151.07	0.94125	0.93969	1.00165
	30	969.50	139.50	0.86916	0.86603	1.00362
	40	953.75	123.75	0.77103	0.76604	1.00651
	50	934.23	104.23	0.64941	0.64279	1.01030
	60	911.53	81.53	0.50798	0.50000	1.01595
	70	886.47	56.47	0.35184	0.34202	1.02871
	80	860.50	30.50	0.19003	0.17365	1.09435
	90	837.20	7.20	0.04486	0.0	—
0.225	0	873.17	43.17	1.0	1.0	1.0
	10	872.52	42.52	0.98494	0.98481	1.000138
	20	870.58	40.58	0.94000	0.93969	1.000332
	30	867.42	37.42	0.86681	0.86603	1.000901
	40	863.13	33.13	0.76743	0.76604	1.00181
	50	857.84	27.84	0.64489	0.64279	1.00327
	60	851.72	21.72	0.50313	0.50000	1.00625
	70	845.04	15.04	0.34839	0.34202	1.01862
	80	838.20	8.20	0.18995	0.17365	1.09386
	90	832.19	2.19	0.05073	0.0	—

TABLE Add-I-2

CIRCUMFERENTIALLY AVERAGED TEMPERATURE:

FOR CONVECTION:

$$T(\theta) = T_{Na} + \Delta T_{PN}(z)\cos\theta = a + b\cos\theta = a + B$$

$$a = T_{Na}(z)$$

$$b = \Delta T_{P-N}(z) = (T_{Peak} - T_{Na})$$

$$B = b\cos\theta$$

$$\bar{\bar{T}}_{CONV} = \frac{\int_0^{\pi/2} T\,d\theta}{\int_0^{\pi/2} d\theta} = \frac{\int_0^{\pi/2}(a + b\cos\theta)\,d\theta}{\pi/2}$$

$$\bar{\bar{T}}_{CONV} = T_{Na} + \frac{2}{\pi} b \int_0^{\pi/2} \cos\theta\,d\theta$$

$$\int_0^{\pi/2} \cos\theta\,d\theta = \Big|_0^{\pi/2} \sin\theta = \sin\frac{\pi}{2} = 1$$

$$\bar{\bar{T}}_{CONV} = T_{Na}(z) + \frac{2}{\pi}\Delta T_{PN}(z)$$

$$\boxed{\bar{\bar{T}}_{CONV} = T_{Na}(z) + \left(\frac{2}{\pi}\right)\Delta T_{P,N}(z)}$$

$$\frac{2}{\pi} = 0.636620 = G_{CONV}$$

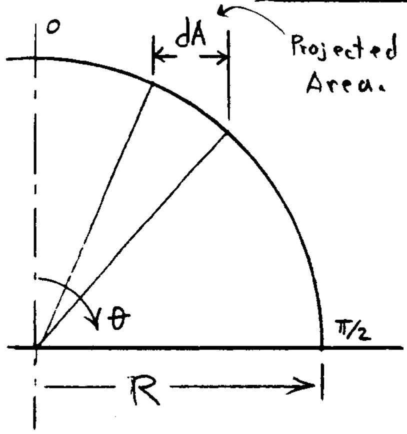
$$\boxed{\bar{\bar{T}}_{CONV} = T_{Na}(z) + \left(\frac{2}{\pi}\right)\Delta T_{(Peak-Na)}(z)}$$

CIRCUMFERENTIAL AVERAGE AROUND INDIVIDUAL TUBE PERIPHERY.

CONVECTION.

TABLE Add-I-3 (a)

CIRCUMFERENTIALLY AVERAGED TEMPERATURE: FOR RADIATION:



$$T(\theta) = T_{Na} + \Delta T_{P\text{-}N} \cos\theta$$

$$\Delta T_{P\text{-}N} = (T_{PEAK} - T_{Na})\ (z)$$

$$T(\theta) = A + B \quad \begin{cases} a = T_{Na}(z) \\ B = \Delta T_{P.N}(z)\cos\theta = b\cos\theta \end{cases}$$

$$dA = [\cos\theta \, d\theta] 2\pi R L$$

$$\overline{T^4} = \frac{\int_0^{\pi/2} T^4 \, dA}{\int_0^{\pi/2} dA} = \frac{2\pi RL \int_0^{\pi/2} T^4 \cos\theta \, d\theta}{2\pi RL \int_0^{\pi/2} \cos\theta \, d\theta} = \frac{\int_0^{\pi/2} T^4 \cos\theta \, d\theta}{\int_0^{\pi/2} \cos\theta \, d\theta}$$

$$T^4 = (a+B)^4 = a^4 + 4a^3B + 6a^2B^2 + 4aB^3 + B^4$$

$$a = T_{Na}$$
$$B = \Delta T_{p.N} \cos\theta = b\cos\theta$$
$$b = \Delta T_{P.N}\ (z)$$

$$T^4 = a^4 + 4a^3 b\cos\theta + 6a^2b^2\cos^2\theta + 4ab^3\cos^3\theta + b^4\cos^4\theta$$

$$T^4 = a^4\cos\theta + 4a^3b\cos^2\theta + 6a^2b^2\cos^3\theta + 4ab^3\cos^4\theta + b^4\cos^5\theta$$

$$\overline{T^4} = \frac{\int_0^{\pi/2} T^4 \cos\theta \, d\theta}{\int_0^{\pi/2} \cos\theta \, d\theta}$$

TABLE Add-I-3(b) $\int_0^{\pi/2} \cos^n\theta \, d\theta = ?$ $\quad n = 1 \to 5$

$\sin 0$	$= 0$
$\sin \frac{\pi}{2}$	$= +1$
$\sin 2(\frac{\pi}{2})$	$= 0$
$\sin 3(\frac{\pi}{2})$	$= -1$
$\sin 4(\frac{\pi}{2})$	$= 0$
$\sin 5(\frac{\pi}{2})$	$= +1$

$$\int_0^{\pi/2} \cos\theta \, d\theta = \Big|_0^{\pi/2} \sin\theta = \sin\frac{\pi}{2} - \sin 0 = 1 - 0 = 1.0$$

$$\int_0^{\pi/2} \cos^2\theta \, d\theta = \Big|_0^{\pi/2} \frac{\theta}{2} + \frac{1}{4}\sin 2\theta = \left(\frac{\pi}{4} - 0\right) - (0 - 0) = \frac{\pi}{4}$$

$$\int_0^{\pi/2} \cos^3\theta \, d\theta = \Big|_0^{\pi/2} \frac{3}{4}\sin\theta + \frac{1}{12}\sin 3\theta = \left\{\frac{3}{4}(1) + \frac{1}{12}(-1) - 0 - 0\right\} = \frac{2}{3}$$

$$\int_0^{\pi/2} \cos^4\theta \, d\theta = \Big|_0^{\pi/2} \frac{3\theta}{8} + \frac{1}{4}\sin 2\theta + \frac{1}{32}\sin 4\theta = \left[\frac{3}{8}\left(\frac{\pi}{2}\right) + 0 + 0 - (0 + 0 + 0)\right] = \frac{3\pi}{16}$$

$$\int_0^{\pi/2} \cos^5 d\theta = \Big|_0^{\pi/2} \frac{5}{8}\sin\theta + \frac{5}{48}\sin 3\theta + \frac{1}{80}\sin 5\theta = \left[\frac{5}{8}(1) + \frac{5}{48}(-1) + \frac{1}{80}(1) - (0+0+0)\right] = \frac{8}{15}$$

SEE: W. MEYER ZUR CAPELLEN, INTEGRALTAFELN, 1950
Pg. 160; (# 2.2.1.1. → 2.2.4)

$$\int_0^{\pi/2} \cos^n\theta \, d\theta = \begin{cases} 1.0 = 1.0 & n = 1 \\ \frac{\pi}{4} = .785398 & n = 2 \\ \frac{2}{3} = .666667 & n = 3 \\ \frac{3\pi}{16} = .589049 & n = 4 \\ \frac{8}{15} = .533333 & n = 5 \end{cases}$$

$$\overline{T^4} = a^4(1) + 4a^3b\left(\frac{\pi}{4}\right) + 6a^2b^2\left(\frac{2}{3}\right) + 4ab^3\left(\frac{3\pi}{16}\right) + b^4\left(\frac{8}{15}\right)$$

$$\overline{(T^4)} = a^4\left\{1 + \underset{01}{\pi}\left(\frac{b}{a}\right) + \underset{02}{4}\left(\frac{b}{a}\right)^2 + \underset{03}{\frac{3\pi}{4}}\left(\frac{b}{a}\right)^3 + \underset{04}{\frac{8}{15}}\left(\frac{b}{a}\right)^4\right\}$$

$$\overline{(T^4)} = a^4\left\{G_{RAD}\right\} = \left(T_{Na\,(°R)}\right)^4\left\{G_{RAD}\right\}; \quad \overline{T}_{°R\,RAD} = T_{Na\,°R}\left\{G_{RAD}\right\}^{1/4}$$

SEE TI58C LISTING

CIRCUMFERENTIAL AVERAGE AROUND INDIVIDUAL TUBE PERIPHERY.
RADIATION

TABLE Add-I-3.(c) TI58C LISTING TO CALCULATE $\{G_{RAD}\}^{1/4}$

Step	Code	Key	Comment
0	76	Lbl A	
1	11		
2	42	STO 00	(b/a)
3	00		
4	01	1.0	
5	42	STO 10	(1.0)
6	10		
7	43	RCL 01	(π)
8	01		
9	65	*	
10	43	RCL 00	(b/a)
11	00		
12	95	=	
13	42	STO 11	π(b/a)
14	11		
15	43	RCL 00	(b/a)
16	00		
17	33	x^2	
18	95	=	
19	65	*	
20	43	RCL 02	(4.0)
21	02		
22	95	=	$4(b/a)^2$
23	42	STO 12	$4(b/a)^2$
24	12		
25	43	RCL 00	(b/a)
26	00		
27	33	x^2	$(b/a)^2$
28	65	*	
29	43	RCL 00	(b/a)
30	00		
31	95	=	$(b/a)^3$
32	65	*	
33	43	RCL 03	$\left(\frac{3\pi}{4}\right)$
34	03		
35	95	=	
36	42	STO 13	$\left(\frac{3\pi}{4}\right)\left(\frac{b}{a}\right)^3$
37	13		
38	43	RCL 00	(b/a)
39	00		
40	33	x^2	
41	33	x^2	$(b/a)^4$
42	65	*	
43	43	RCL 04	(8/15)
44	04		
45	95	=	$(8/15)(b/a)^4$
46	42	STO 14	
47	14		
48	85	+	
49	43	RCL 13	
50	13		
51	85	+	
52	43	RCL 12	
53	12		
54	85	+	
55	43	RCL 11	
56	11		
57	85	+	
58	43		10+11+12+13+14 $\{G_{RAD}\}$
59	10		
60	95	=	
61	42	STO 15	$\{G_{RAD}\}$
62	15		
63	34	$\sqrt{x}$	
64	34	$\sqrt{x}$	
65	42	STO 16	$\{G_{RAD}\}^{1/4}$
66	16		
67	91	R/S	END

$$\frac{b}{a} = \frac{\Delta T(z)_{Pk-Na}}{T_{Na}(^{\circ}R)}$$

STORE BEFORE RUN:

Register	Value
01	π = 3.14159
02	4.0
03	$\frac{3\pi}{4}$ = 2.356195
04	8/15 = .5333

STORE BEFORE RUN:

Register	Value
00	(b/a)
10	1.0
11	π (b/a)
12	$4(b/a)^2$
13	$\frac{3\pi}{4}(b/a)^3$
14	$(8/15)(b/a)^4$
15	G_{RAD}
16	$\{G_{RAD}\}^{1/4}$

$$\overline{T}_{RAD} = T_{Na} * \{G_{RAD}\}^{1/4}$$

°R

(b/a)	$\{G_{RAD}\}$	$\{G_{RAD}\}^{1/4}$
0	1.0	1.0
0.01	1.031818	1.007861
.02	1.064451	1.015737
.03	1.097912	1.023627
.04	1.132216	1.031531
.05	1.167377	1.039448
.06	1.203411	1.047378
.07	1.240332	1.055321
.08	1.278156	1.063276
.09	1.316896	1.071243
.10	1.356569	1.079221

b/a	$\{G_{RAD}\}$	$\{G_{RAD}\}^{1/4}$
.11	1.397189	1.087211
.12	1.438773	1.095212
.13	1.481336	1.103223
.14	1.524893	1.111245
.15	1.569461	1.119277
.16	1.615055	1.127319
.17	1.661692	1.135371
.18	1.709388	1.143432
.19	1.758159	1.151501
.20	1.808021	1.159580
.25	2.074297	1.200101
.30	2.370415	1.240812
.40	3.061087	1.322723
.50	3.898654	1.405169

Addendum to
NO 079TI000002
PAGE 74

TABLE Add-I-4 (a)

TAP LISTING:
CALCULATE CIRCUMFERENTIAL
AND AXIAL MEAN TEMPERATURES

```
//   REGION=500K,TIME=1
// EXEC TAP4                                                                00000001
//G.SYSIN DD *                                                              00000002
00001                                                                       00000010
     E H MOURADIAN    EXT 3320   L830                               (1)     00001020
     67890123456789O                                                        00001030
                                                                            00001050
        TAP-4S    SUPER TAP                                                 00001100
           6903-(AB)  (500K)                                                00001120
                                                                            00001150
     EFFECTIVE MEAN TEMPERATURE OF TUBE  (FOR CCNVECTION & RADIATION)       00002010
        INTEGATED WITH THETA & Z                                            00002030
                                                                            00199999
     DUMMIES:                                                               00200000
        D0001 = DELTA T (CL).   (T:PEAK - T:NA) @ MID-HEIGHT                00204001
        D0300 - D0340 = T:NA (F)                                            00204300
        D0400 - D0440 = T:NA (R)                                            00204400
        D0500 - D0540 = DEL(T) (Z)     (T:PN-T:NA)(Z)                       00204500
        D0600 - D0640 =  (DEL T)/(T:NA (R)) = B/A                           00204600
        D0700 - D0740 = T:BAR (RADIATION) PER NODE    (THETA AVG)           00204700
        D0800 - D0840 = (T(Z-RAD)R)**4                                      00204800
        D0900 - D0940 = (A(Z)/A:TCT)*(T(Z)**4)                              00204900
        E0100 - E0140 = (2/PI)*(DT)     EXTRA INCREMENT, CONV               00205100
        E0200 - E0240 = (G**1/4):RAD      T:BR(RAD)=T:NA*(G)      (R)       00205200
        F0100 - F0140 = HEAT FLOW (REJECTION)        CONVECTION             00206100
        F0150 = TOTAL HEAT FLOW OUT:   CONVECTION                           00206150
        F0200 - F0240 = HEAT FLOW (REJECTION)       RADIATION               00206200
        F0250 = TOTAL HEAT FLOW OUT:   RADIATION                            00206250
        F0260 = SUM (A(Z)/A:TOT)*(T(Z)**4) = *RAD HEAT OUT                  00206260
        H0011 = T:BRBR CNV    CVERALL MEAN TEMP  (0 & Z INTEGRT)  (F)       00208011
        H0021 = T:BRBR RAD    CVERALL MEAN TEMP  (0 & Z INTEGRT)  (F)       00208021
        H0022 = T:BRBR RAD    CVERALL MEAN TEMP  (0 & Z INTEGRT)  (R)       00208022
        H0025 = T:BRBR RAD    CVERALL MEAN TEMP  (0 & Z INTEGRATION)        00208250
         SHOULD BE SAME AS H0021                                            00208251
        H0026 = T:BRBR RAD    CVERALL MEAN TEMP  (0 & Z INTEGRATION)        00208260
         SHOULD BE SAME AS H0022                                            00208261
        N0001 = 0.25 = 1/4                                                  00214010
        N0002 = 459.69                                                      00214020
        N0003 = 0.636620 = 2/PI                                             00214030
        N0004 = 4.0                                                         00214040
        Ø0100 - Ø0140 = NCRMAL DISTRIBUTION:  Ø(Z)                          00215010
                                                                            00227999
     NODES:                                                                 00300000
        T0001 = CONVECTIVE SINK:  T = 0 F                                   00300010

        T0002 = RADIATIVE SINK:   T = -459.69F = 0 R                        00300020
        T0100 - T0140 = "CONVECTIVE" TEMP NODES                             00301000
        T0200 - T0240 = "RADIATIVE" TEMP NCDEES                             00302000
        T0301 - T0302 = DUMMY NODES  (CNV)                          (2)     00303010
        T0401 - T0402 = DUMMY NCDES  (RAD)                                  00304010
           LENGTH CF NODES:                                                 00320001
              T0100 & T0140     L = 1/80 = 0.0125                           00320100
              T0101 - T0139     L = 1/40 = 0.0250                           00320150
              T0200 & T0240     L = 1/80 = 0.0125                           00320200
              T0201 - T0239     L = 1/40 = 0.0250                           00320250
                                                                            00349999
     CONDUCTANCES:                                                          00350000
        Y0100 - Y0140 = CONVECTION OUT                                      00350100
           Y = HA;   HA=1/80 FOR 1 & 40; HA=1/40 FOR 2 THRU 39              00350110
        Y0200 - YC240 = RADIATION OUT                                       00350200
           GAIN = 1/80 FOR 1 & 40;  1/40 FOR 2 THRU 39                      00350210
        Y0301 - Y03C2 = DUMMY CONDUCTANCES                                  00350301
        Y0401 - Y04C2 = DUMMY CCNDUCTANCES                                  00350401
                                                                            00399999
     TABLES:                                                                00400000
        TABLE 2: FOR RADIATION:                                             00420001
              (G**1/4) VS (B/A)                                             00420100
                       B/A =  DEL T/T:NA R                                  00420210
                       (G**1/4) =:      T:BR RAD(0) = (T:NA R)*(G**1/4)     00420220
                                                                            00699999
     SPECIAL CONDITION:                                                     00700000
        SIGMA = 1.0 BTU/HR FT2 R4  (MATHEMATICAL CONTRIVANCE)               00700100
                                                                            00899999
     PROBLEM CASE:                                                          00900000
        T:NA   610F - 1050F                                                 00900100
        (Q/A)CL = 1.20 MW/M2     (T:PR-T:NA)CL = 192.50F                    00900200
00010                                                                       01000000
Y0100Y0140                   T0100T0001   1   0    CONV                     01100100
Y0301                        T0301T0001            CONV                     01100301
Y0302                        T0302T0301            CONV                     01100302
Y0200Y0240                   T0200T0002   1   0    RAD                      01200200
Y0401                        T0401T0002            RAD                      01200401
Y0402                        T0402T0401            RAD                      01200402
00020                                                                       02000000
D0001          192.50                              (T:PR-T:NA)CL            02100100
00             610.0                               SODIUM  T:NA(F)          02100300
00             612.75                              TEMPERATURES             02100301
00             616.08                                                       02100302
00             620.06                              (610F - 1050F)           02100303
```

```
D0304          624.77                                                       02100304
D0305          630.31                              T:NA(F)                  02100305
D0306          636.74                              T:NA(F)                  02100306
D0307          644.14                              T:NA(F)                  02100307
D0308          652.56                              T:NA(F)      (3)         02100308
D0309          662.05                              T:NA(F)                  02100309
D0310          672.65                              T:NA(F)                  02100310
D0311          684.36                              T:NA(F)                  02100311
D0312          697.17                              T:NA(F)                  02100312
D0313          711.05                              T:NA(F)                  02100313
D0314          725.94                              T:NA(F)                  02100314
D0315          741.74                              T:NA(F)                  02100315
D0316          758.35                              T:NA(F)                  02100316
D0317          775.65                              T:NA(F)                  02100317
D0318          793.46                              T:NA(F)                  02100318
D0319          811.64                              T:NA(F)                  02100319
D0320          830.00                              T:NA(F)                  02100320
D0321          848.36                              T:NA(F)                  02100321
D0322          866.54                              T:NA(F)                  02100322
D0323          884.35                              T:NA(F)                  02100323
D0324          901.65                              T:NA(F)                  02100324
D0325          918.26                              T:NA(F)                  02100325
D0326          934.06                              T:NA(F)                  02100326
D0327          948.95                              T:NA(F)                  02100327
D0328          962.83                              T:NA(F)                  02100328
D0329          975.64                              T:NA(F)                  02100329
D0330          987.35                              T:NA(F)                  02100330
D0331          997.95                              T:NA(F)                  02100331
D0332          1007.44                             T:NA(F)                  02100332
D0333          1015.86                             T:NA(F)                  02100333
D0334          1023.26                             T:NA(F)                  02100334
D0335          1029.69                             T:NA(F)                  02100335
D0336          1035.23                             T:NA(F)                  02100336
D0337          1039.94                             T:NA(F)                  02100337
D0338          1043.92                             T:NA(F)                  02100338
D0339          1047.25                             T:NA(F)                  02100339
D0340          1050.00                             T:NA(F)                  02100340
T0001      -1      0.0                             CNV SINK  0.0F           02110110
T0100T0140 -1      0.01                            INT T                    02110120
T0301             25.0                             DUMMY STRING             02110130
T0302      -1   1000.0                             DUMMY STRING             02110140
T0002      -1   -459.69                            RAD SINK  0.0R           02110210
T0200T0240 -1      0.01                            INT T                    02110220
T0401             25.0                             DUMMY STRING             02110230

T0402      -1   1000.0                             DUMMY STRING             02110240
Y0100              0.0125                          CONV HA=1/80             02400110
Y0101Y0139         0.025                           CONV HA=1/40             02400120
Y0140              0.0125                          CONV HA=1/80             02400130
Y0301Y0302         0.4                             DUMMY Y                  02400160
Y0401Y0402         0.4                             DUMMY Y                  02400260
G010000140     0.135335                          40NCRMAL                   02650000
C010100139     0.164474                          38DISTRIBUTION             02650010
C010200138     0.197899                          36FACTCRS:                 02650020
C010300137     0.235746                          34 Ø(Z)                    02650030
C010400136     0.278037                          32 Ø(Z)                    02650040
C010500135     0.324652                          30 Ø(Z)                    02650050
G010600134     0.375311                          28 Ø(Z)        (4)         02650060
C010700133     0.429557                          26 Ø(Z)                    02650070
G010800132     0.486752                          24 Ø(Z)                    02650080
C010900131     0.546074                          22 Ø(Z)                    02650090
C011000130     0.606531                          20 Ø(Z)                    02650100
C011100129     0.666977                          18 Ø(Z)                    02650110
C011200128     0.726149                          16 Ø(Z)                    02650120
C011300127     0.782705                          14 Ø(Z)                    02650130
C011400126     0.835270                          12 Ø(Z)                    02650140
C011500125     0.882497                          10 Ø(Z)                    02650150
G011600124     0.923116                           8 Ø(Z)                    02650160
G011700123     0.955997                           6 Ø(Z)                    02650170
G011800122     0.980199                           4 Ø(Z)                    02650180
C011900121     0.995012                           2 Ø(Z)                    02650190
C0120          1.0                                                          02650200
N0001            0.25                            1/4                        02690010
N0002          459.69                            459.69                     02690020
N0003          0.636620                          2/PI                       02690030
N0004            4.0                             4.0                        02690040
00030                                                                       03000000
D0400D0440 150          1.0   D0300N0002   1   0   T:NA(R)          4  03200100
D0500D0540 152          1.0   D0100D0001   1   0   DT(P-N)(Z)       0  03200200
D0600D0640 153          1.0   D0500D0400   1   1   B/A   DT/T(R)       03200300
E0200E0240-102          1.0   D0600        1       (G**1/4):RAD        03210100
D0700D0740 152          1.0   D0400E0200   1   1   T:BR NDE RAD (R)03220100
T0200T0240 151          1.0   DC700NC002   1   0   T:BR NDE RAD (F)03220200
E0100E0140 152          1.0   D0500N0003   1   0   2/PI * DT(P-N)      03230100
T0100T0140 150          1.0   D0300E0100   1   1   T:BR NDE CNV (F)03230200
Y0200         49     0.0125                        Y-RAD               03405010
Y0201Y[illegible]  49     0.025                         Y-RAD               03405020
Y0240                0.0125                        Y-RAC               03405030
F0100F                  1.0   Y0100        1       HT FLW  CNV         03630100
```

Addendum to 079T100002

NO

TABLE Add-I-4 (b)

```
F0200F0240  40        1.0   Y0200         1       HT FLW  RAD       03630200
F0150       61        1.0   F0100F0140            TOT Q  CNV        03640100
F0250       61        1.0   F0200F0240            TOT Q  RAD        03640200
H0011        1        1.0   FC150                 T:BRBR CNV     F  03650100
H0022       60        1.0   F0250N0001            T:BRBR RAD     B  03650200
H0021       51        1.0   HC022N0002            T:BRBR RAD     F  03650300
D0800D0840 160        1.0   D0700N0004    1   0    T**4             03750100
C0900        1        0.0125 D0800                (1/80)T**4        03750210
D0901D0939   1        0.025  DC801        1       (1/40)T**4        03750220
C0940        1        0.0125 DC840                (1/80)T**4        03750230
F0260       61        1.0   D0900D0940            SUM(A/A)T**4      03750400
H0026       60        1.0   FC260N0001            SUM(T**4)**1/4    03750500
H0025       51        1.0   HC026N0002            T:BR    (F)       03750600
*0040                                                               04000000
    2           0.0     1.0                       TABLE 2 2 2 2 2   04200001
                0.01    1.007861                  (G**1/4) RAD      04200010
                0.02    1.015737                  FACTCR FOR        04200020
                0.03    1.023627                  MEAN TEMPERATURE04200030
                0.04    1.031531                  FOR RADIATION     04200040
                0.05    1.039448                                    04200050
                0.06    1.C47370                                    04200060
                0.07    1.055321                                    04200070
                0.08    1.063276                                    04200080
                0.09    1.071243                                    04200090
                0.10    1.079221                                    04200100
                0.11    1.087211                              (5)   04200110
                0.12    1.095212                                    04200120
                0.13    1.103223                                    04200130
                0.14    1.111245                                    04200140
                0.15    1.119277                                    04200150
                0.16    1.127315                                    04200160
                0.17    1.135371                                    04200170
                0.18    1.143432                                    04200180
                0.19    1.151501                                    04200190
                0.20    1.15958C                                    04200200
                0.25    1.200101                                    04200250
                0.30    1.240812                                    04200300
                0.50    1.405165                  2 2 2 2 2 2 2 2   0420C500
*0070                                                               07000000
   19           1.0                                                 07000190
    4           0.001                                               07000400
    5           1.0                                                 07000500
    6           1.0                                                 07000600
    9           1.0                                                 07000900
   14           1.0                                                 07001400
*0080                                                               08000000
H0011        1                                    T:BR OVL          08220110
A0001A0002   1                                                      08220120
H0021        1                                    T:BR OVL          08220140
H0025        1                                    T:BR OVL          08220150
H0011        1                                    T:B CV F          08220210
A0001        1                                                      08220220
A0002        1                                                      08220230
H0021        1                                    T:B RD F          08220240
H0025        1                                    T:B RD F          08220250
H0011        0                                                      08220310
A0001        1                                                      08220320
A0002        1                                                (6)   08220330
H0021        0                                                      08220340
H0025        0                                                      08220350
A0001A0005   1                                                      08230001
A0001A0003   1                                                      08240110
H0022        1                                    T:BR OVL          08240140
H0026        1                                    T:BR OVL          08240150
A0001A0003   1                                                      08240210
H0022        1                                    T:B RD R          08240240
H0026        1                                    T:B RD A          08240250
A0001A0003   1                                                      08240310
H0022        0                                                      08240340
H0026        0                                                      08240350
A0001A0005   1                                                      08250001
A0001A0005   1                                                      08500100
T0100T0140                                                          08500200
A0001A0CC9   1                                                      08500300
T02CCT0240                                                          08500400
A0001A0004   1                                                      08500500
*0090                                                               09000000
                 0.0        1.0                                     09000100
              1.0                                                   09000202
*0096                                                               09600000
```

```
*0001                                                                         20000010
    2   (Q/A)CL = 0.97 MW/M2       (T:PK-T:NA)CL = 160.50F                    20001022
*0020                                                                         22000000
00001      160.50                                          (DT) Q/A=0.97      22000100
*0070                                                                         27000000
   11        1.0                                                              27000110
*0096                                                                         29600000
*0001                                                                   (7)   30000010
    2   (Q/A)CL = 0.225 MW/M2      (T:PK-T:NA)CL = 43.17F                     30001022
*0020                                                                         32000000
00001       43.17                                          (DT) Q/A=0.225     32000100
*0096                                                                         39600000
*0001                                                                         41000001
    2   (Q/A)CL = 0.318125 MW/M2    (T:PK-T:NA)CL =  57.83625F    (1/8)       41000020
*002C                                                                         41020000
C0001       57.83625                                                          41020100
*0096                                                                         41096000
*0001                                                                         42000001
    2   (Q/A)CL = 0.411255 MW/M2    (T:PK-T:NA)CL =  72.5025 F    (1/4)       42000020
*0020                                                                         42020000
00001       72.5025                                                           42020100
*0096                                                                         42096000
*0001                                                                         43000001
    2   (Q/A)CL = 0.504375 MW/M2    (T:PK-T:NA)CL =  87.16875F    (3/8)       43000020
*0020                                                                         43020000
C0001       87.16875                                                          43020100
*0096                                                                         43096000
*0001                                                                         44000001
    2   (Q/A)CL = 0.5975   MW/M2    (T:PK-T:NA)CL = 101.835  F    (1/2)       44000020
*0020                                                                         44020000
C0001      101.835                                                            44020100
*0096                                                                         44096000
*0001                                                                         45000001
    2   (Q/A)CL = 0.690625 MW/M2    (T:PK-T:NA)CL = 116.50125F    (5/8)       45000020
*0020                                                                         45020000
00001      116.50125                                                          45020100
*0096                                                                         45096000
*0001                                                                         46000001
    2   (Q/A)CL = 0.78375  MW/M2    (T:PK-T:NA)CL = 131.1675 F    (3/4)       46000020
*0020                                                                         46020000
C0001      131.1675                                                           46020100
*0096                                                                         46096000
*0001                                                                         47000001
    2   (Q/A)CL = 0.876875 MW/M2    (T:PK-T:NA)CL = 145.83375F    (7/8)       47000020
*0020                                                                         47020000
C0001      145.83375                                                          47020100
*0096                                                                         47096000
*0001                                                                         51000001
    2   (Q/A)CL = 0.99875  MW/M2    (T:PK-T:NA)CL = 164.50 F      (1/8)       51000020
*0020                                                                         51020000
00001      164.50                                                             51020100
*0096                                                                         51096000
*0001                                                                         52000001
    2   (Q/A)CL = 1.0275   MW/M2    (T:PK-T:NA)CL = 168.50 F      (1/4)       52000020
*0020                                                                         52020000
C0001      168.50                                                   (8)       52020100
*0096                                                                         52096000
*0001                                                                         53000001
    2   (Q/A)CL = 1.05625  MW/M2    (T:PK-T:NA)CL = 172.50 F      (3/8)       53000020
*0020                                                                         53020000
00001      172.50                                                             53020100
*0096                                                                         53096000
*0001                                                                         54000001
    2   (Q/A)CL = 1.085    MW/M2    (T:PK-T:NA)CL = 176.50 F      (1/2)       54000020
*0020                                                                         54020000
00001      176.50                                                             54020100
*0096                                                                         54096000
*0001                                                                         55000001
    2   (Q/A)CL = 1.11375  MW/M2    (T:PK-T:NA)CL = 180.50 F      (5/8)       55000020
*0020                                                                         55020000
C0001      180.50                                                             55020100
*0096                                                                         55096000
*0001                                                                         56000001
    2   (Q/A)CL = 1.1425   MW/M2    (T:PK-T:NA)CL = 184.50 F      (3/4)       56000020
*0020                                                                         56020000
00001      184.50                                                             56020100
*0096                                                                         56096000
*0001                                                                         57000001
    2   (Q/A)CL = 1.17125  MW/M2    (T:PK-T:NA)CL = 188.50 F      (7/8)       57000020
*0020                                                                         57020000
00001      188.50                                                             57020100
*0099                                                                         57099000
```

6903-14
3/29/83
6903 BU = 1.2732

TiNa 610° → 1050°F $\bar{T}_{Na}$ = 830° EFFECTIVE MEAN TEMPERATURE (Z & θ INTEGRATION)

LOCATION	(Q/A)℄ MW/m²	ΔT ℄ Pk-Na	COMPUTER OR INTERPOL.	CONV $\bar{\bar{T}}_{CNV}$ °F	RADIATION $\bar{\bar{T}}_{RAD}$ °F	RADIATION $\bar{\bar{T}}_{RAD}$ °R
FULL LOAD TUBE	1.20	192.50	TAP	903.29	947.70	1407.4
INBOARD	0.97	160.50	TAP	891.10	932.24	1391.9
OUTBOARD	0.225	43.17	TAP	846.43	876.95	1336.6
PANEL 1 — 0	0.225	43.17	TAP	846.43	876.95	1336.64
1/8	.318125	57.83625	Inter	852.02	883.74	1343.49
1/4	.411255	72.5025	Inter	857.60	890.57	1350.26
3/8	.504375	87.16875	Inter	863.18	897.42	1357.11
1/2	.5975	101.835	Inter	868.77	904.32	1364.01
5/8	.690625	116.50125	Inter	874.35	911.25	1370.94
3/4	.78375	131.1675	Inter	879.93	918.21	1377.90
7/8	.876875	145.8337	Inter	885.52	925.21	1384.90
1	0.97	160.50	TAP	891.10	932.24	1391.93
PORTION; PANEL 2 — 0	0.97	160.50	TAP	891.10	932.24	1391.93
1/8	.99875	164.50	Inter	892.62	934.16	1393.85
1/4	1.0275	168.50	Inter	894.15	936.09	1395.78
3/8	1.05625	172.50	Inter	895.67	938.02	1397.71
1/2	1.085	176.50	Inter	897.19	939.95	1399.69
5/8	1.11375	180.50	Inter	898.72	941.88	1401.57
3/4	1.1425	184.50	Inter	900.24	943.82	1403.51
7/8	1.17125	188.50	Inter	901.76	945.75	1405.44
1	1.20	192.50	TAP	903.29	947.70	1407.39

TO DETERMINE "EFFECTIVE MEAN" TEMPERATURE (For Heat Loss Calculation).

TABLE Add-I-5
COMPUTER OUTPUT:
MEAN TEMPERATURES;
Averaged Circumferentially, θ, and Axially, z.

TABLE Add-I-6

TEMPERATURES AVERAGED ACROSS PANEL.

SUB-PANEL 1

(θ, z mean)

FRACTION	LOCATION	$(Q/A)_{℄}$	$\bar{\bar{T}}_{RAD}$ °R	$\left(\frac{\bar{\bar{T}}_{RAD}\ °R}{1000}\right)^4$	$\left(\frac{\bar{\bar{T}}_{RAD}\ (°R)}{1000}\right)^4$ * FRAC	$\bar{\bar{T}}_{CONV}$ °F	$\bar{\bar{T}}_{CONV}$ * FRAC °F
.0625 = 1/16	0	.225	1336.64	3.191963	0.199498	846.43	52.901875
.125 = 1/8	1/8	↓	1343.43	3.257381	0.407165	852.02	106.5025
.125	1/4	↓	1350.26	3.324066	0.415508	857.60	107.2000
.125	3/8	↓	1357.11	3.392034	0.424004	863.18	107.8975
.125	1/2	↓	1364.01	3.461547	0.432693	868.77	108.59625
.125	5/8	↓	1370.94	3.532432	0.441554	874.35	109.29375
.125	3/4	↓	1377.90	3.604714	0.450589	879.93	109.99125
.125 = 1/8	7/8	↓	1384.90	3.678525	0.459816	885.52	110.69000
.0625 = 1/16	1	.970	1391.93	3.753787	0.234612	891.10	55.69375
					Σ= 3.465439		Σ=868.766875 (868.765) °F

$1000 \times (3.465439)^{1/4} = 1364.393°R$

SUB-PANEL 2

FRACTION	$(Q/A)_{℄}$	$\bar{\bar{T}}_{RAD}$ °R	$\left(\frac{\bar{\bar{T}}_{RAD}\ °R}{1000}\right)^4$	$\left(\frac{\bar{\bar{T}}_{RAD}\ (°R)}{1000}\right)^4$ * FRAC	$\bar{\bar{T}}_{CONV}$ °F	$\bar{\bar{T}}_{CONV}$ * FRAC °F
$\frac{1}{16} \times \left(\frac{230}{745}\right)$ = .019 2953	.970	1391.93	3.753 787	0.072 430	891.10	17.194044
$\frac{1}{8} \times \left(\frac{230}{745}\right)$ = .038 5906	↓	1393.85	3.774 541	0.145 662	892.62	34.446745
$\frac{1}{8} \times \left(\frac{230}{745}\right)$ = .038 5906	↓	1395.78	3.795 490	0.146 470	894.15	34.505 789
$\frac{1}{8} \times \left(\frac{230}{745}\right)$ = .038 5906	↓	1397.71	3.816 527	0.147 282	895.67	34.564 446
$\frac{1}{8} \times \left(\frac{230}{745}\right)$ = .038 5906	↓	1399.64	3.837 650	0.148 097	897.19	34.623 104
$\frac{1}{8} \times \left(\frac{230}{745}\right)$ = .038 5906	↓	1401.57	3.858861	0.148 916	898.72	34.682 148
$\frac{1}{8} \times \left(\frac{230}{745}\right)$ = .038 5906	↓	1403.51	3.880 271	0.149 742	900.24	34.740 805
$\frac{1}{8} \times \left(\frac{230}{745}\right)$ = .038 5906	↓	1405.44	3.901658	0.150 567	901.76	34.799 463
$\frac{1}{16} \times \left(\frac{230}{745}\right)$ = .019 2953	1.20	1407.39	3.923 357	0.075 702	903.29	17.429 253
$\left(1 - \frac{230}{745}\right)$ = .691 2752	1.20	1407.39	3.923 357	2.712 119	903.29	624.421946
				Σ=3.896987		Σ=901.406952 °F

$1000 \times (3.896987)^{1/4} = 1405.019°R$

TABLE Add. I-7

OVERALL EFFECTIVE TEMPERATURES
(θ, Z, χ INTEGRATION)

RADIATION:

SUB.PANEL NUMBER	$\overline{\overline{T}}_{AVG}$ RAD °R	$\left(\frac{\overline{\overline{T}}}{1000}\right)^4 *$ FRAC	=	
1, 8	1364.393	3.465436 × (2/8)	= 0.866 359 0952	01
2, 7	1405.019	3.896985 × (2/8)	= 0.974 246 3728	02
3, 6 4, 5	1407.39	3.923357 × (4/8)	= 1.961 678 5707	03
			3.802 284 0387	00

$1000 \times (3.802284)^{1/4} = 1396.404\,°R$ (936.714 °F) $= \overline{\overline{T}}_{EFF\ MEAN}$ OVERALL RADIATION

CONVECTION:

$\overline{\overline{T}}_{EFF\ MEAN\ CONV} = \frac{1}{4}(868.766875) + \frac{1}{4}(901.406952) + \frac{1}{2}(903.29) = 894.188\,°F$

$= 894.188\,°F$

EFFECTIVE MEAN TEMPERATURES:
REFERENCE SOLAR FLUX, 3/4" OD, 0.049" Wall Tubes. { $T_{Na-IN} = 610°F$, $T_{Na-OUT} = 1050°F$ }

INTEGRATION: { θ (CIRCUMFERENTIAL AROUND TUBE); Z (AXIAL - VERTICAL); χ (LATERAL - ACROSS PANEL) }

$\overline{\overline{T}}_{OVERALL} = 1396.40°R$ (936.71°F) RADIATION

$\overline{\overline{T}}_{OVERALL} = 894.19\,°F$ CONVECTION

TABLE Add-I-8 (a)

HEAT LOSS CALCULATIONS:

BASED ON REFERENCE SOLAR FLUX (079TI000002 Pg.7)

SIZE OF ACTIVE PANEL:

HEIGHT: 40 feet

WIDTH: $8_{\text{Sub Panels}} * \left[\left(102_{\text{Tubes/Panel}} \times .75\text{inch}_{\text{OD/Tube}}\right) + \left(101_{\text{Gaps}} + .010\text{inch}_{\text{Gap width}}\right)\right] = 620.08 \text{ inch}$ (51.6733 ft)

Projected Area: $40 \text{ ft} * 51.6733 \text{ ft} = 2066.933 \text{ ft}^2$

$2066.933(.3048)^2 = 192.024 \text{ m}^2$

"PROJECTED AREA" OF ACTIVE PANEL $= \begin{cases} 2066.93 \text{ ft}^2 \\ 192.024 \text{ m}^2 \end{cases}$

ENERGY INCIDENT ON PANEL?

ⓐ Determine $\left(\overline{\frac{Q}{A}}\right)_{℄}$ (Mean) by averaging laterally.

REFERENCE SOLAR FLUX See 079TI000002 Pg.7

ⓑ Determine overall mean by averaging vertically:

ⓒ $Q = A * (Q/A)$ $(Q/A)_{Mean} = .5981441 * (Q/A)_{℄}$

See 079TI000002 Pg. 8

ⓐ (i) 2 Panels: $\left(\overline{\frac{Q}{A}}\right)_{℄} = \frac{1}{2}(.225 + .970) = .5975$

(ii) 2 Panels: $\left(\frac{230}{745}\right)\left[\frac{1}{2}(.970 + 1.20)\right] + \left(1 - \frac{230}{745}\right)(1.20) = 1.1645$

(iii) 4 Panels: 1.20

$$\left(\overline{Q/A}\right)_{℄} = \frac{1}{4}\left\{.5975 + 1.1645 + 2(1.20)\right\} = 1.0405 \text{ MW/m}^2$$

$\left(\overline{\frac{Q}{A}}\right)_{℄} = 1.0405$ LATERALLY AVERAGED MID-HEIGHT FLUXES

ⓑ $\left(\overline{\frac{Q}{A}}\right)_{\text{OVERALL MEAN}} = .598144 * \left(\overline{\frac{Q}{A}}\right)_{℄} = .598144 * 1.0405$

$\left(\overline{Q/A}\right)_{\text{OVERALL MEAN}} = 0.622368 \frac{\text{MW}}{\text{m}^2}$

ⓒ $Q_{\text{TOTAL INCIDENT}} = \left(\overline{\frac{Q}{A}}\right) * A = 0.622368 \frac{\text{MW}}{\text{m}^2} * 192.024 \text{ m}^2 = 119.51 \text{ MW}$

$Q_{\text{PANEL INCIDENT}} = 119.51 \text{ MW}$

8rpm .040499161

TABLE
Add-I-8 (b)

REFLECTION HEAT LOSS:

Assume: $\alpha_{SOLAR} = 0.95$

This means: Reflectivity $= 0.05 = 5\%$

$$Q_{LOSS\,REFLEC} = 0.05 \times Q_{INCID} = 0.05 \times 119.51\ MW = 5.9755\ MW_t$$

$$\boxed{Q_{LOSS\,REFLECTION} = 5.98\ MW}$$

RADIATION HEAT LOSS:

$\left\{\begin{matrix}\text{EMISSIVITY} \\ \text{OF COATING}\end{matrix}\right\} \cong \left\{\begin{matrix}0.85 \\ 0.88\end{matrix}\right.$ "Effective" emissivity (based on projected area) is slightly higher than that of coating.

Let's say: $\epsilon_{EFF} = 0.88$; $\mathcal{F} = \epsilon = 0.88$

$T_{COLD} = 60°F = 519.69\,°R$

$A = 2066.93\ ft^2$

$\sigma = 0.1713 \times 10^{-8} \frac{BTU}{ft^2\,hr\,°R^4}$

$T_{HOT} = 1396.4\,°R$ EFFECTIVE MEAN PANEL TEMP FOR RADIATION.

$$Q_{RAD\,LOSS} = \mathcal{F} A \sigma \left(T_{HOT}^4 - T_{COLD}^4\right)$$

$$= (0.88)(2066.93\ ft^2)\left(.1713 \times 10^{-8} \frac{BTU}{ft^2\,hr\,°R^4}\right)\left\{1396.4^4 - 519.69^4\right\}$$

$$= 1.162 \times 10^7 \frac{BTU}{hr}$$

$$= 3.405\ MW$$

$$\boxed{Q_{LOSS\,RADIATION} = 3.41\ MW}$$

$$\frac{3.40453}{119.51} \Rightarrow 2.85\%$$

TABLE Add - I - 8 (c)

CONVECTION HEAT LOSS:

a) Natural Convection
b) Forced Convection due to Wind
c) Combined effect of h_{Nat} & h_{Forced}.

Effective Mean Temperature of Convection Heat Loss } = 894.19 °F = T_{HOT}

Air Temperature = 60°F = T_{COLD}

$\Delta T = (T_H - T_c) = 894.19 - 60$

$\Delta T = 834.19\ °F$

FOR NATURAL CONVECTION:

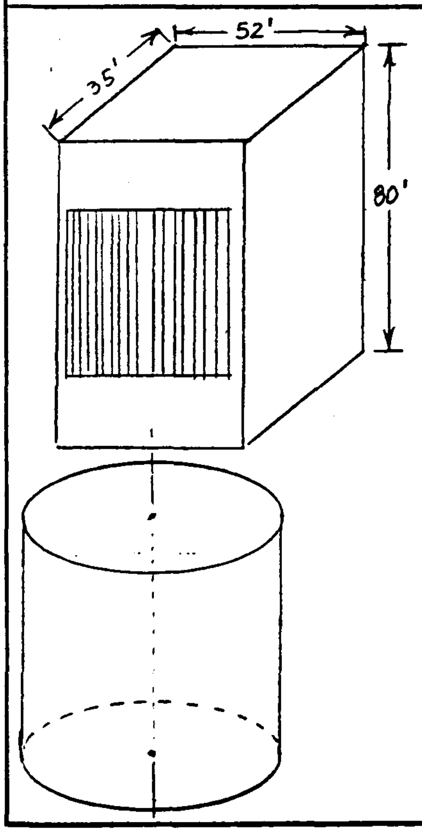
$$h_{NAT\ AIR} = \eta\, \Delta T^{1/3} \cong 0.15\, \Delta T^{1/3}$$

$\Delta T = 834.19$

$\eta \cong 0.15$ @ $\bar{T} \cong 500°F$

$h = 0.15(834.19)^{1/3} = 1.412$

$$h_{air\ NAT\ CONV} \cong 1.412 \frac{BTU}{hr\ ft^2\ °F}$$



TREAT RECTANGULAR CROSS-SECTION AS A CYLINDER:

$\sqrt{35 \times 52} = 42.661'$

$\frac{35+52}{2} = 43.5'$ } → Say $D_o \cong 43$ ft.

USE FORCED CONVECTION CORRELATION FOR CYLINDRICAL GEOMETRY WITH EFFECTIVE DIAMETER = 43 ft

FIGURE Add-I-1

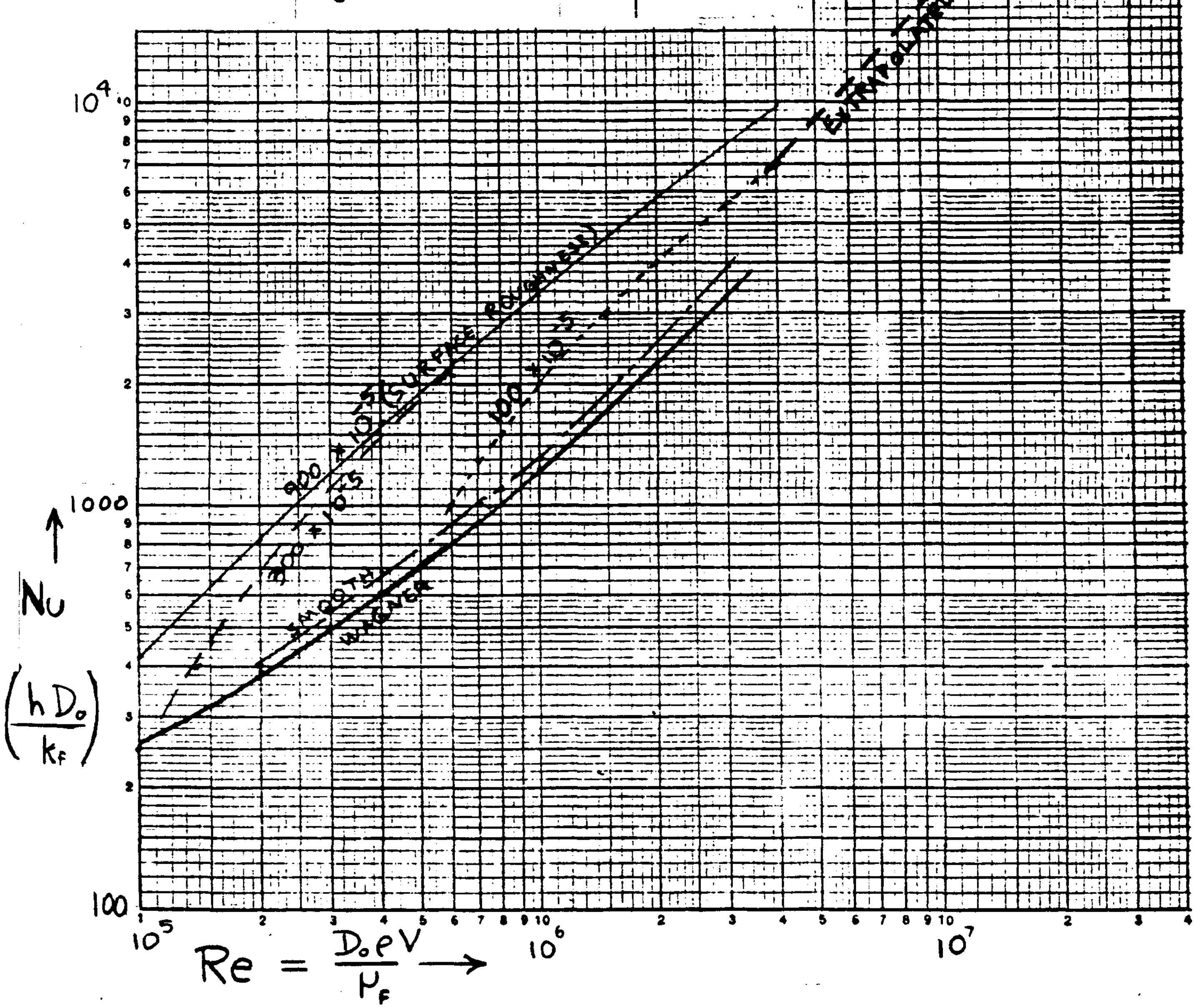
FORCED CONVECTION HEAT TRANSFER CORRELATION

See: 272TI000004
Page 38

Nu_f versus Re_f
Flow normal to cylinder axis

From: **Achenbach, Wagner**

WIND



PREPARED BY: EMM	Rockwell International Energy Systems Group	PAGE NO. 83 OF
CHECKED BY:		Addendum to 079TI0000002 REPORT NO.
DATE:		MODEL NO.

.4606175

TABLE Add-I-9 (a)

AIR VELOCITY:

V_o = GROUND LEVEL VELOCITY

V_{alt} = VELOCITY AT ELEVATION

H(Tower) = 125 meter = 410 ft.

$$V_{alt} = V_o \left(\frac{H(meter)}{10 meter} \right)^{0.15} = V_o \left(\frac{125}{10} \right)^{0.15} = 1.4606\, V_o$$

	GROUND VELOCITY	At 410 ft.	At 410 ft			
MEAN:	7mph	10.224 mph	14.996 FPS	=	15 ft/sec	= V_{MEAN}
MAXIMUM:	30mph	43.819 mph	64.267	=	64 ft/sec	= V_{MAX}

VELOCITIES @ 410 ft ALTITUDE:	
MEAN: Typical Day	= 15 ft/sec
MAXIMUM Operation	= 64 ft/sec

EVALUATE REYNOLDS NUMBER:

AIR PROPERTIES @ 500°F (Film Temp.)

$\rho = 0.041325$ lbm/ft³

$k = 0.02310$ BTU/hr ft °F

$C_p = 0.2470$ BTU/lbm °F

$\mu = 0.06804$ lbm/ft hr

$\nu = 1.64647$ ft²/hr

$Pr = 0.72752$

$$Re_{REYNOLDS} = \frac{V \frac{ft}{sec}\; D_o\, ft\; 3600 \frac{sec}{hr}}{\nu\; ft^2/hr} = \frac{V \frac{ft}{sec}\; 43\, ft\; 3600 \frac{sec}{hr}}{1.64647\; ft^2/hr} = 94020\, V_{FPS}$$

$$Nu_{NUSSELT} = \frac{hD}{k} \qquad h_{BTU/hr\,ft^2\,°F} = \frac{Nu\, k_{\frac{BTU}{hr\,ft\,°F}}}{D_{FT}} = \frac{.02310}{43}\, Nu = .000537\, Nu$$

Use upper roughness curve to account for effect of corners;
See plot of Nu vs. Re.

N 152-R-2 REV. 8-78

TABLE Add - I - 9 (b)

V_{FPS}	$Re = 94020V$	Nu FROM PLOT (UPPER CURVE)	$h = .000537\,Nu$ BTU/hr ft² °F FORCED	$h_{COMB} = \sqrt{h_{FRCD}^2 + h_{NAT}^2}$ BTU/hr ft² °F
15	1.41×10^6	4400	2.363	2.753
64	6.02×10^6	12000	6.444	6.597

$$h = \sqrt{h_{FRCD}^2 + 1.412^2}$$

$$h_{air\,COMBINED}(15_{FPS}) = 2.76 \text{ BTU/hr ft}^2\,°F$$

$$h_{air\,COMBINED}(64_{FPS}) = 6.60 \text{ BTU/hr ft}^2\,°F$$

$$Q_{LOSS\,CONV} = hA\Delta T$$

$\Delta T = 894.19 - 60 = 834.19\,°F$

$A = 2066.93 \text{ ft}^2$

$$Q_{\frac{BTU}{hr}} = \begin{pmatrix} 2.76 \\ 6.60 \end{pmatrix}(2066.93)(834.19) = \begin{matrix} 4{,}758{,}830 \text{ BTU/hr} \\ 11{,}379{,}800 \end{matrix} = \begin{cases} 1.394 \text{ MW} \\ 3.334 \text{ MW} \end{cases}$$

Q CONVECTIVE LOSS

For "MEAN" Typical Day Velocity	7mph Ground	15 FPS Altitude	$Q_{LOSS} = 1.39$ MW	1.17 %
For "MAX" WIND	30mph Ground	64 FPS Altitude	$Q_{LOSS} = 3.34$ MW	2.79 %

TABLE Add-I-10

PANEL HEAT LOSSES:

FOR "REFERENCE" SOLAR FLUX DISTRIBUTION:

SODIUM TEMP: T_{Na} (IN) = 610 °F; T_{Na} (OUT) = 1050 °F

TUBES: 0.75" x 0.049" wall : Stainless Steel.

Q (INCIDENT ON PANEL) = 119.51 MW

Q_{LOSS} (REFLECTION)	= 5.98 MW	5% (Percent of Full Load)
Q_{LOSS} (RADIATION)	= 3.41 MW	2.85%
Q_{LOSS} (COMBINED CONV) (Typical Day)	= 1.39 MW	1.17%

ADD-2 PANEL TEMPERATURE DISTRIBUTION

The temperature distribution is determined for a variety of solar flux and tube orificing conditions. Figure Add-II-1 shows the "reference" solar flux distribution (also see Page 7 of 079TI000002 of March 1983). Figure Add-II-2 shows the "Off-Normal" solar flux distribution. These two patterns are used in the calculations of this section. Furthermore, two orifice conditions have been assumed. No orifices at all,and orifices in Subpanels 1 and 2 such as to cause the sodium flow rate to be distributed in exactly the same proportion as the reference case flux distribution. The orifices are assumed to be such as to result in all tubes discharging the same temperature sodium for the "reference" case and a nonuniform pattern for the "off-normal" case.

Tables Add-II-1 and Add-II-2 deal with the lateral variation of solar flux on the panels for both flux distribution conditions. The "reference" condition distribution is taken as a linear Q/A variation up to the peak Q/A. The "Off-Normal" condition has a parabolic curve fit for the Q/A variation. The Q/L loading is converted to Q/A by assuming the normal distribution curve discussed previously (bell curve, 2 SD upward and downward from mid-height peak). Table Add-II-3 shows the expressions for interpolating the tube wall mid-height $\Delta T'$s for varying Q/A values.

Tables Add-II-4 and Add-II-5 show the $(Q/A)_o$ and tube wall $\Delta T'$s for Subpanels 1 and 2 for both solar flux distributions. Table Add-II-6 shows the set of four cases considered based on flux distribution and orificing. Also shown in Table Add-II-6 is flux and temperature informtion for Case 1 (reference Flux, Orifices).

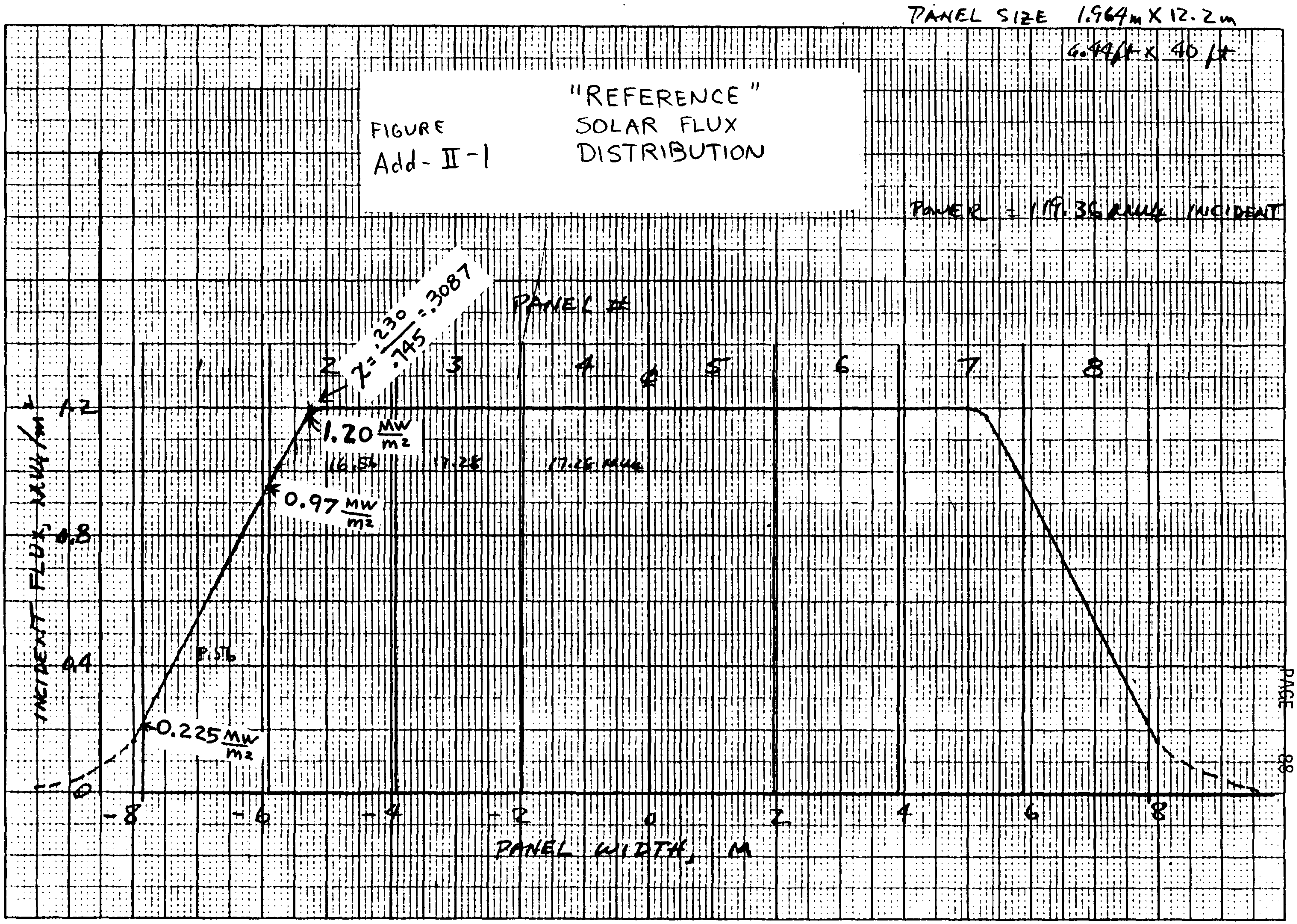
In Tables Add-II-7, Add-II-8, and Add-II-9, flux variation and sodium outlet temperatures are shown for Case 2 (reference Flux, No Orifices), Case 3 (Off-Normal Flux, Orifices), and Case 4 (Off-Normal Flux, No Orifices). Figure Add-II-3 shows the sodium outlet temperatures across the panel for the four cases.

Table Add-II-10 shows the TAP program listing for the calculation of the axial distribution of temperature in a particular tube of the panel. The tube wall ΔTs are input, and the two standard deviation normal distrbution curve is assumed.

Table Add-II-11 explains the computer data sheets that follow it. The four cases are shown. The solar flux distribution and orifice conditions are indicated.

5370F/sjh

46 1240



Addendum to 079TI000002 NO PAGE 88

FIGURE Add-II-2

"OFF-NORMAL" SOLAR FLUX DISTRIBUTION

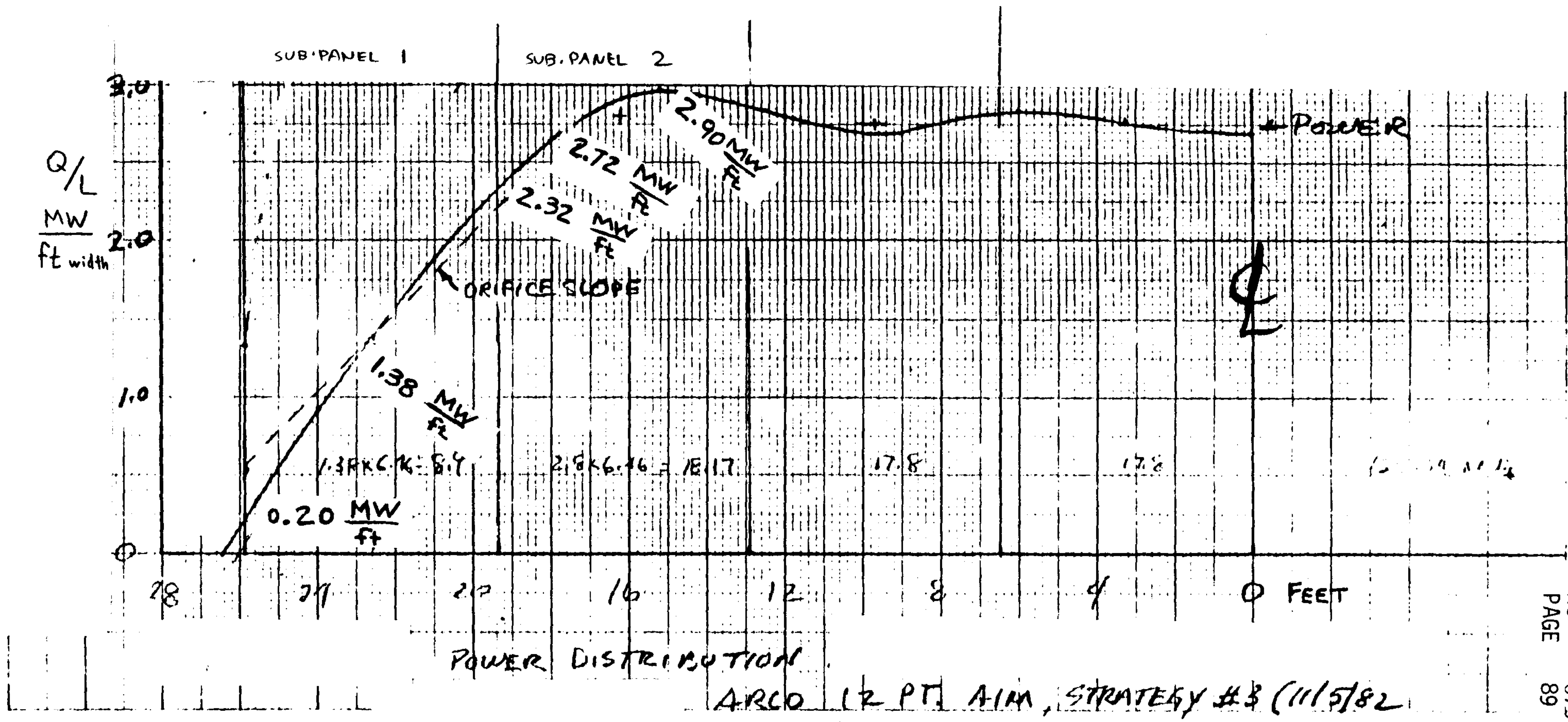
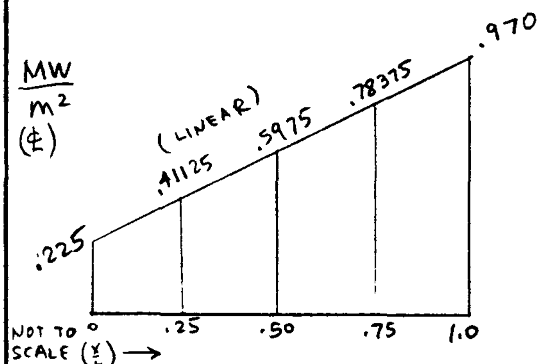


TABLE Add - II - 1

REFERENCE SOLAR FLUX

SUB. PANEL 1



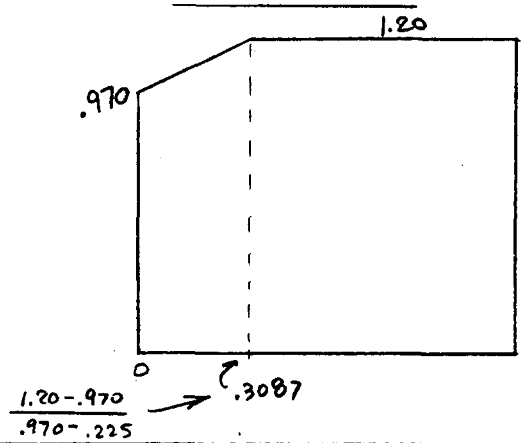
$$\left(\frac{Q}{A}\right)_{℄} = .225 + .745\left(\frac{X}{L}\right) \quad \frac{MW}{m^2}$$

MEAN:

$$\left(\frac{\bar{Q}}{A}\right) = \frac{1}{2}(.225 + .970) = .5975$$

$$\left(\frac{\bar{Q}}{A}\right)_{℄\,MEAN} = 0.5975\ \frac{MW}{m^2}$$

SUB. PANEL 2



$$\left(\frac{Q}{A}\right)_{℄} = .97 + .745\left(\frac{X}{L}\right) \qquad 0 \le \frac{X}{L} \le .3087$$

$$\left(\frac{Q}{A}\right)_{℄} = 1.20 \quad \frac{MW}{m^2} \qquad \frac{X}{L} \ge .3087$$

MEAN:

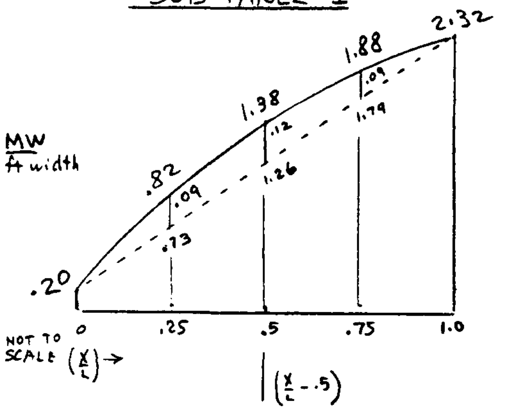
$$\left(\frac{\bar{Q}}{A}\right) = \left(\frac{.230}{.745}\right)\left[\frac{1}{2}(.97 + 1.20)\right] + \left(1 - \frac{.230}{.745}\right)(1.20)$$

$$\left(\frac{\bar{Q}}{A}\right)_{℄} = 1.164496\ \frac{MW}{m^2}$$

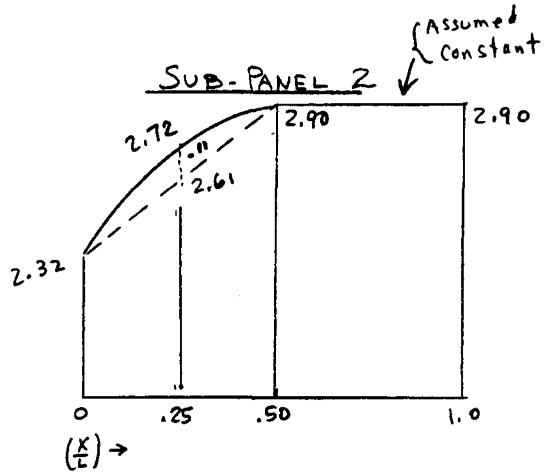
TABLE Add – II – 2 (a)

OFF-NORMAL SOLAR FLUX

SUB-PANEL 1



SUB-PANEL 2

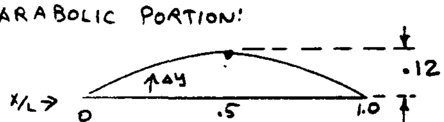


Sub-Panel 1

LINEAR PORTION:

$$y = 0.20 + (2.32 - .20)\frac{x}{L} = 0.20 + 2.12\left(\frac{x}{L}\right)$$

PARABOLIC PORTION:



$$\Delta y = .12 - \left[\left(\frac{x}{L}\right) - .5\right]^2 \left(\frac{.12}{(.5)^2}\right)$$

$$\Delta y = .48\left(.25 - \left(\frac{x}{L} - .5\right)^2\right) = .48\frac{x}{L} - .48\left(\frac{x}{L}\right)^2$$

COMBINED CURVE:

$$y = \left(\frac{Q}{L}\right)\frac{MW}{ft} = 0.20 + 2.60\frac{x}{L} - .48\left(\frac{x}{L}\right)^2$$

MEAN: AREA UNDER CURVE:

$$(1)\left[\frac{0.20 + 2.32}{2}\right] + (1)\frac{2}{3}(.12) = 1.26 + .08 = 1.34$$

TRAPEZOID PARABOLA

OR:

$$\frac{\int \frac{Q}{L}\,dx}{\int dx} = (1)\Big|_0^1 .2x + 2.60\frac{x^2}{2} - .48\frac{x^3}{3}$$

$$= .2 + 2.60\left(\frac{1}{2}\right) - .48\left(\frac{1}{3}\right) =$$

$$= .2 + 1.30 - .16 = 1.34$$

$$\left(\frac{\bar{Q}}{L}\right) = 1.34 \frac{MW}{ft\ width}$$

SUBPANEL 1

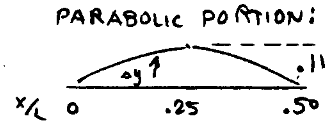
Sub-Panel 2

LINEAR PORTION:

$$y = 2.32 + (2.90 - 2.32)\frac{x/L}{2} = 2.32 + 1.16\left(\frac{x}{L}\right)$$

$$(0 \le x/L \le .5)$$

PARABOLIC PORTION:



$$\left(0 \le \frac{x}{L} \le .5\right)$$

$$\Delta y = .11 - \left[\left(\frac{x}{L}\right) - .25\right]^2 \left(\frac{.11}{(.25)^2}\right) = .88\frac{x}{L} - 1.76\left(\frac{x}{L}\right)^2$$

COMBINED CURVE:

$$y = \left(\frac{Q}{L}\right)\frac{MW}{ft} = 2.32 + 2.04\frac{x}{L} - 1.76\left(\frac{x}{L}\right)^2 \quad \left(0 \le \frac{x}{L} \le .5\right)$$

$$y = \left(\frac{Q}{L}\right)\frac{MW}{ft} = 2.90 \quad \left(.5 \le \frac{x}{L} \le 1.0\right)$$

MEAN: AREA UNDER CURVE:

$$.5(2.90) + .5\left(\frac{2.32 + 2.90}{2}\right) + .5\left(\frac{2}{3}\right)(.11)$$

RECTANGLE TRAPEZOID PARABOLA

1.45 + 1.305 + .036666

$$\left(\overline{Q/L}\right) = 2.791667 \frac{MW}{m^2}$$

$$\frac{\int \frac{Q}{L}\,dx}{\int dx} = \left[2.32x + 2.04\frac{x^2}{2} - 1.76\frac{x^3}{3}\right]_0^{.5} + \frac{2.9}{2}$$

$$= [1.16 + .255 - .07333] + 1.45$$

$$\left(\frac{\bar{Q}}{L}\right) = 2.791667 \frac{MW}{ft\ width}$$

SUBPANEL 2

TABLE Add-II-2(b)

$$\frac{Q}{L}\ \frac{MW}{ft\ width} = \left(\frac{Q}{A}\right)_{℄} (.5981441)\ \frac{MW}{m^2} * .3048^2\ \frac{m^2}{ft^2} * 40\ ft$$

(.5981441) = $\frac{(Q/A)_{MEAN}}{(Q/A)_{PEAK\ ℄}}$; 40 ft = Active Height

$$\left(\frac{Q}{L}\right)\frac{MW}{ft\ width} = \left(\frac{Q}{A}\right)_{℄} (.5981441)(.3048)^2(40) = 2.2227762 = \frac{1}{.44988785}$$

$$\left(\frac{Q}{A}\right)_{℄} \frac{MW}{m^2} = 0.449888 \left(\frac{Q}{L}\right)\frac{MW}{ft}$$

THUS: TO ESTIMATE $\left(\frac{Q}{A}\right)_{℄} \frac{MW}{m^2}$ FOR THESE CASES BASED ON $\left(\frac{Q}{L}\right)\frac{MW}{ft\ width}$,

USE THE FORMULA:

$$(Q/A)_{℄}\ \frac{MW}{m^2} = 0.44989\ (Q/L)\ \frac{MW}{ft\ width}$$

SUB. PANEL 1

x/L	$\frac{Q}{L}\ \frac{MW}{ft}$ $.20 + 2.6\frac{x}{L} - .48\left(\frac{x}{L}\right)^2$	$\left(\frac{Q}{A}\right)_{℄}$ MW/m² $.44989\,(Q/L)$
0.05	.3288	.147923
0.15	.5792	.260575
0.25	.8200	.368903
0.35	1.0512	.472922
0.45	1.2728	.572617
0.55	1.4848	.667993
0.65	1.6872	.759051
0.75	1.8800	.845789
0.85	2.0632	.928209
0.95	2.2368	1.006309
0.0	.20	0.089976
0.25	.82	0.368908
0.50	1.38	0.620845
0.75	1.88	0.845789
1.0	2.32	1.043740

SUB. PANEL 2

x/L	$\frac{Q}{L}\ \frac{MW}{ft}$ $\{2.32 + 2.04\frac{x}{L} - 1.76\left(\frac{x}{L}\right)^2,\ 0 \le \frac{x}{L} \le 0.5$; $\{2.90$ for $\frac{x}{L} > .5$	$\left(\frac{Q}{A}\right)_{℄}\ \frac{MW}{m^2}$ $.44989\,(Q/L)$
.05	2.4176	1.087649
.15	2.5864	1.163590
.25	2.7200	1.223695
.35	2.8184	1.267964
.45	2.8816	1.296397
.50+ 1.0	2.90	1.304675
0	2.32	1.043740
.125	2.5472	1.145954
.25	2.72	1.223695
.375	2.8375	1.276557
.50	2.90	1.304675
1.0	2.90	1.304675

TABLE Add - II - 3 INTERPOLATION OF TUBE WALL MID-HEIGHT ΔT'S:

$\left(\frac{Q}{A}\right)_{℄} \rightarrow q$: $\frac{MW}{m^2}$ RANGE; ΔT℄ ↓	$0 \rightarrow 0.225 \frac{MW}{m^2}$	$0.225 \rightarrow 0.970 \frac{MW}{m^2}$	$0.970 \rightarrow 1.20$ AND ABOVE $\frac{MW}{m^2}$
A0021 $(\bar{T}_{MET} - T_{Na})_{℄}$	$A21 = 9.94 \frac{q}{.225}$	$A21 = 9.94 + (35.16 - 9.94)\left(\frac{q - .225}{.745}\right)$ (25.22) (.970 - .225)	$A21 = 35.16 + (41.74 - 35.16)\left(\frac{q - .97}{.23}\right)$ (1.20 - .97)
A0022 $(\Delta T_1)_{℄}$	$A22 = 33.133 \frac{q}{.225}$	$A22 = 33.133 + (117.57 - 33.133)\left(\frac{q - .225}{.745}\right)$ (84.437)	$A22 = 117.57 + (139.66 - 117.57)\left(\frac{q - .97}{.23}\right)$
A0023 $(T_{PEAK} - T_{Na})_{℄}$	$A23 = 43.17 \frac{q}{.225}$	$A23 = 43.17 + (160.50 - 43.17)\left(\frac{q - .225}{.745}\right)$ (117.33)	$A23 = 160.50 + (192.50 - 160.50)\left(\frac{q - .97}{.23}\right)$
A0024 $(T_{PEAK} - \bar{T}_{MET})_{℄}$	$A24 = 33.23 \frac{q}{.225}$	$A24 = 33.23 + (125.34 - 33.23)\left(\frac{q - .225}{.745}\right)$ (92.11)	$A24 = 125.34 + (150.76 - 125.34)\left(\frac{q - .97}{.23}\right)$
A0025 $(\Delta T_2)_{℄}$	$A25 = 16.662 \frac{q}{.225}$	$A25 = 16.662 + (66.558 - 16.662)\left(\frac{q - .225}{.745}\right)$ (49.896)	$A25 = 66.558 + (80.96 - 66.558)\left(\frac{q - .97}{.23}\right)$

BASED ON INTERPOLATION OF TUBE WALL ΔT'S OF 079TI000002, Page 37

TABLE Add-II-4
REFERENCE FLUX DISTRIBUTION: (Q/A)℄ & TUBE WALL ΔT's

REFERENCE FLUX DISTRIBUTION

STRESS MAP	LOCATION PANEL	LOCATION x/L	$(Q/A)_o$	A0021 $(\bar{T}_{MET}-T_{NA})$ ℄	A0022 ΔT_1 ℄	A0023 $(T_{PH}-T_{NA})$ ℄	A0024 $(T_{PH}-\bar{T}_{MET})$ ℄	A0025 ΔT_2 ℄
	1	0	0.225	9.94	33.133	43.17	33.23	16.662
*	1	.05	.26225	11.201	37.35485	49.0365	37.8355	19.1568
*	1	.15	.33675	13.723	45.79855	60.7695	47.0465	24.1464
*	1	.25	.41125	16.245	54.24225	72.5025	56.2575	29.136
*	1	.35	.48575	18.767	62.68595	84.2355	65.4685	34.1256
*	1	.45	.56025	21.289	71.12965	95.9685	74.6795	39.1152
*	1	.55	.63475	23.811	79.57335	107.7015	83.8905	44.1048
*	1	.65	.70925	26.333	88.01705	119.4345	93.1015	49.0944
*	1	.75	.78375	28.855	96.46075	131.1675	102.3125	54.084
*	1	.85	.85825	31.377	104.90445	142.9005	111.5235	59.0736
*	1	.95	.93275	33.899	113.34815	154.6335	120.7345	64.0632
	1	1.00	0.970	35.16	117.57	160.50	125.34	66.558
	2	0	0.970	35.16	117.57	160.50	125.34	66.558
*	2	.05	1.00725	36.22567	121.14762	165.68261	129.45693	68.89050
*	2	.15	1.08175	38.35702	128.30286	176.04783	137.69080	73.55549
*	2	.25	1.15625	40.48837	135.45810	186.413	145.92467	78.22050
*	2	$\frac{.230}{.745}$+	1.20	41.74	139.66	192.50	150.76	80.96

TABLE Add-II-5
OFF-NORMAL DISTRIBUTION:
$(Q/A)_{\text{℄}}$ & TUBE WALL ΔT's.

"OFF NORMAL FLUX DISTRIBUTION"

$$\left(\frac{Q}{A}\right)_{\text{℄}} \frac{MW}{m^2} = 0.449888 \left(\frac{Q}{L}\right) \frac{MW}{ft\ width}$$

STRESS MAP	LOCATION PANEL	x/L	(Q/L) MW/ft width	$(Q/A)_o$ MW/m²	A0021 $(\bar{T}_{MET} - T_{Na})$ ℄	A0022 ΔT_1 ℄	A0023 $(T_{PK} - T_{Na})$ ℄	A0024 $(T_{PK} - \bar{T}_{MET})$ ℄	A0025 ΔT_2 ℄
	1	0	0.20	0.089976	3.9749	13.250	17.263	13.288	6.6630
*	1	.05	0.3288	.147923	6.5349	21.783	28.381	21.847	10.954
*	1	.15	0.5792	.260575	11.1443	37.1650	48.7727	37.6284	19.0446
*	1	.25	0.8200	.368908	14.8116	49.4433	65.8341	51.0224	26.3002
*	1	.35	1.0512	.472922	18.3327	61.2321	82.2152	63.8825	33.26646
*	1	.45	1.2728	.572617	21.7076	72.5313	97.9162	76.2086	39.94349
*	1	.55	1.4848	.667993	24.9364	83.3411	112.937	88.0006	46.3313
*	1	.65	1.6872	.759051	28.0189	93.6614	127.278	99.2587	52.4298
*	1	.75	1.8800	.845789	30.9552	103.492	140.938	109.983	58.2390
*	1	.85	2.0632	.928209	33.7453	112.833	153.918	120.173	63.7590
*	1	.95	2.2368	1.006309	36.1988	121.057	165.552	129.353	68.8316
	1	1.00	2.32	1.043740	37.2696	124.652	170.759	133.490	71.1754
	2	0	2.32	1.043740	37.2696	124.652	170.759	133.490	71.1754
*	2	.05	2.4176	1.087649	38.5258	128.8694	176.869	138.343	73.9249
*	2	.15	2.5864	1.163590	40.69836	136.163	187.434	146.736	78.6801
*	2	.25	2.7200	1.223695	42.4179	141.936	195.7967	153.379	82.4437
*	2	.35	2.8184	1.267964	43.6844	146.187	201.9558	158.271	85.2157
*	2	.45	2.8816	1.296397	44.4978	148.918	205.912	161.414	86.9961
*	2	.554	2.90	1.304675	44.7346	149.713	207.063	162.329	87.51446

TABLE Add - II - 6

CASES TO CONSIDER:

$T_{Na_{IN}} = 610°F$

	ORIFICIED TUBES (FOR REFERENCE FLUX DIST)	NO ORIFICES
REFERENCE SOLAR FLUX DISTRIBUTION	CASE 1 (1) REF (Q/A); ORIFICED $\overline{T}_{Na_{OUT}} = 1050°F$	CASE 2 (2) REF (Q/A); NO ORIFICES $T_{Na_{OUT}}(Max) = 1100°F$
OFF-NORMAL FLUX DISTRIBUTION	CASE 3 (3) OFF NORMAL Q/A ORIFICIED (FOR REF FLUX) $\overline{T}_{Na\ out} = 1050°F$	CASE 4 (4) OFF NORMAL Q/A NO ORIFICES $T_{Na\ out}(Max) = 1100°F$

CASE 1 REFERENCE SOLAR FLUX DISTRIBUTION
ORIFICED FOR $T_{Na_{OUT}} = 1050°F$.

ALL TUBES: $\begin{cases} T_{IN_{Na}} = 610°F \\ T_{OUT_{Na}} = 1050°F \end{cases}$

ORIFICES TO BE DESIGNED SUCH THAT FOR REFERENCE SOLAR FLUX, ALL TUBES DISCHARGE AT $T_{Na} = 1050°F$. THUS, SODIUM FLOW RATE IN EACH INDIVIDUAL TUBE OF A SUB-PANEL IS PROPORTIONAL TO TOTAL SOLAR ENERGY INCIDENT ON TUBE (hence $\left(\frac{Q}{A}\right)_{℄}$).

SUB-PANEL 1

$$\left(\frac{Q}{A}\right)_{℄} = 0.225 + (.970 - .225)\left(\frac{x}{L}\right)$$

$$\left\{ \left(\frac{Q}{A}\right)_{℄} = 0.225 + 0.745\left(\frac{x}{L}\right) \quad \frac{MW}{m^2}\right.$$

SUB-PANEL 2

$$\left(\frac{Q}{A}\right)_{℄} = 0.97 + (1.20 - .97)\frac{\left(\frac{x}{L}\right)}{\frac{1.20-.97}{.97-.225}} =$$

$$\left(\frac{Q}{A}\right)_{℄} = 0.97 + 0.745\left(\frac{x}{L}\right) : \quad \text{For } 0 \le \frac{x}{L} \le \frac{.230}{.745} \approx .3087$$

$$\left(\frac{Q}{A}\right)_{℄} = 1.20 \quad \text{For } \frac{x}{L} \ge \frac{.230}{.745} = .3087$$

CASE 2

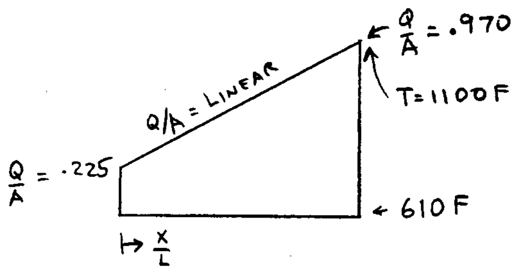
TABLE Add -II- 7

REFERENCE SOLAR FLUX DISTRIBUTION

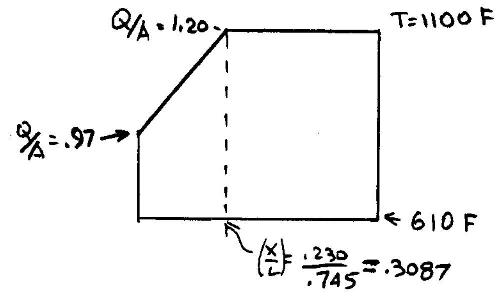
NO ORIFICES:

$T_{IN\,Na} = 610°F \qquad T_{OUT\,Na}\,(MAX) = 1100°F$

SUB·PANEL 1



SUB·PANEL 2



Sub-panel 1:

$$T_{Na\,OUT}\left(\frac{X}{L}\right) = 610 + (1100-610)\left(\frac{Q/A}{.970}\right)$$

(1100 − 610 = 490)

$$\text{But } \frac{Q}{A} = .225 + .745\left(\frac{X}{L}\right)$$

$$T_{Na\,OUT}\left(\frac{X}{L}\right) = 610 + \frac{490}{.970}\left(.225 + .745\frac{X}{L}\right)$$

Sub-panel 2:

$$T_{Na\,OUT} = 610 + 490\left(\frac{Q/A}{1.20}\right)$$

But $Q/A = .97 + .745\left(\frac{X}{L}\right)$ for $\frac{X}{L} \le .3087$

$Q/A = 1.20$ for $\frac{X}{L} \ge .3087$

$T_{Na\,OUT} = 610 + 490\left(\frac{.97 + .745\frac{X}{L}}{1.20}\right)$ for $\frac{X}{L} \le .3087$

$T_{Na\,OUT} = 1100°F$ for $\frac{X}{L} \ge .3087$

SUB·PANEL 1

$\left(\frac{X}{L}\right)$	$T_{Na\,OUT}$
0	723.660
.05	742.48
.15	780.11
.25	817.74
.35	855.38
.45	893.01
.55	930.65
.65	968.28
.75	1005.91
.85	1043.55
.95	1081.18
1.0	1100.0

SUB·PANEL 2

$\frac{X}{L}$	$T_{Na\,OUT}$
0	1006.08
.05	1021.29
.15	1051.71
.25	1082.14
.230/.745 = .3087 AND MORE	1100.0 ↓
1.0	1100.0

TABLE Add-II-8 (a)

CASE 3 — OFF NORMAL SOLAR FLUX DISTRIBUTION

ORIFICES AS DESIGNED FOR REFERENCE FLUX CASE

$T_{IN\,Na} = 610°F \quad \bar{T}_{OUT\,Na\,MEAN} = 1050°F \quad \delta T = 440°$

SUB·PANEL 1

$$T_{OUT\,Na}\left(\frac{x}{L}\right) = 610 + 440\left(\frac{\frac{(Q/L)(x/L)}{(Q/L)_{MEAN}}\ \text{OFF NORM}}{\frac{(Q/A)(x/L)}{(Q/A)_{MEAN}}\ \text{REF}}\right)$$

NOTE: $(Q/A)_{REF}$ is proportional to flow.

$$\frac{Q}{L}\left(\frac{x}{L}\right) = 0.20 + 2.6\left(\frac{x}{L}\right) - .48\left(\frac{x}{L}\right)^2 \quad \text{MW/FT} \quad \text{OFF·NORMAL}$$

$$\frac{Q}{L}\ (\text{MEAN}) = 1.34 \quad \text{MW/FT} \quad \text{OFF·NORMAL}$$

$$\frac{Q}{A}\left(\frac{x}{L}\right) = .225 + .745\left(\frac{x}{L}\right) \quad \text{MW/m}^2 \quad \text{REF}$$

$$\frac{Q}{A}\ (\text{MEAN}) = .5975 \quad \text{MW/m}^2 \quad \text{REF}$$

$$T_{OUT\,Na}\left(\frac{x}{L}\right) = 610 + 440\left(\frac{\frac{.20 + 2.6\left(\frac{x}{L}\right) - .48\left(\frac{x}{L}\right)^2}{1.34}}{\frac{.225 + .745\left(\frac{x}{L}\right)}{.5975}}\right) = 610 + 440\left(\frac{.5975}{1.34}\right)\left(\frac{.20 + 2.6\left(\frac{x}{L}\right) - .48\left(\frac{x}{L}\right)^2}{.225 + .745\left(\frac{x}{L}\right)}\right)$$

SUB·PANEL 1

$\frac{x}{L}$	$T_{Na\,OUT}$	Q/A (Proportional to $\dot{W}$)	$\dot{w}T$ ($Q/A * T_{Na\,OUT}$)
0	784.39		
.05	855.98	.26225	224.4811
.15	947.45	.33675	319.0531
.25	1001.20	.41125	411.7416
.35	1034.58	.48575	502.5467
.45	1055.72	.56025	591.4683
.55	1068.93	.63475	678.5064
.65	1076.72	.70925	763.6611
.75	1080.62	.78375	846.9322
.85	1081.64	.85825	928.3200
.95	1080.49	.93275	1007.8243
1.0	1079.25		
		Σ = 5.975	Σ = 6274.5348

$$\bar{T} = \frac{\Sigma \dot{w} T}{\Sigma \dot{w}}$$

$$\bar{T}_{Na\,OUT} = \frac{6274.5348}{5.975} = 1050.131°$$

(Should be 1050°F)

TABLE Add-II-8 (b)

CASE 3 CON'T — OFF NORMAL SOLAR FLUX DISTRIBUTION

ORIFICES AS DESIGNED FOR REF FLUX CASE

SUB·PANEL 2

$T_{Na_{IN}} = 610°$ $\quad \bar{T}_{Na_{OUT}}$ (MEAN) $= 1050°$

$$T_{OUT_{Na}}\left(\tfrac{X}{L}\right) = 610 + 440\left(\frac{\frac{(Q/L)(X/L)}{(Q/L)_{MEAN}}\ \text{OFF N}}{\frac{(Q/A)(X/L)}{(Q/A)_{MEAN}}\ \text{REF}}\right)$$

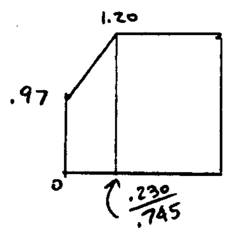
NOTE: $(Q/A)_{REF}$ is proportional to flow

$$\left\{\begin{array}{ll} \frac{Q}{L}\left(\frac{X}{L}\right) = 2.32 + 2.04\left(\frac{X}{L}\right) - 1.76\left(\frac{X}{L}\right)^2 & 0 \le \frac{X}{L} \le .5 \\ \frac{Q}{L}\left(\frac{X}{L}\right) = 2.90 & \frac{X}{L} \ge 0.5 \end{array}\right\} \text{OFF·NORMAL}$$

$$\left\{ \frac{Q}{L}(\text{MEAN}) = 2.791667 \right\} \text{OFF·NORMAL}$$

$$\left\{\begin{array}{ll} \frac{Q}{A}\left(\frac{X}{L}\right) = .97 + .745\frac{X}{L} & 0 \le \frac{X}{L} \le 0.3087 = \frac{.230}{.745} \\ \frac{Q}{A}\left(\frac{X}{L}\right) = 1.20 & \frac{X}{L} \ge .3087 \end{array}\right\} \text{REFERENCE}$$

$$\left\{ \frac{Q}{A}(\text{MEAN}) = 1.1644966 \right\} \text{REF}$$



$$\frac{230}{745}\left(\frac{.97+1.20}{2}\right) + \left(1 - \frac{230}{745}\right)(1.20) = 1.16449664 = Q/A(\text{MEAN})$$

$$T_{OUT_{Na}}\left(\tfrac{X}{L}\right) = 610 + 440\left(\frac{\frac{Q/L\,(X/L)}{2.79166}}{\frac{Q/A\,(X/L)}{1.164496}}\right) =$$

$$T_{OUT_{Na}} = 610 + 440\left(\frac{1.164496}{2.79166}\right)\left(\frac{Q/L\,(X/L)}{Q/A\,(X/L)}\right)$$

SUB·PANEL 2

X/L	Q/L	Q/A REF Proportional to $\dot{w}$	T_{Na} OUT	$\dot{w}T$ ($Q/A * T_{Na\,out}$)
(0)	(2.32)	(0.97)	(1048.98)	
.05	2.4176	1.00725	1050.529	1058.145
.15	2.5864	1.08175	1048.830	1134.572
.25	2.7200	1.15625	1041.762	1204.537
(.3087)	(2.782051)	(1.20)	(1035.5114)	
.35	2.8184	1.20	1041.071	1249.285
.45	2.8816	1.20	1050.737	1260.885
(.50)	(2.90)	(1.20)	(1053.552)	
.55	2.90	1.20	1053.552	1264.262
.65	2.90	1.20	"	"
.75	2.90	1.20	"	"
.85	2.90	1.20	"	"
.95	2.90	1.20	"	"
1.0	(2.90)	(1.20)	1053.552	
		Σ=11.64525 Exclude ( )		Σ=12228.734 Exclude ( )

$$\bar{T} = \frac{\Sigma \dot{w} T}{\Sigma \dot{w}}$$

$$\bar{T}_{Na_{OUT}} = \frac{12228.734}{11.64525} = 1050.105°$$

(Should be 1050°F)

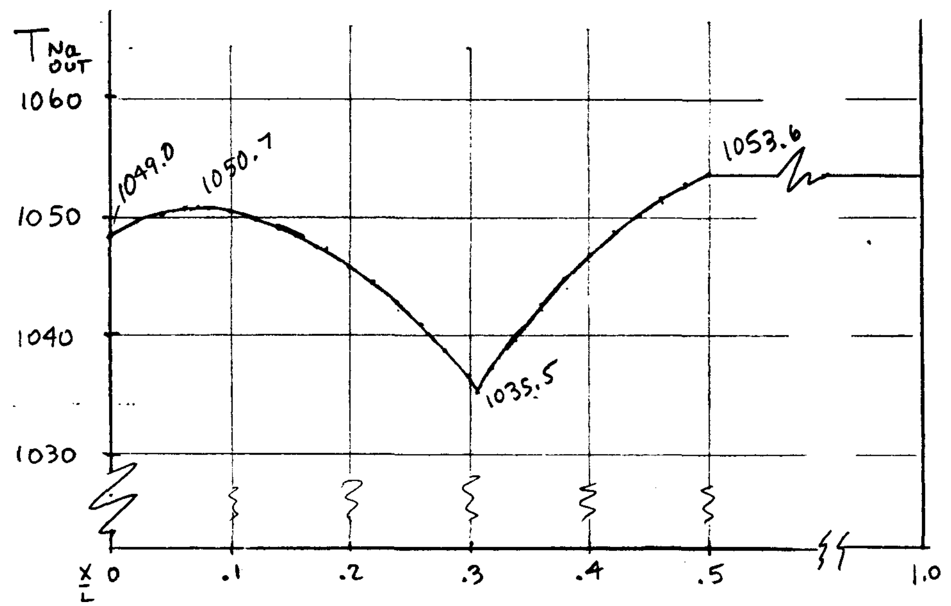
PREPARED BY: EMM	Rockwell International Energy Systems Group	PAGE NO. 100 OF
CHECKED BY:		Addendum to 079TI0000002 REPORT NO.
DATE:		MODEL NO.

CASE 3, CON'T — SUB·PANEL 2 — TABLE Add - II - 8 (c)

X/L	Q/L	Q/A	T_{Na} OUT
0	2.32	0.97	1048.98
.01	2.34022	.97745	1049.43
.02	2.36010	.9849	1049.81
.03	2.37962	.99235	1050.12
.04	2.39878	.9998	1050.36
.05	2.4176	1.00725	1050.53
.06	2.43606	1.0147	1050.63
.07	2.45418	1.02215	1050.675
.08	2.47194	1.0296	1050.65
.09	2.48934	1.03705	1050.57
.10	2.5064	1.0445	1050.42
.11			
.12	2.53946	1.0594	1049.96
.13			
.14	2.571104	1.0743	1049.26
.15	2.5804	1.08175	1048.83
.16	2.60134	1.0892	1048.35
.17	2.61594	1.09665	1047.81
.18	2.63018	1.1041	1047.22

X/L	Q/L	Q/A	T_{Na} OUT
.19	2.64406	1.11155	1046.59
.20	2.6576	1.119	1045.90
.21	2.67078	1.12645	1045.17
.22	2.68362	1.1339	1044.38
.23	2.69610	1.14135	1043.56
.24	2.708224	1.1488	1042.68
.25	2.72	1.15625	1041.76
.26	2.73142	1.1637	1040.80
.27	2.7425	1.17115	1039.79
.28	2.75322	1.1787	1038.75
.29	2.7636	1.1861	1037.66
.30	2.7736	1.1935	1036.53
230/745	2.78205	1.20	1035.511 (Min)
.31	2.78326	1.20	1035.70
.32	2.79258	"	1037.12
.33	2.80154	"	1038.49
.34	2.81014	"	1039.81
.35	2.8184	"	1041.07
.36	2.8263	"	1042.28

X/L	Q/L	Q/A	T_{Na} OUT
.37	2.83386	1.20	1043.44
.38	2.84106	"	1044.54
.39	2.84790	"	1045.58
.40	2.8544	"	1046.58
.41	2.86054	"	1047.52
.42	2.86634	"	1048.40
.43	2.871776	"	1049.24
.44	2.87686	"	1050.01
.45	2.8816	"	1050.74
.46	2.88598	"	1051.41
.47	2.89002	"	1052.03
.48	2.89370	"	1052.59
.49	2.89702	"	1053.1
.50	2.90	"	1053.55
↓	↓	↓	↓
1.0	2.90	1.20	1053.552



SUB·PANEL 2

TABLE Add - II -9

CASE 4 — OFF NORMAL SOLAR FLUX DISTRIBUTION

NO ORIFICES

$T_{IN_{Na}} = 610°F \quad T_{OUT_{Na\,Max}} = 1100°F$

SUB·PANEL 1

$$Q/L = 0.20 + 2.60\left(\frac{x}{L}\right) - .48\left(\frac{x}{L}\right)^2$$

$$T_{Na_{OUT}} = 610 + 490\left(\frac{Q/L}{2.32}\right)$$

$$T_{Na_{OUT}} = 610 + \frac{490}{2.32}\left(.20 + 2.6\frac{x}{L} - .48\left(\frac{x}{L}\right)^2\right)$$

$\frac{X}{L}$	$T_{Na_{OUT}}$
0	652.24
.05	679.44
.15	732.33
.25	783.19
.35	832.02
.45	878.82
.55	923.60
.65	966.35
.75	1007.07
.85	1045.76
.95	1082.43
1.0	1100.0

SUB·PANEL 2

$$\begin{cases} Q/L = 2.32 + 2.04\frac{x}{L} - 1.76\left(\frac{x}{L}\right)^2 & \text{For } 0 \le \frac{x}{L} \le .5 \\ Q/L = 2.90 & \text{For } \frac{x}{L} \ge .5 \end{cases}$$

$$T_{Na_{OUT}} = 610 + \frac{490}{2.90}\left(\frac{Q}{L}(x/L)\right)$$

$\frac{X}{L}$	$T_{Na_{OUT}}$
0	1002.00
.05	1018.49
.15	1047.01
.25	1069.59
$\frac{230}{745}$ = .3087	1080.07
.35	1086.21
.45	1096.89
.50 +	1100.00
↓	↓
1.0	1100.00

FIGURE
Add - II - 3

SODIUM OUTLET TEMPERATURE

$T_{IN_{Na}} = 610°F$

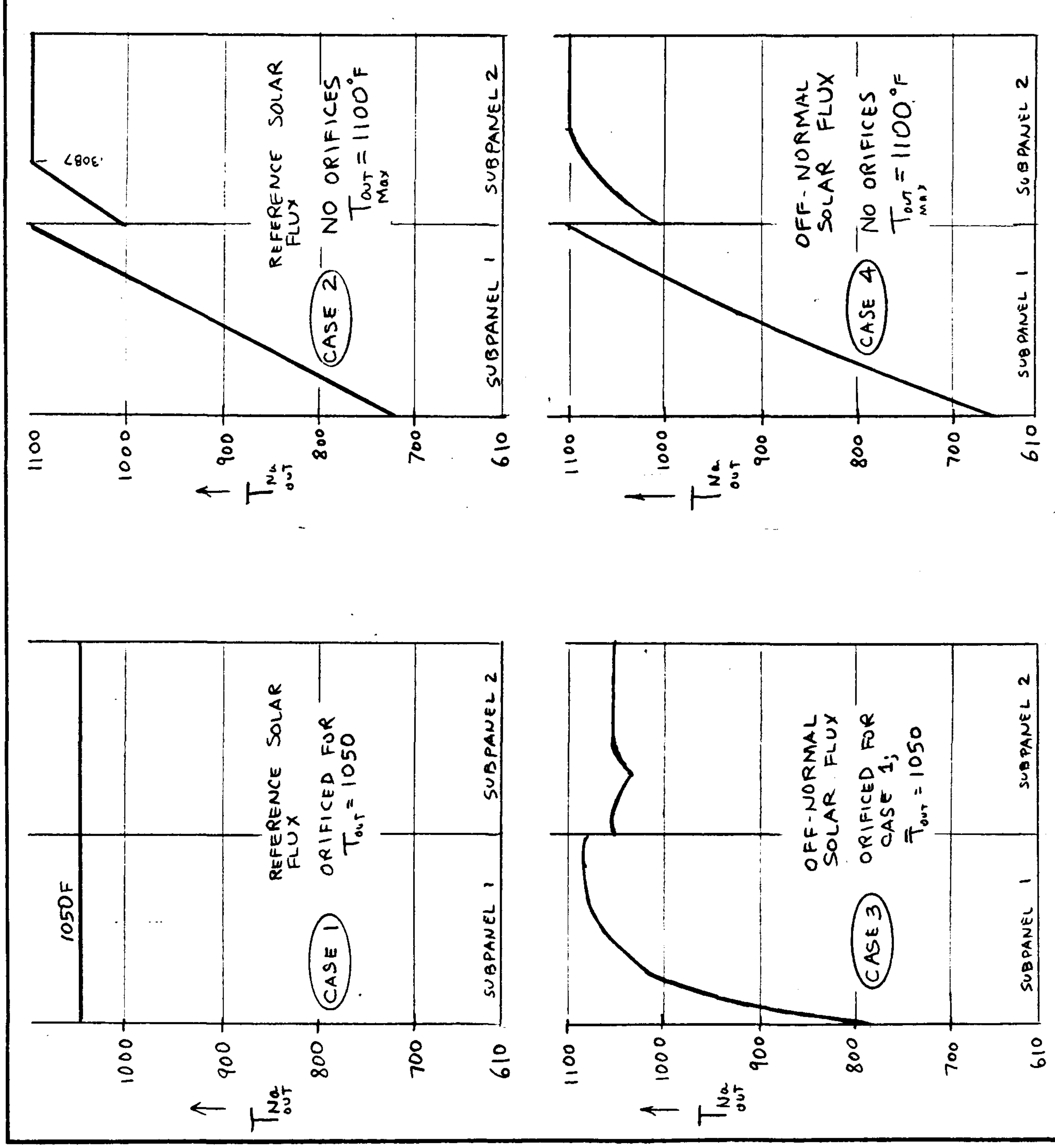


TABLE Add-II-10(a) PANEL TEMP DISTRIB LISTING

```
*0001

                    *** STAR 001 - TITLES & STORED COMMENTS

E M MOURADIAN       EXT 3320     LB30
678901234567890

     TAP-4S     SUPER TAP
        6903-(AB)       (500K)
                                                          (1)

TO DETERMINE TEMPERATURE DISTRIBUTION ON PANEL, BASED ON:
        NORMAL DISTRIBUTION AXIALLY: (S.D.=+-2).
        SODIUM INLET & OUTLET TEMPERATURES          A0001 & A0002
        MID HEIGHT VALUES OF:
             (T:BAR MET  -  T:NA)  . . . . . .  A0021
             (DT 1)                . . . . . .  A0022
             (T:PEAK  -  T:NA)     . . . . . .  A0023
             (T:PEAK  -  T:BAR MET). . . . . .  A0024
             (DT 2)                . . . . . .  A0025

   INPUT VALUES ARE:
       A0001 = T(NA:INLET)
       A0002 = T(NA:OUTLET)
       A0021 = ((T:BAR METAL) - (T:NA))      CL (aZ=20FT)
       A0022 = (DELTA T 1)                   CL (aZ=20FT)
       A0023 = ((T:PEAK) - (T:NA))           CL (aZ=20FT)
       A0024 = ((T:PEAK) - (T:BAR METAL))    CL (aZ=20FT)
       A0025 = (DELTA T 2)                   CL (aZ=20FT)
   DETERMINE SODIUM TEMPERATURE RISE:
       A0011 = DT:NA = T:NA(OUT) - T:NA(IN) = A0002 - A0001
   DETERMINE T:NA(Z):
       T:NA(Z) = T:NA(IN)  +  FRAC(Z)*DT:NA
       N(Z)    = A0001     +  F(Z)*A0011
   DETERMINE T:NA(AXIAL MEAN)
       T:NA(BAR) = (1/80)*(N0+N40) + (1/40)*(SUM N1 THRU N39)
           N101 = (1/2)*(N0000 + N0040)
           N102 = (SUM N0001 THRU N0039)
           N100 = (.025)*(N0101+N0102)
   DETERMINE T:METAL(BAR)(Z). . . MEAN METAL TEMPERATURE (Z)
     (CIRCUMFERENTIAL & RADIAL MEAN)
       T:MET(BAR)(Z) = T:NA(Z)  +  (NORM FACTOR)*(T:BR:M - T:NA)CL
       M(Z)          = N(Z)     +   0(Z)*A0021
   DETERMINE AXIALLY AVERAGED METAL TEMPERATURE:
     (CIRCUM & RADIAL & AXIAL MEAN)
       T:METAL(BAR,BAR) = T:NA(BAR)   + .59814*(T:BR:M - T:NA)CL
       M0100            = N0100       + .59814*A0021
       T:METAL(BAR,BAR) = (1/80)*(M0+M40) + (1/40)*(SUM M1 THRU M39
           M201 = (1/2)*(M0 + M40)
           M202 = (SUM M1 THRU M39)
           M200 = (.025)*(M201+M202)
   DETERMINE DELTA T 1  (Z)
       DT1(Z)  =   (NORM FACTOR)*(DT1)CL
       D(Z)    =   C(Z)*A0022
   DETERMINE DELTA T 2  (Z)
       DT2(Z)  =   (NORM FACTOR)*(DT2)CL
       E(Z)    =   C(Z)*A0025
   DETERMINE  T:FRONT(Z) & T:(BACK)Z
          (1/2)*DT1(Z) = D0100 THRU D0140
      T:FRONT(Z) = T:MET + (1/2)DT1
      G(Z)       = M(Z) +  D(100+Z)
      T:BACK(Z)  = T:MET - (1/2)DT1
      H(Z)       = M(Z)  - D(100+Z)
   DETERMINE PEAK METAL TEMP (Z)
      T:PEAK(Z)  =  T:NA(Z)  +  (NORM FACT)*(T:PK-T:NA)CL
      P(Z)       =  N(Z)     +  C(Z) * A0023
   DETERMINE:  (T:PK(Z) - T:MET(Z))  (Z)
      (T:P-T:M)(Z)  =  (NORM FACT) * (DT:PK-MET)CL
      R(Z)          =  0(Z) * A0024
      (T:P-T:M)(Z)  =  (1/2)DT1(Z) + DT2(Z)
      R(100+Z)      =  D(100+Z)    + E(Z)
      (T:P-T:M)(Z)  =  T:PK(Z) - T:M(Z)
      R(200+Z)      =  P(Z)  -  M(Z)

DUMMIES:
     A0001 = T:NA  INLET
     A0002 = T:NA  OUTLET
     A0011 = DT:NA     (OUT-IN) =  A2 - A1
     A0021 = (T:BR METAL - T:NA)     CL
     A0022 = (DT:1)     CL
     A0023 = (T:PEAK - T:NA)    CL
     A0024 = (T:PEAK - T:BR METAL)    CL
     A0025 = (DT:2)     CL
     C0000 - C0040 = CT(1)    (Z)
```

TABLE Add-II-10(b)

(2)

```
            D0100 - D0140 = DT(1)/2          (Z)                                   00240100
            E0000 - E0040 = DT(2)            (Z)                                   00250010
            F0000 - F0040 = FRACTION OF EFFECTIVE ENERGY ABSORBED                  00260011
                                FROM  Z=0 TO Z.        (Z)                         00260012
                                T:NA(Z) = T:NA(IN) + (DT:NA)*FRAC                  00260020
            G0000 - G0040 = T(FRONT)         (Z)                                   00270010
                    T(FRT) = T:BR MET + DT(1)/2                                    00270020
            H0000 - H0040 = T(BACK)          (Z)                                   00280010
                    T(BCK) = T:BR MET - DT(1)/2                                    00280020
            M0000 - M0040 = T:BR MET(Z).    MEAN TEMP OF METAL   (Z)               00330010
            M0100 = AXIAL AVERAGED METAL TEMPERATURE                               00330100
            M0200 = AXIAL AVERAGED METAL TEMPERATURE                               00330200
                        (AVERAGED BY O, R, & Z).                                   00330300
            N0000 - N0040 = T:NA (Z).   SODIUM TEMPERATURE   (Z)                   00340010
            N0100 = AXIAL AVERAGED SODIUM TEMPERATURE                              00340100
            O0000 - O0040 = O(Z).     NORMALIZED ALTITUDE OF                       00350011
                                  NORMAL DISTRIBUTION CURVE.                       00350012
            P0000 - P0040 = T:PEAK METAL     (Z)                                   00360010
            R0000 - R0040 = T:PK - T:BR MET     (Z)                                00380010
                        O*(DT:PK-MET)                                              00380011
            R0100 - R0140 = T:PK - T:BR MET     (Z)                                00380100
                        DT(1)/2  +  DT(2)                                          00380101
            R0200 - R0240 = T:PK - T:BR MET     (Z)                                00380200
                        T:PK - T:BR MET                                            00380202
            Z0000 - Z0040 = NODAL ALTITUDE (Z)          (FEET)                     00460010
                                                                                   00899999
        PROBLEM CASE:                                                              00900000
   1      *** (Q/A)CL=1.20MW/M2  T:NA(IN)=610F  T:NA(OUT)=1050F ************       00910010
   2      *** A21=41.74  A22=139.66  A23=192.5  A24=150.76  A25=80.98 ******       00910020
*0010                                                                              01000000
```

*** STAR 010 - STATIC NETWORK DESCRIPTION

Y	1	0	0	1.0000	.0	T 1	T 2	0	0	1		01000100
Y	2	0	0	9.0000	.0	T 2	T 3	0	0	1		01000200
*0020												02000000

*** STAR 020 - INITIALIZATION & CONSTANT DATA

A	1	0	0	610.00	.0	0	0	0	0	1	T(NA-IN)	02100010
A	2	0	0	1050.0	.0	0	0	0	0	1	T(NA-OUT)	02100020
A	21	0	0	41.740	.0	0	0	0	0	1	DT:(MET-BR)-(NA)	02100210
A	22	0	0	139.66	.0	0	0	0	0	1	DT1 CL	02100220
A	23	0	0	192.50	.0	0	0	0	0	1	DT:(PK)-(NA) CL	02100230
A	24	0	0	150.76	.0	0	0	0	0	1	DT:(PK)-(MET-BR)	02100240
A	25	0	0	80.980	.0	0	0	0	0	1	DT2 CL	02100250
Z	0 Z 40	0		.0	1.0000	0	0	0	0	1		02740000
F	0	0	0	.0	.0	0	0	0	0	1		02750000
F	1	0	0	6.2510E-03	.0	0	0	0	0	1		02750010
F	2	0	0	1.3808E-02	.0	0	0	0	0	1		02750020
F	3	0	0	2.2855E-02	.0	0	0	0	0	1		02750030
F	4	0	0	3.3577E-02	.0	0	0	0	0	1		02750040
F	5	0	0	4.6157E-02	.0	0	0	0	0	1		02750050
F	6	0	0	6.0772E-02	.0	0	0	0	0	1		02750060
F	7	0	0	7.7580E-02	.0	0	0	0	0	1		02750070
F	8	0	0	9.6720E-02	.0	0	0	0	0	1		02750080
F	9	0	0	.11830	.0	0	0	0	0	1		02750090
F	10	0	0	.14238	.0	0	0	0	0	1		02750100
F	11	0	0	.16900	.0	0	0	0	0	1		02750110
F	12	0	0	.19812	.0	0	0	0	0	1		02750120
F	13	0	0	.22966	.0	0	0	0	0	1		02750130
F	14	0	0	.26349	.0	0	0	0	0	1		02750140
F	15	0	0	.29941	.0	0	0	0	0	1		02750150
F	16	0	0	.33717	.0	0	0	0	0	1		02750160
F	17	0	0	.37647	.0	0	0	0	0	1		02750170
F	18	0	0	.41696	.0	0	0	0	0	1		02750180
F	19	0	0	.45827	.0	0	0	0	0	1		02750190
F	20	0	0	.50000	.0	0	0	0	0	1		02750200
F	21	0	0	.54173	.0	0	0	0	0	1		02750210
F	22	0	0	.58304	.0	0	0	0	0	1		02750220
F	23	0	0	.62353	.0	0	0	0	0	1		02750230
F	24	0	0	.66283	.0	0	0	0	0	1		02750240
F	25	0	0	.70059	.0	0	0	0	0	1		02750250
F	26	0	0	.73651	.0	0	0	0	0	1		02750260
F	27	0	0	.77034	.0	0	0	0	0	1		02750270
F	28	0	0	.80188	.0	0	0	0	0	1		02750280
F	29	0	0	.83100	.0	0	0	0	0	1		02750290
F	30	0	0	.85762	.0	0	0	0	0	1		02750300
F	31	0	0	.88170	.0	0	0	0	0	1		02750310
F	32	0	0	.90328	.0	0	0	0	0	1		02750320
F	33	0	0	.92242	.0	0	0	0	0	1		02750330
F	34	0	0	.93923	.0	0	0	0	0	1		02750340
F	35	0	0	.95384	.0	0	0	0	0	1		02750350
F	36	0	0	.96642	.0	0	0	0	0	1		02750360
F	37	0	0	.97715	.0	0	0	0	0	1		02750370
F	38	0	0	.98619	.0	0	0	0	0	1		02750380
F	39	0	0	.99375	.0	0	0	0	0	1		02750390
F	40	0	0	1.0000	.0	0	0	0	0	1		02750400

TABLE Add-II-10 (c)

(3)

```
0   0 0  40    0   .13534     .0           0    0    0    0   40         02760000
0   1 0  39    0   .16447     .0           0    0    0    0   38         02760010
0   2 0  38    0   .19790     .0           0    0    0    0   36         02760020
0   3 0  37    0   .23575     .0           0    0    0    0   34         02760030
0   4 0  36    0   .27804     .0           0    0    0    0   32         02760040
0   5 0  35    0   .32465     .0           0    0    0    0   30         02760050
0   6 0  34    0   .37531     .0           0    0    0    0   28         02760060
0   7 0  33    0   .42556     .0           0    0    0    0   26         02760070
0   8 0  32    0   .48675     .0           0    0    0    0   24         02760080
0   9 0  31    0   .54607     .0           0    0    0    0   22         02760090
0  10 0  30    0   .60653     .0           0    0    0    0   20         02760100
0  11 0  29    0   .66698     .0           0    0    0    0   18         02760110
0  12 0  28    0   .72615     .0           0    0    0    0   16         02760120
0  13 0  27    0   .78271     .0           0    0    0    0   14         02760130
0  14 0  26    0   .83527     .0           0    0    0    0   12         02760140
0  15 0  25    0   .88250     .0           0    0    0    0   10         02760150
0  16 0  24    0   .92312     .0           0    0    0    0    8         02760160
0  17 0  23    0   .95600     .0           0    0    0    0    6         02760170
0  18 0  22    0   .98020     .0           0    0    0    0    4         02760180
0  19 0  21    0   .99501     .0           0    0    0    0    2         02760190
0  20     0    0   1.0000     .0           0    0    0    0    1         02760200
T   1     0   -1   .0         .0           0    0    0    0    1         02950010
T   2     0    0   500.00     .0           0    0    0    0    1         02950020
T   3     0   -1   1000.0     .0           0    0    0    0    1         02950030
*0030                                                                    03000000
```

*** STAR 030 - FUNCTION STATEMENTS

```
 1 A  11     0 151  .0     1.0000      A   2 A   1   0   0   1 T:NA(OUT-IN)      03100100
 2 N   0 N  40 152  .0     1.0000      F   0 A  11   1   0   1                   03120110
 3 N   0 N  40 150  .0     1.0000      N   0 A   1   1   0   1 T:NA(Z)           03120120
 4 N 101     0 150  .0     .50000      N   0 N  40   0   0   1                   03120310
 5 N 102     0 161  .0     1.0000      N   1 N  39   0   0   1                   03120320
 6 N 100     0 150  .0     2.5000E-02  N 101 N 102   0   0   1 T:NA  BAR         03120330
 7 M   0 M  40 152  .0     1.0000      0   0 A  21   1   0   1                   03150110
 8 M   0 M  40 150  .0     1.0000      M   0 N   0   1   1   1 T:BR MET (Z)      03150120
 9 M 100     0 101  .0     .59814      A  21     0   0   0   1                   03150310
10 M 100     0 150  .0     1.0000      M 100 N 100   0   0   1 T:BR BR MET       03150320
11 M 201     0 150  .0     .50000      M   0 M  40   0   0   1                   03160110
12 M 202     0 161  .0     1.0000      M   1 M  39   0   0   1                   03160120
13 M 200     0 150  .0     2.5000E-02  M 201 M 202   0   0   1 T:BR BR MET       03160130
14 D   0 D  40 152  .0     1.0000      0   0 A  22   1   0   1 DT1 (Z)           03180110
15 D 100 D 140 101  .0     .50000      0   0     0   1   0   1 DT1/2    (Z)      03180120
16 E   0 E  40 152  .0     1.0000      0   0 A  25   1   0   1 DT2      (Z)      03180210
17 G   0 G  40 150  .0     1.0000      M   0 D 100   1   1   1 T(FRONT)  (Z)     03210100
18 H   0 H  40 151  .0     1.0000      M   0 D 100   1   1   1 T(BACK)   (Z)     03210200
19 P   0 P  40 152  .0     1.0000      0   0 A  23   1   0   1                   03250110
20 P   0 P  40 150  .0     1.0000      P   0 N   0   1   1   1 T(PEAK)   (Z)     03250120
21 R   0 R  40 152  .0     1.0000      0   0 A  24   1   0   1 T:PK - T:MET   Z  03280100
22 R 100 R 140 150  .0     1.0000      D 100 E   0   1   1   1 T:PK - T:MET   Z  03280200
23 R 200 R 240 151  .0     1.0000      P   0 M   0   1   1   1 T:PK - T:MET   Z  03280300
   *0070                                                                         07000000
```

*** STAR 070 - SPECIAL CONTROL CONSTANTS

```
    5                1.0000   0. = TRANSIENT: +1. = STEADY STATE                 07000050
    6                1.0000   +1=   DUMP Y,T,C,Q, & DUMMIES AT END OF CASE       07000060
   19                1.0000   +1.0 - TAPOUT ENTRIES ON SEPARATE TITLED PAGE      07000190
*0080                                                                            08000000
```

*** STAR 080 - PRINTOUT SPECIFICATIONS

```
A   1     0    1   .0      .0          0    0    0    0    1 T:NA IN       08101010
A   2     0    1   .0      .0          0    0    0    0    1 T:NA OUT      08101020
A  11     0    1   .0      .0          0    0    0    0    1 DT: NA        08101030
N 100     0    1   .0      .0          0    0    0    0    1 T:B NA        08101040
M 100     0    1   .0      .0          0    0    0    0    1 T:B M         08101050
A  21     0    1   .0      .0          0    0    0    0    1 DT M-N        08102010
A  22     0    1   .0      .0          0    0    0    0    1 DT1           08102020
A  23     0    1   .0      .0          0    0    0    0    1 DT P-N        08102030
A  24     0    1   .0      .0          0    0    0    0    1 DT P-M        08102040
A  25     0    1   .0      .0          0    0    0    0    1 DT2           08102050
B   1 B   5    1   .0      .0          0    0    0    0    1               08300101
N   0 N  40    0   .0      .0          0    0    0    0    1               08300200
B   1 B   9    1   .0      .0          0    0    0    0    1               08300210
M   0 M  40    0   .0      .0          0    0    0    0    1               08300300
B   1 B   9    1   .0      .0          0    0    0    0    1               08300310
P   0 P  40    0   .0      .0          0    0    0    0    1               08300400
B   1 B   9    1   .0      .0          8    0    0    0    1               08300410
G   0 G  40    0   .0      .0          0    0    0    0    1               08300500
B   1 B   9    1   .0      .0          0    0    0    0    1               08300510
H   1 H  40    0   .0      .0          0    0    0    0    1               08300600
B   1 B   4    1   .0      .0          0    0    0    0    1               08300610
*0090                                                                      09000000
```

*** STAR 090 - PRINTOUT & STOP TIMES

```
    0      0      0    .0          2.0000       0      0     0     0    1      09000100
    0      0      0    2.0000      .0           0      0     0     0    1      09000200
 *0096                                                                          09600000
```

TABLE Add - II -10(d)

```
*0001                                                                        10200001

                      *** STAR 001 - TITLES & STORED COMMENTS

    1     *** (Q/A)CL=0.97MW/M2  T:NA(IN)=610F  T:NA(OUT)=1050F ************    10200010
    2     *** A21=35.16  A22=117.57  A23=160.5  A24=125.34  A25=66.558 *****     10200020
*0020                                                                        10202000

                      *** STAR 020 - INITIALIZATION & CONSTANT DATA                (4)

A    1    0    0    610.00      .0           0    0    0    0    1           10202010
A    2    0    0    1050.0      .0           0    0    0    0    1           10202020
A   21    0    0    35.160      .0           0    0    0    0    1           10202210
A   22    0    0    117.57      .0           0    0    0    0    1           10202220
A   23    0    0    160.50      .0           0    0    0    0    1           10202230
A   24    0    0    125.34      .0           0    0    0    0    1           10202240
A   25    0    0    66.558      .0           0    0    0    0    1           10202250
*0070                                                                        10207000

                      *** STAR 070 - SPECIAL CONTROL CONSTANTS

   11               1.0000       NODE SUMMARY: +1.0=NO PRINT:- 1.0= NO COMPILE  10207011
*0096                                                                        10209600


*0001                                                                        10300001

                      *** STAR 001 - TITLES & STORED COMMENTS

    1     *** (Q/A)CL=0.225MW/M2 T:NA(IN)=610F  T:NA(OUT)=1050F ************    10300010
    2     *** A21=9.94   A22=33.133  A23=43.17  A24=33.23   A25=16.662 *****     10300020
*0020                                                                        10302000

                      *** STAR 020 - INITIALIZATION & CONSTANT DATA

A    1    0    0    610.00      .0           0    0    0    0    1           10302010
A    2    0    0    1050.0      .0           0    0    0    0    1           10302020
A   21    0    0    9.9400      .0           0    0    0    0    1           10302210
A   22    0    0    33.133      .0           0    0    0    0    1           10302220
A   23    0    0    43.170      .0           0    0    0    0    1           10302230
A   24    0    0    33.230      .0           0    0    0    0    1           10302240
A   25    0    0    16.662      .0           0    0    0    0    1           10302250
*0096                                                                        10309600
```

TABLE Add - II - 11

PANEL TEMPERATURE DISTRIBUTION

T:NA IN Sodium Inlet Temp (A0001)	T:NA OUT Sodium Outlet Temp (A0002)	DT:NA ($T_{Na_{OUT}} - T_{Na_{IN}}$) (A0011)	$\bar{T}$:B NA Axially Averaged Sodium Temp (N0100)	$\bar{T}$:B M Overall Averaged Metal Temp (z, θ, R) (M0100)
DT M-N ($\bar{T}_{MET} - T_{NA}$) ℄ (A0021)	DT1 ΔT_1 ℄ (A0022)	DT P-N ($T_{Peak} - T_{NA}$) ℄ (A0023)	DT P-M ($T_{Peak} - \bar{T}_{MET}$) ℄ (A0024)	DT2 ΔT_2 ℄ (A0025)

N Sodium Temperature (at elevation Z)

M Mean Metal Temp (Circum & Radial) (at elevation Z)

P Peak Metal Temperature (at elevation Z)

G "Front" Temperature = T(mean) + (ΔT1/2) (at elev Z)

H "Back" Temperature = T(mean) - (ΔT1/2) (at elev Z)

Number (Z): Elevation on active panel (feet).
Example: M0027 = Mean Metal Temp, 27 feet above the bottom of active panel.

PANEL TEMPERATURE DISTRIBUTION

CASE 1
SET 1   Subpanel 1

Solar Flux Distribution: REFERENCE

Orifices: Yes: Orificed to match tube flow rates to reference flux distribution

Sodium Temperatures: T (Na-Inlet) = 610°F
T (Na-Outlet) = 1050°F (all tubes)

5370F/sjh

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 1
Location x/L: 0.05
T(Na-inlet) = 610 F
T(Na-outlet) : 1050F

PANEL 1 LOC=.05 T:NA(IN)=610F T:NA(OUT)=1050F
A21=11.201 A22= 37.355 A23= 49.037 A24= 37.836 A25=19.157

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	836.70
DT M-N =	11.201	DT1 =	37.355	DT P-N =	49.037	DT P=M =	37.836	DT2 =	19.157
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.74	N 7 =	644.14	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	611.52	M 1 =	614.59	M 2 =	618.29	M 3 =	622.70	M 4 =	627.89
M 5 =	633.95	M 6 =	640.94	M 7 =	648.95	M 8 =	658.01	M 9 =	668.17
M 10 =	679.44	M 11 =	691.83	M 12 =	705.31	M 13 =	719.82	M 14 =	735.29
M 15 =	751.63	M 16 =	768.69	M 17 =	786.35	M 18 =	804.64	M 19 =	822.79
M 20 =	841.20	M 21 =	859.50	M 22 =	877.52	M 23 =	895.06	M 24 =	911.99
M 25 =	928.14	M 26 =	943.42	M 27 =	957.72	M 28 =	970.96	M 29 =	983.11
M 30 =	994.14	M 31 =	1004.1	M 32 =	1012.9	M 33 =	1020.7	M 34 =	1027.5
M 35 =	1033.3	M 36 =	1038.3	M 37 =	1042.6	M 38 =	1046.1	M 39 =	1049.1
M 40 =	1051.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
=	616.64	P 1 =	620.82	P 2 =	625.78	P 3 =	631.62	P 4 =	638.41
5 =	646.23	P 6 =	655.14	P 7 =	665.20	P 8 =	676.43	P 9 =	688.83
10 =	702.39	P 11 =	717.07	P 12 =	732.78	P 13 =	749.43	P 14 =	766.90
P 15 =	785.02	P 16 =	803.62	P 17 =	822.52	P 18 =	841.53	P 19 =	860.43
P 20 =	879.04	P 21 =	897.15	P 22 =	914.60	P 23 =	931.23	P 24 =	946.91
P 25 =	961.53	P 26 =	975.02	P 27 =	987.33	P 28 =	998.44	P 29 =	1008.3
P 30 =	1017.1	P 31 =	1024.7	P 32 =	1031.3	P 33 =	1036.9	P 34 =	1041.7
P 35 =	1045.6	P 36 =	1048.9	P 37 =	1051.5	P 38 =	1053.6	P 39 =	1055.3
P 40 =	1056.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	614.04	G 1 =	617.66	G 2 =	621.99	G 3 =	627.10	G 4 =	633.08
G 5 =	640.01	G 6 =	647.95	G 7 =	656.97	G 8 =	667.10	G 9 =	678.37
G 10 =	690.77	G 11 =	704.29	G 12 =	718.87	G 13 =	734.44	G 14 =	750.89
G 15 =	768.11	G 16 =	785.94	G 17 =	804.21	G 18 =	822.75	G 19 =	841.37
G 20 =	859.88	G 21 =	878.09	G 22 =	895.82	G 23 =	912.92	G 24 =	929.23
G 25 =	944.63	G 26 =	959.02	G 27 =	972.33	G 28 =	984.52	G 29 =	995.57
G 30 =	1005.5	G 31 =	1014.3	G 32 =	1022.0	G 33 =	1028.7	G 34 =	1034.5
G 35 =	1039.4	G 36 =	1043.5	G 37 =	1047.0	G 38 =	1049.8	G 39 =	1052.2
G 40 =	1054.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	611.52	H 2 =	614.60	H 3 =	618.29	H 4 =	622.69	H 5 =	627.88
H 6 =	633.93	H 7 =	640.92	H 8 =	648.92	H 9 =	657.97	H 10 =	668.11
H 11 =	679.37	H 12 =	691.74	H 13 =	705.20	H 14 =	719.69	H 15 =	735.14
H 16 =	751.45	H 17 =	768.50	H 18 =	786.13	H 19 =	804.20	H 20 =	822.52
H 21 =	840.92	H 22 =	859.21	H 23 =	877.21	H 24 =	894.74	H 25 =	911.66
H 26 =	927.82	H 27 =	943.10	H 28 =	957.40	H 29 =	970.65	H 30 =	982.82
H 31 =	993.87	H 32 =	1003.8	H 33 =	1012.7	H 34 =	1020.5	H 35 =	1027.3
H 36 =	1033.1	H 37 =	1038.2	H 38 =	1042.4	H 39 =	1046.0	H 40 =	1049.0
=	.0	=	.0	=	.0	=	.0		

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 1
Location x/L: 0.15
T(Na-inlet) = 610 F
T(Na-outlet) : 1050F

PANEL 1 LOC=.15 T:NA(IN)=610F T:NA(OUT)=1050F
A21=13.723 A22= 45.799 A23= 60.770 A24= 47.047 A25=24.146

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	838.21
DT M-N =	13.723	DT1 =	45.799	DT P-N =	60.770	DT P-M =	47.047	DT2 =	24.146
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.74	N 7 =	644.14	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	611.86	M 1 =	615.01	M 2 =	618.79	M 3 =	623.29	M 4 =	628.59
M 5 =	634.76	M 6 =	641.89	M 7 =	650.03	M 8 =	659.24	M 9 =	669.55
M 10 =	680.97	M 11 =	693.51	M 12 =	707.14	M 13 =	721.79	M 14 =	737.40
M 15 =	753.85	M 16 =	771.02	M 17 =	788.76	M 18 =	806.91	M 19 =	825.29
M 20 =	843.72	M 21 =	862.01	M 22 =	879.99	M 23 =	897.47	M 24 =	914.31
M 25 =	930.37	M 26 =	945.53	M 27 =	959.69	M 28 =	972.79	M 29 =	984.79
M 30 =	995.67	M 31 =	1005.4	M 32 =	1014.1	M 33 =	1021.8	M 34 =	1028.4
M 35 =	1034.1	M 36 =	1039.0	M 37 =	1043.2	M 38 =	1046.6	M 39 =	1049.5
M 40 =	1051.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	618.22	P 1 =	622.75	P 2 =	628.10	P 3 =	634.38	P 4 =	641.67
P 5 =	650.04	P 6 =	659.55	P 7 =	670.24	P 8 =	682.14	P 9 =	695.24
P 10 =	709.51	P 11 =	724.89	P 12 =	741.30	P 13 =	758.62	P 14 =	776.70
P 15 =	795.37	P 16 =	814.45	P 17 =	833.74	P 18 =	853.03	P 19 =	872.11
P 20 =	890.77	P 21 =	908.83	P 22 =	926.10	P 23 =	942.45	P 24 =	957.74
P 25 =	971.89	P 26 =	984.82	P 27 =	996.51	P 28 =	1007.0	P 29 =	1016.2
P 30 =	1024.2	P 31 =	1031.1	P 32 =	1037.0	P 33 =	1042.0	P 34 =	1046.1
P 35 =	1049.4	P 36 =	1052.1	P 37 =	1056.3	P 38 =	1056.0	P 39 =	1057.2
P 40 =	1058.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	614.96	G 1 =	618.77	G 2 =	623.32	G 3 =	628.69	G 4 =	634.96
G 5 =	642.20	G 6 =	650.48	G 7 =	659.87	G 8 =	670.38	G 9 =	682.05
G 10 =	694.86	G 11 =	708.79	G 12 =	723.77	G 13 =	739.72	G 14 =	756.53
G 15 =	774.06	G 16 =	792.16	G 17 =	810.66	G 18 =	829.36	G 19 =	848.08
G 20 =	866.62	G 21 =	884.80	G 22 =	902.43	G 23 =	919.36	G 24 =	935.45
G 25 =	950.58	G 26 =	964.65	G 27 =	977.61	G 28 =	989.42	G 29 =	1000.1
G 30 =	1009.6	G 31 =	1017.9	G 32 =	1025.3	G 33 =	1031.6	G 34 =	1037.0
G 35 =	1041.6	G 36 =	1045.4	G 37 =	1048.6	G 38 =	1051.2	G 39 =	1053.3
G 40 =	1055.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0		
H 1 =	611.24	H 2 =	614.26	H 3 =	617.89	H 4 =	622.22	H 5 =	627.33
H 6 =	633.30	H 7 =	640.19	H 8 =	648.09	H 9 =	657.04	H 10 =	667.08
H 11 =	678.24	H 12 =	690.51	H 13 =	703.87	H 14 =	718.27	H 15 =	733.64
H 16 =	749.88	H 17 =	766.87	H 18 =	784.47	H 19 =	802.51	H 20 =	820.82
H 21 =	839.23	H 22 =	857.54	H 23 =	875.58	H 24 =	893.17	H 25 =	910.16
H 26 =	926.40	H 27 =	941.77	H 28 =	956.16	H 29 =	969.52	H 30 =	981.78
H 31 =	992.94	H 32 =	1003.0	H 33 =	1011.9	H 34 =	1019.8	H 35 =	1026.7
H 36 =	1032.7	H 37 =	1037.8	H 38 =	1042.1	H 39 =	1045.7	H 40 =	1048.8
=	.0	=	.0	=	.0	=	.0		

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 1
Location x/L: .25
T(Na-inlet) = 610 F
T(Na-outlet) : 1050 F

PANEL 1 LOC=.25 T:NA(IN)=610F T:NA(OUT)=1050F
A21=16.245 A22= 54.242 A23= 72.503 A24= 56.258 A25=29.136

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	839.71
DT M-N =	16.245	DT1 =	54.242	DT P-N =	72.503	DT P-M =	56.258	DT2 =	29.136
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.74	N 7 =	644.14	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	612.20	M 1 =	615.42	M 2 =	619.29	M 3 =	623.89	M 4 =	629.29
M 5 =	635.58	M 6 =	642.84	M 7 =	651.11	M 8 =	660.46	M 9 =	670.92
M 10 =	682.50	M 11 =	695.19	M 12 =	708.97	M 13 =	723.77	M 14 =	739.51
M 15 =	756.08	M 16 =	773.35	M 17 =	791.18	M 18 =	809.39	M 19 =	827.80
M 20 =	846.24	M 21 =	864.52	M 22 =	882.46	M 23 =	899.88	M 24 =	916.64
M 25 =	932.59	M 26 =	947.63	M 27 =	961.66	M 28 =	974.62	M 29 =	986.47
M 30 =	997.20	M 31 =	1006.8	M 32 =	1015.4	M 33 =	1022.8	M 34 =	1029.4
M 35 =	1035.0	M 36 =	1039.7	M 37 =	1043.8	M 38 =	1047.1	M 39 =	1049.9
M 40 =	1052.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
=	619.81	P 1 =	624.68	P 2 =	630.42	P 3 =	637.15	P 4 =	644.93
5 =	653.85	P 6 =	663.95	P 7 =	675.28	P 8 =	687.85	P 9 =	701.64
10 =	716.62	P 11 =	732.72	P 12 =	749.82	P 13 =	767.80	P 14 =	786.50
P 15 =	805.72	P 16 =	825.28	P 17 =	844.96	P 18 =	864.53	P 19 =	883.78
P 20 =	902.50	P 21 =	920.50	P 22 =	937.60	P 23 =	953.67	P 24 =	968.57
P 25 =	982.24	P 26 =	994.62	P 27 =	1005.7	P 28 =	1015.5	P 29 =	1024.0
P 30 =	1031.3	P 31 =	1037.5	P 32 =	1042.7	P 33 =	1047.0	P 34 =	1050.5
P 35 =	1053.2	P 36 =	1055.4	P 37 =	1057.0	P 38 =	1058.3	P 39 =	1059.2
P 40 =	1059.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	615.87	G 1 =	619.88	G 2 =	624.66	G 3 =	630.28	G 4 =	636.83

G 5 =	644.39	G 6 =	653.02	G 7 =	662.76	G 8 =	673.67	G 9 =	685.73
G 10 =	698.95	G 11 =	713.28	G 12 =	728.66	G 13 =	744.99	G 14 =	762.16
G 15 =	780.01	G 16 =	798.39	G 17 =	817.10	G 18 =	835.97	G 19 =	854.79
G 20 =	873.37	G 21 =	891.51	G 22 =	909.04	G 23 =	925.81	G 24 =	941.68
G 25 =	956.53	G 26 =	970.29	G 27 =	982.89	G 28 =	994.32	G 29 =	1004.6
G 30 =	1013.7	G 31 =	1021.6	G 32 =	1028.6	G 33 =	1034.5	G 34 =	1039.5
G 35 =	1043.8	G 36 =	1047.3	G 37 =	1050.2	G 38 =	1052.5	G 39 =	1054.4
G 40 =	1055.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	610.96	H 2 =	613.92	H 3 =	617.49	H 4 =	621.75	H 5 =	626.78
H 6 =	632.66	H 7 =	639.46	H 8 =	647.26	H 9 =	656.11	H 10 =	666.05
H 11 =	677.11	H 12 =	689.27	H 13 =	702.54	H 14 =	716.85	H 15 =	732.14
H 16 =	748.31	H 17 =	765.25	H 18 =	782.80	H 19 =	800.82	H 20 =	819.12
H 21 =	837.54	H 22 =	855.88	H 23 =	873.96	H 24 =	891.61	H 25 =	908.66
H 26 =	924.98	H 27 =	940.44	H 28 =	954.93	H 29 =	968.39	H 30 =	980.75
H 31 =	992.01	H 32 =	1002.1	H 33 =	1011.2	H 34 =	1019.2	H 35 =	1026.2
H 36 =	1032.2	H 37 =	1037.4	H 38 =	1041.8	H 39 =	1045.5	H 40 =	1048.5
=	.0	=	.0	=	.0	=	.0		

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 1
Location x/L: 0.35
T(Na-inlet) = 610 F
T(Na-outlet) : 1050F

PANEL 1 LOC=.35 T:NA(IN)=610F T:NA(OUT)=1050F
A21=18.767 A22= 62.686 A23= 84.236 A24= 65.469 A25=34.126

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	841.22
DT M-N =	18.767	DTI =	62.686	DT P-N =	84.236	DT P-M =	65.469	DT2 =	34.126
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.74	N 7 =	644.14	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	612.54	M 1 =	615.84	M 2 =	619.79	M 3 =	624.48	M 4 =	629.99
M 5 =	636.40	M 6 =	643.78	M 7 =	652.20	M 8 =	661.69	M 9 =	672.30
M 10 =	684.03	M 11 =	696.88	M 12 =	710.80	M 13 =	725.74	M 14 =	741.61
M 15 =	758.30	M 16 =	775.68	M 17 =	793.59	M 18 =	811.86	M 19 =	830.31
M 20 =	848.77	M 21 =	867.03	M 22 =	884.93	M 23 =	902.30	M 24 =	918.97
M 25 =	934.82	M 26 =	949.74	M 27 =	963.64	M 28 =	976.45	M 29 =	988.16
M 30 =	998.73	M 31 =	1008.2	M 32 =	1016.6	M 33 =	1023.9	M 34 =	1030.3
M 35 =	1035.8	M 36 =	1040.4	M 37 =	1044.4	M 38 =	1047.6	M 39 =	1050.3
M 40 =	1052.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	621.40	P 1 =	626.60	P 2 =	632.75	P 3 =	639.91	P 4 =	648.19
P 5 =	657.66	P 6 =	668.35	P 7 =	680.32	P 8 =	693.56	P 9 =	708.05
P 10 =	723.74	P 11 =	740.54	P 12 =	758.34	P 13 =	776.98	P 14 =	796.30
P 15 =	816.08	P 16 =	836.11	P 17 =	856.18	P 18 =	876.03	P 19 =	895.46
P 20 =	914.24	P 21 =	932.18	P 22 =	949.10	P 23 =	964.88	P 24 =	979.41
P 25 =	992.60	P 26 =	1004.6	P 27 =	1014.9	P 28 =	1024.0	P 29 =	1031.8
P 30 =	1038.4	P 31 =	1043.9	P 32 =	1048.4	P 33 =	1052.0	P 34 =	1054.9
P 35 =	1057.0	P 36 =	1058.6	P 37 =	1059.8	P 38 =	1060.6	P 39 =	1061.1
P 40 =	1061.4	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	616.78	G 1 =	620.99	G 2 =	625.99	G 3 =	631.87	G 4 =	638.71
G 5 =	646.58	G 6 =	655.55	G 7 =	665.66	G 8 =	676.95	G 9 =	689.42
G 10 =	703.04	G 11 =	717.78	G 12 =	733.56	G 13 =	750.27	G 14 =	767.79
G 15 =	785.96	G 16 =	804.61	G 17 =	823.55	G 18 =	842.58	G 19 =	861.50
G 20 =	880.11	G 21 =	898.22	G 22 =	915.65	G 23 =	932.26	G 24 =	947.90
G 25 =	962.48	G 26 =	975.92	G 27 =	988.17	G 28 =	999.21	G 29 =	1009.1
G 30 =	1017.7	G 31 =	1025.3	G 32 =	1031.8	G 33 =	1037.4	G 34 =	1042.1
G 35 =	1046.0	G 36 =	1049.2	G 37 =	1051.8	G 38 =	1053.8	G 39 =	1055.5
G 40 =	1056.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	610.68	H 2 =	613.59	H 3 =	617.09	H 4 =	621.28	H 5 =	626.23
H 6 =	632.02	H 7 =	638.73	H 8 =	646.44	H 9 =	655.18	H 10 =	665.02
H 11 =	675.97	H 12 =	688.04	H 13 =	701.21	H 14 =	715.43	H 15 =	730.64
H 16 =	746.74	H 17 =	763.62	H 18 =	781.14	H 19 =	799.13	H 20 =	817.42
H 21 =	835.85	H 22 =	854.21	H 23 =	872.33	H 24 =	890.04	H 25 =	907.16
H 26 =	923.56	H 27 =	939.10	H 28 =	953.69	H 29 =	967.25	H 30 =	979.72
H 31 =	991.08	H 32 =	1001.3	H 33 =	1010.5	H 34 =	1018.5	H 35 =	1025.6
H 36 =	1031.7	H 37 =	1037.0	H 38 =	1041.4	H 39 =	1045.2	H 40 =	1048.3
=	.0	=	.0	=	.0	=	.0	=	.0

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 1
Location x/L: 0.45
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PANEL 1 LOC=.45 T:NA(IN)=610F T:NA(OUT)=1050F
A21=21.289 A22= 71.130 A23= 95.969 A24= 74.680 A25=39.115

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	842.73
DT M-N =	21.289	DT1 =	71.130	DT P-N =	95.969	DT P-M =	74.680	DT2 =	39.115
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.76	N 7 =	644.14	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	612.88	M 1 =	616.25	M 2 =	620.29	M 3 =	625.07	M 4 =	630.69
M 5 =	637.22	M 6 =	644.73	M 7 =	653.28	M 8 =	662.92	M 9 =	673.68
M 10 =	685.56	M 11 =	698.56	M 12 =	712.63	M 13 =	727.71	M 14 =	743.72
M 15 =	760.53	M 16 =	778.01	M 17 =	796.00	M 18 =	814.33	M 19 =	832.82
M 20 =	851.29	M 21 =	869.54	M 22 =	887.40	M 23 =	904.71	M 24 =	921.30
M 25 =	937.05	M 26 =	951.85	M 27 =	965.61	M 28 =	978.29	M 29 =	989.84
M 30 =	1000.3	M 31 =	1009.6	M 32 =	1017.8	M 33 =	1025.0	M 34 =	1031.3
M 35 =	1036.6	M 36 =	1041.1	M 37 =	1045.0	M 38 =	1048.1	M 39 =	1050.8
M 40 =	1052.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
=	622.99	P 1 =	628.53	P 2 =	635.07	P 3 =	642.68	P 4 =	651.46
5 =	661.47	P 6 =	672.76	P 7 =	685.36	P 8 =	699.27	P 9 =	714.46
P 10 =	730.86	P 11 =	748.37	P 12 =	766.86	P 13 =	786.17	P 14 =	806.10
P 15 =	826.43	P 16 =	846.94	P 17 =	867.39	P 18 =	887.53	P 19 =	907.13
P 20 =	925.97	P 21 =	943.85	P 22 =	960.61	P 23 =	976.10	P 24 =	990.24
P 25 =	1003.0	P 26 =	1014.2	P 27 =	1024.1	P 28 =	1032.5	P 29 =	1039.6
P 30 =	1045.6	P 31 =	1050.4	P 32 =	1054.2	P 33 =	1057.1	P 34 =	1059.3
P 35 =	1060.8	P 36 =	1061.9	P 37 =	1062.6	P 38 =	1062.9	P 39 =	1063.0
P 40 =	1063.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	617.69	G 1 =	622.10	G 2 =	627.33	G 3 =	633.46	G 4 =	640.58
G 5 =	648.77	G 6 =	658.08	G 7 =	668.56	G 8 =	680.23	G 9 =	693.10
G 10 =	707.13	G 11 =	722.28	G 12 =	738.46	G 13 =	755.55	G 14 =	773.42
G 15 =	791.91	G 16 =	810.84	G 17 =	830.00	G 18 =	849.19	G 19 =	868.21
G 20 =	886.85	G 21 =	904.93	G 22 =	922.26	G 23 =	938.71	G 24 =	954.13
G 25 =	968.43	G 26 =	981.55	G 27 =	993.45	G 28 =	1004.1	G 29 =	1013.6
G 30 =	1021.8	G 31 =	1029.0	G 32 =	1035.1	G 33 =	1040.3	G 34 =	1044.6
G 35 =	1048.1	G 36 =	1051.0	G 37 =	1053.3	G 38 =	1055.2	G 39 =	1056.6
G 40 =	1057.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	610.40	H 2 =	613.25	H 3 =	616.69	H 4 =	620.80	H 5 =	625.67
H 6 =	631.38	H 7 =	638.00	H 8 =	645.61	H 9 =	654.26	H 10 =	663.99
H 11 =	674.84	H 12 =	686.81	H 13 =	699.88	H 14 =	714.01	H 15 =	729.14
H 16 =	745.18	H 17 =	762.00	H 18 =	779.47	H 19 =	797.44	H 20 =	815.72
H 21 =	834.15	H 22 =	852.54	H 23 =	870.71	H 24 =	888.47	H 25 =	905.66
H 26 =	922.14	H 27 =	937.77	H 28 =	952.46	H 29 =	966.12	H 30 =	978.69
H 31 =	990.15	H 32 =	1000.5	H 33 =	1009.7	H 34 =	1017.9	H 35 =	1025.1
H 36 =	1031.3	H 37 =	1036.6	H 38 =	1041.1	H 39 =	1044.9	H 40 =	1048.1
=	.0	=	.0	=	.0	=	.0		

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 1
Location x/L: 0.55
T(Na-inlet) = 610 F
T(Na-outlet) : 1050F

PANEL 1 LOC=.55 T:NA(IN)=610F T:NA(OUT)=1050F
A21=23.811 A22= 79.573 A23=107.70 A24= 83.891 A25=44.105

ITER NO. 2 GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN	= 610.00	T:NA OUT	= 1050.0	DT: NA	= 440.00	T:B NA	= 830.00	T:B M	= 844.24
)T M-N	= 23.811	DT1	= 79.573	DT P-N	= 107.70	DT P-M	= 83.891	DT2	= 44.105
	= .0		= .0		= .0		= .0		= .0
N	= 610.00	N 1	= 612.75	N 2	= 616.08	N 3	= 620.06	N 4	= 624.77
N 5	= 630.31	N 6	= 636.74	N 7	= 644.14	N 8	= 652.56	N 9	= 662.05
N 10	= 672.65	N 11	= 684.36	N 12	= 697.17	N 13	= 711.05	N 14	= 725.94
N 15	= 741.74	N 16	= 758.35	N 17	= 775.65	N 18	= 793.46	N 19	= 811.64
N 20	= 830.00	N 21	= 848.36	N 22	= 866.54	N 23	= 884.35	N 24	= 901.65
N 25	= 918.26	N 26	= 934.06	N 27	= 948.95	N 28	= 962.83	N 29	= 975.64
N 30	= 987.35	N 31	= 997.95	N 32	= 1007.4	N 33	= 1015.9	N 34	= 1023.3
N 35	= 1029.7	N 36	= 1035.2	N 37	= 1039.9	N 38	= 1043.9	N 39	= 1047.2
N 40	= 1050.0		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
M	= 613.22	M 1	= 616.67	M 2	= 620.79	M 3	= 625.67	M 4	= 631.39
M 5	= 638.04	M 6	= 645.68	M 7	= 654.36	M 8	= 664.15	M 9	= 675.05
M 10	= 687.09	M 11	= 700.24	M 12	= 714.46	M 13	= 729.69	M 14	= 745.82
M 15	= 762.75	M 16	= 780.33	M 17	= 798.41	M 18	= 816.80	M 19	= 835.33
M 20	= 853.81	M 21	= 872.05	M 22	= 889.88	M 23	= 907.12	M 24	= 923.63
M 25	= 939.27	M 26	= 953.95	M 27	= 967.59	M 28	= 980.12	M 29	= 991.52
M 30	= 1001.8	M 31	= 1011.0	M 32	= 1019.0	M 33	= 1026.1	M 34	= 1032.2
M 35	= 1037.4	M 36	= 1041.8	M 37	= 1045.6	M 38	= 1048.6	M 39	= 1051.2
M 40	= 1053.2		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
P	= 624.58	P 1	= 630.46	P 2	= 637.39	P 3	= 645.45	P 4	= 654.72
P 5	= 665.27	P 6	= 677.16	P 7	= 690.40	P 8	= 704.98	P 9	= 720.86
P 10	= 737.97	P 11	= 756.19	P 12	= 775.38	P 13	= 795.35	P 14	= 815.89
P 15	= 836.79	P 16	= 857.77	P 17	= 878.61	P 18	= 899.03	P 19	= 918.80
P 20	= 937.70	P 21	= 955.52	P 22	= 972.10	P 23	= 987.31	P 24	= 1001.1
P 25	= 1013.3	P 26	= 1024.0	P 27	= 1033.2	P 28	= 1041.0	P 29	= 1047.5
P 30	= 1052.7	P 31	= 1056.8	P 32	= 1059.9	P 33	= 1062.1	P 34	= 1063.7
P 35	= 1064.7	P 36	= 1065.2	P 37	= 1065.3	P 38	= 1065.2	P 39	= 1065.0
P 40	= 1064.6		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
G	= 618.61	G 1	= 623.21	G 2	= 628.66	G 3	= 635.05	G 4	= 642.46
G 5	= 650.96	G 6	= 660.61	G 7	= 671.45	G 8	= 683.51	G 9	= 696.78
G 10	= 711.22	G 11	= 726.78	G 12	= 743.35	G 13	= 760.83	G 14	= 779.06
G 15	= 797.86	G 16	= 817.06	G 17	= 836.44	G 18	= 855.80	G 19	= 874.92
G 20	= 893.60	G 21	= 911.64	G 22	= 928.87	G 23	= 945.15	G 24	= 960.35
G 25	= 974.38	G 26	= 987.18	G 27	= 998.73	G 28	= 1009.0	G 29	= 1018.1
G 30	= 1025.9	G 31	= 1032.7	G 32	= 1038.4	G 33	= 1043.2	G 34	= 1047.1
G 35	= 1050.3	G 36	= 1052.9	G 37	= 1054.9	G 38	= 1056.5	G 39	= 1057.7
G 40	= 1058.6		= .0		= .0		= .0		= .0
	= .0								= .0
H 1	= 610.12	H 2	= 612.91	H 3	= 616.29	H 4	= 620.33	H 5	= 625.12
H 6	= 630.74	H 7	= 637.27	H 8	= 644.78	H 9	= 653.33	H 10	= 662.96
H 11	= 673.70	H 12	= 685.57	H 13	= 698.55	H 14	= 712.59	H 15	= 727.64
H 16	= 743.61	H 17	= 760.37	H 18	= 777.80	H 19	= 795.74	H 20	= 814.02
H 21	= 832.46	H 22	= 850.88	H 23	= 869.08	H 24	= 886.90	H 25	= 904.16
H 26	= 920.72	H 27	= 936.44	H 28	= 951.23	H 29	= 964.98	H 30	= 977.66
H 31	= 989.22	H 32	= 999.67	H 33	= 1009.0	H 34	= 1017.3	H 35	= 1026.5
H 36	= 1030.8	H 37	= 1036.2	H 38	= 1040.8	H 39	= 1044.6	H 40	= 1047.8
	= .0		= .0		= .0		= .0		

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 1
Location x/L: 0.65
T(Na-inlet) = 610 F
T(Na-outlet) : 1050F

PANEL 1 LOC=.65 T:NA(IN)=610F T:NA(OUT)=1050F
A21=26.333 A22= 88.017 A23=119.43 A24= 93.102 A25=49.094

ITER NO. 2 GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	845.75
DT M-N =	26.333	DT1 =	88.017	DT P-N =	119.43	DT P-M =	93.102	DT2 =	49.094
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.74	N 7 =	644.14	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	613.56	M 1 =	617.08	M 2 =	621.29	M 3 =	626.26	M 4 =	632.10
M 5 =	638.86	M 6 =	646.62	M 7 =	655.45	M 8 =	665.37	M 9 =	676.43
M 10 =	688.62	M 11 =	701.92	M 12 =	716.29	M 13 =	731.66	M 14 =	747.93
M 15 =	764.98	M 16 =	782.66	M 17 =	800.82	M 18 =	819.27	M 19 =	837.86
M 20 =	856.33	M 21 =	874.56	M 22 =	892.35	M 23 =	909.53	M 24 =	925.95
M 25 =	941.50	M 26 =	956.06	M 27 =	969.56	M 28 =	981.95	M 29 =	993.20
M 30 =	1003.3	M 31 =	1012.3	M 32 =	1020.3	M 33 =	1027.2	M 34 =	1033.1
M 35 =	1038.2	M 36 =	1042.5	M 37 =	1046.2	M 38 =	1049.1	M 39 =	1051.6
M 40 =	1053.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
=	626.16	P 1 =	632.39	P 2 =	639.71	P 3 =	648.21	P 4 =	657.98
5 =	669.08	P 6 =	681.56	P 7 =	695.44	P 8 =	710.69	P 9 =	727.27
P 10 =	745.09	P 11 =	764.02	P 12 =	783.90	P 13 =	804.53	P 14 =	825.69
P 15 =	847.14	P 16 =	868.60	P 17 =	889.82	P 18 =	910.53	P 19 =	930.47
P 20 =	949.43	P 21 =	967.19	P 22 =	983.60	P 23 =	998.53	P 24 =	1011.9
P 25 =	1023.7	P 26 =	1033.8	P 27 =	1042.4	P 28 =	1049.6	P 29 =	1055.3
P 30 =	1059.8	P 31 =	1063.2	P 32 =	1065.6	P 33 =	1067.2	P 34 =	1068.1
P 35 =	1068.5	P 36 =	1068.4	P 37 =	1068.1	P 38 =	1067.6	P 39 =	1066.9
P 40 =	1066.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	619.52	G 1 =	624.32	G 2 =	630.00	G 3 =	636.64	G 4 =	644.33

G 5 =	653.15	G 6 =	663.14	G 7 =	674.35	G 8 =	686.80	G 9 =	700.46
G 10 =	715.31	G 11 =	731.28	G 12 =	748.25	G 13 =	766.11	G 14 =	784.69
G 15 =	803.82	G 16 =	823.29	G 17 =	842.89	G 18 =	862.41	G 19 =	881.63
G 20 =	900.34	G 21 =	918.35	G 22 =	935.49	G 23 =	951.60	G 24 =	966.58
G 25 =	980.33	G 26 =	992.82	G 27 =	1004.0	G 28 =	1013.9	G 29 =	1022.6
G 30 =	1030.0	G 31 =	1036.4	G 32 =	1041.7	G 33 =	1046.1	G 34 =	1049.7
G 35 =	1052.5	G 36 =	1054.8	G 37 =	1056.5	G 38 =	1057.8	G 39 =	1058.8
G 40 =	1059.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.84	H 2 =	612.58	H 3 =	615.89	H 4 =	619.86	H 5 =	624.57
H 6 =	630.11	H 7 =	636.54	H 8 =	643.95	H 9 =	652.40	H 10 =	661.93
H 11 =	672.57	H 12 =	684.34	H 13 =	697.22	H 14 =	711.17	H 15 =	726.14
H 16 =	742.04	H 17 =	758.75	H 18 =	776.14	H 19 =	794.05	H 20 =	812.32
H 21 =	830.77	H 22 =	849.21	H 23 =	867.46	H 24 =	885.33	H 25 =	902.66
H 26 =	919.30	H 27 =	935.11	H 28 =	949.99	H 29 =	963.85	H 30 =	976.63
H 31 =	988.30	H 32 =	998.84	H 33 =	1008.3	H 34 =	1016.6	H 35 =	1024.0
H 36 =	1030.3	H 37 =	1035.8	H 38 =	1040.4	H 39 =	1044.3	H 40 =	1047.6
=	.0	=	.0	=	.0	=	.0		

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 1
Location x/L: 0.75
T(Na-inlet) = 610 F
T(Na-outlet) : 1050F

PANEL 1 LOC=.75 T:NA(IN)=610F T:NA(OUT)=1050F
A21=28.855 A22= 96.461 A23=131.17 A24=102.31 A25=54.084

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	847.26
DT M-N =	28.855	DT1 =	96.461	DT P-N =	131.17	DT P-M =	102.31	DT2 =	54.084
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.74	N 7 =	644.14	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	613.91	M 1 =	617.50	M 2 =	621.79	M 3 =	626.86	M 4 =	632.80
M 5 =	639.68	M 6 =	647.57	M 7 =	656.53	M 8 =	666.60	M 9 =	677.81
M 10 =	690.15	M 11 =	703.61	M 12 =	718.13	M 13 =	733.64	M 14 =	750.04
M 15 =	767.21	M 16 =	784.99	M 17 =	803.23	M 18 =	821.75	M 19 =	860.35
M 20 =	858.85	M 21 =	877.07	M 22 =	894.82	M 23 =	911.94	M 24 =	928.28
M 25 =	943.72	M 26 =	958.17	M 27 =	971.53	M 28 =	983.78	M 29 =	994.89
M 30 =	1004.9	M 31 =	1013.7	M 32 =	1021.5	M 33 =	1028.3	M 34 =	1034.1
M 35 =	1039.1	M 36 =	1043.2	M 37 =	1046.7	M 38 =	1049.6	M 39 =	1052.0
M 40 =	1053.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	627.75	P 1 =	634.32	P 2 =	642.03	P 3 =	650.98	P 4 =	661.24
P 5 =	672.89	P 6 =	685.97	P 7 =	700.48	P 8 =	716.40	P 9 =	733.68
P 10 =	752.21	P 11 =	771.85	P 12 =	792.42	P 13 =	813.72	P 14 =	835.50
P 15 =	857.50	P 16 =	879.44	P 17 =	901.04	P 18 =	922.04	P 19 =	942.16
P 20 =	961.17	P 21 =	978.87	P 22 =	995.11	P 23 =	1009.8	P 24 =	1022.7
P 25 =	1034.0	P 26 =	1043.6	P 27 =	1051.6	P 28 =	1058.1	P 29 =	1063.1
P 30 =	1066.9	P 31 =	1069.6	P 32 =	1071.3	P 33 =	1072.2	P 34 =	1072.5
P 35 =	1072.3	P 36 =	1071.7	P 37 =	1070.9	P 38 =	1069.9	P 39 =	1068.8
P 40 =	1067.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	620.43	G 1 =	625.43	G 2 =	631.33	G 3 =	638.23	G 4 =	646.21
G 5 =	655.33	G 6 =	665.67	G 7 =	677.25	G 8 =	690.08	G 9 =	704.15
G 10 =	719.40	G 11 =	735.77	G 12 =	753.15	G 13 =	771.39	G 14 =	790.32
G 15 =	809.77	G 16 =	829.51	G 17 =	849.34	G 18 =	869.02	G 19 =	888.34
G 20 =	907.09	G 21 =	925.06	G 22 =	942.10	G 23 =	958.05	G 24 =	972.80
G 25 =	986.29	G 26 =	998.45	G 27 =	1009.3	G 28 =	1018.8	G 29 =	1027.1
G 30 =	1034.1	G 31 =	1040.0	G 32 =	1045.0	G 33 =	1049.0	G 34 =	1052.2
G 35 =	1054.7	G 36 =	1056.7	G 37 =	1058.1	G 38 =	1059.2	G 39 =	1059.9
G 40 =	1060.4	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.56	H 2 =	612.24	H 3 =	615.49	H 4 =	619.39	H 5 =	624.02
H 6 =	629.47	H 7 =	635.81	H 8 =	643.13	H 9 =	651.47	H 10 =	660.90
H 11 =	671.44	H 12 =	683.10	H 13 =	695.89	H 14 =	709.75	H 15 =	724.64
H 16 =	740.47	H 17 =	757.12	H 18 =	774.47	H 19 =	792.36	H 20 =	810.62
H 21 =	829.08	H 22 =	847.54	H 23 =	865.83	H 24 =	883.76	H 25 =	901.16
H 26 =	917.88	H 27 =	933.78	H 28 =	948.76	H 29 =	962.72	H 30 =	975.60
H 31 =	987.37	H 32 =	998.01	H 33 =	1007.5	H 34 =	1016.0	H 35 =	1023.4
H 36 =	1029.8	H 37 =	1035.4	H 38 =	1040.1	H 39 =	1044.1	H 40 =	1047.4
=	.0	=	.0	=	.0	=	.0		

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 1
Location x/L: .85
T(Na-inlet) = 610 F
T(Na-outlet) : 1050F

PANEL 1 LOC=.85 T:NA(IN)=610F T:NA(OUT)=1050F
A21=31.377 A22=104.90 A23=142.90 A24=111.52 A25=59.074

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	848.77
DT M-N =	31.377	DT1 =	104.90	DT P-N =	142.90	DT P-M =	111.52	DT2 =	59.074
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.74	N 7 =	644.14	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	614.25	M 1 =	617.91	M 2 =	622.28	M 3 =	627.45	M 4 =	633.50
M 5 =	640.50	M 6 =	648.52	M 7 =	657.61	M 8 =	667.83	M 9 =	679.19
M 10 =	691.68	M 11 =	705.29	M 12 =	719.96	M 13 =	735.61	M 14 =	752.14
M 15 =	769.43	M 16 =	787.32	M 17 =	805.64	M 18 =	824.22	M 19 =	842.86
M 20 =	861.38	M 21 =	879.58	M 22 =	897.29	M 23 =	914.35	M 24 =	930.61
M 25 =	945.95	M 26 =	960.27	M 27 =	973.51	M 28 =	985.61	M 29 =	996.57
M 30 =	1006.4	M 31 =	1015.1	M 32 =	1022.7	M 33 =	1029.3	M 34 =	1035.0
M 35 =	1039.9	M 36 =	1043.9	M 37 =	1047.3	M 38 =	1050.1	M 39 =	1052.4
M 40 =	1054.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
=	629.34	P 1 =	636.25	P 2 =	644.35	P 3 =	653.74	P 4 =	664.51
5 =	676.70	P 6 =	690.37	P 7 =	705.52	P 8 =	722.11	P 9 =	740.09
10 =	759.32	P 11 =	775.67	P 12 =	800.94	P 13 =	822.90	P 14 =	845.30
P 15 =	867.85	P 16 =	890.27	P 17 =	912.26	P 18 =	933.53	P 19 =	953.83
P 20 =	972.90	P 21 =	990.55	P 22 =	1006.6	P 23 =	1021.0	P 24 =	1033.6
P 25 =	1044.4	P 26 =	1053.4	P 27 =	1060.8	P 28 =	1066.6	P 29 =	1071.0
P 30 =	1074.0	P 31 =	1076.0	P 32 =	1077.0	P 33 =	1077.2	P 34 =	1076.9
P 35 =	1076.1	P 36 =	1075.0	P 37 =	1073.6	P 38 =	1072.2	P 39 =	1070.8
P 40 =	1069.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	621.34	G 1 =	626.54	G 2 =	632.66	G 3 =	639.82	G 4 =	648.08

G 5 =	657.52	G 6 =	668.20	G 7 =	680.14	G 8 =	693.36	G 9 =	707.83
G 10 =	723.49	G 11 =	740.27	G 12 =	758.04	G 13 =	776.66	G 14 =	795.95
G 15 =	815.72	G 16 =	835.74	G 17 =	855.78	G 18 =	875.63	G 19 =	895.05
G 20 =	913.83	G 21 =	931.77	G 22 =	948.70	G 23 =	964.49	G 24 =	979.03
G 25 =	992.24	G 26 =	1004.1	G 27 =	1014.6	G 28 =	1023.7	G 29 =	1031.6
G 30 =	1038.2	G 31 =	1043.7	G 32 =	1048.2	G 33 =	1051.9	G 34 =	1054.7
G 35 =	1056.9	G 36 =	1058.5	G 37 =	1059.7	G 38 =	1060.5	G 39 =	1061.0
G 40 =	1061.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.28	H 2 =	611.91	H 3 =	615.09	H 4 =	618.91	H 5 =	623.47
H 6 =	628.83	H 7 =	635.08	H 8 =	642.30	H 9 =	650.54	H 10 =	659.87
H 11 =	670.30	H 12 =	681.87	H 13 =	694.56	H 14 =	708.33	H 15 =	723.14
H 16 =	738.90	H 17 =	755.50	H 18 =	772.81	H 19 =	790.67	H 20 =	808.93
H 21 =	827.39	H 22 =	845.88	H 23 =	864.21	H 24 =	882.19	H 25 =	899.66
H 26 =	916.46	H 27 =	932.45	H 28 =	947.52	H 29 =	961.58	H 30 =	974.57
H 31 =	986.44	H 32 =	997.19	H 33 =	1006.8	H 34 =	1015.4	H 35 =	1022.8
H 36 =	1029.4	H 37 =	1035.0	H 38 =	1039.8	H 39 =	1043.8	H 40 =	1047.1
=	.0	=	.0	=	.0	=	.0		

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 1
Location x/L: 0.95
T(Na-inlet) = 610 F
T(Na-outlet) : 1050F

PANEL 1 LOC=.95 T:NA(IN)=610F T:NA(OUT)=1050F
A21=33.899 A22=113.35 A23=154.63 A24=120.73 A25=64.063

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	850.27
DT M-N =	33.899	DT1 =	113.35	DT P-N =	154.63	DT P-M =	120.73	DT2 =	64.063
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.74	N 7 =	644.14	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	614.59	M 1 =	618.33	M 2 =	622.78	M 3 =	628.05	M 4 =	634.20
M 5 =	641.31	M 6 =	649.46	M 7 =	658.70	M 8 =	669.06	M 9 =	680.56
M 10 =	693.21	M 11 =	706.97	M 12 =	721.79	M 13 =	737.58	M 14 =	754.25
M 15 =	771.66	M 16 =	789.65	M 17 =	808.05	M 18 =	826.69	M 19 =	845.37
M 20 =	863.90	M 21 =	882.09	M 22 =	899.76	M 23 =	916.76	M 24 =	932.94
M 25 =	948.17	M 26 =	962.38	M 27 =	975.48	M 28 =	987.44	M 29 =	998.25
M 30 =	1007.9	M 31 =	1016.5	M 32 =	1023.9	M 33 =	1030.4	M 34 =	1036.0
M 35 =	1040.7	M 36 =	1044.7	M 37 =	1047.9	M 38 =	1050.6	M 39 =	1052.8
M 40 =	1054.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	630.93	P 1 =	638.18	P 2 =	646.68	P 3 =	656.51	P 4 =	667.77
P 5 =	680.51	P 6 =	694.77	P 7 =	710.56	P 8 =	727.82	P 9 =	746.49
P 10 =	766.44	P 11 =	787.49	P 12 =	809.46	P 13 =	832.08	P 14 =	855.09
P 15 =	878.20	P 16 =	901.10	P 17 =	923.47	P 18 =	945.03	P 19 =	965.50
P 20 =	984.63	P 21 =	1002.2	P 22 =	1018.1	P 23 =	1032.2	P 24 =	1044.4
P 25 =	1054.7	P 26 =	1063.2	P 27 =	1070.0	P 28 =	1075.1	P 29 =	1078.8
P 30 =	1081.1	P 31 =	1082.4	P 32 =	1082.7	P 33 =	1082.3	P 34 =	1081.3
P 35 =	1079.9	P 36 =	1078.2	P 37 =	1076.4	P 38 =	1074.5	P 39 =	1072.7
P 40 =	1070.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	622.26	G 1 =	627.65	G 2 =	634.00	G 3 =	641.41	G 4 =	649.96

G 5 =	659.71	G 6 =	670.73	G 7 =	683.04	G 8 =	696.64	G 9 =	711.51
G 10 =	727.58	G 11 =	744.77	G 12 =	762.94	G 13 =	781.94	G 14 =	801.59
G 15 =	821.67	G 16 =	841.96	G 17 =	862.23	G 18 =	882.24	G 19 =	901.76
G 20 =	920.57	G 21 =	938.48	G 22 =	955.32	G 23 =	970.94	G 24 =	985.26
G 25 =	998.19	G 26 =	1009.7	G 27 =	1019.8	G 28 =	1028.6	G 29 =	1036.1
G 30 =	1042.3	G 31 =	1047.4	G 32 =	1051.5	G 33 =	1054.8	G 34 =	1057.3
G 35 =	1059.1	G 36 =	1060.4	G 37 =	1061.3	G 38 =	1061.8	G 39 =	1062.1
G 40 =	1062.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.00	H 2 =	611.57	H 3 =	614.69	H 4 =	618.44	H 5 =	622.91
H 6 =	628.19	H 7 =	634.35	H 8 =	641.47	H 9 =	649.61	H 10 =	658.83
H 11 =	669.17	H 12 =	680.63	H 13 =	693.22	H 14 =	706.91	H 15 =	721.64
H 16 =	737.33	H 17 =	753.87	H 18 =	771.14	H 19 =	788.98	H 20 =	807.22
H 21 =	825.70	H 22 =	844.21	H 23 =	862.58	H 24 =	880.62	H 25 =	898.16
H 26 =	915.04	H 27 =	931.12	H 28 =	946.29	H 29 =	960.45	H 30 =	973.54
H 31 =	985.51	H 32 =	996.36	H 33 =	1006.1	H 34 =	1014.7	H 35 =	1022.3
H 36 =	1028.9	H 37 =	1034.6	H 38 =	1039.4	H 39 =	1043.5	H 40 =	1046.9
=	.0	=	.0	=	.0	=	.0		

PANEL TEMPERATURE DISTRIBUTION

CASE 1

SET 2 Subpanel 2

Solar Flux Distribution: REFERENCE

Orifices: Yes: Orificed so as to match tube flow rates to reference flux distribution

Sodium Temperatures: T (Na-Inlet) = 610°F
T (Na-Outlet) = 1050°F (all tubes)

5370F/sjh

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 2
Location x/L: 0.05
T(Na-inlet) = 610 F
T(Na-outlet) : 1050F

PANEL 2 LOC=.05 T:NA(IN)=610F T:NA(OUT)=1050F
A21=36.226 A22=121.15 A23=165.68 A24=129.46 A25=68.890

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	851.67
DT M-N =	36.226	DT1 =	121.15	DT P-N =	165.68	DT P-M =	129.46	DT2 =	68.891
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.74	N 7 =	644.14	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	614.90	M 1 =	618.71	M 2 =	623.24	M 3 =	628.60	M 4 =	634.85
M 5 =	642.07	M 6 =	650.34	M 7 =	659.70	M 8 =	670.19	M 9 =	681.83
M 10 =	694.62	M 11 =	708.52	M 12 =	723.48	M 13 =	739.41	M 14 =	756.19
M 15 =	773.71	M 16 =	791.79	M 17 =	810.28	M 18 =	828.97	M 19 =	847.69
M 20 =	866.23	M 21 =	884.40	M 22 =	902.05	M 23 =	918.99	M 24 =	935.09
M 25 =	950.23	M 26 =	964.32	M 27 =	977.30	M 28 =	989.13	M 29 =	999.80
M 30 =	1009.3	M 31 =	1017.7	M 32 =	1025.1	M 33 =	1031.4	M 34 =	1036.9
M 35 =	1041.5	M 36 =	1045.3	M 37 =	1048.5	M 38 =	1051.1	M 39 =	1053.2
M 40 =	1054.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	632.42	P 1 =	640.00	P 2 =	648.86	P 3 =	659.11	P 4 =	670.84
P 5 =	684.10	P 6 =	698.92	P 7 =	715.30	P 8 =	733.20	P 9 =	752.52
P 10 =	773.14	P 11 =	794.86	P 12 =	817.48	P 13 =	840.73	P 14 =	864.32
P 15 =	887.95	P 16 =	911.30	P 17 =	934.04	P 18 =	955.86	P 19 =	976.49
P 20 =	995.68	P 21 =	1013.2	P 22 =	1028.9	P 23 =	1042.7	P 24 =	1054.6
P 25 =	1064.5	P 26 =	1072.5	P 27 =	1078.6	P 28 =	1083.1	P 29 =	1086.1
P 30 =	1087.8	P 31 =	1088.4	P 32 =	1088.1	P 33 =	1087.0	P 34 =	1085.4
P 35 =	1083.5	P 36 =	1081.3	P 37 =	1079.0	P 38 =	1076.7	P 39 =	1074.5
P 40 =	1072.4	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	623.10	G 1 =	628.67	G 2 =	635.23	G 3 =	642.88	G 4 =	651.69
G 5 =	661.74	G 6 =	673.07	G 7 =	685.72	G 8 =	699.67	G 9 =	714.91
G 10 =	731.36	G 11 =	748.92	G 12 =	767.46	G 13 =	786.82	G 14 =	806.79
G 15 =	827.17	G 16 =	847.71	G 17 =	868.19	G 18 =	888.35	G 19 =	907.96
G 20 =	926.80	G 21 =	944.68	G 22 =	961.42	G 23 =	976.90	G 24 =	991.00
G 25 =	1003.7	G 26 =	1014.9	G 27 =	1024.7	G 28 =	1033.1	G 29 =	1040.2
G 30 =	1046.1	G 31 =	1050.8	G 32 =	1054.6	G 33 =	1057.4	G 34 =	1059.6
G 35 =	1061.1	G 36 =	1062.1	G 37 =	1062.8	G 38 =	1063.1	G 39 =	1063.2
G 40 =	1063.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.75	H 2 =	611.26	H 3 =	614.32	H 4 =	618.00	H 5 =	622.40
H 6 =	627.60	H 7 =	633.68	H 8 =	640.70	H 9 =	648.75	H 10 =	657.88
H 11 =	668.12	H 12 =	679.49	H 13 =	691.99	H 14 =	705.60	H 15 =	720.25
H 16 =	735.88	H 17 =	752.37	H 18 =	769.60	H 19 =	787.41	H 20 =	805.65
H 21 =	824.13	H 22 =	842.67	H 23 =	861.08	H 24 =	879.17	H 25 =	896.77
H 26 =	913.73	H 27 =	929.89	H 28 =	945.15	H 29 =	959.40	H 30 =	972.58
H 31 =	984.65	H 32 =	995.59	H 33 =	1005.4	H 34 =	1014.1	H 35 =	1021.8
H 36 =	1028.5	H 37 =	1034.2	H 38 =	1039.1	H 39 =	1043.2	H 40 =	1046.7
=	.0	=	.0	=	.0	=	.0		

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 2
Location x/L: 0.15
T(Na-inlet) = 610 F
T(Na-outlet) : 1050F

PANEL 2 LOC=.15 T:NA(IN)=610F T:NA(OUT)=1050F
A21=38.357 A22=128.30 A23=176.05 A24=137.69 A25=73.555

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	852.94
DT M-N =	38.357	DT1 =	128.30	DT P-N =	176.05	DT P-M =	137.69	DT2 =	73.555
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.74	N 7 =	644.14	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.19	M 1 =	619.06	M 2 =	623.67	M 3 =	629.10	M 4 =	635.44
M 5 =	642.76	M 6 =	651.14	M 7 =	660.61	M 8 =	671.23	M 9 =	683.00
M 10 =	695.91	M 11 =	709.94	M 12 =	725.03	M 13 =	741.07	M 14 =	757.97
M 15 =	775.59	M 16 =	793.76	M 17 =	812.31	M 18 =	831.06	M 19 =	849.81
M 20 =	868.36	M 21 =	886.52	M 22 =	904.13	M 23 =	921.02	M 24 =	937.05
M 25 =	952.11	M 26 =	966.10	M 27 =	978.97	M 28 =	990.68	M 29 =	1001.2
M 30 =	1010.6	M 31 =	1018.9	M 32 =	1026.1	M 33 =	1032.3	M 34 =	1037.7
M 35 =	1042.1	M 36 =	1045.9	M 37 =	1049.0	M 38 =	1051.5	M 39 =	1053.6
M 40 =	1055.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
=	633.83	P 1 =	641.71	P 2 =	650.92	P 3 =	661.56	P 4 =	673.72
5 =	687.46	P 6 =	702.81	P 7 =	719.76	P 8 =	738.25	P 9 =	758.19
10 =	779.43	P 11 =	801.78	P 12 =	825.01	P 13 =	848.85	P 14 =	872.99
15 =	897.10	P 16 =	920.87	P 17 =	943.95	P 18 =	966.03	P 19 =	986.81
P 20 =	1006.0	P 21 =	1023.5	P 22 =	1039.1	P 23 =	1052.7	P 24 =	1064.2
P 25 =	1073.6	P 26 =	1081.1	P 27 =	1086.7	P 28 =	1090.7	P 29 =	1093.1
P 30 =	1094.1	P 31 =	1094.1	P 32 =	1093.1	P 33 =	1091.5	P 34 =	1089.3
P 35 =	1086.8	P 36 =	1084.2	P 37 =	1081.4	P 38 =	1078.8	P 39 =	1076.2
P 40 =	1073.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	623.87	G 1 =	629.61	G 2 =	636.36	G 3 =	644.22	G 4 =	653.27

G 5 =	663.59	G 6 =	675.21	G 7 =	688.17	G 8 =	702.45	G 9 =	718.03
G 10 =	734.82	G 11 =	752.73	G 12 =	771.61	G 13 =	791.28	G 14 =	811.56
G 15 =	832.20	G 16 =	852.98	G 17 =	873.64	G 18 =	893.94	G 19 =	913.64
G 20 =	932.51	G 21 =	950.35	G 22 =	967.01	G 23 =	982.35	G 24 =	996.27
G 25 =	1008.7	G 26 =	1019.7	G 27 =	1029.2	G 28 =	1037.3	G 29 =	1044.0
G 30 =	1049.5	G 31 =	1053.9	G 32 =	1057.3	G 33 =	1059.9	G 34 =	1061.7
G 35 =	1063.0	G 36 =	1063.7	G 37 =	1064.1	G 38 =	1064.2	G 39 =	1064.1
G 40 =	1063.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.51	H 2 =	610.97	H 3 =	613.98	H 4 =	617.60	H 5 =	621.94
H 6 =	627.06	H 7 =	633.06	H 8 =	640.00	H 9 =	647.97	H 10 =	657.00
H 11 =	667.16	H 12 =	678.64	H 13 =	690.86	H 14 =	704.39	H 15 =	718.98
H 16 =	734.54	H 17 =	750.99	H 18 =	768.18	H 19 =	785.98	H 20 =	804.21
H 21 =	822.69	H 22 =	841.25	H 23 =	859.70	H 24 =	877.84	H 25 =	895.50
H 26 =	912.52	H 27 =	928.76	H 28 =	944.10	H 29 =	958.44	H 30 =	971.71
H 31 =	983.86	H 32 =	994.89	H 33 =	1004.8	H 34 =	1013.6	H 35 =	1021.3
H 36 =	1028.1	H 37 =	1033.9	H 38 =	1038.8	H 39 =	1043.0	H 40 =	1046.5
=	.0	=	.0	=	.0	=	.0		

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 2
Location x/L: .25
T(Na-inlet) = 610 F
T(Na-outlet) : 1050F

PANEL 2 LOC=.25 T:NA(IN)=610F T:NA(OUT)=1050F
A21=40.488 A22=135.46 A23=186.41 A24=145.92 A25=78.221

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	854.22
DT M-N =	40.488	DT1 =	135.46	DT P-N =	186.41	DT P-M =	145.92	DT2 =	78.221
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.74	N 7 =	644.14	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.48	M 1 =	619.41	M 2 =	624.09	M 3 =	629.60	M 4 =	636.03
M 5 =	643.45	M 6 =	651.94	M 7 =	661.53	M 8 =	672.26	M 9 =	684.16
M 10 =	697.21	M 11 =	711.36	M 12 =	726.57	M 13 =	742.74	M 14 =	759.75
M 15 =	777.47	M 16 =	795.73	M 17 =	814.35	M 18 =	833.15	M 19 =	851.93
M 20 =	870.49	M 21 =	888.65	M 22 =	906.22	M 23 =	923.06	M 24 =	939.02
M 25 =	953.99	M 26 =	967.88	M 27 =	980.64	M 28 =	992.23	M 29 =	1002.6
M 30 =	1011.9	M 31 =	1020.1	M 32 =	1027.2	M 33 =	1033.3	M 34 =	1038.5
M 35 =	1042.8	M 36 =	1046.5	M 37 =	1049.5	M 38 =	1051.9	M 39 =	1053.9
M 40 =	1055.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	635.23	P 1 =	643.41	P 2 =	652.97	P 3 =	664.00	P 4 =	676.60
P 5 =	690.83	P 6 =	706.70	P 7 =	724.21	P 8 =	743.29	P 9 =	763.84
P 10 =	785.71	P 11 =	808.69	P 12 =	832.53	P 13 =	856.96	P 14 =	881.64
P 15 =	906.25	P 16 =	930.43	P 17 =	953.85	P 18 =	976.18	P 19 =	997.12
P 20 =	1016.4	P 21 =	1033.8	P 22 =	1049.3	P 23 =	1062.6	P 24 =	1073.7
P 25 =	1082.8	P 26 =	1089.8	P 27 =	1094.9	P 28 =	1098.2	P 29 =	1100.0
P 30 =	1100.4	P 31 =	1099.7	P 32 =	1098.2	P 33 =	1095.9	P 34 =	1093.2
P 35 =	1090.2	P 36 =	1087.1	P 37 =	1083.9	P 38 =	1080.8	P 39 =	1077.9
P 40 =	1075.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	624.65	G 1 =	630.55	G 2 =	637.49	G 3 =	645.57	G 4 =	654.86
G 5 =	665.44	G 6 =	677.35	G 7 =	690.62	G 8 =	705.23	G 9 =	721.15
G 10 =	738.29	G 11 =	756.54	G 12 =	775.75	G 13 =	795.75	G 14 =	816.33
G 15 =	837.24	G 16 =	858.25	G 17 =	879.10	G 18 =	899.56	G 19 =	919.32
G 20 =	938.22	G 21 =	956.04	G 22 =	972.61	G 23 =	987.81	G 24 =	1001.5
G 25 =	1013.8	G 26 =	1024.5	G 27 =	1033.7	G 28 =	1041.4	G 29 =	1047.8
G 30 =	1053.0	G 31 =	1057.0	G 32 =	1060.1	G 33 =	1062.4	G 34 =	1063.9
G 35 =	1064.8	G 36 =	1065.3	G 37 =	1065.5	G 38 =	1065.3	G 39 =	1065.0
G 40 =	1064.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.27	H 2 =	610.68	H 3 =	613.63	H 4 =	617.20	H 5 =	621.46
H 6 =	626.52	H 7 =	632.43	H 8 =	639.30	H 9 =	647.18	H 10 =	656.13
H 11 =	666.19	H 12 =	677.39	H 13 =	689.73	H 14 =	703.18	H 15 =	717.70
H 16 =	733.21	H 17 =	749.60	H 18 =	766.76	H 19 =	784.53	H 20 =	802.76
H 21 =	821.25	H 22 =	839.83	H 23 =	858.31	H 24 =	876.50	H 25 =	894.22
H 26 =	911.31	H 27 =	927.63	H 28 =	943.05	H 29 =	957.47	H 30 =	970.83
H 31 =	983.07	H 32 =	994.18	H 33 =	1004.2	H 34 =	1013.0	H 35 =	1020.8
H 36 =	1027.7	H 37 =	1033.5	H 38 =	1038.5	H 39 =	1042.8	H 40 =	1046.3
=	.0	=	.0	=	.0	=	.0		

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 2
Location x/L: FULL
T(Na-inlet) = 610 F
T(Na-outlet) : 1050F

PANEL 2 LOC=FULL T:NA(IN)=610F T:NA(OUT)=1050F
A21=41.740 A22=139.66 A23=192.50 A24=150.76 A25=80.960

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	854.96
DT M-N =	41.740	DT1 =	139.66	DT P-N =	192.50	DT P-M =	150.76	DT2 =	80.960
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.74	N 7 =	644.14	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.65	M 1 =	619.62	M 2 =	624.34	M 3 =	629.90	M 4 =	636.38
M 5 =	643.86	M 6 =	652.40	M 7 =	662.06	M 8 =	672.87	M 9 =	684.84
M 10 =	697.97	M 11 =	712.20	M 12 =	727.48	M 13 =	743.72	M 14 =	760.80
M 15 =	778.58	M 16 =	796.89	M 17 =	815.55	M 18 =	834.38	M 19 =	853.17
M 20 =	871.74	M 21 =	889.89	M 22 =	907.45	M 23 =	924.26	M 24 =	940.18
M 25 =	955.09	M 26 =	968.93	M 27 =	981.62	M 28 =	993.14	M 29 =	1003.5
M 30 =	1012.7	M 31 =	1020.7	M 32 =	1027.8	M 33 =	1033.8	M 34 =	1038.9
M 35 =	1043.2	M 36 =	1046.8	M 37 =	1049.8	M 38 =	1052.2	M 39 =	1054.1
M 40 =	1055.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	636.05	P 1 =	644.41	P 2 =	654.17	P 3 =	665.44	P 4 =	678.30
P 5 =	692.80	P 6 =	708.99	P 7 =	726.82	P 8 =	746.26	P 9 =	767.17
P 10 =	789.41	P 11 =	812.75	P 12 =	836.96	P 13 =	861.72	P 14 =	886.73
15 =	911.62	P 16 =	936.05	P 17 =	959.68	P 18 =	982.15	P 19 =	1003.2
20 =	1022.5	P 21 =	1039.9	P 22 =	1055.2	P 23 =	1068.4	P 24 =	1079.3
25 =	1088.1	P 26 =	1094.9	P 27 =	1099.6	P 28 =	1102.6	P 29 =	1104.0
30 =	1104.1	P 31 =	1103.1	P 32 =	1101.1	P 33 =	1098.6	P 34 =	1095.5
P 35 =	1092.2	P 36 =	1088.7	P 37 =	1085.3	P 38 =	1082.0	P 39 =	1078.9
P 40 =	1076.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	625.10	G 1 =	631.10	G 2 =	638.15	G 3 =	646.36	G 4 =	655.79

G 5 =	666.53	G 6 =	678.61	G 7 =	692.06	G 8 =	706.86	G 9 =	722.98
G 10 =	740.32	G 11 =	758.77	G 12 =	778.19	G 13 =	798.38	G 14 =	819.13
G 15 =	840.20	G 16 =	861.35	G 17 =	882.31	G 18 =	902.82	G 19 =	922.65
G 20 =	941.57	G 21 =	959.37	G 22 =	975.90	G 23 =	991.01	G 24 =	1004.6
G 25 =	1016.7	G 26 =	1027.3	G 27 =	1036.3	G 28 =	1043.8	G 29 =	1050.1
G 30 =	1055.0	G 31 =	1058.9	G 32 =	1061.7	G 33 =	1063.8	G 34 =	1065.1
G 35 =	1065.9	G 36 =	1066.2	G 37 =	1066.2	G 38 =	1066.0	G 39 =	1065.6
G 40 =	1065.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.13	H 2 =	610.52	H 3 =	613.43	H 4 =	616.96	H 5 =	621.19
H 6 =	626.20	H 7 =	632.07	H 8 =	638.88	H 9 =	646.71	H 10 =	655.61
H 11 =	665.62	H 12 =	676.77	H 13 =	689.06	H 14 =	702.47	H 15 =	716.95
H 16 =	732.42	H 17 =	748.79	H 18 =	765.93	H 19 =	783.69	H 20 =	801.91
H 21 =	820.41	H 22 =	839.00	H 23 =	857.50	H 24 =	875.72	H 25 =	893.47
H 26 =	910.60	H 27 =	926.96	H 28 =	942.63	H 29 =	956.90	H 30 =	970.31
H 31 =	982.61	H 32 =	993.77	H 33 =	1003.8	H 34 =	1012.7	H 35 =	1020.6
H 36 =	1027.4	H 37 =	1033.3	H 38 =	1038.4	H 39 =	1042.6	H 40 =	1046.2
=	.0	=	.0	=	.0	=	.0		

PANEL TEMPERATURE DISTRIBUTION

CASE 1

SET 3 Subpanel Boundaries

Solar Flux Distribution: REFERENCE

Orifices: Yes: Orificed so as to match tube flow rates to reference flux distribution

Sodium Temperatures: T (Na-Inlet) = 610°F
T (Na-Outlet) = 1050°F (all tubes)

5370F/sjh

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 1
Location x/L: 0
T(Na-inlet) = 610 F
T(Na-outlet) : 1050F

(Q/A)CL = 0.225 MW/M2   T:NA(IN) = 610F   T:NA(OUT) = 1050F
A21= 9.94 A22= 33.133 A23= 43.17 A24= 33.23 A25= 16.662

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	835.94
DT M-N =	9.9400	DT1 =	33.133	DT P-N =	43.170	DT P-M =	33.230	DT2 =	16.662
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.74	N 7 =	644.14	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	611.35	M 1 =	614.39	M 2 =	618.04	M 3 =	622.40	M 4 =	627.54
M 5 =	633.54	M 6 =	640.47	M 7 =	648.40	M 8 =	657.39	M 9 =	667.48
M 10 =	678.68	M 11 =	690.99	M 12 =	704.39	M 13 =	718.83	M 14 =	734.24
M 15 =	750.51	M 16 =	767.53	M 17 =	785.15	M 18 =	803.21	M 19 =	821.53
M 20 =	839.94	M 21 =	858.25	M 22 =	876.28	M 23 =	893.86	M 24 =	910.82
M 25 =	927.03	M 26 =	942.37	M 27 =	956.73	M 28 =	970.04	M 29 =	982.27
M 30 =	993.38	M 31 =	1003.4	M 32 =	1012.3	M 33 =	1020.1	M 34 =	1027.0
M 35 =	1032.9	M 36 =	1038.0	M 37 =	1042.3	M 38 =	1045.9	M 39 =	1048.9
M 40 =	1051.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	615.84	P 1 =	619.85	P 2 =	624.62	P 3 =	630.23	P 4 =	636.78
P 5 =	644.32	P 6 =	652.94	P 7 =	662.68	P 8 =	673.57	P 9 =	685.63
P 10 =	698.83	P 11 =	713.15	P 12 =	728.52	P 13 =	744.84	P 14 =	761.99
15 =	779.84	P 16 =	798.21	P 17 =	816.92	P 18 =	835.78	P 19 =	854.59
20 =	873.17	P 21 =	891.31	P 22 =	908.85	P 23 =	925.62	P 24 =	941.50
25 =	956.36	P 26 =	970.12	P 27 =	982.74	P 28 =	994.17	P 29 =	1004.4
P 30 =	1013.5	P 31 =	1021.5	P 32 =	1028.5	P 33 =	1034.4	P 34 =	1039.5
P 35 =	1043.7	P 36 =	1047.2	P 37 =	1050.1	P 38 =	1052.5	P 39 =	1054.3
P 40 =	1055.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	613.59	G 1 =	617.11	G 2 =	621.32	G 3 =	626.30	G 4 =	632.14
G 5 =	638.91	G 6 =	646.69	G 7 =	655.52	G 8 =	665.46	G 9 =	676.53
G 10 =	688.73	G 11 =	702.04	G 12 =	716.42	G 13 =	731.80	G 14 =	748.08
G 15 =	765.13	G 16 =	782.82	G 17 =	800.99	G 18 =	819.44	G 19 =	838.01
G 20 =	856.51	G 21 =	874.73	G 22 =	892.52	G 23 =	909.69	G 24 =	926.11
G 25 =	941.65	G 26 =	956.20	G 27 =	969.69	G 28 =	982.07	G 29 =	993.32
G 30 =	1003.4	G 31 =	1012.4	G 32 =	1020.3	G 33 =	1027.3	G 34 =	1033.2
G 35 =	1038.3	G 36 =	1042.6	G 37 =	1046.2	G 38 =	1049.2	G 39 =	1051.6
G 40 =	1053.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	611.66	H 2 =	614.76	H 3 =	618.49	H 4 =	622.93	H 5 =	628.16
H 6 =	634.25	H 7 =	641.29	H 8 =	649.33	H 9 =	658.43	H 10 =	668.63
H 11 =	679.94	H 12 =	692.36	H 13 =	705.86	H 14 =	720.40	H 15 =	735.89
H 16 =	752.24	H 17 =	769.31	H 18 =	786.97	H 19 =	805.05	H 20 =	823.37
H 21 =	841.77	H 22 =	860.04	H 23 =	878.02	H 24 =	895.53	H 25 =	912.41
H 26 =	928.53	H 27 =	943.76	H 28 =	958.02	H 29 =	971.22	H 30 =	983.33
H 31 =	994.33	H 32 =	1004.2	H 33 =	1013.0	H 34 =	1020.8	H 35 =	1027.5
H 36 =	1033.4	H 37 =	1038.4	H 38 =	1042.6	H 39 =	1046.2	H 40 =	1049.1
=	.0	=	.0	=	.0	=	.0	=	.0

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 1 2
Location x/L: 1.0 0
T(Na-inlet) = 610 F
T(Na-outlet) : 1050F

(Q/A)CL = 0.97 MW/M2 T:NA(IN) = 610F T:NA(OUT) = 1050F
A21= 35.16 A22=117.57 A23=160.50 A24=125.34 A25= 66.558

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	851.03
DT M-N =	35.160	DT1 =	117.57	DT P-N =	160.50	DT P-M =	125.34	DT2 =	66.558
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.74	N 7 =	644.14	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	614.76	M 1 =	618.53	M 2 =	623.03	M 3 =	628.34	M 4 =	634.55
M 5 =	641.72	M 6 =	649.94	M 7 =	659.24	M 8 =	669.67	M 9 =	681.25
M 10 =	693.97	M 11 =	707.81	M 12 =	722.70	M 13 =	738.57	M 14 =	755.30
M 15 =	772.77	M 16 =	790.81	M 17 =	809.26	M 18 =	827.93	M 19 =	846.62
M 20 =	865.16	M 21 =	883.34	M 22 =	901.00	M 23 =	917.97	M 24 =	934.10
M 25 =	949.29	M 26 =	963.43	M 27 =	976.47	M 28 =	988.36	M 29 =	999.09
M 30 =	1008.7	M 31 =	1017.1	M 32 =	1024.6	M 33 =	1031.0	M 34 =	1036.5
M 35 =	1041.1	M 36 =	1045.0	M 37 =	1048.2	M 38 =	1050.9	M 39 =	1053.0
M 40 =	1054.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	631.72	P 1 =	639.15	P 2 =	647.84	P 3 =	657.89	P 4 =	669.40
P 5 =	682.42	P 6 =	696.98	P 7 =	713.08	P 8 =	730.68	P 9 =	749.70
P 10 =	770.00	P 11 =	791.41	P 12 =	813.72	P 13 =	836.68	P 14 =	860.00
P 15 =	883.38	P 16 =	906.51	P 17 =	929.08	P 18 =	950.78	P 19 =	971.34
P 20 =	990.50	P 21 =	1008.1	P 22 =	1023.9	P 23 =	1037.8	P 24 =	1049.8
P 25 =	1059.9	P 26 =	1068.1	P 27 =	1074.6	P 28 =	1079.4	P 29 =	1082.7
P 30 =	1084.7	P 31 =	1085.6	P 32 =	1085.6	P 33 =	1084.8	P 34 =	1083.5
P 35 =	1081.8	P 36 =	1079.9	P 37 =	1077.8	P 38 =	1075.7	P 39 =	1073.6
P 40 =	1071.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	622.71	G 1 =	628.20	G 2 =	634.67	G 3 =	642.20	G 4 =	650.89
G 5 =	660.81	G 6 =	672.00	G 7 =	684.49	G 8 =	698.28	G 9 =	713.35
G 10 =	729.63	G 11 =	747.02	G 12 =	765.39	G 13 =	784.58	G 14 =	804.41
G 15 =	824.65	G 16 =	845.08	G 17 =	865.46	G 18 =	885.55	G 19 =	905.12
G 20 =	923.94	G 21 =	941.84	G 22 =	958.62	G 23 =	974.17	G 24 =	988.37
G 25 =	1001.2	G 26 =	1012.5	G 27 =	1022.5	G 28 =	1031.0	G 29 =	1038.3
G 30 =	1044.3	G 31 =	1049.2	G 32 =	1053.2	G 33 =	1056.2	G 34 =	1058.5
G 35 =	1060.2	G 36 =	1061.3	G 37 =	1062.1	G 38 =	1062.5	G 39 =	1062.7
G 40 =	1062.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.86	H 2 =	611.40	H 3 =	614.49	H 4 =	618.20	H 5 =	622.64
H 6 =	627.87	H 7 =	633.99	H 8 =	641.06	H 9 =	649.15	H 10 =	658.32
H 11 =	668.60	H 12 =	680.02	H 13 =	692.56	H 14 =	706.20	H 15 =	720.89
H 16 =	736.55	H 17 =	753.06	H 18 =	770.31	H 19 =	788.13	H 20 =	806.37
H 21 =	824.85	H 22 =	843.38	H 23 =	861.77	H 24 =	879.84	H 25 =	897.41
H 26 =	914.33	H 27 =	930.46	H 28 =	945.67	H 29 =	959.88	H 30 =	973.02
H 31 =	985.05	H 32 =	995.94	H 33 =	1005.7	H 34 =	1014.4	H 35 =	1022.0
H 36 =	1028.7	H 37 =	1034.4	H 38 =	1039.2	H 39 =	1043.4	H 40 =	1046.8
=	.0	=	.0	=	.0	=	.0		

Addendum to
NO 079TI000002
PAGE 127

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 2
Location x/L: 1.0
T(Na-inlet) = 610 F
T(Na-outlet) : 1050F

(Q/A)CL = 1.20 MW/M2 T:NA(IN) = 610F T:NA(OUT) = 105(
A21= 41.74 A22=139.66 A23=192.50 A24=150.76 A25= 80.98

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.0	DT: NA =	440.00	T:B NA =	830.00	T:B M =	854.96
DT M-N =	41.740	DT1 =	139.66	DT P-N =	192.50	DT P-M =	150.76	DT2 =	80.980
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.06	N 4 =	624.77
N 5 =	630.31	N 6 =	636.74	N 7 =	644.16	N 8 =	652.56	N 9 =	662.05
N 10 =	672.65	N 11 =	684.36	N 12 =	697.17	N 13 =	711.05	N 14 =	725.94
N 15 =	741.74	N 16 =	758.35	N 17 =	775.65	N 18 =	793.46	N 19 =	811.64
N 20 =	830.00	N 21 =	848.36	N 22 =	866.54	N 23 =	884.35	N 24 =	901.65
N 25 =	918.26	N 26 =	934.06	N 27 =	948.95	N 28 =	962.83	N 29 =	975.64
N 30 =	987.35	N 31 =	997.95	N 32 =	1007.4	N 33 =	1015.9	N 34 =	1023.3
N 35 =	1029.7	N 36 =	1035.2	N 37 =	1039.9	N 38 =	1043.9	N 39 =	1047.2
N 40 =	1050.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.65	M 1 =	619.62	M 2 =	624.34	M 3 =	629.90	M 4 =	636.38
M 5 =	643.86	M 6 =	652.40	M 7 =	662.06	M 8 =	672.87	M 9 =	684.84
M 10 =	697.97	M 11 =	712.20	M 12 =	727.48	M 13 =	743.72	M 14 =	760.80
M 15 =	778.58	M 16 =	796.89	M 17 =	815.55	M 18 =	834.38	M 19 =	853.17
M 20 =	871.74	M 21 =	889.89	M 22 =	907.45	M 23 =	924.26	M 24 =	940.18
M 25 =	955.09	M 26 =	968.93	M 27 =	981.62	M 28 =	993.14	M 29 =	1003.5
M 30 =	1012.7	M 31 =	1020.7	M 32 =	1027.8	M 33 =	1033.8	M 34 =	1038.9
M 35 =	1043.2	M 36 =	1046.8	M 37 =	1049.8	M 38 =	1052.2	M 39 =	1054.1
M 40 =	1055.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	636.05	P 1 =	644.41	P 2 =	654.17	P 3 =	665.44	P 4 =	678.30
P 5 =	692.80	P 6 =	708.99	P 7 =	726.82	P 8 =	746.26	P 9 =	767.17
P 10 =	789.41	P 11 =	812.75	P 12 =	836.96	P 13 =	861.72	P 14 =	886.73
15 =	911.62	P 16 =	936.05	P 17 =	959.68	P 18 =	982.15	P 19 =	1003.2
20 =	1022.5	P 21 =	1039.9	P 22 =	1055.2	P 23 =	1068.4	P 24 =	1079.3
25 =	1088.1	P 26 =	1094.9	P 27 =	1099.6	P 28 =	1102.6	P 29 =	1104.0
P 30 =	1104.1	P 31 =	1103.1	P 32 =	1101.1	P 33 =	1098.6	P 34 =	1095.5
P 35 =	1092.2	P 36 =	1088.7	P 37 =	1085.3	P 38 =	1082.0	P 39 =	1078.9
P 40 =	1076.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	625.10	G 1 =	631.10	G 2 =	638.15	G 3 =	646.36	G 4 =	655.79
G 5 =	666.53	G 6 =	678.61	G 7 =	692.06	G 8 =	706.86	G 9 =	722.98
G 10 =	740.32	G 11 =	758.77	G 12 =	778.19	G 13 =	798.38	G 14 =	819.13
G 15 =	840.20	G 16 =	861.35	G 17 =	882.31	G 18 =	902.82	G 19 =	922.65
G 20 =	941.57	G 21 =	959.37	G 22 =	975.90	G 23 =	991.01	G 24 =	1004.6
G 25 =	1016.7	G 26 =	1027.3	G 27 =	1036.3	G 28 =	1043.8	G 29 =	1050.1
G 30 =	1055.0	G 31 =	1058.9	G 32 =	1061.7	G 33 =	1063.8	G 34 =	1065.1
G 35 =	1065.9	G 36 =	1066.2	G 37 =	1066.2	G 38 =	1066.0	G 39 =	1065.6
G 40 =	1065.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.13	H 2 =	610.52	H 3 =	613.43	H 4 =	616.96	H 5 =	621.19
H 6 =	626.20	H 7 =	632.07	H 8 =	638.88	H 9 =	646.71	H 10 =	655.61
H 11 =	665.62	H 12 =	676.77	H 13 =	689.06	H 14 =	702.47	H 15 =	716.95
H 16 =	732.42	H 17 =	748.79	H 18 =	765.93	H 19 =	783.69	H 20 =	801.91
H 21 =	820.41	H 22 =	839.00	H 23 =	857.50	H 24 =	875.72	H 25 =	893.47
H 26 =	910.60	H 27 =	926.96	H 28 =	942.63	H 29 =	956.90	H 30 =	970.31
H 31 =	982.61	H 32 =	993.77	H 33 =	1003.8	H 34 =	1012.7	H 35 =	1020.6
H 36 =	1027.4	H 37 =	1033.3	H 38 =	1038.4	H 39 =	1042.6	H 40 =	1046.2
=	.0	=	.0	=	.0	=	.0		

PANEL TEMPERATURE DISTRIBUTION

CASE 1
SET 4 Subpanel Boundaries

Solar Flux Distribution: REFERENCE

Orifices: Yes: Orificed so as to match tube flow rates to reference flux distribution

Sodium Temperatures: T (Na-Inlet) = 610°F
T (Na-Outlet) = 1050°F (all tubes)

5370F/sjh

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 1
Location x/L: 0
T(Na-inlet) = 600 F
T(Na-outlet) : 1100 F

(Q/A)CL = 0.225 MW/M2 T:NA(IN) = 600F T:NA(OUT) = 1100F
A21= 9.94 A22= 33.133 A23= 43.17 A24= 33.23 A25= 16.662

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	600.00	T:NA OUT=	1100.0	DT: NA =	500.00	T:B NA =	850.00	T:B M =	855.94
DT M-N =	9.9400	DT1 =	33.133	DT P-N =	43.170	DT P-M =	33.230	DT2 =	16.662
=	.0	=	.0	=	.0	=	.0	=	.0
N =	600.00	N 1 =	603.13	N 2 =	606.90	N 3 =	611.43	N 4 =	616.79
N 5 =	623.08	N 6 =	630.39	N 7 =	638.79	N 8 =	648.36	N 9 =	659.15
N 10 =	671.19	N 11 =	684.50	N 12 =	699.06	N 13 =	714.83	N 14 =	731.75
N 15 =	749.71	N 16 =	768.58	N 17 =	788.23	N 18 =	808.48	N 19 =	829.14
N 20 =	850.00	N 21 =	870.86	N 22 =	891.52	N 23 =	911.77	N 24 =	931.42
N 25 =	950.29	N 26 =	968.25	N 27 =	985.17	N 28 =	1000.9	N 29 =	1015.5
N 30 =	1028.8	N 31 =	1040.9	N 32 =	1051.6	N 33 =	1061.2	N 34 =	1069.6
N 35 =	1076.9	N 36 =	1083.2	N 37 =	1088.6	N 38 =	1093.1	N 39 =	1096.9
N 40 =	1100.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	601.35	M 1 =	604.76	M 2 =	608.87	M 3 =	613.77	M 4 =	619.55
M 5 =	626.31	M 6 =	634.12	M 7 =	643.06	M 8 =	653.20	M 9 =	664.58
M 10 =	677.22	M 11 =	691.13	M 12 =	706.28	M 13 =	722.61	M 14 =	740.05
M 15 =	758.48	M 16 =	777.76	M 17 =	797.74	M 18 =	818.22	M 19 =	839.03
M 20 =	859.94	M 21 =	880.75	M 22 =	901.26	M 23 =	921.27	M 24 =	940.59
M 25 =	959.07	M 26 =	976.56	M 27 =	992.95	M 28 =	1008.2	M 29 =	1022.1
M 30 =	1034.8	M 31 =	1046.3	M 32 =	1056.5	M 33 =	1065.5	M 34 =	1073.3
M 35 =	1080.1	M 36 =	1086.0	M 37 =	1090.9	M 38 =	1095.1	M 39 =	1098.5
M 40 =	1101.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	605.84	P 1 =	610.23	P 2 =	615.45	P 3 =	621.60	P 4 =	628.79
P 5 =	637.09	P 6 =	646.59	P 7 =	657.33	P 8 =	669.37	P 9 =	682.72
P 10 =	697.38	P 11 =	713.29	P 12 =	730.41	P 13 =	748.62	P 14 =	767.80
15 =	787.80	P 16 =	808.44	P 17 =	829.50	P 18 =	850.80	P 19 =	872.09
20 =	893.17	P 21 =	913.82	P 22 =	933.83	P 23 =	953.04	P 24 =	971.27
25 =	988.39	P 26 =	1004.3	P 27 =	1019.0	P 28 =	1032.3	P 29 =	1044.3
r 30 =	1055.0	P 31 =	1064.4	P 32 =	1072.7	P 33 =	1079.8	P 34 =	1085.8
P 35 =	1090.9	P 36 =	1095.2	P 37 =	1098.7	P 38 =	1101.6	P 39 =	1104.0
P 40 =	1105.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	603.59	G 1 =	607.48	G 2 =	612.15	G 3 =	617.68	G 4 =	624.16
G 5 =	631.68	G 6 =	640.33	G 7 =	650.18	G 8 =	661.26	G 9 =	673.62
G 10 =	687.27	G 11 =	702.18	G 12 =	718.31	G 13 =	735.58	G 14 =	753.89
G 15 =	773.10	G 16 =	793.05	G 17 =	813.57	G 18 =	834.46	G 19 =	855.51
G 20 =	876.51	G 21 =	897.24	G 22 =	917.50	G 23 =	937.11	G 24 =	955.88
G 25 =	973.69	G 26 =	990.39	G 27 =	1005.9	G 28 =	1020.2	G 29 =	1033.2
G 30 =	1044.9	G 31 =	1055.3	G 32 =	1064.5	G 33 =	1072.6	G 34 =	1079.6
G 35 =	1085.5	G 36 =	1090.6	G 37 =	1094.8	G 38 =	1098.3	G 39 =	1101.2
G 40 =	1103.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	602.04	H 2 =	605.59	H 3 =	609.87	H 4 =	614.95	H 5 =	620.93
H 6 =	627.90	H 7 =	635.94	H 8 =	645.13	H 9 =	655.53	H 10 =	667.17
H 11 =	680.08	H 12 =	694.25	H 13 =	709.64	H 14 =	726.21	H 15 =	743.86
H 16 =	762.47	H 17 =	781.90	H 18 =	801.99	H 19 =	822.54	H 20 =	843.37
H 21 =	864.27	H 22 =	885.02	H 23 =	905.43	H 24 =	925.30	H 25 =	944.45
H 26 =	962.72	H 27 =	979.98	H 28 =	996.13	H 29 =	1011.1	H 30 =	1024.8
H 31 =	1037.2	H 32 =	1048.4	H 33 =	1058.4	H 34 =	1067.1	H 35 =	1074.8
H 36 =	1081.4	H 37 =	1087.0	H 38 =	1091.8	H 39 =	1095.8	H 40 =	1099.1
=	.0	=	.0	=	.0	=	.0		

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 1 2
Location x/L: 1.0 0.0
T(Na-inlet) = 600 F
T(Na-outlet) : 1100F

1100F

(Q/A)CL = 0.97 MW/M2 T:NA(IN) = 600F T:NA(OUT) = 1100F
A21= 35.16 A22=117.57 A23=160.50 A24=125.34 A25= 66.558

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	600.00	T:NA OUT=	1100.0	DT: NA =	500.00	T:B NA =	850.00	T:B M =	871.03
DT N-N =	35.160	DT1 =	117.57	DT P-N =	160.50	DT P-M =	125.34	DT2 =	66.558
=	.0	=	.0	=	.0	=	.0	=	.0
N =	600.00	N 1 =	603.13	N 2 =	606.90	N 3 =	611.43	N 4 =	616.79
N 5 =	623.08	N 6 =	630.39	N 7 =	638.79	N 8 =	648.36	N 9 =	659.15
N 10 =	671.19	N 11 =	684.50	N 12 =	699.06	N 13 =	714.83	N 14 =	731.75
N 15 =	749.71	N 16 =	768.58	N 17 =	788.23	N 18 =	808.48	N 19 =	829.14
N 20 =	850.00	N 21 =	870.86	N 22 =	891.52	N 23 =	911.77	N 24 =	931.42
N 25 =	950.29	N 26 =	968.25	N 27 =	985.17	N 28 =	1000.9	N 29 =	1015.5
N 30 =	1028.8	N 31 =	1040.9	N 32 =	1051.6	N 33 =	1061.2	N 34 =	1069.6
N 35 =	1076.9	N 36 =	1083.2	N 37 =	1088.6	N 38 =	1093.1	N 39 =	1096.9
N 40 =	1100.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	604.76	M 1 =	608.91	M 2 =	613.86	M 3 =	619.72	M 4 =	626.56
M 5 =	634.49	M 6 =	643.58	M 7 =	653.89	M 8 =	665.47	M 9 =	678.35
M 10 =	692.52	M 11 =	707.95	M 12 =	724.59	M 13 =	742.35	M 14 =	761.11
M 15 =	780.73	M 16 =	801.06	M 17 =	821.85	M 18 =	842.94	M 19 =	864.12
M 20 =	885.16	M 21 =	905.85	M 22 =	925.98	M 23 =	945.38	M 24 =	963.87
M 25 =	981.32	M 26 =	997.62	M 27 =	1012.7	M 28 =	1026.5	M 29 =	1039.0
M 30 =	1050.1	M 31 =	1060.1	M 32 =	1068.8	M 33 =	1076.3	M 34 =	1082.8
M 35 =	1088.3	M 36 =	1093.0	M 37 =	1096.9	M 38 =	1100.1	M 39 =	1102.7
M 40 =	1104.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	621.72	P 1 =	629.52	P 2 =	638.67	P 3 =	649.26	P 4 =	661.41
P 5 =	675.18	P 6 =	690.62	P 7 =	707.73	P 8 =	726.48	P 9 =	746.79
P 10 =	768.54	P 11 =	791.55	P 12 =	815.61	P 13 =	840.46	P 14 =	865.81
P 15 =	891.35	P 16 =	916.74	P 17 =	941.67	P 18 =	965.80	P 19 =	988.84
P 20 =	1010.5	P 21 =	1030.6	P 22 =	1048.8	P 23 =	1065.2	P 24 =	1079.6
P 25 =	1091.9	P 26 =	1102.3	P 27 =	1110.8	P 28 =	1117.5	P 29 =	1122.5
P 30 =	1126.2	P 31 =	1128.5	P 32 =	1129.8	P 33 =	1130.2	P 34 =	1129.9
P 35 =	1129.0	P 36 =	1127.8	P 37 =	1126.4	P 38 =	1124.9	P 39 =	1123.3
P 40 =	1121.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	612.71	G 1 =	618.58	G 2 =	625.50	G 3 =	633.57	G 4 =	642.91
G 5 =	653.58	G 6 =	665.64	G 7 =	679.14	G 8 =	694.09	G 9 =	710.45
G 10 =	728.17	G 11 =	747.16	G 12 =	767.28	G 13 =	788.36	G 14 =	810.22
G 15 =	832.61	G 16 =	855.31	G 17 =	878.04	G 18 =	900.57	G 19 =	922.61
G 20 =	943.94	G 21 =	964.34	G 22 =	983.60	G 23 =	1001.6	G 24 =	1018.1
G 25 =	1033.2	G 26 =	1046.7	G 27 =	1058.7	G 28 =	1069.2	G 29 =	1078.2
G 30 =	1085.8	G 31 =	1092.2	G 32 =	1097.4	G 33 =	1101.6	G 34 =	1104.9
G 35 =	1107.4	G 36 =	1109.3	G 37 =	1110.7	G 38 =	1111.7	G 39 =	1112.3
G 40 =	1112.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	599.24	H 2 =	602.23	H 3 =	605.86	H 4 =	610.22	H 5 =	615.41
H 6 =	621.52	H 7 =	628.64	H 8 =	636.86	H 9 =	646.25	H 10 =	656.86
H 11 =	668.74	H 12 =	681.90	H 13 =	696.34	H 14 =	712.01	H 15 =	728.86
H 16 =	746.78	H 17 =	765.65	H 18 =	785.32	H 19 =	805.63	H 20 =	826.37
H 21 =	847.36	H 22 =	868.36	H 23 =	889.18	H 24 =	909.61	H 25 =	929.45
H 26 =	948.52	H 27 =	966.68	H 28 =	983.78	H 29 =	999.74	H 30 =	1014.5
H 31 =	1027.9	H 32 =	1040.1	H 33 =	1051.1	H 34 =	1060.7	H 35 =	1069.3
H 36 =	1076.6	H 37 =	1083.0	H 38 =	1088.4	H 39 =	1093.0	H 40 =	1096.8
=	.0	=	.0	=	.0	=	.0		

CASE # 1

Solar Flux: REFERENCE
Orifices: YES
Sub-Panel: 2
Location x/L: 1.0
T(Na-inlet) = 600 F
T(Na-outlet) : 1100F

1100F

(Q/A)CL = 1.20 MW/M2 T:NA(IN) = 600F T:NA(OUT) = 1100F
A21= 41.74 A22=139.66 A23=192.50 A24=150.76 A25= 80.98

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	600.00	T:NA OUT=	1100.0	DT: NA =	500.00	T:B NA =	850.00	T:B M =	874.96
DT M-N =	41.740	DT1 =	139.66	DT P-N =	192.50	DT P-M =	150.76	DT2 =	80.980
=	.0	=	.0	=	.0	=	.0	=	.0
N =	600.00	N 1 =	603.13	N 2 =	606.90	N 3 =	611.43	N 4 =	616.79
N 5 =	623.08	N 6 =	630.39	N 7 =	638.79	N 8 =	648.36	N 9 =	659.15
N 10 =	671.19	N 11 =	684.50	N 12 =	699.06	N 13 =	714.83	N 14 =	731.75
N 15 =	749.71	N 16 =	768.58	N 17 =	788.23	N 18 =	808.48	N 19 =	829.14
N 20 =	850.00	N 21 =	870.86	N 22 =	891.52	N 23 =	911.77	N 24 =	931.42
N 25 =	950.29	N 26 =	968.25	N 27 =	985.17	N 28 =	1000.9	N 29 =	1015.5
N 30 =	1028.8	N 31 =	1040.9	N 32 =	1051.6	N 33 =	1061.2	N 34 =	1069.6
N 35 =	1076.9	N 36 =	1083.2	N 37 =	1088.6	N 38 =	1093.1	N 39 =	1096.9
N 40 =	1100.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	605.65	M 1 =	609.99	M 2 =	615.16	M 3 =	621.27	M 4 =	628.39
M 5 =	636.63	M 6 =	646.05	M 7 =	656.72	M 8 =	668.68	M 9 =	681.94
M 10 =	696.51	M 11 =	712.34	M 12 =	729.37	M 13 =	747.50	M 14 =	766.61
M 15 =	786.54	M 16 =	807.12	M 17 =	828.14	M 18 =	849.39	M 19 =	870.67
M 20 =	891.74	M 21 =	912.39	M 22 =	932.43	M 23 =	951.67	M 24 =	969.95
M 25 =	987.13	M 26 =	1003.1	M 27 =	1017.8	M 28 =	1031.2	M 29 =	1043.3
M 30 =	1054.1	M 31 =	1063.6	M 32 =	1072.0	M 33 =	1079.1	M 34 =	1085.3
M 35 =	1090.5	M 36 =	1094.8	M 37 =	1098.4	M 38 =	1101.4	M 39 =	1103.7
M 40 =	1105.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	626.05	P 1 =	634.79	P 2 =	645.00	P 3 =	656.81	P 4 =	670.31
P 5 =	685.57	P 6 =	702.63	P 7 =	721.48	P 8 =	742.06	P 9 =	764.27
10 =	787.95	P 11 =	812.89	P 12 =	838.84	P 13 =	865.50	P 14 =	892.54
15 =	919.59	P 16 =	946.28	P 17 =	972.26	P 18 =	997.17	P 19 =	1020.7
20 =	1042.5	P 21 =	1062.4	P 22 =	1080.2	P 23 =	1095.8	P 24 =	1109.1
P 25 =	1120.2	P 26 =	1129.0	P 27 =	1135.8	P 28 =	1140.7	P 29 =	1143.9
P 30 =	1145.6	P 31 =	1146.0	P 32 =	1145.3	P 33 =	1143.9	P 34 =	1141.9
P 35 =	1139.4	P 36 =	1136.7	P 37 =	1134.0	P 38 =	1131.2	P 39 =	1128.5
P 40 =	1126.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	615.10	G 1 =	621.48	G 2 =	628.98	G 3 =	637.73	G 4 =	647.81
G 5 =	659.30	G 6 =	672.26	G 7 =	686.72	G 8 =	702.67	G 9 =	720.07
G 10 =	738.86	G 11 =	758.91	G 12 =	780.08	G 13 =	802.16	G 14 =	824.94
G 15 =	848.17	G 16 =	871.58	G 17 =	894.89	G 18 =	917.84	G 19 =	940.15
G 20 =	961.57	G 21 =	981.88	G 22 =	1000.9	G 23 =	1018.4	G 24 =	1034.4
G 25 =	1048.8	G 26 =	1061.4	G 27 =	1072.5	G 28 =	1082.0	G 29 =	1089.9
G 30 =	1096.5	G 31 =	1101.8	G 32 =	1105.9	G 33 =	1109.1	G 34 =	1111.5
G 35 =	1113.1	G 36 =	1114.2	G 37 =	1114.9	G 38 =	1115.2	G 39 =	1115.2
G 40 =	1115.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	598.51	H 2 =	601.34	H 3 =	604.81	H 4 =	608.98	H 5 =	613.96
H 6 =	619.84	H 7 =	626.72	H 8 =	634.69	H 9 =	643.81	H 10 =	654.15
H 11 =	665.76	H 12 =	678.66	H 13 =	692.84	H 14 =	708.28	H 15 =	724.92
H 16 =	742.65	H 17 =	761.38	H 18 =	780.95	H 19 =	801.19	H 20 =	821.91
H 21 =	842.91	H 22 =	863.98	H 23 =	884.91	H 24 =	905.48	H 25 =	925.50
H 26 =	944.79	H 27 =	963.18	H 28 =	980.54	H 29 =	996.76	H 30 =	1011.8
H 31 =	1025.5	H 32 =	1038.0	H 33 =	1049.1	H 34 =	1059.1	H 35 =	1067.8
H 36 =	1075.4	H 37 =	1081.9	H 38 =	1087.5	H 39 =	1092.3	H 40 =	1096.2
=	.0	=	.0	=	.0	=	.0		

PANEL TEMPERATURE DISTRIBUTION

CASE 2

SET 1 Subpanel 1

Solar Flux Distribution: REFERENCE

Orifices: None

Sodium Temperatures: T (Na-Inlet) = 610°F
T (Na-Outlet) = 1100°F maximum
(723.66 to 1100F)

5370F/sjh

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 1
Location x/L: 0.05
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PANEL 1 LOC=.05 T:NA(IN)=610F T:NA(OUT)=742.48
A21=11.201 A22= 37.355 A23= 49.037 A24= 37.836 A25=19.1

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN	= 610.00	T:NA OUT	= 742.48	DT: NA	= 132.48	T:B NA	= 676.24	T:B M	= 682.94
DT M-N	= 11.201	DT1	= 37.355	DT P-N	= 49.037	DT P-M	= 37.836	DT2	= 19.157
	= .0		= .0		= .0		= .0		= .0
N	= 610.00	N 1	= 610.83	N 2	= 611.83	N 3	= 613.03	N 4	= 614.45
N 5	= 616.11	N 6	= 618.05	N 7	= 620.28	N 8	= 622.81	N 9	= 625.67
N 10	= 628.86	N 11	= 632.39	N 12	= 636.25	N 13	= 640.43	N 14	= 644.91
N 15	= 649.67	N 16	= 654.67	N 17	= 659.87	N 18	= 665.24	N 19	= 670.71
N 20	= 676.24	N 21	= 681.77	N 22	= 687.24	N 23	= 692.61	N 24	= 697.81
N 25	= 702.81	N 26	= 707.57	N 27	= 712.05	N 28	= 716.23	N 29	= 720.09
N 30	= 723.62	N 31	= 726.81	N 32	= 729.67	N 33	= 732.20	N 34	= 734.43
N 35	= 736.36	N 36	= 738.03	N 37	= 739.45	N 38	= 740.65	N 39	= 741.65
N 40	= 742.48		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
M	= 611.52	M 1	= 612.67	M 2	= 614.05	M 3	= 615.67	M 4	= 617.56
M 5	= 619.75	M 6	= 622.25	M 7	= 625.09	M 8	= 628.27	M 9	= 631.79
M 10	= 635.66	M 11	= 639.86	M 12	= 644.38	M 13	= 649.19	M 14	= 654.26
M 15	= 659.55	M 16	= 665.01	M 17	= 670.58	M 18	= 676.22	M 19	= 681.86
M 20	= 687.44	M 21	= 692.91	M 22	= 698.22	M 23	= 703.31	M 24	= 708.15
M 25	= 712.70	M 26	= 716.93	M 27	= 720.82	M 28	= 724.37	M 29	= 727.56
M 30	= 730.41	M 31	= 732.92	M 32	= 735.12	M 33	= 737.01	M 34	= 738.63
M 35	= 740.00	M 36	= 741.15	M 37	= 742.09	M 38	= 742.87	M 39	= 743.49
M 40	= 744.00		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
P	= 616.64	P 1	= 618.89	P 2	= 621.53	P 3	= 624.59	P 4	= 628.08
P 5	= 632.03	P 6	= 636.46	P 7	= 641.34	P 8	= 646.68	P 9	= 652.45
P 10	= 658.61	P 11	= 665.10	P 12	= 671.85	P 13	= 678.81	P 14	= 685.87
P 15	= 692.94	P 16	= 699.93	P 17	= 706.75	P 18	= 713.30	P 19	= 719.50
P 20	= 725.28	P 21	= 730.56	P 22	= 735.31	P 23	= 739.48	P 24	= 743.08
P 25	= 746.09	P 26	= 748.53	P 27	= 750.44	P 28	= 751.84	P 29	= 752.80
P 30	= 753.36	P 31	= 753.59	P 32	= 753.54	P 33	= 753.27	P 34	= 752.83
P 35	= 752.28	P 36	= 751.67	P 37	= 751.01	P 38	= 750.35	P 39	= 749.72
P 40	= 749.12		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
G	= 614.04	G 1	= 615.74	G 2	= 617.74	G 3	= 620.07	G 4	= 622.76

G 5	= 625.81	G 6	= 629.26	G 7	= 633.11	G 8	= 637.36	G 9	= 641.99
G 10	= 646.98	G 11	= 652.32	G 12	= 657.94	G 13	= 663.81	G 14	= 669.86
G 15	= 676.03	G 16	= 682.25	G 17	= 688.44	G 18	= 694.53	G 19	= 700.44
G 20	= 706.12	G 21	= 711.50	G 22	= 716.53	G 23	= 721.17	G 24	= 725.39
G 25	= 729.18	G 26	= 732.53	G 27	= 735.44	G 28	= 737.93	G 29	= 740.02
G 30	= 741.74	G 31	= 743.12	G 32	= 744.21	G 33	= 745.04	G 34	= 745.64
G 35	= 746.06	G 36	= 746.34	G 37	= 746.50	G 38	= 746.56	G 39	= 746.57
G 40	= 746.52		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
H 1	= 609.60	H 2	= 610.35	H 3	= 611.26	H 4	= 612.37	H 5	= 613.69
H 6	= 615.24	H 7	= 617.07	H 8	= 619.17	H 9	= 621.59	H 10	= 624.33
H 11	= 627.40	H 12	= 630.82	H 13	= 634.57	H 14	= 638.66	H 15	= 643.07
H 16	= 647.77	H 17	= 652.73	H 18	= 657.91	H 19	= 663.27	H 20	= 668.76
H 21	= 674.33	H 22	= 679.91	H 23	= 685.46	H 24	= 690.91	H 25	= 696.22
H 26	= 701.33	H 27	= 706.20	H 28	= 710.80	H 29	= 715.10	H 30	= 719.08
H 31	= 722.72	H 32	= 726.03	H 33	= 728.99	H 34	= 731.62	H 35	= 733.94
H 36	= 735.95	H 37	= 737.69	H 38	= 739.17	H 39	= 740.42	H 40	= 741.47
	= .0		= .0		= .0		= .0		

Addendum to
NO 079TI000002
PAGE 134

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 1
Location x/L: 0.15
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PANEL 1 LOC=.15 T:NA(IN)=610F T:NA(OUT)=780.11
A21=13.723 A22= 45.799 A23= 60.770 A24= 47.047 A25=24.146

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN	= 610.00	T:NA OUT	= 780.11	DT: NA	= 170.11	T:B NA	= 695.05	T:B M	= 703.26
DT M-N	= 13.723	DT1	= 45.799	DT P-N	= 60.770	DT P-M	= 47.047	DT2	= 24.146
	= .0		= .0		= .0		= .0		= .0
N	= 610.00	N 1	= 611.06	N 2	= 612.35	N 3	= 613.89	N 4	= 615.71
N 5	= 617.85	N 6	= 620.34	N 7	= 623.20	N 8	= 626.45	N 9	= 630.12
N 10	= 634.22	N 11	= 638.75	N 12	= 643.70	N 13	= 649.07	N 14	= 654.82
N 15	= 660.93	N 16	= 667.36	N 17	= 674.04	N 18	= 680.93	N 19	= 687.96
N 20	= 695.05	N 21	= 702.15	N 22	= 709.18	N 23	= 716.07	N 24	= 722.75
N 25	= 729.18	N 26	= 735.29	N 27	= 741.04	N 28	= 746.41	N 29	= 751.36
N 30	= 755.89	N 31	= 759.99	N 32	= 763.66	N 33	= 766.91	N 34	= 769.77
N 35	= 772.26	N 36	= 774.40	N 37	= 776.22	N 38	= 777.76	N 39	= 779.05
N 40	= 780.11		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
M	= 611.86	M 1	= 613.32	M 2	= 615.06	M 3	= 617.12	M 4	= 619.53
M 5	= 622.31	M 6	= 625.49	M 7	= 629.09	M 8	= 633.13	M 9	= 637.62
M 10	= 642.54	M 11	= 647.90	M 12	= 653.67	M 13	= 659.81	M 14	= 666.28
M 15	= 673.04	M 16	= 680.02	M 17	= 687.16	M 18	= 694.38	M 19	= 701.61
M 20	= 708.78	M 21	= 715.81	M 22	= 722.63	M 23	= 729.19	M 24	= 735.42
M 25	= 741.29	M 26	= 746.75	M 27	= 751.78	M 28	= 756.37	M 29	= 760.51
M 30	= 764.21	M 31	= 767.48	M 32	= 770.34	M 33	= 772.81	M 34	= 774.92
M 35	= 776.71	M 36	= 778.21	M 37	= 779.46	M 38	= 780.48	M 39	= 781.30
M 40	= 781.97		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
P	= 618.22	P 1	= 621.06	P 2	= 624.37	P 3	= 628.21	P 4	= 632.61
P 5	= 637.58	P 6	= 643.15	P 7	= 649.30	P 8	= 656.03	P 9	= 663.31
P 10	= 671.08	P 11	= 679.28	P 12	= 687.83	P 13	= 696.63	P 14	= 705.58
P 15	= 714.56	P 16	= 723.45	P 17	= 732.14	P 18	= 740.50	P 19	= 748.42
P 20	= 755.82	P 21	= 762.62	P 22	= 768.75	P 23	= 774.16	P 24	= 778.85
P 25	= 782.81	P 26	= 786.05	P 27	= 788.61	P 28	= 790.54	P 29	= 791.89
P 30	= 792.75	P 31	= 793.17	P 32	= 793.24	P 33	= 793.02	P 34	= 792.58
P 35	= 791.99	P 36	= 791.29	P 37	= 790.55	P 38	= 789.79	P 39	= 789.04
P 40	= 788.33		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
G	= 614.96	G 1	= 617.09	G 2	= 619.60	G 3	= 622.52	G 4	= 625.89
G 5	= 629.74	G 6	= 634.08	G 7	= 638.93	G 8	= 644.28	G 9	= 650.12
G 10	= 656.43	G 11	= 663.17	G 12	= 670.30	G 13	= 677.73	G 14	= 685.41
G 15	= 693.25	G 16	= 701.16	G 17	= 709.05	G 18	= 716.83	G 19	= 724.40
G 20	= 731.68	G 21	= 738.59	G 22	= 745.08	G 23	= 751.08	G 24	= 756.56
G 25	= 761.50	G 26	= 765.88	G 27	= 769.71	G 28	= 773.00	G 29	= 775.79
G 30	= 778.10	G 31	= 779.98	G 32	= 781.48	G 33	= 782.64	G 34	= 783.52
G 35	= 784.15	G 36	= 784.58	G 37	= 784.86	G 38	= 785.01	G 39	= 785.07
G 40	= 785.07		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
H 1	= 609.55	H 2	= 610.53	H 3	= 611.72	H 4	= 613.16	H 5	= 614.87
H 6	= 616.89	H 7	= 619.26	H 8	= 621.99	H 9	= 625.11	H 10	= 628.65
H 11	= 632.63	H 12	= 637.04	H 13	= 641.89	H 14	= 647.16	H 15	= 652.83
H 16	= 658.88	H 17	= 665.27	H 18	= 671.93	H 19	= 678.83	H 20	= 685.88
H 21	= 693.02	H 22	= 700.19	H 23	= 707.30	H 24	= 714.28	H 25	= 721.08
H 26	= 727.62	H 27	= 733.86	H 28	= 739.74	H 29	= 745.24	H 30	= 750.32
H 31	= 754.97	H 32	= 759.19	H 33	= 762.97	H 34	= 766.33	H 35	= 769.28
H 36	= 771.85	H 37	= 774.06	H 38	= 775.94	H 39	= 777.54	H 40	= 778.87
	= .0		= .0		= .0		= .0		

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 1
Location x/L: 0.25
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PANEL 1 LOC=.25 T:NA(IN)=610F T:NA(OUT)=817.74
A21=16.245 A22= 54.242 A23= 72.503 A24= 56.258 A25=29.136

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	817.74	DT: NA =	207.74	T:B NA =	713.87	T:B M =	723.58
DT M-N =	16.245	DT1 =	54.242	DT P-N =	72.503	DT P-M =	56.258	DT2 =	29.136
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	611.30	N 2 =	612.87	N 3 =	614.75	N 4 =	616.98
N 5 =	619.59	N 6 =	622.62	N 7 =	626.12	N 8 =	630.09	N 9 =	634.58
N 10 =	639.58	N 11 =	645.11	N 12 =	651.16	N 13 =	657.71	N 14 =	664.74
N 15 =	672.20	N 16 =	680.04	N 17 =	688.21	N 18 =	696.62	N 19 =	705.20
N 20 =	713.87	N 21 =	722.54	N 22 =	731.12	N 23 =	739.53	N 24 =	747.70
N 25 =	755.54	N 26 =	763.00	N 27 =	770.03	N 28 =	776.58	N 29 =	782.63
N 30 =	788.16	N 31 =	793.16	N 32 =	797.65	N 33 =	801.62	N 34 =	805.11
N 35 =	808.15	N 36 =	810.76	N 37 =	812.99	N 38 =	814.87	N 39 =	816.44
N 40 =	817.74	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	612.20	M 1 =	613.97	M 2 =	616.08	M 3 =	618.58	M 4 =	621.49
M 5 =	624.86	M 6 =	628.72	M 7 =	633.09	M 8 =	638.00	M 9 =	643.45
M 10 =	649.43	M 11 =	655.94	M 12 =	662.95	M 13 =	670.42	M 14 =	678.31
M 15 =	686.54	M 16 =	695.04	M 17 =	703.74	M 18 =	712.54	M 19 =	721.37
M 20 =	730.11	M 21 =	738.70	M 22 =	747.04	M 23 =	755.06	M 24 =	762.69
M 25 =	769.88	M 26 =	776.57	M 27 =	782.74	M 28 =	788.38	M 29 =	793.47
M 30 =	798.01	M 31 =	802.04	M 32 =	805.55	M 33 =	808.60	M 34 =	811.21
M 35 =	813.43	M 36 =	815.28	M 37 =	816.82	M 38 =	818.09	M 39 =	819.11
M 40 =	819.94	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	619.81	P 1 =	623.22	P 2 =	627.22	P 3 =	631.84	P 4 =	637.13
P 5 =	643.13	P 6 =	645.84	P 7 =	657.26	P 8 =	665.38	P 9 =	674.17
P 10 =	683.55	P 11 =	693.47	P 12 =	703.81	P 13 =	714.46	P 14 =	725.30
P 15 =	736.18	P 16 =	746.97	P 17 =	757.52	P 18 =	767.69	P 19 =	777.34
P 20 =	786.37	P 21 =	794.68	P 22 =	802.19	P 23 =	808.84	P 24 =	814.62
P 25 =	819.52	P 26 =	823.56	P 27 =	826.78	P 28 =	829.23	P 29 =	830.99
P 30 =	832.14	P 31 =	832.76	P 32 =	832.94	P 33 =	832.77	P 34 =	832.33
P 35 =	831.69	P 36 =	830.92	P 37 =	830.08	P 38 =	829.22	P 39 =	828.37
P 40 =	827.55	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	615.87	G 1 =	618.43	G 2 =	621.45	G 3 =	624.97	G 4 =	629.03
G 5 =	633.67	G 6 =	638.90	G 7 =	644.74	G 8 =	651.20	G 9 =	658.26
G 10 =	665.88	G 11 =	674.03	G 12 =	682.65	G 13 =	691.65	G 14 =	700.96
G 15 =	710.47	G 16 =	720.07	G 17 =	729.66	G 18 =	739.13	G 19 =	748.35
G 20 =	757.24	G 21 =	765.69	G 22 =	773.63	G 23 =	780.99	G 24 =	787.73
G 25 =	793.81	G 26 =	799.22	G 27 =	803.97	G 28 =	808.07	G 29 =	811.56
G 30 =	814.46	G 31 =	816.85	G 32 =	818.76	G 33 =	820.25	G 34 =	821.39
G 35 =	822.23	G 36 =	822.82	G 37 =	823.22	G 38 =	823.45	G 39 =	823.57
G 40 =	823.61	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.51	H 2 =	610.72	H 3 =	612.18	H 4 =	613.95	H 5 =	616.06
H 6 =	618.54	H 7 =	621.44	H 8 =	624.80	H 9 =	628.64	H 10 =	632.98
H 11 =	637.85	H 12 =	643.26	H 13 =	649.20	H 14 =	655.65	H 15 =	662.60
H 16 =	670.00	H 17 =	677.81	H 18 =	685.96	H 19 =	694.38	H 20 =	702.99
H 21 =	711.72	H 22 =	720.46	H 23 =	729.13	H 24 =	737.66	H 25 =	745.94
H 26 =	753.92	H 27 =	761.52	H 28 =	768.68	H 29 =	775.38	H 30 =	781.56
H 31 =	787.23	H 32 =	792.35	H 33 =	796.95	H 34 =	801.03	H 35 =	804.62
H 36 =	807.74	H 37 =	810.43	H 38 =	812.72	H 39 =	814.65	H 40 =	816.27
=	.0	=	.0	=	.0	=	.0		

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 1
Location x/L: 0.35
T(Na-inlet) = 610 F
T(Na-outlet) :
Max = 1100F

PANEL 1 LOC=.35 T:NA(IN)=610F T:NA(CUT)=855.38
A21=18.767 A22= 62.686 A23= 64.236 A24= 65.469 A25=34.126

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE =

T:NA IN	= 610.00	T:NA OUT	= 855.38	DT: NA	= 245.38	T:B NA	= 732.69	T:B M	= 743.91
DT M-N	= 18.767	DT1	= 62.686	DT P-N	= 84.236	DT P-M	= 65.469	DT2	= 34.126
	= .0		= .0		= .0		= .0		= .0
N	= 610.00	N 1	= 611.53	N 2	= 613.39	N 3	= 615.61	N 4	= 618.24
N 5	= 621.33	N 6	= 624.91	N 7	= 629.04	N 8	= 633.73	N 9	= 639.03
N 10	= 644.94	N 11	= 651.47	N 12	= 658.61	N 13	= 666.35	N 14	= 674.66
N 15	= 683.47	N 16	= 692.73	N 17	= 702.38	N 18	= 712.31	N 19	= 722.45
N 20	= 732.69	N 21	= 742.93	N 22	= 753.07	N 23	= 763.00	N 24	= 772.65
N 25	= 781.91	N 26	= 790.72	N 27	= 799.03	N 28	= 806.77	N 29	= 813.91
N 30	= 820.44	N 31	= 826.35	N 32	= 831.65	N 33	= 836.34	N 34	= 840.47
N 35	= 844.05	N 36	= 847.14	N 37	= 849.77	N 38	= 851.99	N 39	= 853.85
N 40	= 855.38		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
M	= 612.54	M 1	= 614.62	M 2	= 617.10	M 3	= 620.03	M 4	= 623.46
M 5	= 627.42	M 6	= 631.96	M 7	= 637.10	M 8	= 642.87	M 9	= 649.28
M 10	= 656.32	M 11	= 663.99	M 12	= 672.24	M 13	= 681.04	M 14	= 690.33
M 15	= 700.03	M 16	= 710.06	M 17	= 720.32	M 18	= 730.71	M 19	= 741.12
M 20	= 751.46	M 21	= 761.60	M 22	= 771.46	M 23	= 780.94	M 24	= 789.97
M 25	= 798.47	M 26	= 806.40	M 27	= 813.71	M 28	= 820.39	M 29	= 826.43
M 30	= 831.82	M 31	= 836.60	M 32	= 840.78	M 33	= 844.40	M 34	= 847.51
M 35	= 850.15	M 36	= 852.36	M 37	= 854.20	M 38	= 855.71	M 39	= 856.93
M 40	= 857.92		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
P	= 621.40	P 1	= 625.39	P 2	= 630.06	P 3	= 635.47	P 4	= 641.66
P 5	= 648.67	P 6	= 656.53	P 7	= 665.22	P 8	= 674.73	P 9	= 685.03
P 10	= 696.03	P 11	= 707.65	P 12	= 719.78	P 13	= 732.29	P 14	= 745.02
P 15	= 757.81	P 16	= 770.49	P 17	= 782.91	P 18	= 794.88	P 19	= 806.27
P 20	= 816.93	P 21	= 826.74	P 22	= 835.63	P 23	= 843.53	P 24	= 850.40
P 25	= 856.25	P 26	= 861.08	P 27	= 864.96	P 28	= 867.93	P 29	= 870.09
P 30	= 871.53	P 31	= 872.35	P 32	= 872.65	P 33	= 872.53	P 34	= 872.08
P 35	= 871.40	P 36	= 870.56	P 37	= 869.63	P 38	= 868.66	P 39	= 867.70
P 40	= 866.78		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
G	= 616.78	G 1	= 619.78	G 2	= 623.30	G 3	= 627.42	G 4	= 632.17
G 5	= 637.59	G 6	= 643.72	G 7	= 650.56	G 8	= 658.12	G 9	= 666.39
G 10	= 675.33	G 11	= 684.89	G 12	= 695.00	G 13	= 705.58	G 14	= 716.51
G 15	= 727.69	G 16	= 738.99	G 17	= 750.28	G 18	= 761.43	G 19	= 772.31
G 20	= 782.80	G 21	= 792.79	G 22	= 802.18	G 23	= 810.91	G 24	= 818.90
G 25	= 826.13	G 26	= 832.58	G 27	= 838.25	G 28	= 843.15	G 29	= 847.33
G 30	= 850.83	G 31	= 853.72	G 32	= 856.04	G 33	= 857.87	G 34	= 859.27
G 35	= 860.32	G 36	= 861.07	G 37	= 861.58	G 38	= 861.91	G 39	= 862.09
G 40	= 862.16		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
H 1	= 609.47	H 2	= 610.90	H 3	= 612.64	H 4	= 614.74	H 5	= 617.24
H 6	= 620.19	H 7	= 623.63	H 8	= 627.61	H 9	= 632.16	H 10	= 637.31
H 11	= 643.08	H 12	= 649.48	H 13	= 656.51	H 14	= 664.15	H 15	= 672.37
H 16	= 681.12	H 17	= 690.35	H 18	= 699.99	H 19	= 709.94	H 20	= 720.11
H 21	= 730.42	H 22	= 740.74	H 23	= 750.98	H 24	= 761.04	H 25	= 770.81
H 26	= 780.22	H 27	= 789.18	H 28	= 797.63	H 29	= 805.52	H 30	= 812.81
H 31	= 819.48	H 32	= 825.53	H 33	= 830.94	H 34	= 835.75	H 35	= 839.97
H 36	= 843.64	H 37	= 846.81	H 38	= 849.50	H 39	= 851.78	H 40	= 853.68
	= .0		= .0		= .0		= .0		

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 1
Location x/L: 0.45
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PANEL 1 LOC=.45 T:NA(IN)=610F T:NA(OUT)=893.01
A21=21.289 A22= 71.130 A23= 95.969 A24= 74.680 A25=39.115

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = Z

T:NA IN =	610.00	T:NA OUT=	893.01	DT: NA =	283.01	T:B NA =	751.50	T:B M =	764.24
DT M-N =	21.289	DT1 =	71.130	DT P-N =	95.969	DT P-M =	74.680	DT2 =	39.115
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	611.77	N 2 =	613.91	N 3 =	616.47	N 4 =	619.50
N 5 =	623.06	N 6 =	627.20	N 7 =	631.96	N 8 =	637.37	N 9 =	643.48
N 10 =	650.30	N 11 =	657.83	N 12 =	666.07	N 13 =	675.00	N 14 =	684.57
N 15 =	694.74	N 16 =	705.42	N 17 =	716.54	N 18 =	728.00	N 19 =	739.70
N 20 =	751.50	N 21 =	763.31	N 22 =	775.01	N 23 =	786.47	N 24 =	797.59
N 25 =	808.27	N 26 =	818.44	N 27 =	828.01	N 28 =	836.94	N 29 =	845.18
N 30 =	852.71	N 31 =	859.53	N 32 =	865.64	N 33 =	871.05	N 34 =	875.81
N 35 =	879.95	N 36 =	883.51	N 37 =	886.54	N 38 =	889.10	N 39 =	891.24
N 40 =	893.01	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	612.88	M 1 =	615.27	M 2 =	618.12	M 3 =	621.49	M 4 =	625.42
M 5 =	629.97	M 6 =	635.19	M 7 =	641.10	M 8 =	647.73	M 9 =	655.10
M 10 =	663.21	M 11 =	672.03	M 12 =	681.53	M 13 =	691.66	M 14 =	702.35
M 15 =	713.52	M 16 =	725.07	M 17 =	736.90	M 18 =	748.87	M 19 =	760.88
M 20 =	772.79	M 21 =	784.50	M 22 =	795.87	P 23 =	806.82	M 24 =	817.24
M 25 =	827.06	M 26 =	836.22	M 27 =	844.68	M 28 =	852.40	M 29 =	859.38
M 30 =	865.63	M 31 =	871.16	M 32 =	876.00	M 33 =	880.20	M 34 =	883.80
M 35 =	886.86	M 36 =	889.43	M 37 =	891.56	M 38 =	893.31	M 39 =	894.74
M 40 =	895.89	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	622.99	P 1 =	627.55	P 2 =	632.90	P 3 =	639.09	P 4 =	646.19
P 5 =	654.22	P 6 =	663.22	P 7 =	673.18	P 8 =	684.09	P 9 =	695.89
P 10 =	708.50	P 11 =	721.84	P 12 =	735.76	P 13 =	750.11	P 14 =	764.73
P 15 =	779.43	P 16 =	794.01	P 17 =	808.29	P 18 =	822.07	P 19 =	835.19
P 20 =	847.47	P 21 =	858.80	P 22 =	869.07	P 23 =	878.21	P 24 =	886.18
P 25 =	892.97	P 26 =	898.60	P 27 =	903.13	P 28 =	906.63	P 29 =	909.19
P 30 =	910.92	P 31 =	911.94	P 32 =	912.35	P 33 =	912.28	P 34 =	911.83
P 35 =	911.10	P 36 =	910.19	P 37 =	909.17	P 38 =	908.09	P 39 =	907.02
P 40 =	906.00	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	617.69	G 1 =	621.12	G 2 =	625.16	G 3 =	629.87	G 4 =	635.31
G 5 =	641.52	G 6 =	648.54	G 7 =	656.38	G 8 =	665.05	G 9 =	674.53
G 10 =	684.78	G 11 =	695.75	G 12 =	707.35	G 13 =	719.50	G 14 =	732.06
G 15 =	744.91	G 16 =	757.90	G 17 =	770.90	G 18 =	783.73	G 19 =	796.27
G 20 =	808.36	G 21 =	819.88	G 22 =	830.73	G 23 =	840.82	G 24 =	850.07
G 25 =	858.45	G 26 =	865.93	G 27 =	872.51	G 28 =	878.22	G 29 =	883.10
G 30 =	887.20	G 31 =	890.58	G 32 =	893.31	G 33 =	895.48	G 34 =	897.15
G 35 =	898.40	G 36 =	899.31	G 37 =	899.94	G 38 =	900.35	G 39 =	900.59
G 40 =	900.70	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.42	H 2 =	611.08	H 3 =	613.10	H 4 =	615.53	H 5 =	618.43
H 6 =	621.84	H 7 =	625.82	H 8 =	630.42	H 9 =	635.68	H 10 =	641.64
H 11 =	648.31	H 12 =	655.70	H 13 =	663.82	H 14 =	672.65	H 15 =	682.14
H 16 =	692.24	H 17 =	702.90	H 18 =	714.01	H 19 =	725.49	H 20 =	737.23
H 21 =	749.11	H 22 =	761.01	H 23 =	772.82	H 24 =	784.41	H 25 =	795.67
H 26 =	806.51	H 27 =	816.84	H 28 =	826.57	H 29 =	835.66	H 30 =	844.05
H 31 =	851.73	H 32 =	858.69	H 33 =	864.92	H 34 =	870.45	H 35 =	875.31
H 36 =	879.54	H 37 =	883.18	H 38 =	886.28	H 39 =	888.89	H 40 =	891.08
=	.0	=	.0	=	.0	=	.0		

Addendum to
NO 079TI000002
PAGE 138

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 1
Location x/L: 0.55
T(Na-inlet) = 610 F
T(Na-outlet) :
Max = 1100F

PANEL 1 LOC=.55 T:NA(IN)=610F T:NA(OUT)=930.65
A21=23.811 A22= 79.573 A23=107.70 A24= 83.891 A25=44.105

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	930.65	DT: NA =	320.65	T:B NA =	770.32	T:B M =	784.57
DT M-N =	23.811	DT1 =	79.573	DT P-N =	107.70	DT P-M =	83.891	DT2 =	44.105
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.00	N 2 =	614.43	N 3 =	617.33	N 4 =	620.77
N 5 =	624.80	N 6 =	629.49	N 7 =	634.88	N 8 =	641.01	N 9 =	647.93
N 10 =	655.66	N 11 =	664.19	N 12 =	673.53	N 13 =	683.64	N 14 =	694.49
N 15 =	706.01	N 16 =	718.11	N 17 =	730.71	N 18 =	743.70	N 19 =	756.95
N 20 =	770.32	N 21 =	783.70	N 22 =	796.95	N 23 =	809.94	N 24 =	822.54
N 25 =	834.64	N 26 =	846.16	N 27 =	857.01	N 28 =	867.12	N 29 =	876.46
N 30 =	884.99	N 31 =	892.72	N 32 =	899.64	N 33 =	905.77	N 34 =	911.16
N 35 =	915.85	N 36 =	919.88	N 37 =	923.32	N 38 =	926.22	N 39 =	928.65
N 40 =	930.65	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	613.22	M 1 =	615.92	M 2 =	619.14	M 3 =	622.94	M 4 =	627.39
M 5 =	632.53	M 6 =	638.42	M 7 =	645.10	M 8 =	652.60	M 9 =	660.93
M 10 =	670.10	M 11 =	680.07	M 12 =	690.82	M 13 =	702.28	M 14 =	714.38
M 15 =	727.02	M 16 =	740.09	M 17 =	753.48	M 18 =	767.04	M 19 =	780.64
M 20 =	794.14	M 21 =	807.40	M 22 =	820.29	M 23 =	832.70	M 24 =	844.52
M 25 =	855.66	M 26 =	866.05	M 27 =	875.65	M 28 =	884.41	M 29 =	892.34
M 30 =	899.44	M 31 =	905.72	M 32 =	911.23	M 33 =	916.00	M 34 =	920.10
M 35 =	923.58	M 36 =	926.50	M 37 =	928.93	M 38 =	930.93	M 39 =	932.56
M 40 =	933.87	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	624.58	P 1 =	629.72	P 2 =	635.74	P 3 =	642.72	P 4 =	650.71
P 5 =	659.76	P 6 =	669.91	P 7 =	681.14	P 8 =	693.44	P 9 =	706.74
P 10 =	720.98	P 11 =	736.02	P 12 =	751.73	P 13 =	767.94	P 14 =	784.45
P 15 =	801.05	P 16 =	817.53	P 17 =	833.68	P 18 =	849.27	P 19 =	864.11
P 20 =	878.02	P 21 =	890.87	P 22 =	902.52	P 23 =	912.90	P 24 =	921.96
P 25 =	929.69	P 26 =	936.12	P 27 =	941.31	P 28 =	945.33	P 29 =	948.29
P 30 =	950.32	P 31 =	951.53	P 32 =	952.06	P 33 =	952.04	P 34 =	951.58
P 35 =	950.81	P 36 =	949.83	P 37 =	948.71	P 38 =	947.54	P 39 =	946.36
P 40 =	945.23	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	618.61	G 1 =	622.46	G 2 =	627.01	G 3 =	632.32	G 4 =	638.45
G 5 =	645.45	G 6 =	653.35	G 7 =	662.19	G 8 =	671.97	G 9 =	682.66
G 10 =	694.23	G 11 =	706.61	G 12 =	719.71	G 13 =	733.42	G 14 =	747.61
G 15 =	762.13	G 16 =	776.82	G 17 =	791.51	G 18 =	806.04	G 19 =	820.23
G 20 =	833.92	G 21 =	846.98	G 22 =	859.29	G 23 =	870.73	G 24 =	881.24
G 25 =	890.77	G 26 =	899.28	G 27 =	906.79	G 28 =	913.30	G 29 =	918.88
G 30 =	923.57	G 31 =	927.45	G 32 =	930.59	G 33 =	933.09	G 34 =	935.03
G 35 =	936.50	G 36 =	937.57	G 37 =	938.31	G 38 =	938.81	G 39 =	939.11
G 40 =	939.26	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.38	H 2 =	611.27	H 3 =	613.56	H 4 =	616.32	H 5 =	619.61
H 6 =	623.49	H 7 =	628.01	H 8 =	633.24	H 9 =	639.21	H 10 =	645.97
H 11 =	653.53	H 12 =	661.93	H 13 =	671.14	H 14 =	681.14	H 15 =	691.91
H 16 =	703.37	H 17 =	715.44	H 18 =	728.04	H 19 =	741.05	H 20 =	754.35
H 21 =	767.81	H 22 =	781.29	H 23 =	794.66	H 24 =	807.79	H 25 =	820.54
H 26 =	832.82	H 27 =	844.50	H 28 =	855.52	H 29 =	865.80	H 30 =	875.30
H 31 =	883.99	H 32 =	891.86	H 33 =	898.91	H 34 =	905.17	H 35 =	910.66
H 36 =	915.44	H 37 =	919.55	H 38 =	923.06	H 39 =	926.02	H 40 =	928.49
=	.0	=	.0	=	.0	=	.0		

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 1
Location x/L: 0.65
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PANEL 1 LOC=.65 T:NA(IN)=610F T:NA(OUT)=968.28
A21=26.333 A22= 88.017 A23=119.43 A24= 93.102 A25=49.094

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	968.28	DT: NA =	358.28	T:B NA =	789.14	T:B M =	804.89
DT M-N =	26.333	DT1 =	88.017	DT P-N =	119.43	DT P-M =	93.102	DT2 =	49.094
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.24	N 2 =	614.95	N 3 =	618.19	N 4 =	622.03
N 5 =	626.54	N 6 =	631.77	N 7 =	637.80	N 8 =	644.65	N 9 =	652.38
N 10 =	661.01	N 11 =	670.55	N 12 =	680.98	N 13 =	692.28	N 14 =	704.40
N 15 =	717.27	N 16 =	730.80	N 17 =	744.88	N 18 =	759.39	N 19 =	774.19
N 20 =	789.14	N 21 =	804.09	N 22 =	818.89	N 23 =	833.40	N 24 =	847.48
N 25 =	861.01	N 26 =	873.88	N 27 =	886.00	N 28 =	897.30	N 29 =	907.73
N 30 =	917.27	N 31 =	925.90	N 32 =	933.63	N 33 =	940.48	N 34 =	946.51
N 35 =	951.74	N 36 =	956.25	N 37 =	960.09	N 38 =	963.33	N 39 =	966.04
N 40 =	968.28	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	613.56	M 1 =	616.57	M 2 =	620.16	M 3 =	624.40	M 4 =	629.35
M 5 =	635.09	M 6 =	641.66	M 7 =	649.11	M 8 =	657.47	M 9 =	666.76
M 10 =	676.98	M 11 =	688.11	M 12 =	700.10	M 13 =	712.89	M 14 =	726.40
M 15 =	740.51	M 16 =	755.11	M 17 =	770.05	M 18 =	785.20	M 19 =	800.39
M 20 =	815.47	M 21 =	830.29	M 22 =	844.70	M 23 =	858.57	M 24 =	871.79
M 25 =	884.25	M 26 =	895.87	M 27 =	906.61	M 28 =	916.42	M 29 =	925.29
M 30 =	933.24	M 31 =	940.28	M 32 =	946.44	M 33 =	951.80	M 34 =	956.39
M 35 =	960.29	M 36 =	963.57	M 37 =	966.30	M 38 =	968.54	M 39 =	970.37
M 40 =	971.84	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	626.16	P 1 =	631.88	P 2 =	638.58	P 3 =	646.34	P 4 =	655.24
P 5 =	665.31	P 6 =	676.60	P 7 =	689.10	P 8 =	702.79	P 9 =	717.60
P 10 =	733.45	P 11 =	750.21	P 12 =	767.71	P 13 =	785.76	P 14 =	804.16
P 15 =	822.67	P 16 =	841.05	P 17 =	859.06	P 18 =	876.45	P 19 =	893.02
P 20 =	908.57	P 21 =	922.92	P 22 =	935.96	P 23 =	947.57	P 24 =	957.73
P 25 =	966.40	P 26 =	973.63	P 27 =	979.47	P 28 =	984.02	P 29 =	987.39
P 30 =	989.70	P 31 =	991.11	P 32 =	991.76	P 33 =	991.79	P 34 =	991.33
P 35 =	990.52	P 36 =	989.46	P 37 =	988.25	P 38 =	986.97	P 39 =	985.68
P 40 =	984.44	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	619.52	G 1 =	623.81	G 2 =	628.87	G 3 =	634.77	G 4 =	641.59
G 5 =	649.37	G 6 =	658.17	G 7 =	668.01	G 8 =	678.89	G 9 =	690.80
G 10 =	703.68	G 11 =	717.47	G 12 =	732.06	G 13 =	747.34	G 14 =	763.16
G 15 =	779.35	G 16 =	795.73	G 17 =	812.13	G 18 =	828.34	G 19 =	844.18
G 20 =	859.48	G 21 =	874.08	G 22 =	887.84	G 23 =	900.64	G 24 =	912.41
G 25 =	923.08	G 26 =	932.63	G 27 =	941.05	G 28 =	948.38	G 29 =	954.65
G 30 =	959.93	G 31 =	964.31	G 32 =	967.87	G 33 =	970.70	G 34 =	972.91
G 35 =	974.58	G 36 =	975.81	G 37 =	976.67	G 38 =	977.25	G 39 =	977.61
G 40 =	977.80	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.33	H 2 =	611.45	H 3 =	614.02	H 4 =	617.12	H 5 =	620.80
H 6 =	625.14	H 7 =	630.20	H 8 =	636.05	H 9 =	642.73	H 10 =	650.29
H 11 =	658.76	H 12 =	668.15	H 13 =	678.45	H 14 =	689.64	H 15 =	701.67
H 16 =	714.48	H 17 =	727.98	H 18 =	742.06	H 19 =	756.60	H 20 =	771.46
H 21 =	786.50	H 22 =	801.56	H 23 =	816.50	H 24 =	831.16	H 25 =	845.41
H 26 =	859.11	H 27 =	872.16	H 28 =	884.46	H 29 =	895.94	H 30 =	906.55
H 31 =	916.24	H 32 =	925.02	H 33 =	932.89	H 34 =	939.87	H 35 =	946.00
H 36 =	951.34	H 37 =	955.92	H 38 =	959.83	H 39 =	963.13	H 40 =	965.89
=	.0	=	.0	=	.0	=	.0		

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 1
Location x/L: 0.75
T(Na-inlet) = 610 F
T(Na-outlet) :
Max = 1100F

PANEL 1 LOC=.75 T:NA(IN)=610F T:NA(OUT)=1005.91
A21=28.855 A22= 96.461 A23=131.17 A24=102.31 A25=54.084

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = Z

T:NA IN =	610.00	T:NA OUT=	1005.9	DT: NA =	395.91	T:B NA =	807.95	T:B M =	825.21
DT M-N =	28.855	DT1 =	96.461	DT P-N =	131.17	DT P-M =	102.31	DT2 =	54.084
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.47	N 2 =	615.47	N 3 =	619.05	N 4 =	623.29
N 5 =	628.27	N 6 =	634.06	N 7 =	640.71	N 8 =	648.29	N 9 =	656.84
N 10 =	666.37	N 11 =	676.91	N 12 =	688.44	N 13 =	700.93	N 14 =	714.32
N 15 =	728.54	N 16 =	743.49	N 17 =	759.05	N 18 =	775.08	N 19 =	791.44
N 20 =	807.95	N 21 =	824.47	N 22 =	840.83	N 23 =	856.86	N 24 =	872.42
N 25 =	887.37	N 26 =	901.59	N 27 =	914.98	N 28 =	927.47	N 29 =	939.00
N 30 =	949.54	N 31 =	959.07	N 32 =	967.62	N 33 =	975.20	N 34 =	981.85
N 35 =	987.64	N 36 =	992.62	N 37 =	996.86	N 38 =	1000.4	N 39 =	1003.4
N 40 =	1005.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	613.91	M 1 =	617.22	M 2 =	621.18	M 3 =	625.85	M 4 =	631.32
M 5 =	637.64	M 6 =	644.89	M 7 =	653.11	M 8 =	662.34	M 9 =	672.59
M 10 =	683.87	M 11 =	696.15	M 12 =	709.39	M 13 =	723.51	M 14 =	738.42
M 15 =	754.00	M 16 =	770.12	M 17 =	786.63	M 18 =	803.36	M 19 =	820.15
M 20 =	836.81	M 21 =	853.19	M 22 =	869.11	M 23 =	884.45	M 24 =	899.06
M 25 =	912.83	M 26 =	925.69	M 27 =	937.57	M 28 =	948.43	M 29 =	958.25
M 30 =	967.04	M 31 =	974.83	M 32 =	981.66	M 33 =	987.59	M 34 =	992.68
M 35 =	997.00	M 36 =	1000.6	M 37 =	1003.7	M 38 =	1006.2	M 39 =	1008.2
M 40 =	1009.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	627.75	P 1 =	634.05	P 2 =	641.42	P 3 =	649.97	P 4 =	659.76
P 5 =	670.86	P 6 =	683.29	P 7 =	697.06	P 8 =	712.14	P 9 =	728.46
P 10 =	745.93	P 11 =	764.40	P 12 =	783.69	P 13 =	803.59	P 14 =	823.88
P 15 =	844.30	P 16 =	864.57	P 17 =	884.45	P 18 =	903.65	P 19 =	921.95
P 20 =	939.12	P 21 =	954.99	P 22 =	969.40	P 23 =	982.26	P 24 =	993.51
P 25 =	1003.1	P 26 =	1011.2	P 27 =	1017.7	P 28 =	1022.7	P 29 =	1026.5
P 30 =	1029.1	P 31 =	1030.7	P 32 =	1031.5	P 33 =	1031.5	P 34 =	1031.1
P 35 =	1030.2	P 36 =	1029.1	P 37 =	1027.8	P 38 =	1026.4	P 39 =	1025.0
P 40 =	1023.7	=	.0	=	.C	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	620.43	G 1 =	625.15	G 2 =	630.72	G 3 =	637.22	G 4 =	644.73

G 5 =	653.30	G 6 =	662.99	G 7 =	673.83	G 8 =	685.81	G 9 =	698.93
G 10 =	713.13	G 11 =	728.32	G 12 =	744.41	G 13 =	761.26	G 14 =	778.71
G 15 =	796.57	G 16 =	814.65	G 17 =	832.74	G 18 =	850.64	G 19 =	868.14
G 20 =	885.04	G 21 =	901.18	G 22 =	916.39	G 23 =	930.56	G 24 =	943.58
G 25 =	955.40	G 26 =	965.98	G 27 =	975.32	G 28 =	983.45	G 29 =	990.42
G 30 =	996.29	G 31 =	1001.2	G 32 =	1005.1	G 33 =	1008.3	G 34 =	1010.8
G 35 =	1012.7	G 36 =	1014.0	G 37 =	1015.0	G 38 =	1015.7	G 39 =	1016.1
G 40 =	1016.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.29	H 2 =	611.63	H 3 =	614.48	H 4 =	617.91	H 5 =	621.98
H 6 =	626.79	H 7 =	632.39	H 8 =	638.86	H 9 =	646.25	H 10 =	654.62
H 11 =	663.99	H 12 =	674.37	H 13 =	685.76	H 14 =	698.13	H 15 =	711.44
H 16 =	725.60	H 17 =	740.52	H 18 =	756.09	H 19 =	772.16	H 20 =	788.58
H 21 =	805.20	H 22 =	821.84	H 23 =	838.34	H 24 =	854.54	H 25 =	870.27
H 26 =	885.41	H 27 =	895.82	H 28 =	913.40	H 29 =	926.08	H 30 =	937.79
H 31 =	948.49	H 32 =	958.19	H 33 =	966.87	H 34 =	974.58	H 35 =	981.35
H 36 =	987.23	H 37 =	992.29	H 38 =	996.61	H 39 =	1000.2	H 40 =	1003.3
=	.0	=	.0	=	.0	=	.0		

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 1
Location x/L: 0.85
T(Na-inlet) = 610 F
T(Na-outlet) :
Max = 1100F

PANEL 1 LOC=.85 T:NA(IN)=610F T:NA(OUT)=1043.55
A21=31.377 A22=104.90 A23=142.90 A24=111.52 A25=59.074

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN	= 610.00	T:NA OUT	= 1043.6	DT: NA	= 433.55	T:B NA	= 826.77	T:B M	= 845.54
DT M-N	= 31.377	DT1	= 104.90	DT P-N	= 142.9C	DT P-M	= 111.52	DT2	= 59.074
	= .0		= .0		= .0		= .0		= .0
N	= 610.00	N 1	= 612.71	N 2	= 615.99	N 3	= 619.91	N 4	= 624.56
N 5	= 630.01	N 6	= 636.35	N 7	= 643.63	N 8	= 651.93	N 9	= 661.29
N 10	= 671.73	N 11	= 683.27	N 12	= 695.89	N 13	= 709.57	N 14	= 724.24
N 15	= 739.81	N 16	= 756.18	N 17	= 773.22	N 18	= 790.77	N 19	= 808.68
N 20	= 826.77	N 21	= 844.87	N 22	= 862.78	N 23	= 880.33	N 24	= 897.37
N 25	= 913.74	N 26	= 929.31	N 27	= 943.98	N 28	= 957.66	N 29	= 970.28
N 30	= 981.82	N 31	= 992.26	N 32	= 1001.6	N 33	= 1009.9	N 34	= 1017.2
N 35	= 1023.5	N 36	= 1029.0	N 37	= 1033.6	N 38	= 1037.6	N 39	= 1040.8
N 40	= 1043.6		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
M	= 614.25	M 1	= 617.87	M 2	= 622.20	M 3	= 627.31	M 4	= 633.28
M 5	= 640.20	M 6	= 646.12	M 7	= 657.11	M 8	= 667.21	M 9	= 678.42
M 10	= 690.76	M 11	= 704.20	M 12	= 718.68	M 13	= 734.13	M 14	= 750.45
M 15	= 767.50	M 16	= 785.14	M 17	= 803.21	M 18	= 821.53	M 19	= 839.91
M 20	= 858.15	M 21	= 876.09	M 22	= 893.53	M 23	= 910.33	M 24	= 926.33
M 25	= 941.43	M 26	= 955.52	M 27	= 968.54	M 28	= 980.44	M 29	= 991.21
M 30	= 1000.9	M 31	= 1009.4	M 32	= 1016.5	M 33	= 1023.4	M 34	= 1029.0
M 35	= 1033.7	M 36	= 1037.7	M 37	= 1041.C	M 38	= 1043.8	M 39	= 1046.0
M 40	= 1047.8		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
P	= 629.34	P 1	= 636.21	P 2	= 644.27	P 3	= 653.60	P 4	= 664.29
P 5	= 676.40	P 6	= 685.98	P 7	= 705.02	P 8	= 721.49	P 9	= 739.32
P 10	= 758.40	P 11	= 778.58	P 12	= 799.66	P 13	= 821.42	P 14	= 843.60
P 15	= 865.92	P 16	= 888.09	P 17	= 909.83	P 18	= 930.84	P 19	= 950.87
P 20	= 969.67	P 21	= 987.05	P 22	= 1002.8	P 23	= 1016.9	P 24	= 1029.3
P 25	= 1039.8	P 26	= 1048.7	P 27	= 1055.8	P 28	= 1061.4	P 29	= 1065.6
P 30	= 1068.5	P 31	= 1070.3	P 32	= 1071.2	P 33	= 1071.3	P 34	= 1070.8
P 35	= 1069.9	P 36	= 1068.7	P 37	= 1067.3	P 38	= 1065.8	P 39	= 1064.3
P 40	= 1062.9		= .0		= .C		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
G	= 621.34	G 1	= 626.50	G 2	= 632.58	G 3	= 639.67	G 4	= 647.86

G 5	= 657.23	G 6	= 667.81	G 7	= 679.64	G 8	= 692.74	G 9	= 707.06
G 10	= 722.57	G 11	= 739.18	G 12	= 756.77	G 13	= 775.18	G 14	= 794.25
G 15	= 813.79	G 16	= 833.56	G 17	= 853.36	G 18	= 872.94	G 19	= 892.09
G 20	= 910.60	G 21	= 928.27	G 22	= 944.94	G 23	= 960.47	G 24	= 974.75
G 25	= 987.72	G 26	= 999.33	G 27	= 1009.6	G 28	= 1018.5	G 29	= 1026.2
G 30	= 1032.7	G 31	= 1038.0	G 32	= 1042.4	G 33	= 1045.9	G 34	= 1048.7
G 35	= 1050.8	G 36	= 1052.3	G 37	= 1053.4	G 38	= 1054.2	G 39	= 1054.6
G 40	= 1054.9		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
H 1	= 609.24	H 2	= 611.82	H 3	= 614.94	H 4	= 618.70	H 5	= 623.17
H 6	= 628.44	H 7	= 634.58	H 8	= 641.68	H 9	= 649.78	H 10	= 658.95
H 11	= 669.21	H 12	= 680.59	H 13	= 693.08	H 14	= 706.64	H 15	= 721.21
H 16	= 736.73	H 17	= 753.07	H 18	= 770.12	H 19	= 787.72	H 20	= 805.7C
H 21	= 823.90	H 22	= 842.12	H 23	= 860.19	H 24	= 877.92	H 25	= 895.14
H 26	= 911.71	H 27	= 927.49	H 28	= 942.35	H 29	= 956.22	H 30	= 969.04
H 31	= 980.75	H 32	= 991.36	H 33	= 1000.9	H 34	= 1009.3	H 35	= 1016.7
H 36	= 1023.1	H 37	= 1028.7	H 38	= 1033.4	H 39	= 1037.4	H 40	= 1040.7
	= .C		= .0		= .0		= .0		

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 1
Location x/L: 0.95
T(Na-inlet) = 610 F
T(Na-outlet) :
Max = 1100F

PANEL 1 LOC=.95 T:NA(IN)=610F T:NA(CUT)=1081.18
A21=33.899 A22=113.35 A23=154.63 A24=120.73 A25=64.063

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1081.2	DT: NA =	471.18	T:B NA =	845.59	T:B M =	865.86
DT M-N =	33.899	DT1 =	113.35	DT P-N =	154.63	DT P-M =	120.73	DT2 =	64.063
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.95	N 2 =	616.51	N 3 =	620.77	N 4 =	625.82
N 5 =	631.75	N 6 =	638.63	N 7 =	646.55	N 8 =	655.57	N 9 =	665.74
N 10 =	677.09	N 11 =	689.63	N 12 =	703.35	N 13 =	718.21	N 14 =	734.15
N 15 =	751.08	N 16 =	768.87	N 17 =	787.38	N 18 =	806.46	N 19 =	825.93
N 20 =	845.59	N 21 =	865.25	N 22 =	884.72	N 23 =	903.80	N 24 =	922.31
N 25 =	940.10	N 26 =	957.03	N 27 =	972.97	N 28 =	987.83	N 29 =	1001.6
N 30 =	1014.1	N 31 =	1025.4	N 32 =	1035.6	N 33 =	1044.6	N 34 =	1052.5
N 35 =	1059.4	N 36 =	1065.4	N 37 =	1070.4	N 38 =	1074.7	N 39 =	1078.2
N 40 =	1081.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	614.59	M 1 =	616.52	M 2 =	623.21	M 3 =	628.76	M 4 =	635.25
M 5 =	642.75	M 6 =	651.36	M 7 =	661.12	M 8 =	672.07	M 9 =	684.25
M 10 =	697.65	M 11 =	712.24	M 12 =	727.97	M 13 =	744.75	M 14 =	762.47
M 15 =	780.99	M 16 =	800.16	M 17 =	819.79	M 18 =	839.69	M 19 =	859.66
M 20 =	879.49	M 21 =	898.98	M 22 =	917.94	M 23 =	936.20	M 24 =	953.60
M 25 =	970.02	M 26 =	985.34	M 27 =	999.50	M 28 =	1012.4	M 29 =	1024.2
M 30 =	1034.7	M 31 =	1044.0	M 32 =	1052.1	M 33 =	1059.2	M 34 =	1065.3
M 35 =	1070.4	M 36 =	1074.8	M 37 =	1078.4	M 38 =	1081.4	M 39 =	1083.8
M 40 =	1085.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	630.93	P 1 =	638.38	P 2 =	647.11	P 3 =	657.22	P 4 =	668.81
P 5 =	681.95	P 6 =	696.67	P 7 =	712.98	P 8 =	730.84	P 9 =	750.18
P 10 =	770.88	P 11 =	792.76	P 12 =	815.63	P 13 =	839.24	P 14 =	863.31
P 15 =	887.54	P 16 =	911.61	P 17 =	935.21	P 18 =	958.03	P 19 =	979.79
P 20 =	1000.2	P 21 =	1019.1	P 22 =	1036.3	P 23 =	1051.6	P 24 =	1065.1
P 25 =	1076.6	P 26 =	1086.2	P 27 =	1094.0	P 28 =	1100.1	P 29 =	1104.7
P 30 =	1107.9	P 31 =	1109.9	P 32 =	1110.9	P 33 =	1111.0	P 34 =	1110.6
P 35 =	1109.6	P 36 =	1108.4	P 37 =	1106.9	P 38 =	1105.3	P 39 =	1103.7
P 40 =	1102.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	622.26	G 1 =	627.84	G 2 =	634.43	G 3 =	642.12	G 4 =	651.00
G 5 =	661.15	G 6 =	672.63	G 7 =	685.46	G 8 =	699.66	G 9 =	715.20
G 10 =	732.02	G 11 =	750.04	G 12 =	769.12	G 13 =	789.10	G 14 =	809.81
G 15 =	831.01	G 16 =	852.48	G 17 =	873.97	G 18 =	895.24	G 19 =	916.05
G 20 =	936.16	G 21 =	955.37	G 22 =	973.50	G 23 =	990.38	G 24 =	1005.9
G 25 =	1020.0	G 26 =	1032.7	G 27 =	1043.9	G 28 =	1053.6	G 29 =	1062.0
G 30 =	1069.0	G 31 =	1074.9	G 32 =	1079.7	G 33 =	1083.5	G 34 =	1086.5
G 35 =	1088.8	G 36 =	1090.5	G 37 =	1091.8	G 38 =	1092.6	G 39 =	1093.1
G 40 =	1093.4	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.20	H 2 =	612.00	H 3 =	615.40	H 4 =	619.49	H 5 =	624.35
H 6 =	630.09	H 7 =	636.77	H 8 =	644.49	H 9 =	653.30	H 10 =	663.27
H 11 =	674.44	H 12 =	686.81	H 13 =	700.39	H 14 =	715.13	H 15 =	730.98
H 16 =	747.84	H 17 =	765.61	H 18 =	784.14	H 19 =	803.27	H 20 =	822.81
H 21 =	842.59	H 22 =	862.39	H 23 =	882.02	H 24 =	901.29	H 25 =	920.00
H 26 =	938.00	H 27 =	955.14	H 28 =	971.29	H 29 =	986.36	H 30 =	1000.3
H 31 =	1013.0	H 32 =	1024.5	H 33 =	1034.8	H 34 =	1044.0	H 35 =	1052.0
H 36 =	1059.0	H 37 =	1065.0	H 38 =	1070.2	H 39 =	1074.5	H 40 =	1078.1
=	.0	=	.0	=	.0	=	.0		

PANEL TEMPERATURE DISTRIBUTION

CASE 2

SET 2 Subpanel 2

Solar Flux Distribution: REFERENCE

Orifices: None

Sodium Temperatures: T (Na-Inlet) = 610°F
T (Na-Outlet) = 1100°F maximum
(1006.08 to 1100.0)

5370F/sjh

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 2
Location x/L: 0.05
T(Na-inlet) = 610 F
T(Na-outlet) :
Max = 1100F

PANEL 2 LOC=.05 T:NA(IN)=610F T:NA(CUT)=1021.29
A21=36.226 A22=121.15 A23=165.68 A24=129.46 A25=68.890

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA CUT=	1021.3	DT: NA =	411.29	T:B NA =	815.64	T:B M =	837.31
DT M-N =	36.226	DT1 =	121.15	DT F-N =	165.68	DT P-M =	129.46	DT2 =	68.891
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.57	N 2 =	615.68	N 3 =	619.40	N 4 =	623.81
N 5 =	628.98	N 6 =	634.99	N 7 =	641.91	N 8 =	649.78	N 9 =	658.66
N 10 =	668.56	N 11 =	675.51	N 12 =	691.48	N 13 =	704.46	N 14 =	718.37
N 15 =	733.14	N 16 =	746.67	N 17 =	764.84	N 18 =	781.49	N 19 =	798.48
N 20 =	815.65	N 21 =	832.81	N 22 =	849.80	N 23 =	866.45	N 24 =	882.62
N 25 =	898.15	N 26 =	912.92	N 27 =	926.83	N 28 =	939.81	N 29 =	951.78
N 30 =	962.73	N 31 =	972.63	N 32 =	981.51	N 33 =	989.38	N 34 =	996.29
N 35 =	1002.3	N 36 =	1007.5	N 37 =	1011.9	N 38 =	1015.6	N 39 =	1018.7
N 40 =	1021.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	614.90	M 1 =	618.53	M 2 =	622.85	M 3 =	627.94	M 4 =	633.88
M 5 =	640.74	M 6 =	648.59	M 7 =	657.47	M 8 =	667.41	M 9 =	678.44
M 10 =	690.53	M 11 =	703.67	M 12 =	717.79	M 13 =	732.81	M 14 =	748.63
M 15 =	765.11	M 16 =	782.11	M 17 =	799.47	M 18 =	817.00	M 19 =	834.53
M 20 =	851.87	M 21 =	868.85	M 22 =	885.31	M 23 =	901.08	M 24 =	916.06
M 25 =	930.11	M 26 =	943.18	M 27 =	955.19	M 28 =	966.11	M 29 =	975.94
M 30 =	984.70	M 31 =	992.42	M 32 =	999.14	M 33 =	1004.9	M 34 =	1009.9
M 35 =	1014.1	M 36 =	1017.6	M 37 =	1020.4	M 38 =	1022.8	M 39 =	1024.7
M 40 =	1026.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	632.42	P 1 =	635.82	P 2 =	648.47	P 3 =	658.46	P 4 =	669.87
P 5 =	682.77	P 6 =	697.18	P 7 =	713.08	P 8 =	730.42	P 9 =	749.13
P 10 =	769.05	P 11 =	790.01	P 12 =	811.79	P 13 =	834.14	P 14 =	856.76
P 15 =	879.36	P 16 =	901.62	P 17 =	923.23	P 18 =	943.89	P 19 =	963.34
P 20 =	981.32	P 21 =	997.66	P 22 =	1012.2	P 23 =	1024.8	P 24 =	1035.6
P 25 =	1044.4	P 26 =	1051.3	P 27 =	1056.5	P 28 =	1060.1	P 29 =	1062.3
P 30 =	1063.2	P 31 =	1063.1	P 32 =	1062.2	P 33 =	1060.6	P 34 =	1058.5
P 35 =	1056.1	P 36 =	1053.5	P 37 =	1050.9	P 38 =	1048.4	P 39 =	1046.0
P 40 =	1043.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	623.10	G 1 =	628.49	G 2 =	634.84	G 3 =	642.22	G 4 =	650.72
G 5 =	660.41	G 6 =	671.33	G 7 =	683.49	G 8 =	696.90	G 9 =	711.52
G 10 =	727.27	G 11 =	744.07	G 12 =	761.78	G 13 =	780.22	G 14 =	799.23
G 15 =	818.57	G 16 =	838.03	G 17 =	857.38	G 18 =	876.38	G 19 =	894.80
G 20 =	912.45	G 21 =	929.12	G 22 =	944.68	G 23 =	958.99	G 24 =	971.97
G 25 =	983.57	G 26 =	993.77	G 27 =	1002.6	G 28 =	1010.1	G 29 =	1016.3
G 30 =	1021.4	G 31 =	1025.5	G 32 =	1028.6	G 33 =	1031.0	G 34 =	1032.6
G 35 =	1033.7	G 36 =	1034.4	G 37 =	1034.7	G 38 =	1034.8	G 39 =	1034.6
G 40 =	1034.4	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.57	H 2 =	610.86	H 3 =	613.66	H 4 =	617.04	H 5 =	621.08
H 6 =	625.86	H 7 =	631.45	H 8 =	637.93	H 9 =	645.36	H 10 =	653.79
H 11 =	663.27	H 12 =	673.80	H 13 =	685.40	H 14 =	698.03	H 15 =	711.66
H 16 =	726.20	H 17 =	741.56	H 18 =	757.62	H 19 =	774.26	H 20 =	791.30
H 21 =	808.58	H 22 =	825.93	H 23 =	843.17	H 24 =	860.14	H 25 =	876.66
H 26 =	892.58	H 27 =	907.77	H 28 =	922.12	H 29 =	935.54	H 30 =	947.96
H 31 =	959.34	H 32 =	969.66	H 33 =	978.92	H 34 =	987.16	H 35 =	994.40
H 36 =	1000.7	H 37 =	1006.1	H 38 =	1010.8	H 39 =	1014.7	H 40 =	1018.0
=	.0	=	.0	=	.0	=	.0		

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 2
Location x/L: 0.15
T(Na-inlet) = 610 F
T(Na-outlet) :
Max = 1100F

PANEL 2 LOC=.15 T:NA(IN)=610F T:NA(OUT)=1051.71
A21=38.357 A22=128.30 A23=176.05 A24=137.69 A25=73.555

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN	= 610.00	T:NA OUT	= 1051.7	DT: NA	= 441.71	T:B NA	= 830.85	T:B M	= 853.80
DT M-N	= 38.357	DT1	= 128.30	DT P-N	= 176.05	DT P-M	= 137.69	DT2	= 73.555
	= .0		= .0		= .0		= .0		= .0
N	= 610.00	N 1	= 612.76	N 2	= 616.10	N 3	= 620.10	N 4	= 624.83
N 5	= 630.39	N 6	= 636.84	N 7	= 644.27	N 8	= 652.72	N 9	= 662.25
N 10	= 672.89	N 11	= 684.65	N 12	= 697.51	N 13	= 711.44	N 14	= 726.39
N 15	= 742.25	N 16	= 758.93	N 17	= 776.29	N 18	= 794.18	N 19	= 812.42
N 20	= 830.85	N 21	= 849.29	N 22	= 867.53	N 23	= 885.42	N 24	= 902.78
N 25	= 919.46	N 26	= 935.32	N 27	= 950.27	N 28	= 964.20	N 29	= 977.06
N 30	= 988.82	N 31	= 999.46	N 32	= 1009.0	N 33	= 1017.4	N 34	= 1024.9
N 35	= 1031.3	N 36	= 1036.9	N 37	= 1041.6	N 38	= 1045.6	N 39	= 1048.9
N 40	= 1051.7		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
M	= 615.19	M 1	= 619.07	M 2	= 623.69	M 3	= 629.14	M 4	= 635.50
M 5	= 642.84	M 6	= 651.24	M 7	= 660.74	M 8	= 671.39	M 9	= 683.20
M 10	= 696.16	M 11	= 710.23	M 12	= 725.36	M 13	= 741.47	M 14	= 758.43
M 15	= 776.10	M 16	= 794.34	M 17	= 812.96	M 18	= 831.77	M 19	= 850.59
M 20	= 869.21	M 21	= 887.45	M 22	= 905.13	M 23	= 922.09	M 24	= 938.19
M 25	= 953.31	M 26	= 967.36	M 27	= 980.29	M 28	= 992.05	M 29	= 1002.6
M 30	= 1012.1	M 31	= 1020.4	M 32	= 1027.7	M 33	= 1033.9	M 34	= 1039.3
M 35	= 1043.8	M 36	= 1047.5	M 37	= 1050.7	M 38	= 1053.2	M 39	= 1055.3
M 40	= 1056.9		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
P	= 633.83	P 1	= 641.72	P 2	= 650.94	P 3	= 661.60	P 4	= 673.78
P 5	= 687.54	P 6	= 702.92	P 7	= 719.89	P 8	= 738.41	P 9	= 758.39
P 10	= 779.67	P 11	= 802.07	P 12	= 825.35	P 13	= 849.24	P 14	= 873.44
P 15	= 897.62	P 16	= 921.45	P 17	= 944.59	P 18	= 966.74	P 19	= 987.60
P 20	= 1006.9	P 21	= 1024.5	P 22	= 1040.1	P 23	= 1053.7	P 24	= 1065.3
P 25	= 1074.8	P 26	= 1082.4	P 27	= 1088.1	P 28	= 1092.0	P 29	= 1094.5
P 30	= 1095.6	P 31	= 1095.6	P 32	= 1094.7	P 33	= 1093.1	P 34	= 1090.9
P 35	= 1088.5	P 36	= 1085.8	P 37	= 1083.1	P 38	= 1080.5	P 39	= 1077.9
P 40	= 1075.5		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
G	= 623.87	G 1	= 625.62	G 2	= 636.38	G 3	= 644.26	G 4	= 653.33
G 5	= 663.67	G 6	= 675.32	G 7	= 688.30	G 8	= 702.62	G 9	= 718.23
G 10	= 735.07	G 11	= 753.02	G 12	= 771.95	G 13	= 791.68	G 14	= 812.01
G 15	= 832.71	G 16	= 853.56	G 17	= 874.29	G 18	= 894.65	G 19	= 914.42
G 20	= 933.36	G 21	= 951.28	G 22	= 968.01	G 23	= 983.42	G 24	= 997.40
G 25	= 1009.9	G 26	= 1020.9	G 27	= 1030.5	G 28	= 1038.6	G 29	= 1045.4
G 30	= 1051.0	G 31	= 1055.4	G 32	= 1058.9	G 33	= 1061.5	G 34	= 1063.3
G 35	= 1064.6	G 36	= 1065.4	G 37	= 1065.8	G 38	= 1065.9	G 39	= 1065.8
G 40	= 1065.6		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
H 1	= 608.52	H 2	= 610.99	H 3	= 614.01	H 4	= 617.66	H 5	= 622.01
H 6	= 627.16	H 7	= 633.19	H 8	= 640.17	H 9	= 648.17	H 10	= 657.25
H 11	= 667.45	H 12	= 676.78	H 13	= 691.26	H 14	= 704.84	H 15	= 719.49
H 16	= 735.12	H 17	= 751.63	H 18	= 768.89	H 19	= 786.76	H 20	= 805.06
H 21	= 823.62	H 22	= 842.25	H 23	= 860.76	H 24	= 878.97	H 25	= 896.69
H 26	= 913.78	H 27	= 930.08	H 28	= 945.47	H 29	= 959.86	H 30	= 973.17
H 31	= 985.37	H 32	= 996.43	H 33	= 1006.4	H 34	= 1015.2	H 35	= 1022.9
H 36	= 1029.7	H 37	= 1035.5	H 38	= 1040.5	H 39	= 1044.7	H 40	= 1048.2
	= .0		= .0		= .0		= .0		

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 2
Location x/L: 0.25
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PANEL 2 LOC=.25 T:NA(IN)=610F T:NA(OUT)=1082.14
A21=40.488 A22=135.46 A23=186.41 A24=145.92 A25=78.221

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1082.1	DT: NA =	472.14	T:B NA =	846.07	T:B M =	870.29
DT M-N =	40.488	DT1 =	135.46	DT P-N =	186.41	DT P-M =	145.92	DT2 =	78.221
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.95	N 2 =	616.52	N 3 =	620.79	N 4 =	625.85
N 5 =	631.79	N 6 =	638.69	N 7 =	646.63	N 8 =	655.67	N 9 =	665.85
N 10 =	677.23	N 11 =	689.79	N 12 =	703.54	N 13 =	718.43	N 14 =	734.41
N 15 =	751.36	N 16 =	769.19	N 17 =	787.75	N 18 =	806.86	N 19 =	826.37
N 20 =	846.07	N 21 =	865.77	N 22 =	885.28	N 23 =	904.39	N 24 =	922.95
N 25 =	940.78	N 26 =	957.73	N 27 =	973.71	N 28 =	988.60	N 29 =	1002.3
N 30 =	1014.9	N 31 =	1026.3	N 32 =	1036.5	N 33 =	1045.5	N 34 =	1053.4
N 35 =	1060.3	N 36 =	1066.3	N 37 =	1071.3	N 38 =	1075.6	N 39 =	1079.2
N 40 =	1082.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.48	M 1 =	619.61	M 2 =	624.53	M 3 =	630.34	M 4 =	637.11
M 5 =	644.94	M 6 =	653.89	M 7 =	664.02	M 8 =	675.37	M 9 =	687.96
M 10 =	701.78	M 11 =	716.80	M 12 =	732.94	M 13 =	750.12	M 14 =	768.22
M 15 =	787.09	M 16 =	806.57	M 17 =	826.45	M 18 =	846.55	M 19 =	866.66
M 20 =	886.56	M 21 =	906.06	M 22 =	924.96	M 23 =	943.10	M 24 =	960.32
M 25 =	976.51	M 26 =	991.55	M 27 =	1005.4	M 28 =	1018.0	M 29 =	1029.4
M 30 =	1039.5	M 31 =	1048.4	M 32 =	1056.2	M 33 =	1062.9	M 34 =	1068.6
M 35 =	1073.5	M 36 =	1077.5	M 37 =	1080.9	M 38 =	1083.6	M 39 =	1085.8
M 40 =	1087.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	635.23	P 1 =	643.61	P 2 =	653.41	P 3 =	664.74	P 4 =	677.68
P 5 =	692.31	P 6 =	708.65	P 7 =	726.70	P 8 =	746.40	P 9 =	767.65
P 10 =	790.29	P 11 =	814.12	P 12 =	838.90	P 13 =	864.34	P 14 =	890.11
P 15 =	915.87	P 16 =	941.27	P 17 =	965.95	P 18 =	989.58	P 19 =	1011.8
P 20 =	1032.5	P 21 =	1051.3	P 22 =	1068.0	P 23 =	1082.6	P 24 =	1095.0
P 25 =	1105.3	P 26 =	1113.4	P 27 =	1119.6	P 28 =	1124.0	P 29 =	1126.7
P 30 =	1128.0	P 31 =	1128.1	P 32 =	1127.2	P 33 =	1125.6	P 34 =	1123.4
P 35 =	1120.9	P 36 =	1118.1	P 37 =	1115.3	P 38 =	1112.5	P 39 =	1109.8
P 40 =	1107.4	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	624.65	G 1 =	630.75	G 2 =	637.94	G 3 =	646.30	G 4 =	655.94
G 5 =	666.93	G 6 =	679.31	G 7 =	693.11	G 8 =	708.34	G 9 =	724.95
G 10 =	742.86	G 11 =	761.97	G 12 =	782.12	G 13 =	803.14	G 14 =	824.80
G 15 =	846.87	G 16 =	869.09	G 17 =	891.20	G 18 =	912.94	G 19 =	934.05
G 20 =	954.29	G 21 =	973.45	G 22 =	991.35	G 23 =	1007.9	G 24 =	1022.8
G 25 =	1036.3	G 26 =	1048.1	G 27 =	1058.4	G 28 =	1067.2	G 29 =	1074.5
G 30 =	1080.6	G 31 =	1085.4	G 32 =	1089.1	G 33 =	1092.0	G 34 =	1094.1
G 35 =	1095.5	G 36 =	1096.4	G 37 =	1096.9	G 38 =	1097.0	G 39 =	1097.0
G 40 =	1096.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.47	H 2 =	611.13	H 3 =	614.37	H 4 =	618.28	H 5 =	622.95
H 6 =	628.47	H 7 =	634.93	H 8 =	642.41	H 9 =	650.98	H 10 =	660.70
H 11 =	671.62	H 12 =	683.76	H 13 =	697.11	H 14 =	711.65	H 15 =	727.32
H 16 =	744.04	H 17 =	761.70	H 18 =	780.16	H 19 =	799.26	H 20 =	818.83
H 21 =	838.66	H 22 =	858.57	H 23 =	878.35	H 24 =	897.80	H 25 =	916.73
H 26 =	934.98	H 27 =	952.38	H 28 =	968.82	H 29 =	984.18	H 30 =	998.39
H 31 =	1011.4	H 32 =	1023.2	H 33 =	1033.8	H 34 =	1043.2	H 35 =	1051.5
H 36 =	1058.7	H 37 =	1064.9	H 38 =	1070.2	H 39 =	1074.7	H 40 =	1078.5
=	.0	=	.0	=	.0	=	.0		

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 2
Location x/L: FULL
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PANEL 2 LOC=FULL T:NA(IN)=610F T:NA(OUT)=1100.00
A21=41.740 A22=139.66 A23=192.50 A24=150.76 A25=80.960

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1100.0	DT: NA =	490.00	T:B NA =	855.00	T:B M =	879.96
DT M-N =	41.740	DT1 =	139.66	DT P-N =	192.50	DT P-M =	150.76	DT2 =	80.960
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	613.06	N 2 =	616.77	N 3 =	621.20	N 4 =	626.45
N 5 =	632.62	N 6 =	639.78	N 7 =	648.01	N 8 =	657.39	N 9 =	667.97
N 10 =	679.77	N 11 =	692.81	N 12 =	707.08	N 13 =	722.53	N 14 =	739.11
N 15 =	756.71	N 16 =	775.21	N 17 =	794.47	N 18 =	814.31	N 19 =	834.55
N 20 =	855.00	N 21 =	875.45	N 22 =	895.69	N 23 =	915.53	N 24 =	934.79
N 25 =	953.29	N 26 =	970.89	N 27 =	987.47	N 28 =	1002.9	N 29 =	1017.2
N 30 =	1030.2	N 31 =	1042.0	N 32 =	1052.6	N 33 =	1062.0	N 34 =	1070.2
N 35 =	1077.4	N 36 =	1083.5	N 37 =	1088.8	N 38 =	1093.2	N 39 =	1096.9
N 40 =	1100.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.65	M 1 =	619.93	M 2 =	625.03	M 3 =	631.04	M 4 =	638.06
M 5 =	646.17	M 6 =	655.44	M 7 =	665.94	M 8 =	677.71	M 9 =	690.76
M 10 =	705.08	M 11 =	720.65	M 12 =	737.39	M 13 =	755.20	M 14 =	773.97
M 15 =	793.55	M 16 =	813.74	M 17 =	834.37	M 18 =	855.22	M 19 =	876.09
M 20 =	896.74	M 21 =	916.98	M 22 =	936.60	M 23 =	955.43	M 24 =	973.32
M 25 =	990.12	M 26 =	1005.8	M 27 =	1020.1	M 28 =	1033.2	M 29 =	1045.0
M 30 =	1055.5	M 31 =	1064.0	M 32 =	1072.9	M 33 =	1079.9	M 34 =	1085.9
M 35 =	1090.9	M 36 =	1095.2	M 37 =	1098.6	M 38 =	1101.5	M 39 =	1103.8
M 40 =	1105.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	636.05	P 1 =	644.72	P 2 =	654.86	P 3 =	666.58	P 4 =	679.97
P 5 =	695.11	P 6 =	712.03	P 7 =	730.70	P 8 =	751.09	P 9 =	773.09
P 10 =	796.53	P 11 =	821.20	P 12 =	846.86	P 13 =	873.21	P 14 =	899.90
P 15 =	926.59	P 16 =	952.91	P 17 =	978.50	P 18 =	1003.0	P 19 =	1026.1
P 20 =	1047.5	P 21 =	1067.0	P 22 =	1084.4	P 23 =	1099.6	P 24 =	1112.5
P 25 =	1123.2	P 26 =	1131.7	P 27 =	1138.1	P 28 =	1142.7	P 29 =	1145.6
P 30 =	1147.0	P 31 =	1147.2	P 32 =	1146.3	P 33 =	1144.7	P 34 =	1142.5
P 35 =	1139.9	P 36 =	1137.1	P 37 =	1134.2	P 38 =	1131.3	P 39 =	1128.6
P 40 =	1126.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	625.10	G 1 =	631.41	G 2 =	638.85	G 3 =	647.50	G 4 =	657.47
G 5 =	668.84	G 6 =	681.65	G 7 =	695.94	G 8 =	711.70	G 9 =	728.89
G 10 =	747.44	G 11 =	767.22	G 12 =	788.09	G 13 =	809.86	G 14 =	832.30
G 15 =	855.17	G 16 =	878.20	G 17 =	901.13	G 18 =	923.67	G 19 =	945.57
G 20 =	966.57	G 21 =	986.46	G 22 =	1005.0	G 23 =	1022.2	G 24 =	1037.8
G 25 =	1051.7	G 26 =	1064.1	G 27 =	1074.8	G 28 =	1083.9	G 29 =	1091.6
G 30 =	1097.9	G 31 =	1103.0	G 32 =	1106.9	G 33 =	1109.9	G 34 =	1112.1
G 35 =	1113.6	G 36 =	1114.6	G 37 =	1115.1	G 38 =	1115.3	G 39 =	1115.3
G 40 =	1115.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.44	H 2 =	611.21	H 3 =	614.58	H 4 =	618.64	H 5 =	623.50
H 6 =	629.24	H 7 =	635.95	H 8 =	643.72	H 9 =	652.63	H 10 =	662.73
H 11 =	674.07	H 12 =	686.68	H 13 =	700.55	H 14 =	715.65	H 15 =	731.92
H 16 =	749.28	H 17 =	767.61	H 18 =	786.78	H 19 =	806.60	H 20 =	826.91
H 21 =	847.50	H 22 =	868.15	H 23 =	888.68	H 24 =	908.86	H 25 =	928.50
H 26 =	947.43	H 27 =	965.48	H 28 =	982.52	H 29 =	998.45	H 30 =	1013.2
H 31 =	1026.7	H 32 =	1038.9	H 33 =	1049.9	H 34 =	1059.7	H 35 =	1068.3
H 36 =	1075.7	H 37 =	1082.2	H 38 =	1087.7	H 39 =	1092.3	H 40 =	1096.2
=	.0	=	.0	=	.0	=	.0		

PANEL TEMPERATURE DISTRIBUTION

CASE 2
SET 3 Subpanel Boundaries

Solar Flux Distribution: REFERENCE

Orifices: None

Sodium Temperatures: T (Na-Inlet) = 610°F
T (Na-Outlet) = 1100°F maximum
(723.66 to 1100F)

5370F/sjh

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 1
Location x/L: OUT (0.0)
T(Na-inlet) = 610 F
T(Na-outlet) :
Max = 1100F

(Q/A)=0.225MW/M2 T:NA(IN)=610F T:NA(OUT)=723.66 PL 1,OUT
A21=9.94 A22=33.133 A23=43.17 A24=33.23 A25=16.662

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	723.66	DT: NA =	113.66	T:B NA =	666.83	T:B M =	672.77
DT M-N =	9.9400	DT1 =	33.133	DT P-N =	43.170	DT P-M =	33.230	DT2 =	16.662
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	610.71	N 2 =	611.57	N 3 =	612.60	N 4 =	613.82
N 5 =	615.25	N 6 =	616.91	N 7 =	618.82	N 8 =	620.99	N 9 =	623.45
N 10 =	626.18	N 11 =	629.21	N 12 =	632.52	N 13 =	636.10	N 14 =	639.95
N 15 =	644.03	N 16 =	648.32	N 17 =	652.79	N 18 =	657.39	N 19 =	662.09
N 20 =	666.83	N 21 =	671.57	N 22 =	676.27	N 23 =	680.87	N 24 =	685.34
N 25 =	689.63	N 26 =	693.71	N 27 =	697.56	N 28 =	701.14	N 29 =	704.45
N 30 =	707.48	N 31 =	710.21	N 32 =	712.67	N 33 =	714.84	N 34 =	716.75
N 35 =	718.41	N 36 =	719.84	N 37 =	721.06	N 38 =	722.09	N 39 =	722.95
N 40 =	723.66	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	611.35	M 1 =	612.35	M 2 =	613.54	M 3 =	614.94	M 4 =	616.58
M 5 =	618.47	M 6 =	620.64	M 7 =	623.09	M 8 =	625.83	M 9 =	628.87
M 10 =	632.21	M 11 =	635.84	M 12 =	639.74	M 13 =	643.88	M 14 =	648.25
M 15 =	652.80	M 16 =	657.50	M 17 =	662.29	M 18 =	667.14	M 19 =	671.98
M 20 =	676.77	M 21 =	681.46	M 22 =	686.01	M 23 =	690.37	M 24 =	694.51
M 25 =	698.40	M 26 =	702.01	M 27 =	705.34	M 28 =	708.36	M 29 =	711.08
M 30 =	713.51	M 31 =	715.64	M 32 =	717.50	M 33 =	719.11	M 34 =	720.48
M 35 =	721.64	M 36 =	722.61	M 37 =	723.41	M 38 =	724.06	M 39 =	724.58
M 40 =	725.01	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	615.84	P 1 =	617.81	P 2 =	620.11	P 3 =	622.77	P 4 =	625.82
P 5 =	629.26	P 6 =	633.11	P 7 =	637.36	P 8 =	642.01	P 9 =	647.02
P 10 =	652.37	P 11 =	658.00	P 12 =	663.87	P 13 =	669.89	P 14 =	676.01
P 15 =	682.13	P 16 =	688.17	P 17 =	694.06	P 18 =	699.71	P 19 =	705.04
P 20 =	710.00	P 21 =	714.53	P 22 =	718.58	P 23 =	722.14	P 24 =	725.19
P 25 =	727.73	P 26 =	729.77	P 27 =	731.35	P 28 =	732.49	P 29 =	733.24
P 30 =	733.66	P 31 =	733.79	P 32 =	733.68	P 33 =	733.39	P 34 =	732.95
P 35 =	732.43	P 36 =	731.85	P 37 =	731.24	P 38 =	730.63	P 39 =	730.05
P 40 =	729.50	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	613.59	G 1 =	615.07	G 2 =	616.81	G 3 =	618.85	G 4 =	621.19
G 5 =	623.85	G 6 =	626.86	G 7 =	630.20	G 8 =	633.90	G 9 =	637.92
G 10 =	642.26	G 11 =	646.89	G 12 =	651.77	G 13 =	656.85	G 14 =	662.09
G 15 =	667.42	G 16 =	672.79	G 17 =	678.13	G 18 =	683.37	G 19 =	688.46
G 20 =	693.34	G 21 =	697.95	G 22 =	702.25	G 23 =	706.21	G 24 =	709.81
G 25 =	713.02	G 26 =	715.85	G 27 =	718.30	G 28 =	720.39	G 29 =	722.13
G 30 =	723.55	G 31 =	724.69	G 32 =	725.57	G 33 =	726.23	G 34 =	726.70
G 35 =	727.02	G 36 =	727.21	G 37 =	727.31	G 38 =	727.34	G 39 =	727.31
G 40 =	727.25	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.62	H 2 =	610.26	H 3 =	611.04	H 4 =	611.97	H 5 =	613.09
H 6 =	614.42	H 7 =	615.97	H 8 =	617.77	H 9 =	619.83	H 10 =	622.16
H 11 =	624.79	H 12 =	627.71	H 13 =	630.92	H 14 =	634.41	H 15 =	638.18
H 16 =	642.21	H 17 =	646.45	H 18 =	650.90	H 19 =	655.49	H 20 =	660.20
H 21 =	664.98	H 22 =	669.77	H 23 =	674.54	H 24 =	679.22	H 25 =	683.78
H 26 =	688.18	H 27 =	692.37	H 28 =	696.33	H 29 =	700.03	H 30 =	703.46
H 31 =	706.59	H 32 =	709.44	H 33 =	712.00	H 34 =	714.27	H 35 =	716.26
H 36 =	718.00	H 37 =	719.50	H 38 =	720.78	H 39 =	721.86	H 40 =	722.76
=	.0	=	.0	=	.0	=	.0		

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 1
Location x/L: IN (1.0)
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

(Q/A)=0.970MW/M2 T:NA(IN)=610F T:NA(OUT)=1100.0 PL 1,IN
A21=35.16 A22=117.57 A23=160.5 A24=125.34 A25=66.558

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1100.0	DT: NA =	490.00	T:B NA =	855.00	T:B M =	876.03
DT M-N =	35.160	DT1 =	117.57	DT F-N =	160.50	DT P-M =	125.34	DT2 =	66.558
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	613.06	N 2 =	616.77	N 3 =	621.20	N 4 =	626.45
N 5 =	632.62	N 6 =	635.78	N 7 =	648.01	N 8 =	657.39	N 9 =	667.97
N 10 =	679.77	N 11 =	692.81	N 12 =	707.08	N 13 =	722.53	N 14 =	739.11
N 15 =	756.71	N 16 =	775.21	N 17 =	794.47	N 18 =	814.31	N 19 =	834.55
N 20 =	855.00	N 21 =	875.45	N 22 =	895.69	N 23 =	915.53	N 24 =	934.79
N 25 =	953.29	N 26 =	970.89	N 27 =	987.47	N 28 =	1002.9	N 29 =	1017.2
N 30 =	1030.2	N 31 =	1042.0	N 32 =	1052.6	N 33 =	1062.0	N 34 =	1070.2
N 35 =	1077.4	N 36 =	1083.5	N 37 =	1088.8	N 38 =	1093.2	N 39 =	1096.9
N 40 =	1100.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	614.76	M 1 =	618.85	M 2 =	623.72	M 3 =	629.49	M 4 =	636.23
M 5 =	644.03	M 6 =	652.97	M 7 =	663.12	M 8 =	674.51	M 9 =	687.17
M 10 =	701.09	M 11 =	716.26	M 12 =	732.61	M 13 =	750.05	M 14 =	768.48
M 15 =	787.74	M 16 =	807.67	M 17 =	828.08	M 18 =	848.77	M 19 =	869.54
M 20 =	890.16	M 21 =	910.43	M 22 =	930.15	M 23 =	949.14	M 24 =	967.24
M 25 =	984.32	M 26 =	1000.3	M 27 =	1015.0	M 28 =	1028.5	M 29 =	1040.6
M 30 =	1051.6	M 31 =	1061.2	M 32 =	1069.7	M 33 =	1077.1	M 34 =	1083.4
M 35 =	1088.8	M 36 =	1093.3	M 37 =	1097.1	M 38 =	1100.2	M 39 =	1102.7
M 40 =	1104.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	631.72	P 1 =	639.46	P 2 =	648.53	P 3 =	659.04	P 4 =	671.08
P 5 =	684.72	P 6 =	700.02	P 7 =	716.96	P 8 =	735.52	P 9 =	755.61
P 10 =	777.12	P 11 =	799.86	P 12 =	823.63	P 13 =	848.16	P 14 =	873.17
P 15 =	898.35	P 16 =	923.37	P 17 =	947.91	P 18 =	971.63	P 19 =	994.25
P 20 =	1015.5	P 21 =	1035.1	P 22 =	1053.0	P 23 =	1069.0	P 24 =	1082.9
P 25 =	1094.9	P 26 =	1104.9	P 27 =	1113.1	P 28 =	1119.5	P 29 =	1124.2
P 30 =	1127.6	P 31 =	1129.7	P 32 =	1130.7	P 33 =	1130.9	P 34 =	1130.5
P 35 =	1129.5	P 36 =	1128.2	P 37 =	1126.6	P 38 =	1125.0	P 39 =	1123.3
P 40 =	1121.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	622.71	G 1 =	628.51	G 2 =	635.36	G 3 =	643.35	G 4 =	652.57
G 5 =	663.12	G 6 =	675.04	G 7 =	688.37	G 8 =	703.12	G 9 =	719.27
G 10 =	736.75	G 11 =	755.47	G 12 =	775.30	G 13 =	796.07	G 14 =	817.58
G 15 =	839.62	G 16 =	861.93	G 17 =	884.28	G 18 =	906.40	G 19 =	928.03
G 20 =	948.94	G 21 =	968.92	G 22 =	987.77	G 23 =	1005.3	G 24 =	1021.5
G 25 =	1036.2	G 26 =	1049.4	G 27 =	1061.0	G 28 =	1071.1	G 29 =	1079.8
G 30 =	1087.2	G 31 =	1093.3	G 32 =	1098.3	G 33 =	1102.3	G 34 =	1105.5
G 35 =	1107.9	G 36 =	1109.7	G 37 =	1110.9	G 38 =	1111.8	G 39 =	1112.4
G 40 =	1112.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.18	H 2 =	612.09	H 3 =	615.63	H 4 =	619.88	H 5 =	624.95
H 6 =	630.91	H 7 =	637.87	H 8 =	645.89	H 9 =	655.07	H 10 =	665.44
H 11 =	677.05	H 12 =	689.92	H 13 =	704.04	H 14 =	719.38	H 15 =	735.86
H 16 =	753.40	H 17 =	771.88	H 18 =	791.15	H 19 =	811.05	H 20 =	831.37
H 21 =	851.94	H 22 =	872.53	H 23 =	892.94	H 24 =	912.98	H 25 =	932.44
H 26 =	951.16	H 27 =	968.97	H 28 =	985.77	H 29 =	1001.4	H 30 =	1015.9
H 31 =	1029.1	H 32 =	1041.1	H 33 =	1051.8	H 34 =	1061.4	H 35 =	1069.7
H 36 =	1077.0	H 37 =	1083.2	H 38 =	1088.6	H 39 =	1093.1	H 40 =	1096.8
=	.0	=	.0	=	.0	=	.0		

Addendum to
NO 079TI000002
PAGE 151

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 2
Location x/L: OUT
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

(Q/A)=0.970MW/M2 T:NA(IN)=610F T:NA(OUT)=1006.08 PL 2,OUT
A21=35.16 A22=117.57 A23=160.5 A24=125.34 A25=66.558

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1006.1	DT: NA =	396.08	T:B NA =	808.04	T:B M =	829.07
DT M-N =	35.160	DT1 =	117.57	DT F-N =	160.50	DT P-M =	125.34	DT2 =	66.558
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.48	N 2 =	615.47	N 3 =	619.05	N 4 =	623.30
N 5 =	628.28	N 6 =	634.07	N 7 =	640.73	N 8 =	648.31	N 9 =	656.86
N 10 =	666.40	N 11 =	676.94	N 12 =	688.47	N 13 =	700.96	N 14 =	714.36
N 15 =	728.59	N 16 =	743.55	N 17 =	759.11	N 18 =	775.15	N 19 =	791.51
N 20 =	808.04	N 21 =	824.57	N 22 =	840.93	N 23 =	856.97	N 24 =	872.53
N 25 =	887.49	N 26 =	901.72	N 27 =	915.11	N 28 =	927.61	N 29 =	939.14
N 30 =	949.68	N 31 =	959.22	N 32 =	967.77	N 33 =	975.35	N 34 =	982.01
N 35 =	987.80	N 36 =	992.78	N 37 =	997.03	N 38 =	1000.6	N 39 =	1003.6
N 40 =	1006.1	=	.0	=	.C	=	.0	=	.0
=	.C	=	.0	=	.0	=	.0	=	.0
M =	614.76	M 1 =	618.26	M 2 =	622.43	M 3 =	627.34	M 4 =	633.07
M 5 =	639.70	M 6 =	647.27	M 7 =	655.83	M 8 =	665.42	M 9 =	676.06
M 10 =	687.72	M 11 =	700.39	M 12 =	714.0C	M 13 =	728.48	M 14 =	743.73
M 15 =	759.62	M 16 =	776.00	M 17 =	792.72	M 18 =	809.61	M 19 =	826.50
M 20 =	843.20	M 21 =	859.55	M 22 =	875.39	M 23 =	890.58	M 24 =	904.99
M 25 =	918.52	M 26 =	931.08	M 27 =	942.63	M 28 =	953.14	M 29 =	962.59
M 30 =	971.01	M 31 =	978.42	M 32 =	984.89	M 33 =	990.46	M 34 =	995.21
M 35 =	999.21	M 36 =	1002.6	M 37 =	1005.3	M 38 =	1007.6	M 39 =	1009.4
M 40 =	1010.8	=	.0	=	.C	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	631.72	P 1 =	636.87	P 2 =	647.23	P 3 =	656.89	P 4 =	667.92
P 5 =	680.39	P 6 =	694.31	P 7 =	709.67	P 8 =	726.43	P 9 =	744.50
P 10 =	763.74	P 11 =	783.99	P 12 =	805.02	P 13 =	826.59	P 14 =	848.42
P 15 =	870.23	P 16 =	891.71	P 17 =	912.55	P 18 =	932.47	P 19 =	951.21
P 20 =	966.54	P 21 =	984.27	P 22 =	998.25	P 23 =	1010.4	P 24 =	1020.7
P 25 =	1029.1	P 26 =	1035.8	P 27 =	1040.7	P 28 =	1044.2	P 29 =	1046.2
P 30 =	1047.0	P 31 =	1046.9	P 32 =	1045.9	P 33 =	1044.3	P 34 =	1042.2
P 35 =	1039.9	P 36 =	1037.4	P 37 =	1034.9	P 38 =	1032.4	P 39 =	1030.0
P 40 =	1027.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	622.71	G 1 =	627.93	G 2 =	634.06	G 3 =	641.20	G 4 =	649.42
G 5 =	658.78	G 6 =	669.33	G 7 =	681.08	G 8 =	694.04	G 9 =	708.16
G 10 =	723.38	G 11 =	739.60	G 12 =	756.69	G 13 =	774.50	G 14 =	792.83
G 15 =	811.50	G 16 =	830.27	G 17 =	848.92	G 18 =	867.23	G 19 =	884.99
G 20 =	901.98	G 21 =	918.04	G 22 =	933.01	G 23 =	946.78	G 24 =	959.26
G 25 =	970.40	G 26 =	980.19	G 27 =	988.65	G 28 =	995.83	G 29 =	1001.8
G 30 =	1006.7	G 31 =	1010.5	G 32 =	1013.5	G 33 =	1015.7	G 34 =	1017.3
G 35 =	1018.3	G 36 =	1018.9	G 37 =	1019.2	G 38 =	1019.2	G 39 =	1019.1
G 40 =	1018.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.59	H 2 =	610.79	H 3 =	613.48	H 4 =	616.73	H 5 =	620.61
H 6 =	625.20	H 7 =	630.58	H 8 =	636.81	H 9 =	643.95	H 10 =	652.07
H 11 =	661.18	H 12 =	671.32	H 13 =	682.47	H 14 =	694.63	H 15 =	707.74
H 16 =	721.74	H 17 =	736.53	H 18 =	751.99	H 19 =	768.01	H 20 =	784.41
H 21 =	801.06	H 22 =	817.77	H 23 =	834.38	H 24 =	850.73	H 25 =	866.64
H 26 =	881.98	H 27 =	896.62	H 28 =	910.45	H 29 =	923.38	H 30 =	935.35
H 31 =	946.32	H 32 =	956.27	H 33 =	965.20	H 34 =	973.14	H 35 =	980.13
H 36 =	986.21	H 37 =	991.46	H 38 =	995.94	H 39 =	999.72	H 40 =	1002.9
=	.0	=	.0	=	.C	=	.0		

CASE # 2

Solar Flux: REFERENCE
Orifices: NO
Sub-Panel: 2
Location x/L: IN (1.0)
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

(Q/A)=1.20 MW/M2 T:NA(IN)=610F T:NA(OUT)=1100.0 PL 2,IN
A21=41.74 A22=139.66 A23=152.5 A24=150.76 A25=80.96

2

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1100.0	DT: NA =	490.00	T:B NA =	855.00	T:B M =	879.96
DT M-N =	41.740	DT1 =	139.66	DT P-N =	192.50	DT P-M =	150.76	DT2 =	80.960
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	613.06	N 2 =	616.77	N 3 =	621.20	N 4 =	626.45
N 5 =	632.62	N 6 =	635.78	N 7 =	648.01	N 8 =	657.39	N 9 =	667.97
N 10 =	679.77	N 11 =	692.81	N 12 =	707.08	N 13 =	722.53	N 14 =	739.11
N 15 =	756.71	N 16 =	775.21	N 17 =	794.47	N 18 =	814.31	N 19 =	834.55
N 20 =	855.00	N 21 =	875.45	N 22 =	895.69	N 23 =	915.53	N 24 =	934.79
N 25 =	953.29	N 26 =	970.89	N 27 =	987.47	N 28 =	1002.9	N 29 =	1017.2
N 30 =	1030.2	N 31 =	1042.0	N 32 =	1052.6	N 33 =	1062.0	N 34 =	1070.2
N 35 =	1077.4	N 36 =	1083.5	N 37 =	1088.8	N 38 =	1093.2	N 39 =	1096.9
N 40 =	1100.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.65	M 1 =	619.93	M 2 =	625.03	M 3 =	631.04	M 4 =	638.06
M 5 =	646.17	M 6 =	655.44	M 7 =	665.94	M 8 =	677.71	M 9 =	690.76
M 10 =	705.08	M 11 =	720.65	M 12 =	737.39	M 13 =	755.20	M 14 =	773.97
M 15 =	793.55	M 16 =	813.74	M 17 =	834.37	M 18 =	855.22	M 19 =	876.09
M 20 =	896.74	M 21 =	916.98	M 22 =	936.60	M 23 =	955.43	M 24 =	973.32
M 25 =	990.12	M 26 =	1005.8	M 27 =	1020.1	M 28 =	1033.2	M 29 =	1045.0
M 30 =	1055.5	M 31 =	1064.8	M 32 =	1072.9	M 33 =	1079.9	M 34 =	1085.9
M 35 =	1090.9	M 36 =	1095.2	M 37 =	1098.6	M 38 =	1101.5	M 39 =	1103.8
M 40 =	1105.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	636.05	P 1 =	644.72	P 2 =	654.86	P 3 =	666.58	P 4 =	679.97
P 5 =	695.11	P 6 =	712.03	P 7 =	730.70	P 8 =	751.09	P 9 =	773.09
P 10 =	796.53	P 11 =	821.20	P 12 =	846.86	P 13 =	873.21	P 14 =	899.90
P 15 =	926.59	P 16 =	952.91	P 17 =	978.50	P 18 =	1003.0	P 19 =	1026.1
P 20 =	1047.5	P 21 =	1067.0	P 22 =	1084.4	P 23 =	1099.6	P 24 =	1112.5
P 25 =	1123.2	P 26 =	1131.7	P 27 =	1138.1	P 28 =	1142.7	P 29 =	1145.6
P 30 =	1147.0	P 31 =	1147.2	P 32 =	1146.3	P 33 =	1144.7	P 34 =	1142.5
P 35 =	1139.9	P 36 =	1137.1	P 37 =	1134.2	P 38 =	1131.3	P 39 =	1128.6
P 40 =	1126.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	625.10	G 1 =	631.41	G 2 =	638.85	G 3 =	647.50	G 4 =	657.47
G 5 =	668.84	G 6 =	681.65	G 7 =	695.94	G 8 =	711.70	G 9 =	728.89
G 10 =	747.44	G 11 =	767.22	G 12 =	788.09	G 13 =	809.86	G 14 =	832.30
G 15 =	855.17	G 16 =	878.20	G 17 =	901.13	G 18 =	923.67	G 19 =	945.57
G 20 =	966.57	G 21 =	986.46	G 22 =	1005.0	G 23 =	1022.2	G 24 =	1037.8
G 25 =	1051.7	G 26 =	1064.1	G 27 =	1074.8	G 28 =	1083.9	G 29 =	1091.6
G 30 =	1097.9	G 31 =	1103.0	G 32 =	1106.9	G 33 =	1109.9	G 34 =	1112.1
G 35 =	1113.6	G 36 =	1114.6	G 37 =	1115.1	G 38 =	1115.3	G 39 =	1115.3
G 40 =	1115.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.44	H 2 =	611.21	H 3 =	614.58	H 4 =	618.64	H 5 =	623.50
H 6 =	629.24	H 7 =	635.95	H 8 =	643.72	H 9 =	652.63	H 10 =	662.73
H 11 =	674.07	H 12 =	686.68	H 13 =	700.55	H 14 =	715.65	H 15 =	731.92
H 16 =	749.28	H 17 =	767.61	H 18 =	786.78	H 19 =	806.60	H 20 =	826.91
H 21 =	847.50	H 22 =	868.15	H 23 =	888.68	H 24 =	908.86	H 25 =	928.50
H 26 =	947.43	H 27 =	965.48	H 28 =	982.52	H 29 =	998.45	H 30 =	1013.2
H 31 =	1026.7	H 32 =	1038.9	H 33 =	1049.9	H 34 =	1059.7	H 35 =	1068.3
H 36 =	1075.7	H 37 =	1082.2	H 38 =	1087.7	H 39 =	1092.3	H 40 =	1096.2
=	.0	=	.0	=	.0	=	.0		

PANEL TEMPERATURE DISTRIBUTION

CASE 3
SET 1 Subpanel 1

Solar Flux Distribution: OFF NORMAL

Orifices: Yes: Orificed so as to match tube flow rates to reference flux distribution

Sodium Temperatures: T (Na-Inlet) = 610°F
T (Na-Outlet) = 1050°F (mean)
(784.4 to 1081.6)

5370F/sjh

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 1
Location x/L: 0.05
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 1 LOC=.05 T:IN=610F T:OUT=855.98 C/A=0.14792 MW/M2
A21=6.535 A22=21.783 A23=28.381 A24=21.847 A25=10.954

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	855.98	DT: NA =	245.98	T:B NA =	732.99	T:B M =	736.90
DT M-N =	6.5350	DT1 =	21.783	DT P-N =	28.381	DT P-M =	21.847	DT2 =	10.954
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	611.54	N 2 =	613.40	N 3 =	615.62	N 4 =	618.26
N 5 =	621.35	N 6 =	624.95	N 7 =	629.08	N 8 =	633.79	N 9 =	639.10
N 10 =	645.02	N 11 =	651.57	N 12 =	658.73	N 13 =	666.49	N 14 =	674.81
N 15 =	683.65	N 16 =	692.94	N 17 =	702.60	N 18 =	712.56	N 19 =	722.73
N 20 =	732.99	N 21 =	743.25	N 22 =	753.42	N 23 =	763.36	N 24 =	773.04
N 25 =	782.33	N 26 =	791.17	N 27 =	799.49	N 28 =	807.25	N 29 =	814.41
N 30 =	820.96	N 31 =	826.88	N 32 =	832.19	N 33 =	836.90	N 34 =	841.03
N 35 =	844.63	N 36 =	847.72	N 37 =	850.36	N 38 =	852.58	N 39 =	854.44
N 40 =	855.98	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	610.88	M 1 =	612.61	M 2 =	614.69	M 3 =	617.16	M 4 =	620.08
M 5 =	623.48	M 6 =	627.40	M 7 =	631.89	M 8 =	636.97	M 9 =	642.67
M 10 =	648.99	M 11 =	655.93	M 12 =	663.48	M 13 =	671.61	M 14 =	680.27
M 15 =	689.42	M 16 =	698.97	M 17 =	706.85	M 18 =	718.97	M 19 =	729.23
M 20 =	739.52	M 21 =	749.76	M 22 =	759.82	M 23 =	769.62	M 24 =	779.08
M 25 =	788.10	M 26 =	796.62	M 27 =	804.60	M 28 =	811.99	M 29 =	818.77
M 30 =	824.92	M 31 =	830.45	M 32 =	835.37	M 33 =	839.70	M 34 =	843.48
M 35 =	846.75	M 36 =	849.54	M 37 =	851.90	M 38 =	853.88	M 39 =	855.52
M 40 =	856.86	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	613.84	P 1 =	616.21	P 2 =	619.01	P 3 =	622.31	P 4 =	626.15
P 5 =	630.57	P 6 =	635.60	P 7 =	641.27	P 8 =	647.61	P 9 =	654.60
P 10 =	662.24	P 11 =	670.50	P 12 =	679.34	P 13 =	688.71	P 14 =	698.52
P 15 =	708.70	P 16 =	719.14	P 17 =	729.74	P 18 =	740.38	P 19 =	750.97
P 20 =	761.37	P 21 =	771.49	P 22 =	781.23	P 23 =	790.51	P 24 =	799.24
P 25 =	807.38	P 26 =	814.87	P 27 =	821.70	P 28 =	827.85	P 29 =	833.34
P 30 =	838.17	P 31 =	842.38	P 32 =	846.00	P 33 =	849.09	P 34 =	851.68
P 35 =	853.84	P 36 =	855.61	P 37 =	857.05	P 38 =	858.20	P 39 =	859.11
P 40 =	859.82	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	612.36	G 1 =	614.40	G 2 =	616.84	G 3 =	619.73	G 4 =	623.10
G 5 =	627.01	G 6 =	631.49	G 7 =	636.57	G 8 =	642.27	G 9 =	648.61
G 10 =	655.59	G 11 =	663.19	G 12 =	671.39	G 13 =	680.13	G 14 =	689.37
G 15 =	699.03	G 16 =	709.02	G 17 =	719.26	G 18 =	729.65	G 19 =	740.07
G 20 =	750.42	G 21 =	760.59	G 22 =	770.50	G 23 =	780.04	G 24 =	789.13
G 25 =	797.71	G 26 =	805.72	G 27 =	813.13	G 28 =	819.90	G 29 =	826.03
G 30 =	831.53	G 31 =	836.40	G 32 =	840.67	G 33 =	844.38	G 34 =	847.57
G 35 =	850.28	G 36 =	852.57	G 37 =	854.47	G 38 =	856.03	G 39 =	857.31
G 40 =	858.34	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	610.82	H 2 =	612.53	H 3 =	614.59	H 4 =	617.05	H 5 =	619.94
H 6 =	623.31	H 7 =	627.21	H 8 =	631.67	H 9 =	636.72	H 10 =	642.38
H 11 =	648.66	H 12 =	655.57	H 13 =	663.08	H 14 =	671.17	H 15 =	679.80
H 16 =	688.92	H 17 =	698.44	H 18 =	708.29	H 19 =	718.39	H 20 =	728.63
H 21 =	738.92	H 22 =	749.15	H 23 =	759.21	H 24 =	769.02	H 25 =	778.49
H 26 =	787.53	H 27 =	796.08	H 28 =	804.08	H 29 =	811.50	H 30 =	818.31
H 31 =	824.50	H 32 =	830.07	H 33 =	835.03	H 34 =	839.40	H 35 =	843.21
H 36 =	846.51	H 37 =	849.33	H 38 =	851.72	H 39 =	853.73	H 40 =	855.39
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 1
Location x/L: 0.15
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 1 LOC=.15 T:IN=610F T:OUT=947.45 Q/A=0.26058 MW/M2
A21=11.144 A22=37.165 A23=48.773 A24=37.628 A25=19.04

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	947.45	DT: NA =	337.45	T:B NA =	778.72	T:B M =	785.39
DT M-N =	11.144	DT1 =	37.165	DT P-N =	48.773	DT P-M =	37.628	DT2 =	19.045
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.11	N 2 =	614.66	N 3 =	617.71	N 4 =	621.33
N 5 =	625.58	N 6 =	630.51	N 7 =	636.18	N 8 =	642.64	N 9 =	649.92
N 10 =	658.05	N 11 =	667.03	N 12 =	676.86	N 13 =	687.50	N 14 =	698.92
N 15 =	711.04	N 16 =	723.78	N 17 =	737.04	N 18 =	750.70	N 19 =	764.64
N 20 =	778.72	N 21 =	792.81	N 22 =	806.75	N 23 =	820.41	N 24 =	833.67
N 25 =	846.41	N 26 =	858.53	N 27 =	869.95	N 28 =	880.59	N 29 =	890.42
N 30 =	899.40	N 31 =	907.53	N 32 =	914.81	N 33 =	921.27	N 34 =	926.94
N 35 =	931.87	N 36 =	936.12	N 37 =	939.74	N 38 =	942.79	N 39 =	945.34
N 40 =	947.45	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	611.51	M 1 =	613.94	M 2 =	616.86	M 3 =	620.34	M 4 =	624.43
M 5 =	629.19	M 6 =	634.69	M 7 =	640.97	M 8 =	648.06	M 9 =	656.01
M 10 =	664.81	M 11 =	674.46	M 12 =	684.95	M 13 =	696.22	M 14 =	708.22
M 15 =	720.87	M 16 =	734.06	M 17 =	747.69	M 18 =	761.63	M 19 =	775.73
M 20 =	789.87	M 21 =	803.89	M 22 =	817.67	M 23 =	831.06	M 24 =	843.96
M 25 =	856.25	M 26 =	867.84	M 27 =	878.67	M 28 =	888.69	M 29 =	897.85
M 30 =	906.16	M 31 =	913.61	M 32 =	920.24	M 33 =	926.06	M 34 =	931.12
M 35 =	935.49	M 36 =	939.22	M 37 =	942.36	M 38 =	945.00	M 39 =	947.17
M 40 =	948.96	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	616.60	P 1 =	620.13	P 2 =	624.31	P 3 =	629.21	P 4 =	634.89
P 5 =	641.41	P 6 =	648.81	P 7 =	657.13	P 8 =	666.38	P 9 =	676.55
P 10 =	687.63	P 11 =	699.56	P 12 =	712.27	P 13 =	725.67	P 14 =	739.65
P 15 =	754.08	P 16 =	768.80	P 17 =	783.67	P 18 =	798.51	P 19 =	813.17
P 20 =	827.50	P 21 =	841.33	P 22 =	854.55	P 23 =	867.04	P 24 =	878.70
P 25 =	889.46	P 26 =	899.27	P 27 =	908.12	P 28 =	916.01	P 29 =	922.95
P 30 =	928.98	P 31 =	934.16	P 32 =	938.55	P 33 =	942.22	P 34 =	945.25
P 35 =	947.71	P 36 =	949.68	P 37 =	951.24	P 38 =	952.44	P 39 =	953.36
P 40 =	954.05	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	614.02	G 1 =	617.00	G 2 =	620.54	G 3 =	624.72	G 4 =	629.60
G 5 =	635.23	G 6 =	641.66	G 7 =	648.95	G 8 =	657.11	G 9 =	666.15
G 10 =	676.08	G 11 =	686.86	G 12 =	698.44	G 13 =	710.77	G 14 =	723.74
G 15 =	737.27	G 16 =	751.22	G 17 =	765.46	G 18 =	779.84	G 19 =	794.22
G 20 =	808.45	G 21 =	822.38	G 22 =	835.88	G 23 =	848.83	G 24 =	861.11
G 25 =	872.65	G 26 =	883.36	G 27 =	893.22	G 28 =	902.18	G 29 =	910.25
G 30 =	917.43	G 31 =	923.76	G 32 =	929.28	G 33 =	934.04	G 34 =	938.10
G 35 =	941.52	G 36 =	944.38	G 37 =	946.74	G 38 =	948.67	G 39 =	950.23
G 40 =	951.47	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	610.89	H 2 =	613.19	H 3 =	615.96	H 4 =	619.26	H 5 =	623.16
H 6 =	627.72	H 7 =	632.98	H 8 =	639.02	H 9 =	645.86	H 10 =	653.54
H 11 =	662.07	H 12 =	671.45	H 13 =	681.68	H 14 =	692.70	H 15 =	704.47
H 16 =	716.91	H 17 =	729.93	H 18 =	743.41	H 19 =	757.24	H 20 =	771.29
H 21 =	785.40	H 22 =	799.45	H 23 =	813.30	H 24 =	826.81	H 25 =	839.85
H 26 =	852.32	H 27 =	864.13	H 28 =	875.19	H 29 =	885.46	H 30 =	894.89
H 31 =	903.47	H 32 =	911.19	H 33 =	918.07	H 34 =	924.15	H 35 =	929.46
H 36 =	934.05	H 37 =	937.98	H 38 =	941.32	H 39 =	944.12	H 40 =	946.44
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 1
Location x/L: 0.25
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 1 LOC=.25 T:IN=610F T:OUT=1001.20 C/A=0.36891 MW/M2
A21=14.812 A22=49.443 A23=65.834 A24=51.022 A25=26.300

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1001.2	DT: NA =	391.20	T:B NA =	805.60	T:B M =	814.46
DT M-N =	14.812	DT1 =	49.443	DT P-N =	65.834	DT P-M =	51.022	DT2 =	26.300
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.45	N 2 =	615.40	N 3 =	618.94	N 4 =	623.14
N 5 =	628.06	N 6 =	633.77	N 7 =	640.35	N 8 =	647.84	N 9 =	656.28
N 10 =	665.70	N 11 =	676.11	N 12 =	687.50	N 13 =	699.84	N 14 =	713.06
N 15 =	727.13	N 16 =	741.90	N 17 =	757.27	N 18 =	773.12	N 19 =	789.26
N 20 =	805.60	N 21 =	821.92	N 22 =	838.08	N 23 =	853.93	N 24 =	869.30
N 25 =	884.07	N 26 =	898.12	N 27 =	911.36	N 28 =	923.70	N 29 =	935.09
N 30 =	945.50	N 31 =	954.92	N 32 =	963.36	N 33 =	970.85	N 34 =	977.43
N 35 =	983.14	N 36 =	988.06	N 37 =	992.26	N 38 =	995.80	N 39 =	998.75
N 40 =	1001.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	612.00	M 1 =	614.88	M 2 =	618.33	M 3 =	622.43	M 4 =	627.25
M 5 =	632.86	M 6 =	635.33	M 7 =	646.71	M 8 =	655.05	M 9 =	664.37
M 10 =	674.68	M 11 =	685.99	M 12 =	698.26	M 13 =	711.44	M 14 =	725.45
M 15 =	740.20	M 16 =	755.57	M 17 =	771.43	M 18 =	787.63	M 19 =	804.01
M 20 =	820.41	M 21 =	836.66	M 22 =	852.60	M 23 =	868.09	M 24 =	882.97
M 25 =	897.14	M 26 =	910.49	M 27 =	922.95	M 28 =	934.45	M 29 =	944.97
M 30 =	954.48	M 31 =	963.01	M 32 =	970.57	M 33 =	977.21	M 34 =	982.98
M 35 =	987.95	M 36 =	992.18	M 37 =	995.75	M 38 =	998.73	M 39 =	1001.2
M 40 =	1003.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	618.91	P 1 =	623.27	P 2 =	628.43	P 3 =	634.46	P 4 =	641.44
P 5 =	649.43	P 6 =	658.48	P 7 =	668.63	P 8 =	679.88	P 9 =	692.25
P 10 =	705.63	P 11 =	720.02	P 12 =	735.31	P 13 =	751.37	P 14 =	768.07
P 15 =	785.23	P 16 =	802.67	P 17 =	820.21	P 18 =	837.65	P 19 =	854.76
P 20 =	871.43	P 21 =	887.43	P 22 =	902.61	P 23 =	916.86	P 24 =	930.07
P 25 =	942.17	P 26 =	953.11	P 27 =	962.88	P 28 =	971.50	P 29 =	979.00
P 30 =	985.43	P 31 =	990.87	P 32 =	995.41	P 33 =	999.13	P 34 =	1002.1
P 35 =	1004.5	P 36 =	1006.4	P 37 =	1007.8	P 38 =	1008.8	P 39 =	1009.6
P 40 =	1010.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	615.35	G 1 =	618.95	G 2 =	623.23	G 3 =	628.26	G 4 =	634.13
G 5 =	640.89	G 6 =	646.61	G 7 =	657.33	G 8 =	667.08	G 9 =	677.87
G 10 =	689.68	G 11 =	702.48	G 12 =	716.21	G 13 =	730.79	G 14 =	746.10
G 15 =	762.02	G 16 =	778.39	G 17 =	795.07	G 18 =	811.67	G 19 =	828.61
G 20 =	845.13	G 21 =	861.26	G 22 =	876.83	G 23 =	891.72	G 24 =	905.79
G 25 =	918.96	G 26 =	931.14	G 27 =	942.30	G 28 =	952.40	G 29 =	961.45
G 30 =	969.48	G 31 =	976.51	G 32 =	982.61	G 33 =	987.83	G 34 =	992.26
G 35 =	995.98	G 36 =	999.06	G 37 =	1001.6	G 38 =	1003.6	G 39 =	1005.3
G 40 =	1006.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	610.82	H 2 =	613.44	H 3 =	616.60	H 4 =	620.38	H 5 =	624.84
H 6 =	630.05	H 7 =	636.09	H 8 =	643.01	H 9 =	650.87	H 10 =	659.69
H 11 =	669.50	H 12 =	680.31	H 13 =	692.09	H 14 =	704.80	H 15 =	718.39
H 16 =	732.75	H 17 =	747.80	H 18 =	763.40	H 19 =	779.42	H 20 =	795.69
H 21 =	812.06	H 22 =	828.37	H 23 =	844.45	H 24 =	860.15	H 25 =	875.33
H 26 =	889.84	H 27 =	903.60	H 28 =	916.50	H 29 =	928.48	H 30 =	939.49
H 31 =	949.51	H 32 =	958.54	H 33 =	966.59	H 34 =	973.71	H 35 =	979.93
H 36 =	985.31	H 37 =	989.92	H 38 =	993.84	H 39 =	997.12	H 40 =	999.86
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 1
Location x/L: 0.35
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 1 LOC=.35 T:IN=610F T:OUT=1034.58 C/A=0.47292 MW/M2
A21=18.333 A22=61.232 A23=82.215 A24=63.883 A25=33.266

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1034.6	DT: NA =	424.58	T:B NA =	822.29	T:B P =	833.25
DT N-N =	18.333	DT1 =	61.232	DT P-N =	82.215	DT P-P =	63.883	DT2 =	33.266
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.65	N 2 =	615.86	N 3 =	619.70	N 4 =	624.26
N 5 =	629.60	N 6 =	635.80	N 7 =	642.94	N 8 =	651.07	N 9 =	660.23
N 10 =	670.45	N 11 =	681.75	N 12 =	694.12	N 13 =	707.51	N 14 =	721.87
N 15 =	737.12	N 16 =	753.16	N 17 =	769.84	N 18 =	787.03	N 19 =	804.57
N 20 =	822.29	N 21 =	840.01	N 22 =	857.55	N 23 =	874.74	N 24 =	891.42
N 25 =	907.46	N 26 =	922.71	N 27 =	937.07	N 28 =	950.46	N 29 =	962.83
N 30 =	974.13	N 31 =	984.35	N 32 =	993.51	N 33 =	1001.6	N 34 =	1008.8
N 35 =	1015.0	N 36 =	1020.3	N 37 =	1024.9	N 38 =	1028.7	N 39 =	1031.9
N 40 =	1034.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	612.48	M 1 =	615.67	M 2 =	619.49	M 3 =	624.03	M 4 =	629.35
M 5 =	635.55	M 6 =	642.68	M 7 =	650.81	M 8 =	659.99	M 9 =	670.24
M 10 =	681.57	M 11 =	693.98	M 12 =	707.43	M 13 =	721.86	M 14 =	737.19
M 15 =	753.30	M 16 =	770.08	M 17 =	787.37	M 18 =	805.00	M 19 =	822.82
M 20 =	840.62	M 21 =	858.25	M 22 =	875.52	M 23 =	892.27	M 24 =	908.35
M 25 =	923.63	M 26 =	936.02	M 27 =	951.42	M 28 =	963.77	M 29 =	975.05
M 30 =	985.25	M 31 =	994.36	M 32 =	1002.4	M 33 =	1009.5	M 34 =	1015.7
M 35 =	1020.9	M 36 =	1025.4	M 37 =	1029.2	M 38 =	1032.3	M 39 =	1034.9
M 40 =	1037.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	621.13	P 1 =	626.18	P 2 =	632.13	P 3 =	639.09	P 4 =	647.41
P 5 =	656.29	P 6 =	666.66	P 7 =	678.25	P 8 =	691.08	P 9 =	705.12
P 10 =	720.32	P 11 =	736.59	P 12 =	753.82	P 13 =	771.86	P 14 =	790.54
P 15 =	809.68	P 16 =	829.05	P 17 =	848.44	P 18 =	867.62	P 19 =	886.38
P 20 =	904.50	P 21 =	921.81	P 22 =	938.13	P 23 =	953.34	P 24 =	967.32
P 25 =	980.01	P 26 =	991.38	P 27 =	1001.4	P 28 =	1010.2	P 29 =	1017.7
P 30 =	1024.0	P 31 =	1029.2	P 32 =	1033.5	P 33 =	1037.0	P 34 =	1039.6
P 35 =	1041.7	P 36 =	1043.2	P 37 =	1044.3	P 38 =	1045.0	P 39 =	1045.4
P 40 =	1045.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	616.62	G 1 =	620.70	G 2 =	625.55	G 3 =	631.24	G 4 =	637.87
G 5 =	645.49	G 6 =	654.17	G 7 =	663.96	G 8 =	674.89	G 9 =	686.96
G 10 =	700.14	G 11 =	714.40	G 12 =	729.66	G 13 =	745.82	G 14 =	762.76
G 15 =	780.32	G 16 =	798.34	G 17 =	816.64	G 18 =	835.01	G 19 =	853.28
G 20 =	871.24	G 21 =	888.71	G 22 =	905.53	G 23 =	921.53	G 24 =	936.61
G 25 =	950.65	G 26 =	963.59	G 27 =	975.38	G 28 =	986.01	G 29 =	995.47
G 30 =	1003.8	G 31 =	1011.1	G 32 =	1017.3	G 33 =	1022.7	G 34 =	1027.1
G 35 =	1030.9	G 36 =	1033.9	G 37 =	1036.4	G 38 =	1038.4	G 39 =	1040.0
G 40 =	1041.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	610.63	H 2 =	613.43	H 3 =	616.81	H 4 =	620.84	H 5 =	625.61
H 6 =	631.19	H 7 =	637.66	H 8 =	645.09	H 9 =	653.52	H 10 =	663.00
H 11 =	673.56	H 12 =	685.20	H 13 =	697.90	H 14 =	711.61	H 15 =	726.28
H 16 =	741.82	H 17 =	758.10	H 18 =	774.99	H 19 =	792.35	H 20 =	810.01
H 21 =	827.78	H 22 =	845.51	H 23 =	863.00	H 24 =	880.09	H 25 =	896.62
H 26 =	912.45	H 27 =	927.46	H 28 =	941.54	H 29 =	954.63	H 30 =	966.08
H 31 =	977.64	H 32 =	987.54	H 33 =	996.36	H 34 =	1004.2	H 35 =	1011.0
H 36 =	1016.9	H 37 =	1022.0	H 38 =	1026.3	H 39 =	1029.9	H 40 =	1032.9
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 1
Location x/L: 0.45
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 1 LOC=.45 T:IN=610F T:OUT=1055.72 Q/A=0.57262 MW/M2
A21=21.708 A22=72.531 A23=97.916 A24=76.209 A25=39.943

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1055.7	DT: NA =	445.72	T:B NA =	832.86	T:B M =	845.84
DT M-N =	21.708	DT1 =	72.531	DT P-N =	97.916	DT P-M =	76.209	DT2 =	39.943
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.79	N 2 =	616.15	N 3 =	620.19	N 4 =	624.97
N 5 =	630.57	N 6 =	637.09	N 7 =	644.58	N 8 =	653.11	N 9 =	662.73
N 10 =	673.46	N 11 =	685.33	N 12 =	698.31	N 13 =	712.37	N 14 =	727.44
N 15 =	743.45	N 16 =	760.28	N 17 =	777.80	N 18 =	795.85	N 19 =	814.26
N 20 =	832.86	N 21 =	851.46	N 22 =	869.87	N 23 =	887.92	N 24 =	905.44
N 25 =	922.27	N 26 =	938.28	N 27 =	953.35	N 28 =	967.41	N 29 =	980.39
N 30 =	992.26	N 31 =	1003.0	N 32 =	1012.6	N 33 =	1021.1	N 34 =	1028.6
N 35 =	1035.1	N 36 =	1040.6	N 37 =	1045.5	N 38 =	1049.6	N 39 =	1052.9
N 40 =	1055.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	612.94	M 1 =	616.36	M 2 =	620.45	M 3 =	625.30	M 4 =	631.00
M 5 =	637.62	M 6 =	645.23	M 7 =	653.90	M 8 =	663.68	M 9 =	674.58
M 10 =	686.63	M 11 =	695.81	M 12 =	714.07	M 13 =	729.36	M 14 =	745.58
M 15 =	762.61	M 16 =	780.32	M 17 =	798.55	M 18 =	817.13	M 19 =	835.86
M 20 =	854.57	M 21 =	873.06	M 22 =	891.15	M 23 =	908.67	M 24 =	925.48
M 25 =	941.42	M 26 =	956.41	M 27 =	970.35	M 28 =	983.18	M 29 =	994.87
M 30 =	1005.4	M 31 =	1014.8	M 32 =	1023.2	M 33 =	1030.5	M 34 =	1036.8
M 35 =	1042.2	M 36 =	1046.8	M 37 =	1050.7	M 38 =	1053.9	M 39 =	1056.5
M 40 =	1058.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	623.25	P 1 =	628.89	P 2 =	635.53	P 3 =	643.27	P 4 =	652.19
P 5 =	662.36	P 6 =	673.84	P 7 =	686.64	P 8 =	700.77	P 9 =	716.20
P 10 =	732.85	P 11 =	750.63	P 12 =	769.41	P 13 =	789.00	P 14 =	805.23
P 15 =	829.86	P 16 =	850.67	P 17 =	871.41	P 18 =	891.83	P 19 =	911.69
P 20 =	930.78	P 21 =	948.89	P 22 =	965.85	P 23 =	981.53	P 24 =	995.82
P 25 =	1008.7	P 26 =	1020.1	P 27 =	1030.0	P 28 =	1038.5	P 29 =	1045.7
P 30 =	1051.6	P 31 =	1056.5	P 32 =	1060.3	P 33 =	1063.2	P 34 =	1065.4
P 35 =	1066.9	P 36 =	1068.0	P 37 =	1068.6	P 38 =	1068.9	P 39 =	1069.0
P 40 =	1069.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	617.85	G 1 =	622.32	G 2 =	627.63	G 3 =	633.85	G 4 =	641.08
G 5 =	649.39	G 6 =	658.85	G 7 =	669.48	G 8 =	681.33	G 9 =	694.39
G 10 =	708.63	G 11 =	723.99	G 12 =	740.40	G 13 =	757.74	G 14 =	775.87
G 15 =	794.61	G 16 =	813.80	G 17 =	833.22	G 18 =	852.67	G 19 =	871.95
G 20 =	890.83	G 21 =	909.14	G 22 =	926.70	G 23 =	943.34	G 24 =	958.95
G 25 =	973.43	G 26 =	986.70	G 27 =	998.73	G 28 =	1009.5	G 29 =	1019.1
G 30 =	1027.4	G 31 =	1034.6	G 32 =	1040.8	G 33 =	1046.0	G 34 =	1050.4
G 35 =	1054.0	G 36 =	1056.9	G 37 =	1059.2	G 38 =	1061.0	G 39 =	1062.5
G 40 =	1063.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	610.39	H 2 =	613.27	H 3 =	616.75	H 4 =	620.92	H 5 =	625.85
H 6 =	631.62	H 7 =	638.33	H 8 =	646.02	H 9 =	654.78	H 10 =	664.63
H 11 =	675.62	H 12 =	687.73	H 13 =	700.97	H 14 =	715.26	H 15 =	730.61
H 16 =	746.84	H 17 =	763.88	H 18 =	781.58	H 19 =	799.78	H 20 =	818.30
H 21 =	836.97	H 22 =	855.60	H 23 =	874.00	H 24 =	892.00	H 25 =	909.42
H 26 =	926.12	H 27 =	941.96	H 28 =	956.84	H 29 =	970.68	H 30 =	983.43
H 31 =	995.04	H 32 =	1005.5	H 33 =	1014.9	H 34 =	1023.2	H 35 =	1030.4
H 36 =	1036.7	H 37 =	1042.1	H 38 =	1046.7	H 39 =	1050.5	H 40 =	1053.7
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 1
Location x/L: 0.55
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 1 LOC=.55 T:IN=610F T:OUT=1068.93 C/A=0.66799 MW/M2
A21=24.936 A22=83.341 A23=112.94 A24=88.001 A25=46.331

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1068.9	DT: NA =	458.93	T:B NA =	839.46	T:B M =	854.38
DT M-N =	24.936	DT1 =	83.341	DT P-N =	112.94	DT P-M =	88.001	DT2 =	46.331
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.87	N 2 =	616.34	N 3 =	620.49	N 4 =	625.41
N 5 =	631.18	N 6 =	637.89	N 7 =	645.60	N 8 =	654.39	N 9 =	664.29
N 10 =	675.34	N 11 =	687.56	N 12 =	700.92	N 13 =	715.40	N 14 =	730.92
N 15 =	747.41	N 16 =	764.74	N 17 =	782.77	N 18 =	801.36	N 19 =	820.32
N 20 =	839.46	N 21 =	858.61	N 22 =	877.57	N 23 =	896.16	N 24 =	914.19
N 25 =	931.52	N 26 =	948.01	N 27 =	963.53	N 28 =	978.01	N 29 =	991.37
N 30 =	1003.6	N 31 =	1014.6	N 32 =	1024.5	N 33 =	1033.3	N 34 =	1041.0
N 35 =	1047.7	N 36 =	1053.5	N 37 =	1058.4	N 38 =	1062.6	N 39 =	1066.1
N 40 =	1068.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	613.37	M 1 =	616.97	M 2 =	621.27	M 3 =	626.37	M 4 =	632.34
M 5 =	639.28	M 6 =	647.25	M 7 =	656.32	M 8 =	666.52	M 9 =	677.91
M 10 =	690.47	M 11 =	704.19	M 12 =	719.03	M 13 =	734.92	M 14 =	751.75
M 15 =	769.41	M 16 =	787.76	M 17 =	806.61	M 18 =	825.80	M 19 =	845.13
M 20 =	864.40	M 21 =	883.43	M 22 =	902.02	M 23 =	920.00	M 24 =	937.21
M 25 =	953.53	M 26 =	968.83	M 27 =	983.05	M 28 =	996.11	M 29 =	1008.0
M 30 =	1018.7	M 31 =	1028.3	M 32 =	1036.7	M 33 =	1044.0	M 34 =	1050.4
M 35 =	1055.8	M 36 =	1060.5	M 37 =	1064.3	M 38 =	1067.5	M 39 =	1070.2
M 40 =	1072.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	625.28	P 1 =	631.44	P 2 =	638.69	P 3 =	647.11	P 4 =	656.81
P 5 =	667.85	P 6 =	680.28	P 7 =	694.12	P 8 =	709.36	P 9 =	725.96
P 10 =	743.85	P 11 =	762.89	P 12 =	782.93	P 13 =	803.80	P 14 =	825.26
P 15 =	847.08	P 16 =	868.99	P 17 =	890.74	P 18 =	912.06	P 19 =	932.69
P 20 =	952.40	P 21 =	970.99	P 22 =	988.28	P 23 =	1004.1	P 24 =	1018.4
P 25 =	1031.2	P 26 =	1042.3	P 27 =	1051.9	P 28 =	1060.0	P 29 =	1066.7
P 30 =	1072.1	P 31 =	1076.3	P 32 =	1079.5	P 33 =	1081.8	P 34 =	1083.4
P 35 =	1084.4	P 36 =	1084.9	P 37 =	1085.1	P 38 =	1084.9	P 39 =	1084.6
P 40 =	1084.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	619.01	G 1 =	623.82	G 2 =	629.52	G 3 =	636.19	G 4 =	643.93
G 5 =	652.81	G 6 =	662.89	G 7 =	674.21	G 8 =	686.81	G 9 =	700.66
G 10 =	715.74	G 11 =	731.98	G 12 =	749.29	G 13 =	767.53	G 14 =	786.56
G 15 =	806.19	G 16 =	826.22	G 17 =	846.45	G 18 =	866.64	G 19 =	886.59
G 20 =	906.07	G 21 =	924.89	G 22 =	942.86	G 23 =	959.83	G 24 =	975.68
G 25 =	990.30	G 26 =	1003.6	G 27 =	1015.7	G 28 =	1026.4	G 29 =	1035.8
G 30 =	1044.0	G 31 =	1051.0	G 32 =	1057.0	G 33 =	1061.9	G 34 =	1066.0
G 35 =	1069.4	G 36 =	1072.0	G 37 =	1074.1	G 38 =	1075.8	G 39 =	1077.0
G 40 =	1077.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	610.12	H 2 =	613.02	H 3 =	616.54	H 4 =	620.76	H 5 =	625.75
H 6 =	631.61	H 7 =	638.42	H 8 =	646.24	H 9 =	655.15	H 10 =	665.19
H 11 =	676.40	H 12 =	688.77	H 13 =	702.30	H 14 =	716.95	H 15 =	732.64
H 16 =	749.29	H 17 =	766.77	H 18 =	784.95	H 19 =	803.66	H 20 =	822.73
H 21 =	841.96	H 22 =	861.17	H 23 =	880.16	H 24 =	898.74	H 25 =	916.75
H 26 =	934.03	H 27 =	950.43	H 28 =	965.85	H 29 =	980.21	H 30 =	993.44
H 31 =	1005.5	H 32 =	1016.4	H 33 =	1026.1	H 34 =	1034.8	H 35 =	1042.3
H 36 =	1048.9	H 37 =	1054.5	H 38 =	1059.3	H 39 =	1063.3	H 40 =	1066.7
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 1
Location x/L: 0.65
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 1 LOC=.65 T:IN=610F T:OUT=1076.72 Q/A=0.75905 MW/M2
A21=28.019 A22=93.661 A23=127.28 A24=99.259 A25=52.430

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1076.7	DT: NA =	466.72	T:B NA =	843.36	T:B M =	860.12
DT M-N =	28.019	DT1 =	93.661	DT P-N =	127.28	DT P-M =	99.259	DT2 =	52.430
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.92	N 2 =	616.44	N 3 =	620.67	N 4 =	625.67
N 5 =	631.54	N 6 =	638.36	N 7 =	646.21	N 8 =	655.14	N 9 =	665.21
N 10 =	676.45	N 11 =	686.88	N 12 =	702.47	N 13 =	717.19	N 14 =	732.98
N 15 =	749.74	N 16 =	767.36	N 17 =	785.71	N 18 =	804.60	N 19 =	823.89
N 20 =	843.36	N 21 =	862.83	N 22 =	882.12	N 23 =	901.01	N 24 =	919.36
N 25 =	936.98	N 26 =	953.74	N 27 =	969.53	N 28 =	984.25	N 29 =	997.84
N 30 =	1010.3	N 31 =	1021.5	N 32 =	1031.6	N 33 =	1040.5	N 34 =	1048.4
N 35 =	1055.2	N 36 =	1061.0	N 37 =	1066.1	N 38 =	1070.3	N 39 =	1073.8
N 40 =	1076.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	613.79	M 1 =	617.53	M 2 =	621.99	M 3 =	627.27	M 4 =	633.46
M 5 =	640.64	M 6 =	648.88	M 7 =	658.24	M 8 =	668.78	M 9 =	680.51
M 10 =	693.45	M 11 =	707.56	M 12 =	722.81	M 13 =	739.12	M 14 =	756.38
M 15 =	774.47	M 16 =	793.23	M 17 =	812.49	M 18 =	832.07	M 19 =	851.76
M 20 =	871.38	M 21 =	890.71	M 22 =	909.58	M 23 =	927.80	M 24 =	945.22
M 25 =	961.71	M 26 =	977.15	M 27 =	991.46	M 28 =	1004.6	M 29 =	1016.5
M 30 =	1027.3	M 31 =	1036.8	M 32 =	1045.2	M 33 =	1052.5	M 34 =	1058.9
M 35 =	1064.3	M 36 =	1068.8	M 37 =	1072.7	M 38 =	1075.8	M 39 =	1078.4
M 40 =	1080.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	627.23	P 1 =	633.85	P 2 =	641.63	P 3 =	650.67	P 4 =	661.06
P 5 =	672.86	P 6 =	686.13	P 7 =	700.88	P 8 =	717.09	P 9 =	734.72
P 10 =	753.65	P 11 =	773.77	P 12 =	794.89	P 13 =	816.81	P 14 =	839.29
P 15 =	862.06	P 16 =	884.96	P 17 =	907.38	P 18 =	929.36	P 19 =	950.53
P 20 =	970.64	P 21 =	989.48	P 22 =	1006.9	P 23 =	1022.7	P 24 =	1036.9
P 25 =	1049.3	P 26 =	1060.1	P 27 =	1069.2	P 28 =	1076.7	P 29 =	1082.7
P 30 =	1087.5	P 31 =	1091.0	P 32 =	1093.5	P 33 =	1095.2	P 34 =	1096.1
P 35 =	1096.5	P 36 =	1056.4	P 37 =	1096.1	P 38 =	1095.5	P 39 =	1094.7
P 40 =	1093.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	620.13	G 1 =	625.23	G 2 =	631.26	G 3 =	638.31	G 4 =	646.48
G 5 =	655.84	G 6 =	666.45	G 7 =	678.36	G 8 =	691.57	G 9 =	706.09
G 10 =	721.85	G 11 =	738.80	G 12 =	756.82	G 13 =	775.77	G 14 =	795.50
G 15 =	815.80	G 16 =	836.46	G 17 =	857.26	G 18 =	877.97	G 19 =	898.36
G 20 =	918.21	G 21 =	937.31	G 22 =	955.48	G 23 =	972.57	G 24 =	988.45
G 25 =	1003.0	G 26 =	1016.3	G 27 =	1028.1	G 28 =	1038.6	G 29 =	1047.6
G 30 =	1055.7	G 31 =	1062.4	G 32 =	1068.0	G 33 =	1072.7	G 34 =	1076.4
G 35 =	1079.5	G 36 =	1081.9	G 37 =	1083.7	G 38 =	1085.1	G 39 =	1086.1
G 40 =	1086.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.82	H 2 =	612.72	H 3 =	616.23	H 4 =	620.44	H 5 =	625.43
H 6 =	631.30	H 7 =	638.13	H 8 =	645.98	H 9 =	654.94	H 10 =	665.04
H 11 =	676.33	H 12 =	688.81	H 13 =	702.46	H 14 =	717.26	H 15 =	733.14
H 16 =	750.00	H 17 =	767.72	H 18 =	786.17	H 19 =	805.17	H 20 =	824.55
H 21 =	844.12	H 22 =	863.68	H 23 =	883.03	H 24 =	901.99	H 25 =	920.38
H 26 =	938.03	H 27 =	954.81	H 28 =	970.59	H 29 =	985.30	H 30 =	998.86
H 31 =	1011.2	H 32 =	1022.4	H 33 =	1032.4	H 34 =	1041.3	H 35 =	1049.1
H 36 =	1055.8	H 37 =	1061.6	H 38 =	1066.6	H 39 =	1070.7	H 40 =	1074.2
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 1
Location x/L: 0.75
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 1 LOC=.75 T:IN=610F T:OUT=1080.62 Q/A=0.84579 MW/M2
A21=30.955 A22=103.49 A23=140.94 A24=109.98 A25=58.239

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1080.6	DT: NA =	470.62	T:B NA =	845.31	T:B M =	863.82
DT M-N =	30.955	DT1 =	103.49	DT P-N =	140.94	DT P-M =	109.98	DT2 =	58.239
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.94	N 2 =	616.50	N 3 =	620.76	N 4 =	625.80
N 5 =	631.72	N 6 =	638.60	N 7 =	646.51	N 8 =	655.52	N 9 =	665.67
N 10 =	677.01	N 11 =	689.53	N 12 =	703.24	N 13 =	718.08	N 14 =	734.00
N 15 =	750.91	N 16 =	768.68	N 17 =	787.17	N 18 =	806.23	N 19 =	825.67
N 20 =	845.31	N 21 =	864.95	N 22 =	884.39	N 23 =	903.45	N 24 =	921.94
N 25 =	939.71	N 26 =	956.62	N 27 =	972.54	N 28 =	987.38	N 29 =	1001.1
N 30 =	1013.6	N 31 =	1024.9	N 32 =	1035.1	N 33 =	1044.1	N 34 =	1052.0
N 35 =	1058.9	N 36 =	1064.8	N 37 =	1069.9	N 38 =	1074.1	N 39 =	1077.7
N 40 =	1080.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	614.19	M 1 =	618.03	M 2 =	622.62	M 3 =	628.05	M 4 =	634.41
M 5 =	641.77	M 6 =	650.22	M 7 =	659.81	M 8 =	670.59	M 9 =	682.58
M 10 =	695.78	M 11 =	710.18	M 12 =	725.72	M 13 =	742.31	M 14 =	759.86
M 15 =	778.23	M 16 =	797.25	M 17 =	816.77	M 18 =	836.57	M 19 =	856.47
M 20 =	876.26	M 21 =	895.75	M 22 =	914.73	M 23 =	933.04	M 24 =	950.52
M 25 =	967.03	M 26 =	982.47	M 27 =	996.76	M 28 =	1009.9	M 29 =	1021.7
M 30 =	1032.4	M 31 =	1041.8	M 32 =	1050.2	M 33 =	1057.4	M 34 =	1063.6
M 35 =	1068.9	M 36 =	1073.4	M 37 =	1077.2	M 38 =	1080.2	M 39 =	1082.8
M 40 =	1084.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	629.07	P 1 =	636.12	P 2 =	644.39	P 3 =	653.98	P 4 =	664.99
P 5 =	677.48	P 6 =	691.50	P 7 =	707.05	P 8 =	724.12	P 9 =	742.64
P 10 =	762.49	P 11 =	783.54	P 12 =	805.58	P 13 =	828.40	P 14 =	851.73
P 15 =	875.29	P 16 =	898.78	P 17 =	921.91	P 18 =	944.38	P 19 =	965.91
P 20 =	986.25	P 21 =	1005.2	P 22 =	1022.5	P 23 =	1038.2	P 24 =	1052.6
P 25 =	1064.1	P 26 =	1074.3	P 27 =	1082.9	P 28 =	1089.7	P 29 =	1095.1
P 30 =	1099.1	P 31 =	1101.9	P 32 =	1103.7	P 33 =	1104.7	P 34 =	1104.9
P 35 =	1104.7	P 36 =	1104.0	P 37 =	1103.1	P 38 =	1102.0	P 39 =	1100.9
P 40 =	1099.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	621.19	G 1 =	626.54	G 2 =	632.86	G 3 =	640.25	G 4 =	648.60
G 5 =	658.57	G 6 =	669.64	G 7 =	682.03	G 8 =	695.77	G 9 =	710.83
G 10 =	727.17	G 11 =	744.69	G 12 =	763.29	G 13 =	782.81	G 14 =	803.06
G 15 =	823.89	G 16 =	845.02	G 17 =	866.23	G 18 =	887.29	G 19 =	907.96
G 20 =	928.01	G 21 =	947.23	G 22 =	965.45	G 23 =	982.51	G 24 =	998.28
G 25 =	1012.7	G 26 =	1025.7	G 27 =	1037.3	G 28 =	1047.4	G 29 =	1056.2
G 30 =	1063.8	G 31 =	1070.1	G 32 =	1075.4	G 33 =	1079.6	G 34 =	1083.1
G 35 =	1085.7	G 36 =	1087.8	G 37 =	1089.4	G 38 =	1090.5	G 39 =	1091.3
G 40 =	1091.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.52	H 2 =	612.38	H 3 =	615.85	H 4 =	620.02	H 5 =	624.97
H 6 =	630.80	H 7 =	637.58	H 8 =	645.40	H 9 =	654.32	H 10 =	664.40
H 11 =	675.67	H 12 =	688.14	H 13 =	701.81	H 14 =	716.64	H 15 =	732.56
H 16 =	749.49	H 17 =	767.30	H 18 =	785.85	H 19 =	804.99	H 20 =	824.52
H 21 =	844.26	H 22 =	864.01	H 23 =	883.57	H 24 =	902.75	H 25 =	921.36
H 26 =	939.25	H 27 =	956.26	H 28 =	972.28	H 29 =	987.22	H 30 =	1001.0
H 31 =	1013.6	H 32 =	1025.0	H 33 =	1035.2	H 34 =	1044.2	H 35 =	1052.1
H 36 =	1059.0	H 37 =	1065.0	H 38 =	1070.0	H 39 =	1074.3	H 40 =	1077.8
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 1
Location x/L: 0.85
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 1 LOC=.85 T:IN=610F T:OUT=1081.64 Q/A=0.92821 MW/M2
A21=33.745 A22=112.83 A23=153.92 A24=120.17 A25=63.759

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1081.6	DT: NA =	471.64	T:B NA =	845.82	T:B M =	866.00
DT M-N =	33.745	DT1 =	112.83	DT P-N =	153.92	DT P-M =	120.17	DT2 =	63.759
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.95	N 2 =	616.51	N 3 =	620.78	N 4 =	625.84
N 5 =	631.77	N 6 =	638.66	N 7 =	646.59	N 8 =	655.62	N 9 =	665.79
N 10 =	677.15	N 11 =	689.71	N 12 =	703.44	N 13 =	718.32	N 14 =	734.27
N 15 =	751.21	N 16 =	769.02	N 17 =	787.56	N 18 =	806.66	N 19 =	826.14
N 20 =	845.82	N 21 =	865.50	N 22 =	884.98	N 23 =	904.08	N 24 =	922.62
N 25 =	940.43	N 26 =	957.37	N 27 =	973.32	N 28 =	988.20	N 29 =	1001.9
N 30 =	1014.5	N 31 =	1025.8	N 32 =	1036.0	N 33 =	1045.1	N 34 =	1053.0
N 35 =	1059.9	N 36 =	1065.8	N 37 =	1070.9	N 38 =	1075.1	N 39 =	1078.7
N 40 =	1081.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	614.57	M 1 =	616.50	M 2 =	623.19	M 3 =	626.73	M 4 =	635.22
M 5 =	642.72	M 6 =	651.33	M 7 =	661.08	M 8 =	672.04	M 9 =	684.22
M 10 =	697.62	M 11 =	712.21	M 12 =	727.94	M 13 =	744.73	M 14 =	762.46
M 15 =	780.99	M 16 =	800.17	M 17 =	819.82	M 18 =	839.73	M 19 =	859.72
M 20 =	879.56	M 21 =	899.08	M 22 =	918.06	M 23 =	936.34	M 24 =	953.77
M 25 =	970.21	M 26 =	985.55	M 27 =	999.73	M 28 =	1012.7	M 29 =	1024.4
M 30 =	1035.0	M 31 =	1044.3	M 32 =	1052.4	M 33 =	1059.5	M 34 =	1065.6
M 35 =	1070.8	M 36 =	1075.2	M 37 =	1078.8	M 38 =	1081.8	M 39 =	1084.2
M 40 =	1086.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	630.83	P 1 =	638.26	P 2 =	646.97	P 3 =	657.07	P 4 =	668.03
P 5 =	681.74	P 6 =	696.43	P 7 =	712.71	P 8 =	730.54	P 9 =	749.85
P 10 =	770.51	P 11 =	792.37	P 12 =	815.21	P 13 =	838.79	P 14 =	862.84
P 15 =	887.05	P 16 =	911.11	P 17 =	934.70	P 18 =	957.53	P 19 =	979.29
P 20 =	999.74	P 21 =	1018.7	P 22 =	1035.9	P 23 =	1051.2	P 24 =	1064.7
P 25 =	1076.3	P 26 =	1085.9	P 27 =	1093.8	P 28 =	1100.0	P 29 =	1104.6
P 30 =	1107.8	P 31 =	1109.9	P 32 =	1110.9	P 33 =	1111.2	P 34 =	1110.7
P 35 =	1109.8	P 36 =	1108.6	P 37 =	1107.1	P 38 =	1105.6	P 39 =	1104.0
P 40 =	1102.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	622.20	G 1 =	627.78	G 2 =	634.35	G 3 =	642.03	G 4 =	650.90
G 5 =	661.04	G 6 =	672.50	G 7 =	685.32	G 8 =	699.50	G 9 =	715.03
G 10 =	731.84	G 11 =	749.84	G 12 =	768.91	G 13 =	788.89	G 14 =	809.56
G 15 =	830.78	G 16 =	852.25	G 17 =	873.75	G 18 =	895.03	G 19 =	915.35
G 20 =	935.98	G 21 =	955.21	G 22 =	973.36	G 23 =	990.27	G 24 =	1005.8
G 25 =	1020.0	G 26 =	1032.7	G 27 =	1043.9	G 28 =	1053.7	G 29 =	1062.1
G 30 =	1069.2	G 31 =	1075.1	G 32 =	1079.9	G 33 =	1083.8	G 34 =	1086.3
G 35 =	1089.1	G 36 =	1090.9	G 37 =	1092.1	G 38 =	1093.0	G 39 =	1093.5
G 40 =	1093.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.22	H 2 =	612.03	H 3 =	615.43	H 4 =	619.53	H 5 =	624.41
H 6 =	630.15	H 7 =	636.85	H 8 =	644.58	H 9 =	653.41	H 10 =	663.40
H 11 =	674.59	H 12 =	686.98	H 13 =	700.57	H 14 =	715.34	H 15 =	731.21
H 16 =	748.09	H 17 =	765.88	H 18 =	784.43	H 19 =	803.58	H 20 =	823.15
H 21 =	842.94	H 22 =	862.76	H 23 =	882.41	H 24 =	901.69	H 25 =	920.42
H 26 =	938.43	H 27 =	955.58	H 28 =	971.74	H 29 =	986.81	H 30 =	1000.7
H 31 =	1013.5	H 32 =	1025.0	H 33 =	1035.3	H 34 =	1044.5	H 35 =	1052.5
H 36 =	1059.5	H 37 =	1065.5	H 38 =	1070.6	H 39 =	1075.0	H 40 =	1078.6
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 1
Location x/L: 0.95
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 1 LOC=.95 T:IN=610F T:OUT=1080.49 C/A=1.00631 MW/M2
A21=36.199 A22=121.06 A23=165.55 A24=129.35 A25=68.832

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1080.5	DT: NA =	470.49	T:B NA =	845.24	T:B M =	866.90
DT M-N =	36.199	DT1 =	121.06	DT P-N =	165.55	DT P-M =	129.35	DT2 =	68.832
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.94	N 2 =	616.50	N 3 =	620.75	N 4 =	625.80
N 5 =	631.72	N 6 =	638.59	N 7 =	646.50	N 8 =	655.51	N 9 =	665.66
N 10 =	676.99	N 11 =	689.51	N 12 =	703.21	N 13 =	718.05	N 14 =	733.97
N 15 =	750.87	N 16 =	768.63	N 17 =	787.12	N 18 =	806.18	N 19 =	825.61
N 20 =	845.24	N 21 =	864.88	N 22 =	884.31	N 23 =	903.37	N 24 =	921.86
N 25 =	939.62	N 26 =	956.52	N 27 =	972.44	N 28 =	987.28	N 29 =	1001.0
N 30 =	1013.5	N 31 =	1024.8	N 32 =	1035.0	N 33 =	1044.0	N 34 =	1051.9
N 35 =	1058.8	N 36 =	1064.7	N 37 =	1069.7	N 38 =	1074.0	N 39 =	1077.5
N 40 =	1080.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	614.90	M 1 =	618.89	M 2 =	623.66	M 3 =	629.29	M 4 =	635.86
M 5 =	643.47	M 6 =	652.18	M 7 =	662.05	M 8 =	673.13	M 9 =	685.43
M 10 =	698.95	M 11 =	713.66	M 12 =	729.50	M 13 =	746.39	M 14 =	764.21
M 15 =	782.82	M 16 =	802.05	M 17 =	821.73	M 18 =	841.66	M 19 =	861.63
M 20 =	881.44	M 21 =	900.89	M 22 =	919.80	M 23 =	937.97	M 24 =	955.27
M 25 =	971.57	M 26 =	986.76	M 27 =	1000.8	M 28 =	1013.6	M 29 =	1025.1
M 30 =	1035.5	M 31 =	1044.6	M 32 =	1052.6	M 33 =	1059.5	M 34 =	1065.5
M 35 =	1070.5	M 36 =	1074.8	M 37 =	1078.3	M 38 =	1081.2	M 39 =	1083.5
M 40 =	1085.4	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	632.40	P 1 =	640.17	P 2 =	649.26	P 3 =	659.78	P 4 =	671.85
P 5 =	685.46	P 6 =	700.73	P 7 =	717.61	P 8 =	736.09	P 9 =	754.06
P 10 =	777.40	P 11 =	799.93	P 12 =	823.43	P 13 =	847.63	P 14 =	872.25
P 15 =	896.97	P 16 =	921.46	P 17 =	945.39	P 18 =	968.45	P 19 =	990.34
P 20 =	1010.8	P 21 =	1029.6	P 22 =	1046.6	P 23 =	1061.6	P 24 =	1074.7
P 25 =	1085.7	P 26 =	1094.8	P 27 =	1102.0	P 28 =	1107.5	P 29 =	1111.4
P 30 =	1113.9	P 31 =	1115.2	P 32 =	1115.6	P 33 =	1115.1	P 34 =	1114.0
P 35 =	1112.5	P 36 =	1110.7	P 37 =	1108.8	P 38 =	1106.8	P 39 =	1104.8
P 40 =	1102.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	623.09	G 1 =	628.85	G 2 =	635.64	G 3 =	643.56	G 4 =	652.69
G 5 =	663.12	G 6 =	674.90	G 7 =	688.05	G 8 =	702.59	G 9 =	718.48
G 10 =	735.66	G 11 =	754.03	G 12 =	773.45	G 13 =	793.76	G 14 =	814.70
G 15 =	836.23	G 16 =	857.93	G 17 =	879.60	G 18 =	900.99	G 19 =	921.86
G 20 =	941.97	G 21 =	961.12	G 22 =	979.13	G 23 =	995.84	G 24 =	1011.1
G 25 =	1025.0	G 26 =	1037.3	G 27 =	1048.1	G 28 =	1057.5	G 29 =	1065.5
G 30 =	1072.2	G 31 =	1077.7	G 32 =	1082.1	G 33 =	1085.5	G 34 =	1088.2
G 35 =	1090.2	G 36 =	1091.6	G 37 =	1092.5	G 38 =	1093.1	G 39 =	1093.5
G 40 =	1093.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.94	H 2 =	611.68	H 3 =	615.02	H 4 =	619.03	H 5 =	623.82
H 6 =	629.46	H 7 =	636.05	H 8 =	643.66	H 9 =	652.37	H 10 =	662.23
H 11 =	673.28	H 12 =	685.55	H 13 =	699.01	H 14 =	713.65	H 15 =	729.40
H 16 =	746.17	H 17 =	763.86	H 18 =	782.33	H 19 =	801.40	H 20 =	820.91
H 21 =	840.67	H 22 =	860.46	H 23 =	880.10	H 24 =	899.39	H 25 =	918.15
H 26 =	936.20	H 27 =	953.39	H 28 =	969.61	H 29 =	984.75	H 30 =	998.74
H 31 =	1011.5	H 32 =	1023.1	H 33 =	1033.5	H 34 =	1042.8	H 35 =	1050.9
H 36 =	1057.9	H 37 =	1064.0	H 38 =	1069.2	H 39 =	1073.5	H 40 =	1077.2
=	.0	=	.0	=	.0	=	.0		

PANEL TEMPERATURE DISTRIBUTION

CASE 3

SET 2 Subpanel 2

Solar Flux Distribution: OFF NORMAL

Orifices: Yes: Orificed so as to match tube flow rates to reference flux distribution

Sodium Temperatures: T (Na-Inlet) = 610°F
T (Na-Outlet) = 1050°F (mean)
(1035.5 to 1053.6F)

5370F/sjh

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 2
Location x/L: 0.05
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 2 LOC=.05 T:IN=610F T:OUT=1050.53 Q/A=1.08765 MW/M2
A21=38.526 A22=128.87 A23=176.87 A24=138.34 A25=73.925

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.5	DT: NA =	440.53	T:B NA =	830.26	T:B M =	853.31
DT M-N =	38.526	DT1 =	128.87	DT P-N =	176.87	DT P-M =	138.34	DT2 =	73.925
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.08	N 3 =	620.07	N 4 =	624.79
N 5 =	630.33	N 6 =	636.77	N 7 =	644.18	N 8 =	652.61	N 9 =	662.11
N 10 =	672.72	N 11 =	684.45	N 12 =	697.28	N 13 =	711.17	N 14 =	726.08
N 15 =	741.90	N 16 =	758.53	N 17 =	775.85	N 18 =	793.68	N 19 =	811.88
N 20 =	830.26	N 21 =	848.65	N 22 =	866.85	N 23 =	884.68	N 24 =	902.00
N 25 =	918.63	N 26 =	934.45	N 27 =	949.36	N 28 =	963.25	N 29 =	976.08
N 30 =	987.81	N 31 =	998.42	N 32 =	1007.9	N 33 =	1016.4	N 34 =	1023.8
N 35 =	1030.2	N 36 =	1035.7	N 37 =	1040.5	N 38 =	1044.4	N 39 =	1047.8
N 40 =	1050.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.21	M 1 =	615.09	M 2 =	623.71	M 3 =	629.15	M 4 =	635.50
M 5 =	642.84	M 6 =	651.23	M 7 =	660.73	M 8 =	671.36	M 9 =	683.15
M 10 =	696.09	M 11 =	710.15	M 12 =	725.25	M 13 =	741.33	M 14 =	758.26
M 15 =	775.90	M 16 =	794.10	M 17 =	812.68	M 18 =	831.45	M 19 =	850.22
M 20 =	868.79	M 21 =	886.98	M 22 =	904.61	M 23 =	921.51	M 24 =	937.56
M 25 =	952.63	M 26 =	966.63	M 27 =	979.51	M 28 =	991.23	M 29 =	1001.0
M 30 =	1011.2	M 31 =	1019.5	M 32 =	1026.7	M 33 =	1032.9	M 34 =	1038.2
M 35 =	1042.7	M 36 =	1046.4	M 37 =	1049.5	M 38 =	1052.1	M 39 =	1054.1
M 40 =	1055.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	633.94	P 1 =	641.84	P 2 =	651.08	P 3 =	661.76	P 4 =	673.97
P 5 =	687.75	P 6 =	703.15	P 7 =	720.15	P 8 =	738.70	P 9 =	758.70
P 10 =	780.00	P 11 =	802.42	P 12 =	825.71	P 13 =	849.61	P 14 =	873.81
P 15 =	897.99	P 16 =	921.80	P 17 =	944.93	P 18 =	967.05	P 19 =	987.67
P 20 =	1007.1	P 21 =	1024.6	P 22 =	1040.2	P 23 =	1053.8	P 24 =	1065.3
P 25 =	1074.7	P 26 =	1082.2	P 27 =	1087.8	P 28 =	1091.7	P 29 =	1094.0
P 30 =	1095.1	P 31 =	1095.0	P 32 =	1094.0	P 33 =	1092.3	P 34 =	1090.1
P 35 =	1087.6	P 36 =	1084.9	P 37 =	1082.2	P 38 =	1079.4	P 39 =	1076.9
P 40 =	1074.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	623.93	G 1 =	625.69	G 2 =	636.46	G 3 =	644.34	G 4 =	653.42
G 5 =	663.76	G 6 =	675.41	G 7 =	688.40	G 8 =	702.72	G 9 =	718.34
G 10 =	735.17	G 11 =	753.12	G 12 =	772.04	G 13 =	791.76	G 14 =	812.08
G 15 =	832.76	G 16 =	853.58	G 17 =	874.28	G 18 =	894.61	G 19 =	914.33
G 20 =	933.23	G 21 =	951.09	G 22 =	967.77	G 23 =	983.11	G 24 =	997.04
G 25 =	1009.5	G 26 =	1020.5	G 27 =	1029.9	G 28 =	1038.0	G 29 =	1044.8
G 30 =	1050.3	G 31 =	1054.6	G 32 =	1058.0	G 33 =	1060.6	G 34 =	1062.4
G 35 =	1063.6	G 36 =	1064.4	G 37 =	1064.7	G 38 =	1064.8	G 39 =	1064.7
G 40 =	1064.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.49	H 2 =	610.96	H 3 =	613.96	H 4 =	617.59	H 5 =	621.92
H 6 =	627.05	H 7 =	633.05	H 8 =	640.00	H 9 =	647.97	H 10 =	657.01
H 11 =	667.17	H 12 =	678.46	H 13 =	690.89	H 14 =	704.43	H 15 =	719.03
H 16 =	734.62	H 17 =	751.08	H 18 =	768.29	H 19 =	786.10	H 20 =	804.36
H 21 =	822.87	H 22 =	841.45	H 23 =	859.92	H 24 =	878.08	H 25 =	895.77
H 26 =	912.81	H 27 =	929.08	H 28 =	944.44	H 29 =	958.80	H 30 =	972.09
H 31 =	984.27	H 32 =	995.31	H 33 =	1005.2	H 34 =	1014.0	H 35 =	1021.8
H 36 =	1028.5	H 37 =	1034.4	H 38 =	1039.3	H 39 =	1043.5	H 40 =	1047.0
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 2
Location x/L: 0.15
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 2 LOC=.15 T:IN=610F T:OUT=1048.83 C/A=1.16359 MW/M2
A21=40.698 A22=136.16 A23=187.43 A24=146.74 A25=78.680

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1048.8	DT: NA =	438.83	T:B NA =	829.41	T:B M =	853.76
DT M-N =	40.698	DT1 =	136.16	DT F-N =	187.43	DT F-M =	146.74	DT2 =	78.680
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.74	N 2 =	616.06	N 3 =	620.03	N 4 =	624.73
N 5 =	630.25	N 6 =	636.67	N 7 =	644.04	N 8 =	652.44	N 9 =	661.91
N 10 =	672.48	N 11 =	684.16	N 12 =	696.94	N 13 =	710.78	N 14 =	725.63
N 15 =	741.39	N 16 =	757.96	N 17 =	775.21	N 18 =	792.98	N 19 =	811.10
N 20 =	829.42	N 21 =	847.73	N 22 =	865.85	N 23 =	883.62	N 24 =	900.87
N 25 =	917.44	N 26 =	933.20	N 27 =	948.05	N 28 =	961.89	N 29 =	974.67
N 30 =	986.35	N 31 =	996.92	N 32 =	1006.4	N 33 =	1014.8	N 34 =	1022.2
N 35 =	1028.6	N 36 =	1034.1	N 37 =	1038.8	N 38 =	1042.8	N 39 =	1046.1
N 40 =	1048.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.51	M 1 =	619.44	M 2 =	624.11	M 3 =	629.62	M 4 =	636.05
M 5 =	643.47	M 6 =	651.94	M 7 =	661.53	M 8 =	672.25	M 9 =	684.14
M 10 =	697.17	M 11 =	711.31	M 12 =	726.49	M 13 =	742.64	M 14 =	759.62
M 15 =	777.31	M 16 =	795.53	M 17 =	814.11	M 18 =	832.87	M 19 =	851.60
M 20 =	870.11	M 21 =	888.22	M 22 =	905.75	M 23 =	922.53	M 24 =	938.44
M 25 =	953.36	M 26 =	967.20	M 27 =	979.90	M 28 =	991.44	M 29 =	1001.8
M 30 =	1011.0	M 31 =	1019.1	M 32 =	1026.2	M 33 =	1032.3	M 34 =	1037.4
M 35 =	1041.8	M 36 =	1045.4	M 37 =	1048.4	M 38 =	1050.8	M 39 =	1052.6
M 40 =	1054.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	635.37	P 1 =	643.57	P 2 =	653.15	P 3 =	664.22	P 4 =	676.85
P 5 =	691.10	P 6 =	707.01	P 7 =	724.55	P 8 =	743.68	P 9 =	764.23
P 10 =	786.16	P 11 =	809.17	P 12 =	833.04	P 13 =	857.49	P 14 =	882.18
P 15 =	906.80	P 16 =	930.98	P 17 =	954.39	P 18 =	976.69	P 19 =	997.60
P 20 =	1016.8	P 21 =	1034.2	P 22 =	1049.6	P 23 =	1062.8	P 24 =	1073.9
P 25 =	1082.8	P 26 =	1089.8	P 27 =	1094.7	P 28 =	1098.0	P 29 =	1099.7
P 30 =	1100.0	P 31 =	1099.3	P 32 =	1097.6	P 33 =	1095.3	P 34 =	1092.5
P 35 =	1089.4	P 36 =	1086.2	P 37 =	1083.0	P 38 =	1079.9	P 39 =	1076.9
P 40 =	1074.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	624.72	G 1 =	630.63	G 2 =	637.59	G 3 =	645.67	G 4 =	654.98
G 5 =	665.57	G 6 =	677.49	G 7 =	690.77	G 8 =	705.39	G 9 =	721.31
G 10 =	738.46	G 11 =	756.71	G 12 =	775.93	G 13 =	795.92	G 14 =	816.49
G 15 =	837.39	G 16 =	858.37	G 17 =	879.20	G 18 =	899.60	G 19 =	919.34
G 20 =	938.19	G 21 =	955.96	G 22 =	972.48	G 23 =	987.62	G 24 =	1001.3
G 25 =	1013.4	G 26 =	1024.1	G 27 =	1033.2	G 28 =	1040.9	G 29 =	1047.2
G 30 =	1052.3	G 31 =	1056.3	G 32 =	1059.3	G 33 =	1061.5	G 34 =	1063.0
G 35 =	1063.9	G 36 =	1064.3	G 37 =	1064.4	G 38 =	1064.3	G 39 =	1064.0
G 40 =	1063.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.24	H 2 =	610.64	H 3 =	613.57	H 4 =	617.12	H 5 =	621.37
H 6 =	626.39	H 7 =	632.28	H 8 =	639.12	H 9 =	646.96	H 10 =	655.87
H 11 =	665.90	H 12 =	677.06	H 13 =	689.35	H 14 =	702.76	H 15 =	717.23
H 16 =	732.68	H 17 =	749.03	H 18 =	766.14	H 19 =	783.86	H 20 =	802.03
H 21 =	820.48	H 22 =	839.01	H 23 =	857.45	H 24 =	875.59	H 25 =	893.27
H 26 =	910.33	H 27 =	926.61	H 28 =	942.01	H 29 =	956.40	H 30 =	969.74
H 31 =	981.96	H 32 =	993.06	H 33 =	1003.0	H 34 =	1011.9	H 35 =	1019.7
H 36 =	1026.5	H 37 =	1032.3	H 38 =	1037.4	H 39 =	1041.6	H 40 =	1045.1
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 2
Location x/L: 0.25
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 2 LOC=.25 T:IN=610F T:OUT=1041.76 G/A=1.22369 MW/M2
A21=42.418 A22=141.94 A23=195.80 A24=153.38 A25=82.444

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1041.8	DT: NA =	431.76	T:B NA =	825.88	T:B M =	851.25
DT M-N =	42.418	DT1 =	141.94	DT P-N =	195.80	DT P-M =	153.38	DT2 =	82.444
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.70	N 2 =	615.96	N 3 =	619.87	N 4 =	624.50
N 5 =	629.93	N 6 =	636.24	N 7 =	643.50	N 8 =	651.76	N 9 =	661.08
N 10 =	671.48	N 11 =	682.97	N 12 =	695.54	N 13 =	709.16	N 14 =	723.77
N 15 =	739.27	N 16 =	755.58	N 17 =	772.54	N 18 =	790.03	N 19 =	807.86
N 20 =	825.88	N 21 =	843.90	N 22 =	861.73	N 23 =	879.22	N 24 =	896.18
N 25 =	912.49	N 26 =	927.99	N 27 =	942.60	N 28 =	956.22	N 29 =	968.79
N 30 =	980.28	N 31 =	990.68	N 32 =	1000.0	N 33 =	1008.3	N 34 =	1015.5
N 35 =	1021.8	N 36 =	1027.3	N 37 =	1031.9	N 38 =	1035.8	N 39 =	1039.1
N 40 =	1041.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.74	M 1 =	619.68	M 2 =	624.36	M 3 =	629.87	M 4 =	636.29
M 5 =	643.70	M 6 =	652.16	M 7 =	661.72	M 8 =	672.41	M 9 =	684.24
M 10 =	697.20	M 11 =	711.26	M 12 =	726.34	M 13 =	742.36	M 14 =	759.20
M 15 =	776.71	M 16 =	794.73	M 17 =	813.09	M 18 =	831.61	M 19 =	850.07
M 20 =	868.30	M 21 =	886.10	M 22 =	903.31	M 23 =	919.77	M 24 =	935.34
M 25 =	949.92	M 26 =	963.43	M 27 =	975.80	M 28 =	987.02	M 29 =	997.08
M 30 =	1006.0	M 31 =	1013.8	M 32 =	1020.6	M 33 =	1026.5	M 34 =	1031.4
M 35 =	1035.6	M 36 =	1039.1	M 37 =	1041.9	M 38 =	1044.2	M 39 =	1046.0
M 40 =	1047.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	636.50	P 1 =	644.90	P 2 =	654.71	P 3 =	666.03	P 4 =	678.94
P 5 =	693.50	P 6 =	709.72	P 7 =	727.60	P 8 =	747.07	P 9 =	768.00
P 10 =	790.23	P 11 =	813.56	P 12 =	837.72	P 13 =	862.41	P 14 =	887.31
P 15 =	912.07	P 16 =	936.32	P 17 =	959.73	P 18 =	981.95	P 19 =	1002.7
P 20 =	1021.7	P 21 =	1038.7	P 22 =	1053.7	P 23 =	1066.4	P 24 =	1076.9
P 25 =	1085.3	P 26 =	1091.5	P 27 =	1095.9	P 28 =	1098.4	P 29 =	1099.4
P 30 =	1099.0	P 31 =	1097.6	P 32 =	1095.3	P 33 =	1092.4	P 34 =	1084.0
P 35 =	1085.4	P 36 =	1081.7	P 37 =	1078.1	P 38 =	1074.5	P 39 =	1071.3
P 40 =	1068.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	625.34	G 1 =	631.35	G 2 =	638.40	G 3 =	646.60	G 4 =	656.02
G 5 =	666.74	G 6 =	678.79	G 7 =	692.20	G 8 =	706.95	G 9 =	722.99
G 10 =	740.25	G 11 =	758.59	G 12 =	777.88	G 13 =	797.91	G 14 =	818.47
G 15 =	839.34	G 16 =	860.25	G 17 =	880.94	G 18 =	901.17	G 19 =	920.69
G 20 =	939.27	G 21 =	956.72	G 22 =	972.87	G 23 =	987.61	G 24 =	1000.9
G 25 =	1012.6	G 26 =	1022.7	G 27 =	1031.3	G 28 =	1038.6	G 29 =	1044.4
G 30 =	1049.1	G 31 =	1052.6	G 32 =	1055.2	G 33 =	1057.0	G 34 =	1058.1
G 35 =	1058.6	G 36 =	1058.8	G 37 =	1058.6	G 38 =	1058.2	G 39 =	1057.7
G 40 =	1057.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.00	H 2 =	610.31	H 3 =	613.14	H 4 =	616.56	H 5 =	620.66
H 6 =	625.52	H 7 =	631.23	H 8 =	637.86	H 9 =	645.49	H 10 =	654.16
H 11 =	663.92	H 12 =	674.81	H 13 =	686.81	H 14 =	699.92	H 15 =	714.08
H 16 =	729.22	H 17 =	745.25	H 18 =	762.04	H 19 =	779.45	H 20 =	797.33
H 21 =	815.49	H 22 =	833.75	H 23 =	851.92	H 24 =	869.83	H 25 =	887.29
H 26 =	904.15	H 27 =	920.25	H 28 =	935.49	H 29 =	949.75	H 30 =	962.97
H 31 =	975.09	H 32 =	986.10	H 33 =	996.00	H 34 =	1004.8	H 35 =	1012.6
H 36 =	1019.3	H 37 =	1025.2	H 38 =	1030.1	H 39 =	1034.4	H 40 =	1037.7
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 2
Location x/L: 0.35
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 2 LOC=.35 T:IN=610F T:OUT=1041.07 Q/A=1.26796 MW/M2
A21=43.684 A22=146.19 A23=201.96 A24=158.27 A25=85.216

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1041.1	DT: NA =	431.07	T:B NA =	825.53	T:B M =	851.66
DT M-N =	43.684	DT1 =	146.19	DT P-N =	201.96	DT P-M =	158.27	DT2 =	85.216
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.69	N 2 =	615.95	N 3 =	619.85	N 4 =	624.47
N 5 =	629.90	N 6 =	636.20	N 7 =	643.44	N 8 =	651.69	N 9 =	661.00
N 10 =	671.38	N 11 =	682.85	N 12 =	695.40	N 13 =	709.00	N 14 =	723.58
N 15 =	739.07	N 16 =	755.34	N 17 =	772.28	N 18 =	789.74	N 19 =	807.55
N 20 =	825.53	N 21 =	843.52	N 22 =	861.33	N 23 =	878.79	N 24 =	895.73
N 25 =	912.00	N 26 =	927.49	N 27 =	942.07	N 28 =	955.67	N 29 =	968.22
N 30 =	979.69	N 31 =	990.07	N 32 =	999.38	N 33 =	1007.6	N 34 =	1014.9
N 35 =	1021.2	N 36 =	1026.6	N 37 =	1031.2	N 38 =	1035.1	N 39 =	1038.4
N 40 =	1041.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.91	M 1 =	619.88	M 2 =	624.60	M 3 =	630.15	M 4 =	636.62
M 5 =	644.08	M 6 =	652.59	M 7 =	662.21	M 8 =	672.96	M 9 =	684.85
M 10 =	697.87	M 11 =	711.99	M 12 =	727.12	M 13 =	743.19	M 14 =	760.07
M 15 =	777.62	M 16 =	795.67	M 17 =	814.05	M 18 =	832.56	M 19 =	851.01
M 20 =	869.22	M 21 =	886.99	M 22 =	904.15	M 23 =	920.55	M 24 =	936.05
M 25 =	950.55	M 26 =	963.97	M 27 =	976.26	M 28 =	987.39	M 29 =	997.35
M 30 =	1006.2	M 31 =	1013.9	M 32 =	1020.6	M 33 =	1026.4	M 34 =	1031.3
M 35 =	1035.4	M 36 =	1038.7	M 37 =	1041.5	M 38 =	1043.8	M 39 =	1045.6
M 40 =	1047.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	637.33	P 1 =	645.91	P 2 =	655.92	P 3 =	667.46	P 4 =	680.63
P 5 =	695.46	P 6 =	711.99	P 7 =	730.20	P 8 =	750.00	P 9 =	771.28
P 10 =	793.87	P 11 =	817.55	P 12 =	842.06	P 13 =	867.08	P 14 =	892.27
P 15 =	917.30	P 16 =	941.78	P 17 =	965.36	P 18 =	987.70	P 19 =	1008.5
P 20 =	1027.5	P 21 =	1044.5	P 22 =	1059.3	P 23 =	1071.9	P 24 =	1082.2
P 25 =	1090.2	P 26 =	1096.2	P 27 =	1100.1	P 28 =	1102.3	P 29 =	1102.9
P 30 =	1102.2	P 31 =	1100.4	P 32 =	1097.7	P 33 =	1094.4	P 34 =	1090.7
P 35 =	1086.7	P 36 =	1082.7	P 37 =	1078.8	P 38 =	1075.1	P 39 =	1071.6
P 40 =	1068.4	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	625.80	G 1 =	631.90	G 2 =	639.06	G 3 =	647.38	G 4 =	656.94
G 5 =	667.81	G 6 =	680.03	G 7 =	693.61	G 8 =	708.54	G 9 =	724.76
G 10 =	742.21	G 11 =	760.74	G 12 =	780.20	G 13 =	800.40	G 14 =	821.13
G 15 =	842.12	G 16 =	863.14	G 17 =	883.92	G 18 =	904.21	G 19 =	923.74
G 20 =	942.31	G 21 =	959.72	G 22 =	975.80	G 23 =	990.43	G 24 =	1003.5
G 25 =	1015.1	G 26 =	1025.0	G 27 =	1033.5	G 28 =	1040.5	G 29 =	1046.1
G 30 =	1050.5	G 31 =	1053.8	G 32 =	1056.2	G 33 =	1057.8	G 34 =	1058.7
G 35 =	1059.1	G 36 =	1059.1	G 37 =	1058.7	G 38 =	1058.2	G 39 =	1057.6
G 40 =	1056.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	607.86	H 2 =	610.13	H 3 =	612.92	H 4 =	616.30	H 5 =	620.35
H 6 =	625.16	H 7 =	630.81	H 8 =	637.38	H 9 =	644.93	H 10 =	653.54
H 11 =	663.23	H 12 =	674.05	H 13 =	685.98	H 14 =	699.02	H 15 =	713.11
H 16 =	728.19	H 17 =	744.17	H 18 =	760.91	H 19 =	778.28	H 20 =	796.12
H 21 =	814.26	H 22 =	832.50	H 23 =	850.67	H 24 =	868.58	H 25 =	886.05
H 26 =	902.92	H 27 =	919.05	H 28 =	934.31	H 29 =	948.60	H 30 =	961.85
H 31 =	974.01	H 32 =	985.06	H 33 =	994.99	H 34 =	1003.8	H 35 =	1011.6
H 36 =	1018.4	H 37 =	1024.3	H 38 =	1029.3	H 39 =	1033.5	H 40 =	1037.1
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 2
Location x/L: 0.45
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 2 LOC=.45 T:IN=610F T:OUT=1050.74 Q/A=1.29640 MW/M2
A21=44.498 A22=148.92 A23=205.91 A24=161.41 A25=86.996

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1050.7	DT: NA =	440.74	T:B NA =	830.37	T:B M =	856.98
DT M-N =	44.498	DT1 =	146.92	DT P-N =	205.91	DT P-M =	161.41	DT2 =	86.996
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.75	N 2 =	616.09	N 3 =	620.07	N 4 =	624.80
N 5 =	630.34	N 6 =	636.78	N 7 =	644.19	N 8 =	652.63	N 9 =	662.14
N 10 =	672.75	N 11 =	684.48	N 12 =	697.32	N 13 =	711.22	N 14 =	726.13
N 15 =	741.96	N 16 =	758.60	N 17 =	775.92	N 18 =	793.77	N 19 =	811.98
N 20 =	830.37	N 21 =	848.76	N 22 =	866.97	N 23 =	884.82	N 24 =	902.14
N 25 =	918.78	N 26 =	934.61	N 27 =	949.52	N 28 =	963.42	N 29 =	976.25
N 30 =	987.99	N 31 =	998.60	N 32 =	1008.1	N 33 =	1016.5	N 34 =	1024.0
N 35 =	1030.4	N 36 =	1035.9	N 37 =	1040.7	N 38 =	1044.7	N 39 =	1048.0
N 40 =	1050.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	616.02	M 1 =	620.07	M 2 =	624.89	M 3 =	630.56	M 4 =	637.17
M 5 =	644.79	M 6 =	653.48	M 7 =	663.31	M 8 =	674.29	M 9 =	686.44
M 10 =	699.74	M 11 =	714.16	M 12 =	729.63	M 13 =	746.05	M 14 =	763.30
M 15 =	781.23	M 16 =	799.68	M 17 =	818.46	M 18 =	837.39	M 19 =	856.26
M 20 =	874.87	M 21 =	893.04	M 22 =	910.58	M 23 =	927.36	M 24 =	943.21
M 25 =	958.05	M 26 =	971.78	M 27 =	984.35	M 28 =	995.73	M 29 =	1005.9
M 30 =	1015.0	M 31 =	1022.9	M 32 =	1029.8	M 33 =	1035.7	M 34 =	1040.7
M 35 =	1044.8	M 36 =	1048.3	M 37 =	1051.2	M 38 =	1053.5	M 39 =	1055.3
M 40 =	1056.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	637.87	P 1 =	646.62	P 2 =	656.83	P 3 =	668.62	P 4 =	682.05
P 5 =	697.19	P 6 =	714.06	P 7 =	732.64	P 8 =	752.86	P 9 =	774.58
P 10 =	797.64	P 11 =	821.82	P 12 =	846.84	P 13 =	872.39	P 14 =	898.12
P 15 =	923.68	P 16 =	948.68	P 17 =	972.77	P 18 =	995.60	P 19 =	1016.9
P 20 =	1036.3	P 21 =	1053.6	P 22 =	1068.8	P 23 =	1081.7	P 24 =	1092.2
P 25 =	1100.5	P 26 =	1106.6	P 27 =	1110.7	P 28 =	1112.9	P 29 =	1113.6
P 30 =	1112.9	P 31 =	1111.0	P 32 =	1108.3	P 33 =	1105.0	P 34 =	1101.2
P 35 =	1097.2	P 36 =	1093.2	P 37 =	1089.2	P 38 =	1085.4	P 39 =	1081.9
P 40 =	1078.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	626.10	G 1 =	632.32	G 2 =	639.63	G 3 =	648.12	G 4 =	657.87
G 5 =	668.96	G 6 =	681.43	G 7 =	695.29	G 8 =	710.53	G 9 =	727.10
G 10 =	744.91	G 11 =	763.83	G 12 =	783.70	G 13 =	804.33	G 14 =	825.49
G 15 =	846.94	G 16 =	868.42	G 17 =	889.65	G 18 =	910.37	G 19 =	930.34
G 20 =	949.33	G 21 =	967.12	G 22 =	983.57	G 23 =	998.54	G 24 =	1011.9
G 25 =	1023.8	G 26 =	1034.0	G 27 =	1042.6	G 28 =	1049.8	G 29 =	1055.6
G 30 =	1060.1	G 31 =	1063.6	G 32 =	1066.0	G 33 =	1067.6	G 34 =	1068.6
G 35 =	1069.0	G 36 =	1069.0	G 37 =	1068.7	G 38 =	1068.2	G 39 =	1067.6
G 40 =	1066.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	607.83	H 2 =	610.16	H 3 =	613.01	H 4 =	616.47	H 5 =	620.62
H 6 =	625.54	H 7 =	631.32	H 8 =	638.04	H 9 =	645.78	H 10 =	654.58
H 11 =	664.50	H 12 =	675.56	H 13 =	687.77	H 14 =	701.10	H 15 =	715.52
H 16 =	730.95	H 17 =	747.28	H 18 =	764.40	H 19 =	782.17	H 20 =	800.41
H 21 =	818.95	H 22 =	837.60	H 23 =	856.17	H 24 =	874.48	H 25 =	892.34
H 26 =	909.58	H 27 =	926.07	H 28 =	941.66	H 29 =	956.27	H 30 =	969.81
H 31 =	982.24	H 32 =	993.53	H 33 =	1003.7	H 34 =	1012.7	H 35 =	1020.7
H 36 =	1027.6	H 37 =	1033.6	H 38 =	1038.7	H 39 =	1043.1	H 40 =	1046.7
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 2
Location x/L: FULL
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 2 LOC=FULLT:IN=610F T:OUT=1053.55 G/A=1.3046E MW/M2
A21=44.735 A22=149.71 A23=207.06 A24=162.33 A25=87.514

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN	= 610.00	T:NA OUT	= 1053.6	DT: NA	= 443.55	T:B NA	= 831.77	T:B M	= 858.53
DT M-N	= 44.735	DT1	= 149.71	DT P-N	= 207.06	DT P-M	= 162.33	DT2	= 87.514
	= .0		= .0		= .0		= .0		= .0
N	= 610.00	N 1	= 612.77	N 2	= 616.12	N 3	= 620.14	N 4	= 624.89
N 5	= 630.47	N 6	= 636.96	N 7	= 644.41	N 8	= 652.90	N 9	= 662.47
N 10	= 673.15	N 11	= 684.96	N 12	= 697.88	N 13	= 711.87	N 14	= 726.87
N 15	= 742.80	N 16	= 759.55	N 17	= 776.98	N 18	= 794.94	N 19	= 813.27
N 20	= 831.77	N 21	= 850.28	N 22	= 868.61	N 23	= 886.57	N 24	= 904.00
N 25	= 920.75	N 26	= 936.68	N 27	= 951.68	N 28	= 965.67	N 29	= 978.59
N 30	= 990.40	N 31	= 1001.1	N 32	= 1010.6	N 33	= 1019.1	N 34	= 1026.6
N 35	= 1033.1	N 36	= 1038.7	N 37	= 1043.4	N 38	= 1047.4	N 39	= 1050.9
N 40	= 1053.6		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
M	= 616.05	M 1	= 620.13	M 2	= 624.98	M 3	= 630.68	M 4	= 637.33
M 5	= 645.00	M 6	= 653.74	M 7	= 663.63	M 8	= 674.67	M 9	= 686.90
M 10	= 700.29	M 11	= 714.80	M 12	= 730.36	M 13	= 746.88	M 14	= 764.24
M 15	= 782.28	M 16	= 800.85	M 17	= 819.75	M 18	= 838.79	M 19	= 857.78
M 20	= 876.51	M 21	= 894.79	M 22	= 912.46	M 23	= 929.33	M 24	= 945.29
M 25	= 960.22	M 26	= 974.04	M 27	= 986.70	M 28	= 998.16	M 29	= 1008.4
M 30	= 1017.5	M 31	= 1025.5	M 32	= 1032.4	M 33	= 1038.4	M 34	= 1043.4
M 35	= 1047.6	M 36	= 1051.1	M 37	= 1054.0	M 38	= 1056.3	M 39	= 1058.1
M 40	= 1059.6		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
P	= 638.02	P 1	= 646.83	P 2	= 657.10	P 3	= 668.95	P 4	= 682.40
P 5	= 697.70	P 6	= 714.67	P 7	= 733.35	P 8	= 753.69	P 9	= 775.54
P 10	= 798.74	P 11	= 823.06	P 12	= 848.23	P 13	= 873.93	P 14	= 899.82
P 15	= 925.53	P 16	= 950.69	P 17	= 974.93	P 18	= 997.90	P 19	= 1019.3
P 20	= 1038.8	P 21	= 1056.3	P 22	= 1071.6	P 23	= 1084.5	P 24	= 1095.1
P 25	= 1103.5	P 26	= 1109.6	P 27	= 1113.7	P 28	= 1116.0	P 29	= 1116.7
P 30	= 1116.0	P 31	= 1114.1	P 32	= 1111.4	P 33	= 1108.1	P 34	= 1104.3
P 35	= 1100.3	P 36	= 1096.2	P 37	= 1092.2	P 38	= 1088.4	P 39	= 1084.6
P 40	= 1081.6		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
G	= 626.18	G 1	= 632.44	G 2	= 639.79	G 3	= 648.33	G 4	= 658.14
G 5	= 669.30	G 6	= 681.84	G 7	= 695.78	G 8	= 711.11	G 9	= 727.78
G 10	= 745.69	G 11	= 764.72	G 12	= 784.72	G 13	= 805.47	G 14	= 826.76
G 15	= 848.34	G 16	= 869.95	G 17	= 891.31	G 18	= 912.17	G 19	= 932.26
G 20	= 951.36	G 21	= 969.28	G 22	= 985.83	G 23	= 1000.9	G 24	= 1014.4
G 25	= 1026.3	G 26	= 1036.6	G 27	= 1045.3	G 28	= 1052.5	G 29	= 1058.4
G 30	= 1062.9	G 31	= 1066.4	G 32	= 1068.9	G 33	= 1070.5	G 34	= 1071.5
G 35	= 1071.9	G 36	= 1071.9	G 37	= 1071.6	G 38	= 1071.1	G 39	= 1070.4
G 40	= 1069.7		= .0		= .0		= .0		= .0
	= .0		= .0		= .0		= .0		= .0
H 1	= 607.82	H 2	= 610.16	H 3	= 613.04	H 4	= 616.52	H 5	= 620.69
H 6	= 625.65	H 7	= 631.47	H 8	= 638.24	H 9	= 646.02	H 10	= 654.89
H 11	= 664.87	H 12	= 676.00	H 13	= 688.29	H 14	= 701.71	H 15	= 716.22
H 16	= 731.75	H 17	= 748.19	H 18	= 765.42	H 19	= 783.30	H 20	= 801.65
H 21	= 820.31	H 22	= 839.08	H 23	= 857.77	H 24	= 876.19	H 25	= 894.17
H 26	= 911.52	H 27	= 928.11	H 28	= 943.80	H 29	= 958.50	H 30	= 972.13
H 31	= 984.63	H 32	= 995.99	H 33	= 1006.2	H 34	= 1015.3	H 35	= 1023.3
H 36	= 1030.3	H 37	= 1036.3	H 38	= 1041.5	H 39	= 1045.6	H 40	= 1049.5
	= .0		= .0		= .0		= .0		

PANEL TEMPERATURE DISTRIBUTION

CASE 3
SET 3 Subpanel Boundaries

Solar Flux Distribution: OFF NORMAL

Orifices: Yes: Orificed so as to match tube flow rates to reference flux distribution

Sodium Temperatures: T (Na-Inlet) = 610°F
T (Na-Outlet) = 1050°F (mean)
(784.4 to 1053.6F)

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 1
Location x/L: 0.0(OUT)
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 1 LOC=0 T:IN=610F T:OUT=784.39 C/A=0.08998 MW/M2
A21=3.975 A22=13.250 A23=17.263 A24=13.288 A25=6.6630

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN	610.00	T:NA OUT	784.39	DT: NA	174.39	T:B NA	697.19	T:B M	699.57
DT M-N	3.9750	DT1	13.250	DT P-N	17.263	DT P-M	13.288	DT2	6.6630
	.0		.0		.0		.0		.0
N	610.00	N 1	611.09	N 2	612.41	N 3	613.99	N 4	615.86
N 5	618.05	N 6	620.60	N 7	623.53	N 8	626.87	N 9	630.63
N 10	634.83	N 11	639.47	N 12	644.55	N 13	650.05	N 14	655.95
N 15	662.21	N 16	668.80	N 17	675.65	N 18	682.71	N 19	689.92
N 20	697.19	N 21	704.47	N 22	711.68	N 23	718.74	N 24	725.59
N 25	732.18	N 26	738.44	N 27	744.34	N 28	749.84	N 29	754.92
N 30	759.56	N 31	763.76	N 32	767.52	N 33	770.86	N 34	773.79
N 35	776.34	N 36	778.53	N 37	780.40	N 38	781.98	N 39	783.30
N 40	784.39		.0		.0		.0		.0
	.0		.0		.0		.0		.0
M	610.54	M 1	611.74	M 2	613.19	M 3	614.92	M 4	616.90
M 5	619.34	M 6	622.09	M 7	625.24	M 8	628.80	M 9	632.80
M 10	637.24	M 11	642.12	M 12	647.44	M 13	653.16	M 14	659.27
M 15	665.72	M 16	672.47	M 17	679.45	M 18	686.61	M 19	693.87
M 20	701.17	M 21	708.43	M 22	715.57	M 23	722.54	M 24	729.26
M 25	735.68	M 26	741.76	M 27	747.45	M 28	752.73	M 29	757.57
M 30	761.97	M 31	765.93	M 32	769.46	M 33	772.57	M 34	775.28
M 35	777.63	M 36	779.64	M 37	781.34	M 38	782.77	M 39	783.95
M 40	784.93		.0		.0		.0		.0
	.0		.0		.0		.0		.0
P	612.34	P 1	613.93	P 2	615.82	P 3	618.06	P 4	620.66
P 5	623.65	P 6	627.08	P 7	630.94	P 8	635.27	P 9	640.06
P 10	645.30	P 11	650.99	P 12	657.09	P 13	663.56	P 14	670.37
P 15	677.45	P 16	684.73	P 17	692.16	P 18	699.64	P 19	707.09
P 20	714.46	P 21	721.65	P 22	728.60	P 23	735.24	P 24	741.53
P 25	747.41	P 26	752.86	P 27	757.85	P 28	762.37	P 29	766.43
P 30	770.03	P 31	773.19	P 32	775.93	P 33	778.28	P 34	780.27
P 35	781.94	P 36	783.33	P 37	784.47	P 38	785.40	P 39	786.14
P 40	786.73		.0		.0		.0		.0
	.0		.0		.0		.0		.0
G	611.43	G 1	612.83	G 2	614.51	G 3	616.48	G 4	618.80
G 5	621.49	G 6	624.58	G 7	628.08	G 8	632.03	G 9	636.42
G 10	641.26	G 11	646.54	G 12	652.25	G 13	658.35	G 14	664.80
G 15	671.57	G 16	678.58	G 17	685.79	G 18	693.10	G 19	700.47
G 20	707.79	G 21	715.02	G 22	722.07	G 23	728.87	G 24	735.38
G 25	741.53	G 26	747.29	G 27	752.64	G 28	757.54	G 29	761.99
G 30	765.99	G 31	769.55	G 32	772.68	G 33	775.41	G 34	777.77
G 35	779.78	G 36	781.48	G 37	782.90	G 38	784.08	G 39	785.04
G 40	785.82		.0		.0		.0		.0
	.0		.0		.0		.0		.0
H 1	610.65	H 2	611.88	H 3	613.36	H 4	615.12	H 5	617.19
H 6	619.60	H 7	622.39	H 8	625.58	H 9	629.16	H 10	633.22
H 11	637.70	H 12	642.63	H 13	647.98	H 14	653.74	H 15	659.88
H 16	666.35	H 17	673.12	H 18	680.12	H 19	687.28	H 20	694.54
H 21	701.83	H 22	709.08	H 23	716.20	H 24	723.14	H 25	729.84
H 26	736.23	H 27	742.26	H 28	747.92	H 29	753.15	H 30	757.95
H 31	762.31	H 32	766.23	H 33	769.72	H 34	772.80	H 35	775.48
H 36	777.80	H 37	779.78	H 38	781.46	H 39	782.86	H 40	784.03
	.0		.0		.0		.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 1
Location x/L: 1.0 (IN)
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 1 LOC=1 T:IN=610F T:OUT=1079.25 G/A=1.04374 MW/M2
A21=37.270 A22=124.65 A23=170.76 A24=133.49 A25=71.175

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1079.2	DT: NA =	469.25	T:B NA =	844.62	T:B M =	866.92
DT M-N =	37.270	DTI =	124.65	DT F-N =	170.76	DT P-M =	133.49	DT2 =	71.175
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.93	N 2 =	616.48	N 3 =	620.72	N 4 =	625.76
N 5 =	631.66	N 6 =	638.52	N 7 =	646.40	N 8 =	655.39	N 9 =	665.51
N 10 =	676.81	N 11 =	685.30	N 12 =	702.97	N 13 =	717.77	N 14 =	733.64
N 15 =	750.50	N 16 =	768.22	N 17 =	786.66	N 18 =	805.66	N 19 =	825.04
N 20 =	844.62	N 21 =	864.20	N 22 =	883.59	N 23 =	902.59	N 24 =	921.03
N 25 =	938.75	N 26 =	955.61	N 27 =	971.48	N 28 =	986.28	N 29 =	999.95
N 30 =	1012.4	N 31 =	1023.7	N 32 =	1033.9	N 33 =	1042.8	N 34 =	1050.7
N 35 =	1057.6	N 36 =	1063.5	N 37 =	1068.5	N 38 =	1072.8	N 39 =	1076.3
N 40 =	1079.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.04	M 1 =	615.06	M 2 =	623.85	M 3 =	629.51	M 4 =	636.12
M 5 =	643.76	M 6 =	652.50	M 7 =	662.41	M 8 =	673.53	M 9 =	685.86
M 10 =	699.42	M 11 =	714.16	M 12 =	730.03	M 13 =	746.94	M 14 =	764.77
M 15 =	783.39	M 16 =	802.62	M 17 =	822.29	M 18 =	842.19	M 19 =	862.13
M 20 =	881.89	M 21 =	901.29	M 22 =	920.12	M 23 =	938.22	M 24 =	955.44
M 25 =	971.64	M 26 =	986.74	M 27 =	1000.7	M 28 =	1013.3	M 29 =	1024.8
M 30 =	1035.0	M 31 =	1044.1	M 32 =	1052.0	M 33 =	1058.9	M 34 =	1064.7
M 35 =	1069.7	M 36 =	1073.9	M 37 =	1077.3	M 38 =	1080.1	M 39 =	1082.4
M 40 =	1084.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	633.11	P 1 =	641.02	P 2 =	650.27	P 3 =	660.98	P 4 =	673.23
P 5 =	687.10	P 6 =	702.60	P 7 =	719.76	P 8 =	738.50	P 9 =	758.76
P 10 =	780.38	P 11 =	803.20	P 12 =	826.96	P 13 =	851.42	P 14 =	876.27
P 15 =	901.19	P 16 =	925.85	P 17 =	949.90	P 18 =	973.04	P 19 =	994.95
P 20 =	1015.4	P 21 =	1034.1	P 22 =	1051.0	P 23 =	1065.8	P 24 =	1078.7
P 25 =	1089.4	P 26 =	1098.2	P 27 =	1105.1	P 28 =	1110.3	P 29 =	1113.8
P 30 =	1116.0	P 31 =	1117.0	P 32 =	1117.0	P 33 =	1116.2	P 34 =	1114.9
P 35 =	1113.0	P 36 =	1111.0	P 37 =	1108.8	P 38 =	1106.6	P 39 =	1104.4
P 40 =	1102.4	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	623.48	G 1 =	629.31	G 2 =	636.19	G 3 =	644.20	G 4 =	653.45
G 5 =	663.99	G 6 =	675.90	G 7 =	689.19	G 8 =	703.86	G 9 =	719.90
G 10 =	737.22	G 11 =	755.73	G 12 =	775.29	G 13 =	795.72	G 14 =	816.83
G 15 =	838.39	G 16 =	860.15	G 17 =	881.87	G 18 =	903.28	G 19 =	924.14
G 20 =	944.22	G 21 =	963.30	G 22 =	981.21	G 23 =	997.80	G 24 =	1013.0
G 25 =	1026.6	G 26 =	1038.8	G 27 =	1049.4	G 28 =	1058.6	G 29 =	1066.4
G 30 =	1072.8	G 31 =	1078.1	G 32 =	1082.3	G 33 =	1085.6	G 34 =	1088.1
G 35 =	1089.9	G 36 =	1091.2	G 37 =	1092.0	G 38 =	1092.5	G 39 =	1092.7
G 40 =	1092.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.81	H 2 =	611.52	H 3 =	614.82	H 4 =	618.79	H 5 =	623.52
H 6 =	629.11	H 7 =	635.64	H 8 =	643.19	H 9 =	651.83	H 10 =	661.62
H 11 =	672.59	H 12 =	684.77	H 13 =	698.16	H 14 =	712.72	H 15 =	728.39
H 16 =	745.09	H 17 =	762.70	H 18 =	781.10	H 19 =	800.11	H 20 =	819.57
H 21 =	839.27	H 22 =	859.03	H 23 =	878.64	H 24 =	897.90	H 25 =	916.64
H 26 =	934.68	H 27 =	951.87	H 28 =	968.09	H 29 =	983.24	H 30 =	997.24
H 31 =	1010.1	H 32 =	1021.7	H 33 =	1032.1	H 34 =	1041.3	H 35 =	1049.5
H 36 =	1056.5	H 37 =	1062.6	H 38 =	1067.8	H 39 =	1072.2	H 40 =	1075.9
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 2
Location x/L: 0.0 (OUT)
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 2 LOC=0 T:IN=610F T:OUT=1046.98 C/A=1.04374 MW/M2
A21=37.270 A22=124.65 A23=170.76 A24=133.49 A25=71.175

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1049.0	DT: NA =	438.98	T:B NA =	829.49	T:B M =	851.76
DT M-N =	37.270	DT1 =	124.65	DT P-N =	170.76	DT P-M =	133.49	DT2 =	71.175
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.74	N 2 =	616.06	N 3 =	620.03	N 4 =	624.74
N 5 =	630.26	N 6 =	636.68	N 7 =	644.06	N 8 =	652.46	N 9 =	661.93
N 10 =	672.50	N 11 =	684.19	N 12 =	696.97	N 13 =	710.82	N 14 =	725.67
N 15 =	741.44	N 16 =	758.01	N 17 =	775.26	N 18 =	793.04	N 19 =	811.17
N 20 =	829.49	N 21 =	847.81	N 22 =	865.94	N 23 =	883.72	N 24 =	900.97
N 25 =	917.54	N 26 =	933.31	N 27 =	948.16	N 28 =	962.01	N 29 =	974.79
N 30 =	986.48	N 31 =	997.05	N 32 =	1006.5	N 33 =	1014.9	N 34 =	1022.3
N 35 =	1028.7	N 36 =	1034.2	N 37 =	1038.9	N 38 =	1042.9	N 39 =	1046.2
N 40 =	1049.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.04	M 1 =	616.87	M 2 =	623.44	M 3 =	628.82	M 4 =	635.10
M 5 =	642.36	M 6 =	650.67	M 7 =	660.07	M 8 =	670.60	M 9 =	682.28
M 10 =	695.11	M 11 =	709.05	M 12 =	724.03	M 13 =	739.99	M 14 =	756.80
M 15 =	774.33	M 16 =	792.41	M 17 =	810.89	M 18 =	829.57	M 19 =	848.26
M 20 =	866.76	M 21 =	884.89	M 22 =	902.47	M 23 =	919.35	M 24 =	935.37
M 25 =	950.44	M 26 =	964.44	M 27 =	977.33	M 28 =	989.07	M 29 =	999.65
M 30 =	1009.1	M 31 =	1017.4	M 32 =	1024.7	M 33 =	1030.9	M 34 =	1036.3
M 35 =	1040.8	M 36 =	1044.6	M 37 =	1047.7	M 38 =	1050.3	M 39 =	1052.4
M 40 =	1054.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	633.11	P 1 =	640.83	P 2 =	645.85	P 3 =	660.29	P 4 =	672.22
P 5 =	685.70	P 6 =	700.77	P 7 =	717.41	P 8 =	735.58	P 9 =	755.18
P 10 =	776.07	P 11 =	798.08	P 12 =	820.97	P 13 =	844.47	P 14 =	868.30
P 15 =	892.13	P 16 =	915.64	P 17 =	938.51	P 18 =	960.42	P 19 =	981.08
P 20 =	1000.2	P 21 =	1017.7	P 22 =	1033.3	P 23 =	1047.0	P 24 =	1058.8
P 25 =	1068.2	P 26 =	1075.9	P 27 =	1081.6	P 28 =	1086.0	P 29 =	1088.7
P 30 =	1090.0	P 31 =	1090.3	P 32 =	1089.6	P 33 =	1088.3	P 34 =	1086.4
P 35 =	1084.2	P 36 =	1081.7	P 37 =	1079.2	P 38 =	1076.7	P 39 =	1074.3
P 40 =	1072.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	623.48	G 1 =	629.12	G 2 =	635.77	G 3 =	643.51	G 4 =	652.43
G 5 =	662.60	G 6 =	674.06	G 7 =	686.84	G 8 =	700.94	G 9 =	716.32
G 10 =	732.91	G 11 =	750.61	G 12 =	769.29	G 13 =	788.77	G 14 =	808.86
G 15 =	829.33	G 16 =	849.95	G 17 =	870.47	G 18 =	890.66	G 19 =	910.27
G 20 =	929.08	G 21 =	946.90	G 22 =	963.56	G 23 =	978.93	G 24 =	992.91
G 25 =	1005.4	G 26 =	1016.5	G 27 =	1026.1	G 28 =	1034.3	G 29 =	1041.2
G 30 =	1046.9	G 31 =	1051.4	G 32 =	1055.0	G 33 =	1057.7	G 34 =	1059.7
G 35 =	1061.1	G 36 =	1061.9	G 37 =	1062.4	G 38 =	1062.6	G 39 =	1062.6
G 40 =	1062.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.62	H 2 =	611.10	H 3 =	614.13	H 4 =	617.77	H 5 =	622.13
H 6 =	627.27	H 7 =	633.29	H 8 =	640.26	H 9 =	648.25	H 10 =	657.31
H 11 =	667.48	H 12 =	678.78	H 13 =	691.21	H 14 =	704.74	H 15 =	719.32
H 16 =	734.88	H 17 =	751.31	H 18 =	768.48	H 19 =	786.24	H 20 =	804.43
H 21 =	822.88	H 22 =	841.38	H 23 =	859.77	H 24 =	877.84	H 25 =	895.43
H 26 =	912.38	H 27 =	926.55	H 28 =	943.82	H 29 =	958.08	H 30 =	971.28
H 31 =	983.37	H 32 =	994.33	H 33 =	1004.2	H 34 =	1012.9	H 35 =	1020.6
H 36 =	1027.3	H 37 =	1033.0	H 38 =	1038.0	H 39 =	1042.1	H 40 =	1045.6
=	.0	=	.0	=	.0	=	.0		

CASE # 3

Solar Flux: OFF-NORMAL
Orifices: YES
Sub-Panel: 2
Location x/L: 1.0 (IN)
T(Na-inlet) = 610 F
T(Na-outlet) : Mean = 1050F

PNL 2 LOC=1 T:IN=610F T:OUT=1053.55 Q/A=1.30468 MW/M2
A21=44.735 A22=149.71 A23=207.06 A24=162.33 A25=87.514

3

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1053.6	DT: NA =	443.55	T:B NA =	631.77	T:B M =	858.53
DT M-N =	44.735	DT1 =	145.71	DT P-N =	207.06	DT P-M =	162.33	DT2 =	87.514
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.77	N 2 =	616.12	N 3 =	620.14	N 4 =	624.89
N 5 =	630.47	N 6 =	636.96	N 7 =	644.41	N 8 =	652.90	N 9 =	662.47
N 10 =	673.15	N 11 =	684.96	N 12 =	697.88	N 13 =	711.87	N 14 =	726.87
N 15 =	742.80	N 16 =	759.55	N 17 =	776.98	N 18 =	794.94	N 19 =	813.27
N 20 =	831.77	N 21 =	850.28	N 22 =	868.61	N 23 =	886.57	N 24 =	904.00
N 25 =	920.75	N 26 =	936.68	N 27 =	951.68	N 28 =	965.67	N 29 =	978.59
N 30 =	990.40	N 31 =	1001.1	N 32 =	1010.6	N 33 =	1019.1	N 34 =	1026.6
N 35 =	1033.1	N 36 =	1038.7	N 37 =	1043.4	N 38 =	1047.4	N 39 =	1050.8
N 40 =	1053.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	616.05	M 1 =	620.13	M 2 =	624.98	M 3 =	630.68	M 4 =	637.33
M 5 =	645.00	M 6 =	653.74	M 7 =	663.63	M 8 =	674.67	M 9 =	686.90
M 10 =	700.29	M 11 =	714.80	M 12 =	730.36	M 13 =	746.88	M 14 =	764.24
M 15 =	782.28	M 16 =	800.85	M 17 =	819.75	M 18 =	838.79	M 19 =	857.78
M 20 =	876.51	M 21 =	894.79	M 22 =	912.46	M 23 =	929.33	M 24 =	945.29
M 25 =	960.22	M 26 =	974.04	M 27 =	986.70	M 28 =	998.16	M 29 =	1008.4
M 30 =	1017.5	M 31 =	1025.5	M 32 =	1032.4	M 33 =	1036.4	M 34 =	1043.4
M 35 =	1047.6	M 36 =	1051.1	M 37 =	1054.0	M 38 =	1056.3	M 39 =	1058.1
M 40 =	1059.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	638.02	P 1 =	646.83	P 2 =	657.10	P 3 =	668.95	P 4 =	682.46
P 5 =	697.70	P 6 =	714.67	P 7 =	733.35	P 8 =	753.69	P 9 =	775.54
P 10 =	798.74	P 11 =	823.06	P 12 =	848.23	P 13 =	873.93	P 14 =	899.82
P 15 =	925.53	P 16 =	950.69	P 17 =	974.93	P 18 =	997.90	P 19 =	1019.3
P 20 =	1038.8	P 21 =	1056.3	P 22 =	1071.6	P 23 =	1084.5	P 24 =	1095.1
P 25 =	1103.5	P 26 =	1109.6	P 27 =	1113.7	P 28 =	1116.0	P 29 =	1116.7
P 30 =	1116.0	P 31 =	1114.1	P 32 =	1111.4	P 33 =	1108.1	P 34 =	1104.3
P 35 =	1100.3	P 36 =	1096.2	P 37 =	1092.2	P 38 =	1088.4	P 39 =	1084.8
P 40 =	1081.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	626.18	G 1 =	632.44	G 2 =	639.79	G 3 =	648.33	G 4 =	658.14
G 5 =	669.30	G 6 =	681.84	G 7 =	695.78	G 8 =	711.11	G 9 =	727.76
G 10 =	745.69	G 11 =	764.72	G 12 =	784.72	G 13 =	805.47	G 14 =	826.76
G 15 =	848.34	G 16 =	869.95	G 17 =	891.31	G 18 =	912.17	G 19 =	932.26
G 20 =	951.36	G 21 =	969.28	G 22 =	985.83	G 23 =	1000.9	G 24 =	1014.4
G 25 =	1026.3	G 26 =	1036.6	G 27 =	1045.3	G 28 =	1052.5	G 29 =	1058.4
G 30 =	1062.9	G 31 =	1066.4	G 32 =	1068.9	G 33 =	1070.5	G 34 =	1071.5
G 35 =	1071.9	G 36 =	1071.9	G 37 =	1071.6	G 38 =	1071.1	G 39 =	1070.4
G 40 =	1069.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	607.82	H 2 =	610.16	H 3 =	613.04	H 4 =	616.52	H 5 =	620.69
H 6 =	625.65	H 7 =	631.47	H 8 =	638.24	H 9 =	646.02	H 10 =	654.89
H 11 =	664.87	H 12 =	676.00	H 13 =	688.29	H 14 =	701.71	H 15 =	716.22
H 16 =	731.75	H 17 =	748.19	H 18 =	765.42	H 19 =	783.30	H 20 =	801.65
H 21 =	820.31	H 22 =	839.08	H 23 =	857.77	H 24 =	876.19	H 25 =	894.17
H 26 =	911.52	H 27 =	928.11	H 28 =	943.80	H 29 =	958.50	H 30 =	972.13
H 31 =	984.63	H 32 =	995.99	H 33 =	1006.2	H 34 =	1015.3	H 35 =	1023.3
H 36 =	1030.3	H 37 =	1036.3	H 38 =	1041.5	H 39 =	1045.8	H 40 =	1049.5
=	.0	=	.0	=	.0	=	.0		

PANEL TEMPERATURE DISTRIBUTION

CASE 4

SET 1 Subpanel 1

Solar Flux Distribution: OFF NORMAL

Orifices: None

Sodium Temperatures: T (Na-Inlet) = 610°F
T (Na-Outlet) = 1100°F maximum
(652.2 to 1100F)

5370F/sjh

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 1
Location x/L: 0.05
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 1 LOC=.05 T:IN=610F T:OUT=679.44 Q/A=0.14792 MW/M2
A21=6.535 A22=21.783 A23=28.381 A24=21.847 A25=10.954

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	679.44	DT: NA =	69.440	T:B NA =	644.72	T:B M =	648.63
DT M-N =	6.5350	DT1 =	21.783	DT P-N =	28.381	DT P-M =	21.847	DT2 =	10.954
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	610.43	N 2 =	610.96	N 3 =	611.59	N 4 =	612.33
N 5 =	613.21	N 6 =	614.22	N 7 =	615.39	N 8 =	616.72	N 9 =	618.21
N 10 =	619.89	N 11 =	621.74	N 12 =	623.76	N 13 =	625.95	N 14 =	628.30
N 15 =	630.79	N 16 =	633.41	N 17 =	636.14	N 18 =	638.95	N 19 =	641.82
N 20 =	644.72	N 21 =	647.62	N 22 =	650.49	N 23 =	653.30	N 24 =	656.03
N 25 =	658.65	N 26 =	661.14	N 27 =	663.49	N 28 =	665.68	N 29 =	667.70
N 30 =	669.55	N 31 =	671.23	N 32 =	672.72	N 33 =	674.05	N 34 =	675.22
N 35 =	676.23	N 36 =	677.11	N 37 =	677.85	N 38 =	678.48	N 39 =	679.01
N 40 =	679.44	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	610.88	M 1 =	611.51	M 2 =	612.25	M 3 =	613.13	M 4 =	614.15
M 5 =	615.33	M 6 =	616.67	M 7 =	618.19	M 8 =	619.90	M 9 =	621.78
M 10 =	623.85	M 11 =	626.09	M 12 =	628.50	M 13 =	631.06	M 14 =	633.75
M 15 =	636.56	M 16 =	639.45	M 17 =	642.39	M 18 =	645.36	M 19 =	648.32
M 20 =	651.25	M 21 =	654.12	M 22 =	656.89	M 23 =	659.55	M 24 =	662.06
M 25 =	664.42	M 26 =	666.60	M 27 =	668.61	M 28 =	670.43	M 29 =	672.06
M 30 =	673.52	M 31 =	674.79	M 32 =	675.90	M 33 =	676.86	M 34 =	677.67
M 35 =	678.36	M 36 =	678.93	M 37 =	679.39	M 38 =	679.77	M 39 =	680.08
M 40 =	680.32	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	613.84	P 1 =	615.10	P 2 =	616.58	P 3 =	618.28	P 4 =	620.22
P 5 =	622.42	P 6 =	624.87	P 7 =	627.58	P 8 =	630.53	P 9 =	633.71
P 10 =	637.10	P 11 =	640.66	P 12 =	644.37	P 13 =	648.16	P 14 =	652.00
P 15 =	655.84	P 16 =	659.61	P 17 =	663.27	P 18 =	666.77	P 19 =	670.06
P 20 =	673.10	P 21 =	675.86	P 22 =	678.30	P 23 =	680.43	P 24 =	682.23
P 25 =	683.69	P 26 =	684.85	P 27 =	685.71	P 28 =	686.29	P 29 =	686.63
P 30 =	686.77	P 31 =	686.72	P 32 =	686.54	P 33 =	686.24	P 34 =	685.87
P 35 =	685.45	P 36 =	685.00	P 37 =	684.54	P 38 =	684.10	P 39 =	683.67
P 40 =	683.28	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	612.36	G 1 =	613.30	G 2 =	614.41	G 3 =	615.70	G 4 =	617.18
G 5 =	618.86	G 6 =	620.76	G 7 =	622.87	G 8 =	625.20	G 9 =	627.73
G 10 =	630.46	G 11 =	633.36	G 12 =	636.41	G 13 =	639.59	G 14 =	642.85
G 15 =	646.17	G 16 =	649.50	G 17 =	652.80	G 18 =	656.03	G 19 =	659.16
G 20 =	662.15	G 21 =	664.96	G 22 =	667.57	G 23 =	669.96	G 24 =	672.11
G 25 =	674.03	G 26 =	675.70	G 27 =	677.13	G 28 =	678.34	G 29 =	679.33
G 30 =	680.12	G 31 =	680.74	G 32 =	681.21	G 33 =	681.54	G 34 =	681.76
G 35 =	681.89	G 36 =	681.95	G 37 =	681.96	G 38 =	681.93	G 39 =	681.87
G 40 =	681.80	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.72	H 2 =	610.10	H 3 =	610.56	H 4 =	611.12	H 5 =	611.79
H 6 =	612.58	H 7 =	613.52	H 8 =	614.60	H 9 =	615.84	H 10 =	617.24
H 11 =	618.83	H 12 =	620.59	H 13 =	622.54	H 14 =	624.66	H 15 =	626.95
H 16 =	629.39	H 17 =	631.98	H 18 =	634.68	H 19 =	637.49	H 20 =	640.36
H 21 =	643.28	H 22 =	646.22	H 23 =	649.13	H 24 =	652.01	H 25 =	654.80
H 26 =	657.50	H 27 =	660.08	H 28 =	662.52	H 29 =	664.80	H 30 =	666.91
H 31 =	668.85	H 32 =	670.60	H 33 =	672.18	H 34 =	673.58	H 35 =	674.82
H 36 =	675.90	H 37 =	676.83	H 38 =	677.62	H 39 =	678.29	H 40 =	678.85
=	.0	=	.0	=	.0	=	.0		

Addendum to
NO 079TI000002
PAGE 178

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 1
Location x/L: 0.15
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 1 LOC=.15 T:IN=610F T:OUT=732.33 Q/A=0.26058 MW/M2
A21=11.144 A22=37.165 A23=48.773 A24=37.628 A25=19.045

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	732.33	DT: NA =	122.33	T:B NA =	671.16	T:B M =	677.83
DT M-N =	11.144	DT1 =	37.165	DT P-N =	48.773	DT P-M =	37.628	DT2 =	19.045
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	610.76	N 2 =	611.69	N 3 =	612.80	N 4 =	614.11
N 5 =	615.65	N 6 =	617.43	N 7 =	619.49	N 8 =	621.83	N 9 =	624.47
N 10 =	627.42	N 11 =	630.67	N 12 =	634.24	N 13 =	638.09	N 14 =	642.23
N 15 =	646.63	N 16 =	651.25	N 17 =	656.05	N 18 =	661.01	N 19 =	666.06
N 20 =	671.17	N 21 =	676.27	N 22 =	681.32	N 23 =	686.28	N 24 =	691.08
N 25 =	695.70	N 26 =	700.10	N 27 =	704.24	N 28 =	708.09	N 29 =	711.66
N 30 =	714.91	N 31 =	717.86	N 32 =	720.50	N 33 =	722.84	N 34 =	724.90
N 35 =	726.68	N 36 =	728.22	N 37 =	729.53	N 38 =	730.64	N 39 =	731.57
N 40 =	732.33	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	611.51	M 1 =	612.60	M 2 =	613.89	M 3 =	615.42	M 4 =	617.21
M 5 =	619.26	M 6 =	621.62	M 7 =	624.28	M 8 =	627.26	M 9 =	630.56
M 10 =	634.18	M 11 =	638.11	M 12 =	642.33	M 13 =	646.82	M 14 =	651.54
M 15 =	656.46	M 16 =	661.53	M 17 =	666.71	M 18 =	671.93	M 19 =	677.15
M 20 =	682.31	M 21 =	687.36	M 22 =	692.25	M 23 =	696.93	M 24 =	701.37
M 25 =	705.54	M 26 =	709.41	M 27 =	712.96	M 28 =	716.19	M 29 =	719.09
M 30 =	721.67	M 31 =	723.94	M 32 =	725.92	M 33 =	727.63	M 34 =	729.08
M 35 =	730.30	M 36 =	731.32	M 37 =	732.16	M 38 =	732.85	M 39 =	733.40
M 40 =	733.84	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	616.60	P 1 =	618.79	P 2 =	621.34	P 3 =	624.29	P 4 =	627.67
P 5 =	631.48	P 6 =	635.74	P 7 =	640.44	P 8 =	645.57	P 9 =	651.10
P 10 =	657.00	P 11 =	663.20	P 12 =	669.65	P 13 =	676.27	P 14 =	682.97
P 15 =	689.67	P 16 =	696.27	P 17 =	702.68	P 18 =	708.81	P 19 =	714.59
P 20 =	719.94	P 21 =	724.80	P 22 =	729.13	P 23 =	732.90	P 24 =	736.11
P 25 =	738.74	P 26 =	740.84	P 27 =	742.41	P 28 =	743.51	P 29 =	744.19
P 30 =	744.49	P 31 =	744.49	P 32 =	744.24	P 33 =	743.79	P 34 =	743.20
P 35 =	742.52	P 36 =	741.78	P 37 =	741.03	P 38 =	740.29	P 39 =	739.59
P 40 =	738.93	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	614.02	G 1 =	615.65	G 2 =	617.57	G 3 =	619.80	G 4 =	622.37
G 5 =	625.30	G 6 =	628.59	G 7 =	632.26	G 8 =	636.30	G 9 =	640.70
G 10 =	645.45	G 11 =	650.50	G 12 =	655.82	G 13 =	661.36	G 14 =	667.06
G 15 =	672.86	G 16 =	678.69	G 17 =	684.47	G 18 =	690.14	G 19 =	695.64
G 20 =	700.89	G 21 =	705.85	G 22 =	710.46	G 23 =	714.69	G 24 =	718.52
G 25 =	721.94	G 26 =	724.93	G 27 =	727.50	G 28 =	729.68	G 29 =	731.48
G 30 =	732.94	G 31 =	734.09	G 32 =	734.97	G 33 =	735.61	G 34 =	736.05
G 35 =	736.33	G 36 =	736.49	G 37 =	736.54	G 38 =	736.52	G 39 =	736.45
G 40 =	736.35	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.54	H 2 =	610.22	H 3 =	611.04	H 4 =	612.04	H 5 =	613.23
H 6 =	614.64	H 7 =	616.29	H 8 =	618.21	H 9 =	620.41	H 10 =	622.91
H 11 =	625.71	H 12 =	628.83	H 13 =	632.27	H 14 =	636.02	H 15 =	640.06
H 16 =	644.38	H 17 =	648.94	H 18 =	653.72	H 19 =	658.66	H 20 =	663.73
H 21 =	668.87	H 22 =	674.03	H 23 =	679.17	H 24 =	684.22	H 25 =	689.14
H 26 =	693.88	H 27 =	698.41	H 28 =	702.69	H 29 =	706.69	H 30 =	710.40
H 31 =	713.80	H 32 =	716.88	H 33 =	719.64	H 34 =	722.10	H 35 =	724.27
H 36 =	726.15	H 37 =	727.78	H 38 =	729.17	H 39 =	730.34	H 40 =	731.32
=	.0	=	.0	=	.0	=	.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 1
Location x/L: 0.25
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 1 LOC=.25 T:IN=610F T:OUT=783.19 Q/A=0.36891 MW/M2
A21=14.812 A22=49.443 A23=65.834 A24=51.022 A25=26.300

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	783.19	DT: NA =	173.19	T:B NA =	696.59	T:B M =	705.45
DT M-N =	14.812	DT1 =	49.443	DT P-N =	65.834	DT P-M =	51.022	DT2 =	26.300
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	611.08	N 2 =	612.39	N 3 =	613.96	N 4 =	615.82
N 5 =	617.99	N 6 =	620.52	N 7 =	623.44	N 8 =	626.75	N 9 =	630.49
N 10 =	634.66	N 11 =	639.27	N 12 =	644.31	N 13 =	649.78	N 14 =	655.63
N 15 =	661.85	N 16 =	668.39	N 17 =	675.20	N 18 =	682.21	N 19 =	689.37
N 20 =	696.59	N 21 =	703.82	N 22 =	710.98	N 23 =	717.99	N 24 =	724.80
N 25 =	731.33	N 26 =	737.56	N 27 =	743.41	N 28 =	748.88	N 29 =	753.92
N 30 =	758.53	N 31 =	762.70	N 32 =	766.44	N 33 =	769.75	N 34 =	772.66
N 35 =	775.20	N 36 =	777.37	N 37 =	779.23	N 38 =	780.80	N 39 =	782.11
N 40 =	783.19	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	612.00	M 1 =	613.52	M 2 =	615.32	M 3 =	617.45	M 4 =	619.93
M 5 =	622.80	M 6 =	626.08	M 7 =	629.80	M 8 =	633.96	M 9 =	638.58
M 10 =	643.64	M 11 =	649.15	M 12 =	655.07	M 13 =	661.37	M 14 =	668.01
M 15 =	674.93	M 16 =	682.07	M 17 =	689.36	M 18 =	696.73	M 19 =	704.11
M 20 =	711.41	M 21 =	718.56	M 22 =	725.49	M 23 =	732.15	M 24 =	738.47
M 25 =	744.41	M 26 =	749.93	M 27 =	755.01	M 28 =	759.63	M 29 =	763.80
M 30 =	767.51	M 31 =	770.79	M 32 =	773.65	M 33 =	776.12	M 34 =	778.22
M 35 =	780.00	M 36 =	781.49	M 37 =	782.72	M 38 =	783.73	M 39 =	784.54
M 40 =	785.19	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	618.91	P 1 =	621.91	P 2 =	625.42	P 3 =	629.48	P 4 =	634.12
P 5 =	639.37	P 6 =	645.23	P 7 =	651.72	P 8 =	658.80	P 9 =	666.44
P 10 =	674.59	P 11 =	683.18	P 12 =	692.12	P 13 =	701.30	P 14 =	710.62
P 15 =	719.95	P 16 =	729.17	P 17 =	738.14	P 18 =	746.74	P 19 =	754.87
P 20 =	762.43	P 21 =	769.33	P 22 =	775.51	P 23 =	780.93	P 24 =	785.57
P 25 =	789.43	P 26 =	792.54	P 27 =	794.94	P 28 =	796.68	P 29 =	797.83
P 30 =	798.46	P 31 =	798.65	P 32 =	798.48	P 33 =	798.03	P 34 =	797.37
P 35 =	796.57	P 36 =	795.68	P 37 =	794.75	P 38 =	793.83	P 39 =	792.94
P 40 =	792.10	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	615.35	G 1 =	617.58	G 2 =	620.21	G 3 =	623.28	G 4 =	626.81
G 5 =	630.83	G 6 =	635.36	G 7 =	640.42	G 8 =	645.99	G 9 =	652.08
G 10 =	658.64	G 11 =	665.64	G 12 =	673.02	G 13 =	680.72	G 14 =	688.65
G 15 =	696.74	G 16 =	704.89	G 17 =	712.99	G 18 =	720.96	G 19 =	728.70
G 20 =	736.13	G 21 =	743.16	G 22 =	749.73	G 23 =	755.78	G 24 =	761.29
G 25 =	766.22	G 26 =	770.58	G 27 =	774.36	G 28 =	777.58	G 29 =	780.29
G 30 =	782.51	G 31 =	784.29	G 32 =	785.68	G 33 =	786.74	G 34 =	787.50
G 35 =	788.03	G 36 =	788.37	G 37 =	788.55	G 38 =	788.62	G 39 =	788.61
G 40 =	788.54	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.45	H 2 =	610.43	H 3 =	611.62	H 4 =	613.06	H 5 =	614.78
H 6 =	616.81	H 7 =	619.18	H 8 =	621.93	H 9 =	625.08	H 10 =	628.65
H 11 =	632.66	H 12 =	637.12	H 13 =	642.02	H 14 =	647.36	H 15 =	653.11
H 16 =	659.25	H 17 =	665.73	H 18 =	672.50	H 19 =	679.51	H 20 =	686.69
H 21 =	693.96	H 22 =	701.26	H 23 =	708.52	H 24 =	715.65	H 25 =	722.59
H 26 =	729.28	H 27 =	735.66	H 28 =	741.68	H 29 =	747.31	H 30 =	752.52
H 31 =	757.29	H 32 =	761.62	H 33 =	765.50	H 34 =	768.95	H 35 =	771.98
H 36 =	774.62	H 37 =	776.90	H 38 =	778.84	H 39 =	780.48	H 40 =	781.85
=	.0	=	.0	=	.0	=	.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 1
Location x/L: 0.35
T(Na-inlet) = 610 F
T(Na-outlet) :
Max = 1100F

PNL 1 LOC=.35 T:IN=610F T:OUT=832.02 Q/A=0.47292 MW/M2
A21=18.333 A22=61.232 A23=82.215 A24=63.883 A25=33.266

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	832.02	DT: NA =	222.02	T:B NA =	721.01	T:B M =	731.97
DT M-N =	18.333	DT1 =	61.232	DT P-N =	82.215	DT P-M =	63.883	DT2 =	33.266
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	611.39	N 2 =	613.07	N 3 =	615.07	N 4 =	617.45
N 5 =	620.25	N 6 =	623.49	N 7 =	627.22	N 8 =	631.47	N 9 =	636.26
N 10 =	641.61	N 11 =	647.52	N 12 =	653.99	N 13 =	660.99	N 14 =	668.50
N 15 =	676.48	N 16 =	684.86	N 17 =	693.58	N 18 =	702.57	N 19 =	711.75
N 20 =	721.01	N 21 =	73C.27	N 22 =	739.45	N 23 =	748.44	N 24 =	757.16
N 25 =	765.54	N 26 =	773.52	N 27 =	781.03	N 28 =	788.03	N 29 =	794.50
N 30 =	800.41	N 31 =	805.76	N 32 =	81C.55	N 33 =	814.80	N 34 =	818.53
N 35 =	821.77	N 36 =	824.57	N 37 =	826.95	N 38 =	828.95	N 39 =	830.63
N 40 =	832.02	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	612.48	M 1 =	614.40	M 2 =	616.69	M 3 =	619.40	M 4 =	622.55
M 5 =	626.20	M 6 =	63C.37	M 7 =	635.10	M 8 =	640.40	M 9 =	646.28
M 10 =	652.73	M 11 =	659.75	M 12 =	667.30	M 13 =	675.34	M 14 =	683.81
M 15 =	692.65	M 16 =	701.78	M 17 =	711.11	M 18 =	720.54	M 19 =	729.99
M 20 =	739.34	M 21 =	748.52	M 22 =	757.42	M 23 =	765.96	M 24 =	774.08
M 25 =	781.72	M 26 =	788.83	M 27 =	795.38	M 28 =	801.35	M 29 =	806.73
M 30 =	811.53	M 31 =	815.77	M 32 =	819.47	M 33 =	822.67	M 34 =	825.41
M 35 =	827.72	M 36 =	829.66	M 37 =	831.27	M 38 =	832.58	M 39 =	833.65
M 40 =	834.50	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	621.13	P 1 =	624.91	P 2 =	629.34	P 3 =	634.46	P 4 =	640.31
P 5 =	646.94	P 6 =	654.35	P 7 =	662.54	P 8 =	671.49	P 9 =	681.16
P 10 =	691.48	P 11 =	702.36	P 12 =	713.69	P 13 =	725.34	P 14 =	737.17
P 15 =	749.03	P 16 =	76C.75	P 17 =	772.18	P 18 =	783.16	P 19 =	793.55
P 20 =	803.22	P 21 =	812.08	P 22 =	820.03	P 23 =	827.03	P 24 =	833.06
P 25 =	838.10	P 26 =	842.19	P 27 =	845.38	P 28 =	847.73	P 29 =	849.33
P 30 =	850.27	P 31 =	85C.65	P 32 =	850.56	P 33 =	850.11	P 34 =	849.38
P 35 =	848.46	P 36 =	847.42	P 37 =	846.33	P 38 =	845.22	P 39 =	844.15
P 40 =	843.15	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	616.62	G 1 =	619.44	G 2 =	622.75	G 3 =	626.61	G 4 =	631.06
G 5 =	636.14	G 6 =	641.86	G 7 =	648.25	G 8 =	655.30	G 9 =	662.99
G 10 =	671.30	G 11 =	68C.17	G 12 =	689.53	G 13 =	699.30	G 14 =	709.39
G 15 =	719.67	G 16 =	73C.04	G 17 =	74C.38	G 18 =	750.55	G 19 =	760.45
G 20 =	769.96	G 21 =	778.98	G 22 =	787.43	G 23 =	795.23	G 24 =	802.35
G 25 =	808.74	G 26 =	814.40	G 27 =	819.34	G 28 =	823.58	G 29 =	827.15
G 30 =	830.10	G 31 =	832.48	G 32 =	834.37	G 33 =	835.82	G 34 =	836.90
G 35 =	837.66	G 36 =	838.17	G 37 =	838.48	G 38 =	838.64	G 39 =	838.68
G 40 =	838.64	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.37	H 2 =	61C.63	H 3 =	612.18	H 4 =	614.04	H 5 =	616.26
H 6 =	618.88	H 7 =	621.95	H 8 =	625.49	H 9 =	629.56	H 10 =	634.16
H 11 =	639.33	H 12 =	645.07	H 13 =	651.38	H 14 =	658.24	H 15 =	665.64
H 16 =	673.52	H 17 =	681.84	H 18 =	690.53	H 19 =	699.52	H 20 =	708.73
H 21 =	718.05	H 22 =	727.41	H 23 =	736.69	H 24 =	745.82	H 25 =	754.70
H 26 =	763.26	H 27 =	771.42	H 28 =	779.11	H 29 =	786.31	H 30 =	792.96
H 31 =	799.05	H 32 =	804.57	H 33 =	809.52	H 34 =	813.92	H 35 =	817.78
H 36 =	821.15	H 37 =	824.C5	H 38 =	826.52	H 39 =	828.61	H 40 =	830.36
=	.0	=	.0	=	.0	=	.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 1
Location x/L: 0.45
T(Na-inlet) = 610 F
T(Na-outlet) :
Max = 1100F

PNL 1 LOC=.45 T:IN=610F T:OUT=878.82 Q/A=0.57262 MW/M2
A21=21.708 A22=72.531 A23=97.916 A24=76.209 A25=39.943

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN	610.00	T:NA OUT	878.82	DT: NA	268.82	T:B NA	744.41	T:B M	757.39
DT M-N	21.708	DT1	72.531	DT P-N	97.916	DT P-M	76.209	DT2	39.943
	.0		.0		.0		.0		.0
N	610.00	N 1	611.68	N 2	613.71	N 3	616.14	N 4	619.03
N 5	622.41	N 6	626.34	N 7	630.85	N 8	636.00	N 9	641.80
N 10	648.28	N 11	655.43	N 12	663.26	N 13	671.74	N 14	680.83
N 15	690.49	N 16	700.64	N 17	711.20	N 18	722.09	N 19	733.19
N 20	744.41	N 21	755.63	N 22	766.73	N 23	777.62	N 24	788.18
N 25	798.33	N 26	807.99	N 27	817.08	N 28	825.56	N 29	833.39
N 30	840.54	N 31	847.02	N 32	852.82	N 33	857.96	N 34	862.48
N 35	866.41	N 36	869.79	N 37	872.68	N 38	875.11	N 39	877.14
N 40	878.82		.0		.0		.0		.0
	.0		.0		.0		.0		.0
M	612.94	M 1	615.25	M 2	618.01	M 3	621.26	M 4	625.06
M 5	629.46	M 6	634.48	M 7	640.18	M 8	646.57	M 9	653.66
M 10	661.44	M 11	669.91	M 12	679.02	M 13	688.73	M 14	698.96
M 15	709.64	M 16	720.68	M 17	731.95	M 18	743.37	M 19	754.79
M 20	766.12	M 21	777.23	M 22	788.01	M 23	798.37	M 24	808.22
M 25	817.49	M 26	826.12	M 27	834.07	M 28	841.32	M 29	847.87
M 30	853.71	M 31	858.87	M 32	863.39	M 33	867.29	M 34	870.63
M 35	873.46	M 36	875.83	M 37	877.79	M 38	879.40	M 39	880.71
M 40	881.76		.0		.0		.0		.0
	.0		.0		.0		.0		.0
P	623.25	P 1	627.78	P 2	633.09	P 3	639.23	P 4	646.25
P 5	654.20	P 6	663.09	P 7	672.92	P 8	683.66	P 9	695.27
P 10	707.66	P 11	720.74	P 12	734.36	P 13	748.38	P 14	762.62
P 15	776.90	P 16	791.03	P 17	804.81	P 18	818.06	P 19	830.62
P 20	842.33	P 21	853.05	P 22	862.71	P 23	871.22	P 24	878.57
P 25	884.74	P 26	889.77	P 27	893.72	P 28	896.66	P 29	898.70
P 30	899.93	P 31	900.49	P 32	900.48	P 33	900.03	P 34	899.23
P 35	898.20	P 36	897.02	P 37	895.76	P 38	894.49	P 39	893.24
P 40	892.07		.0		.0		.0		.0
	.0		.0		.0		.0		.0
G	617.85	G 1	621.22	G 2	625.18	G 3	629.81	G 4	635.14
G 5	641.23	G 6	648.09	G 7	655.76	G 8	664.22	G 9	673.46
G 10	683.44	G 11	694.10	G 12	705.36	G 13	717.11	G 14	729.25
G 15	741.65	G 16	754.15	G 17	766.62	G 18	778.91	G 19	790.88
G 20	802.38	G 21	813.31	G 22	823.56	G 23	833.04	G 24	841.70
G 25	849.49	G 26	856.41	G 27	862.46	G 28	867.66	G 29	872.06
G 30	875.71	G 31	878.68	G 32	881.04	G 33	882.87	G 34	884.24
G 35	885.23	G 36	885.91	G 37	886.34	G 38	886.58	G 39	886.67
G 40	886.67		.0		.0		.0		.0
	.0		.0		.0		.0		.0
H 1	609.29	H 2	610.83	H 3	612.71	H 4	614.98	H 5	617.68
H 6	620.87	H 7	624.60	H 8	628.91	H 9	633.85	H 10	639.45
H 11	645.72	H 12	652.69	H 13	660.34	H 14	668.67	H 15	677.64
H 16	687.20	H 17	697.28	H 18	707.82	H 19	718.71	H 20	729.85
H 21	741.14	H 22	752.46	H 23	763.70	H 24	774.74	H 25	785.49
H 26	795.83	H 27	805.69	H 28	814.99	H 29	823.68	H 30	831.71
H 31	839.07	H 32	845.73	H 33	851.71	H 34	857.02	H 35	861.69
H 36	865.75	H 37	869.24	H 38	872.23	H 39	874.75	H 40	876.85
	.0		.0		.0		.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 1
Location x/L: 0.55
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 1 LOC=.55 T:IN=610F T:OUT=923.60 Q/A=0.66799 MW/M2
A21=24.936 A22=83.341 A23=112.94 A24=88.001 A25=46.331

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	923.60	DT: NA =	313.60	T:B NA =	766.80	T:B M =	781.71
DT M-N =	24.936	DT1 =	83.341	DT P-N =	112.94	DT P-M =	88.001	DT2 =	46.331
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	611.96	N 2 =	614.33	N 3 =	617.17	N 4 =	620.53
N 5 =	624.47	N 6 =	629.06	N 7 =	634.33	N 8 =	640.33	N 9 =	647.10
N 10 =	654.65	N 11 =	663.00	N 12 =	672.13	N 13 =	682.02	N 14 =	692.63
N 15 =	703.90	N 16 =	715.74	N 17 =	728.06	N 18 =	740.76	N 19 =	753.71
N 20 =	766.80	N 21 =	779.89	N 22 =	792.84	N 23 =	805.54	N 24 =	817.86
N 25 =	829.70	N 26 =	840.97	N 27 =	851.58	N 28 =	861.47	N 29 =	870.60
N 30 =	878.95	N 31 =	886.50	N 32 =	893.27	N 33 =	899.27	N 34 =	904.54
N 35 =	909.13	N 36 =	913.07	N 37 =	916.43	N 38 =	919.27	N 39 =	921.64
N 40 =	923.60	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	613.37	M 1 =	616.06	M 2 =	619.26	M 3 =	623.05	M 4 =	627.46
M 5 =	632.57	M 6 =	638.42	M 7 =	645.04	M 8 =	652.47	M 9 =	660.72
M 10 =	669.78	M 11 =	679.63	M 12 =	690.24	M 13 =	701.54	M 14 =	713.46
M 15 =	725.90	M 16 =	738.75	M 17 =	751.90	M 18 =	765.20	M 19 =	778.53
M 20 =	791.74	M 21 =	804.70	M 22 =	817.28	M 23 =	829.38	M 24 =	840.88
M 25 =	851.71	M 26 =	861.80	M 27 =	871.09	M 28 =	879.58	M 29 =	887.23
M 30 =	894.07	M 31 =	900.12	M 32 =	905.41	M 33 =	909.98	M 34 =	913.90
M 35 =	917.22	M 36 =	920.00	M 37 =	922.31	M 38 =	924.20	M 39 =	925.74
M 40 =	926.97	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	625.28	P 1 =	630.54	P 2 =	636.68	P 3 =	643.79	P 4 =	651.93
P 5 =	661.14	P 6 =	671.45	P 7 =	682.84	P 8 =	695.30	P 9 =	708.77
P 10 =	723.15	P 11 =	738.33	P 12 =	754.14	P 13 =	770.42	P 14 =	786.97
P 15 =	803.56	P 16 =	819.99	P 17 =	836.03	P 18 =	851.46	P 19 =	866.09
P 20 =	879.74	P 21 =	892.26	P 22 =	903.54	P 23 =	913.51	P 24 =	922.12
P 25 =	929.37	P 26 =	935.30	P 27 =	939.98	P 28 =	943.48	P 29 =	945.93
P 30 =	947.45	P 31 =	948.18	P 32 =	948.24	P 33 =	947.79	P 34 =	946.93
P 35 =	945.79	P 36 =	944.47	P 37 =	943.06	P 38 =	941.62	P 39 =	940.22
P 40 =	938.88	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	619.01	G 1 =	622.92	G 2 =	627.51	G 3 =	632.87	G 4 =	639.05
G 5 =	646.10	G 6 =	654.06	G 7 =	662.94	G 8 =	672.75	G 9 =	683.47
G 10 =	695.05	G 11 =	707.42	G 12 =	720.50	G 13 =	734.16	G 14 =	748.27
G 15 =	762.68	G 16 =	777.22	G 17 =	791.74	G 18 =	806.05	G 19 =	819.99
G 20 =	833.41	G 21 =	846.16	G 22 =	858.13	G 23 =	869.21	G 24 =	879.35
G 25 =	888.48	G 26 =	896.60	G 27 =	903.71	G 28 =	909.84	G 29 =	915.03
G 30 =	919.35	G 31 =	922.87	G 32 =	925.69	G 33 =	927.88	G 34 =	929.54
G 35 =	930.75	G 36 =	931.59	G 37 =	932.13	G 38 =	932.45	G 39 =	932.59
G 40 =	932.61	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.21	H 2 =	611.02	H 3 =	613.22	H 4 =	615.88	H 5 =	619.04
H 6 =	622.78	H 7 =	627.14	H 8 =	632.19	H 9 =	637.96	H 10 =	644.50
H 11 =	651.84	H 12 =	659.98	H 13 =	668.92	H 14 =	678.65	H 15 =	689.13
H 16 =	700.29	H 17 =	712.06	H 18 =	724.36	H 19 =	737.06	H 20 =	750.07
H 21 =	763.23	H 22 =	776.44	H 23 =	789.54	H 24 =	802.42	H 25 =	814.94
H 26 =	826.99	H 27 =	838.48	H 28 =	849.32	H 29 =	859.44	H 30 =	868.80
H 31 =	877.36	H 32 =	885.12	H 33 =	892.08	H 34 =	898.26	H 35 =	903.69
H 36 =	908.42	H 37 =	912.49	H 38 =	915.96	H 39 =	918.89	H 40 =	921.33
=	.0	=	.0	=	.0	=	.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 1
Location x/L: 0.65
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 1 LOC=.65 T:IN=610F T:OUT=966.35 Q/A=0.75905 MW/M2
A21=28.019 A22=93.661 A23=127.28 A24=99.259 A25=52.430

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	966.35	DT: NA =	356.35	T:B NA =	788.17	T:B M =	804.93
DT M-N =	28.019	DT1 =	93.661	DT P-N =	127.28	DT P-M =	99.259	DT2 =	52.430
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.23	N 2 =	614.92	N 3 =	618.14	N 4 =	621.97
N 5 =	626.45	N 6 =	631.66	N 7 =	637.65	N 8 =	644.47	N 9 =	652.16
N 10 =	660.74	N 11 =	670.22	N 12 =	680.60	N 13 =	691.84	N 14 =	703.90
N 15 =	716.70	N 16 =	730.15	N 17 =	744.15	N 18 =	758.58	N 19 =	773.31
N 20 =	788.18	N 21 =	803.04	N 22 =	817.77	N 23 =	832.20	N 24 =	846.20
N 25 =	859.65	N 26 =	872.45	N 27 =	884.51	N 28 =	895.75	N 29 =	906.13
N 30 =	915.61	N 31 =	924.19	N 32 =	931.88	N 33 =	938.70	N 34 =	944.69
N 35 =	949.90	N 36 =	954.38	N 37 =	958.21	N 38 =	961.43	N 39 =	964.12
N 40 =	966.35	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	613.79	M 1 =	616.84	M 2 =	620.47	M 3 =	624.75	M 4 =	629.76
M 5 =	635.54	M 6 =	642.17	M 7 =	649.68	M 8 =	658.10	M 9 =	667.46
M 10 =	677.73	M 11 =	686.91	M 12 =	700.95	M 13 =	713.77	M 14 =	727.30
M 15 =	741.42	M 16 =	756.01	M 17 =	770.94	M 18 =	786.05	M 19 =	801.19
M 20 =	816.19	M 21 =	830.92	M 22 =	845.23	M 23 =	858.98	M 24 =	872.06
M 25 =	884.38	M 26 =	895.86	M 27 =	906.44	M 28 =	916.10	M 29 =	924.81
M 30 =	932.61	M 31 =	939.49	M 32 =	945.52	M 33 =	950.74	M 34 =	955.21
M 35 =	959.00	M 36 =	962.18	M 37 =	964.81	M 38 =	966.97	M 39 =	968.73
M 40 =	970.14	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	627.23	P 1 =	633.16	P 2 =	640.11	P 3 =	648.15	P 4 =	657.35
P 5 =	667.77	P 6 =	679.43	P 7 =	692.32	P 8 =	706.42	P 9 =	721.66
P 10 =	737.94	P 11 =	755.12	P 12 =	773.02	P 13 =	791.46	P 14 =	810.21
P 15 =	829.02	P 16 =	847.64	P 17 =	865.83	P 18 =	883.34	P 19 =	899.95
P 20 =	915.45	P 21 =	929.69	P 22 =	942.53	P 23 =	953.87	P 24 =	963.69
P 25 =	971.98	P 26 =	978.77	P 27 =	984.13	P 28 =	988.17	P 29 =	991.02
P 30 =	992.81	P 31 =	993.70	P 32 =	993.84	P 33 =	993.38	P 34 =	992.46
P 35 =	991.22	P 36 =	989.77	P 37 =	988.21	P 38 =	986.62	P 39 =	985.06
P 40 =	983.58	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	620.13	G 1 =	624.54	G 2 =	629.73	G 3 =	635.79	G 4 =	642.78
G 5 =	650.75	G 6 =	659.75	G 7 =	669.80	G 8 =	680.90	G 9 =	693.03
G 10 =	706.14	G 11 =	720.15	G 12 =	734.95	G 13 =	750.43	G 14 =	766.41
G 15 =	782.75	G 16 =	799.24	G 17 =	815.71	G 18 =	831.95	G 19 =	847.78
G 20 =	863.02	G 21 =	877.52	G 22 =	891.13	G 23 =	903.75	G 24 =	915.29
G 25 =	925.71	G 26 =	934.97	G 27 =	943.09	G 28 =	950.10	G 29 =	956.05
G 30 =	961.01	G 31 =	965.07	G 32 =	968.32	G 33 =	970.86	G 34 =	972.79
G 35 =	974.20	G 36 =	975.20	G 37 =	975.85	G 38 =	976.24	G 39 =	976.43
G 40 =	976.48	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.13	H 2 =	611.20	H 3 =	613.71	H 4 =	616.73	H 5 =	620.34
H 6 =	624.60	H 7 =	629.56	H 8 =	635.31	H 9 =	641.88	H 10 =	649.33
H 11 =	657.68	H 12 =	666.94	H 13 =	677.12	H 14 =	688.18	H 15 =	700.09
H 16 =	712.78	H 17 =	726.17	H 18 =	740.15	H 19 =	754.59	H 20 =	769.36
H 21 =	784.33	H 22 =	799.33	H 23 =	814.21	H 24 =	828.83	H 25 =	843.05
H 26 =	856.74	H 27 =	869.79	H 28 =	882.09	H 29 =	893.58	H 30 =	904.20
H 31 =	913.92	H 32 =	922.73	H 33 =	930.62	H 34 =	937.63	H 35 =	943.79
H 36 =	949.15	H 37 =	953.77	H 38 =	957.71	H 39 =	961.03	H 40 =	963.80
=	.0	=	.0	=	.0	=	.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 1
Location x/L: 0.75
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 1 LOC=.75 T:IN=610F T:OUT=1007.07 Q/A=0.84579 MW/M2
A21=30.955 A22=103.49 A23=140.94 A24=109.98 A25=58.239

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1007.1	DT: NA =	397.07	T:B NA =	808.53	T:B M =	827.05
DT M-N =	30.955	DT1 =	103.49	DT P-N =	140.94	DT P-M =	109.98	DT2 =	58.239
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.48	N 2 =	615.48	N 3 =	619.07	N 4 =	623.33
N 5 =	628.33	N 6 =	634.13	N 7 =	640.80	N 8 =	648.40	N 9 =	656.97
N 10 =	666.54	N 11 =	677.10	N 12 =	688.67	N 13 =	701.19	N 14 =	714.62
N 15 =	728.89	N 16 =	743.88	N 17 =	759.48	N 18 =	775.56	N 19 =	791.97
N 20 =	808.53	N 21 =	825.10	N 22 =	841.51	N 23 =	857.59	N 24 =	873.19
N 25 =	888.18	N 26 =	902.45	N 27 =	915.88	N 28 =	928.40	N 29 =	939.97
N 30 =	950.53	N 31 =	960.10	N 32 =	968.67	N 33 =	976.27	N 34 =	982.94
N 35 =	988.74	N 36 =	993.74	N 37 =	997.99	N 38 =	1001.6	N 39 =	1004.6
N 40 =	1007.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	614.19	M 1 =	617.57	M 2 =	621.61	M 3 =	626.37	M 4 =	631.94
M 5 =	638.38	M 6 =	645.75	M 7 =	654.10	M 8 =	663.47	M 9 =	673.88
M 10 =	685.31	M 11 =	697.75	M 12 =	711.15	M 13 =	725.42	M 14 =	740.48
M 15 =	756.20	M 16 =	772.45	M 17 =	789.08	M 18 =	805.91	M 19 =	822.77
M 20 =	839.49	M 21 =	855.90	M 22 =	871.85	M 23 =	887.18	M 24 =	901.77
M 25 =	915.50	M 26 =	928.30	M 27 =	940.11	M 28 =	950.88	M 29 =	960.61
M 30 =	969.31	M 31 =	977.00	M 32 =	983.73	M 33 =	989.56	M 34 =	994.56
M 35 =	998.79	M 36 =	1002.3	M 37 =	1005.3	M 38 =	1007.7	M 39 =	1009.7
M 40 =	1011.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	629.07	P 1 =	635.66	P 2 =	643.37	P 3 =	652.30	P 4 =	662.52
P 5 =	674.08	P 6 =	687.03	P 7 =	701.35	P 8 =	717.01	P 9 =	733.94
P 10 =	752.02	P 11 =	771.11	P 12 =	791.01	P 13 =	811.51	P 14 =	832.35
P 15 =	853.27	P 16 =	873.98	P 17 =	894.22	P 18 =	913.71	P 19 =	932.20
P 20 =	949.47	P 21 =	965.34	P 22 =	979.66	P 23 =	992.32	P 24 =	1003.3
P 25 =	1012.6	P 26 =	1020.2	P 27 =	1026.2	P 28 =	1030.7	P 29 =	1034.0
P 30 =	1036.0	P 31 =	1037.1	P 32 =	1037.3	P 33 =	1036.8	P 34 =	1035.8
P 35 =	1034.5	P 36 =	1032.9	P 37 =	1031.2	P 38 =	1029.5	P 39 =	1027.8
P 40 =	1026.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	621.19	G 1 =	626.08	G 2 =	631.85	G 3 =	638.57	G 4 =	646.33
G 5 =	655.18	G 6 =	665.17	G 7 =	676.33	G 8 =	688.66	G 9 =	702.13
G 10 =	716.70	G 11 =	732.26	G 12 =	748.72	G 13 =	765.92	G 14 =	783.70
G 15 =	801.87	G 16 =	820.22	G 17 =	838.54	G 18 =	856.63	G 19 =	874.25
G 20 =	891.23	G 21 =	907.39	G 22 =	922.57	G 23 =	936.65	G 24 =	949.53
G 25 =	961.17	G 26 =	971.52	G 27 =	980.61	G 28 =	988.45	G 29 =	995.12
G 30 =	1000.7	G 31 =	1005.3	G 32 =	1008.9	G 33 =	1011.8	G 34 =	1014.0
G 35 =	1015.6	G 36 =	1016.7	G 37 =	1017.5	G 38 =	1018.0	G 39 =	1018.2
G 40 =	1018.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.06	H 2 =	611.37	H 3 =	614.17	H 4 =	617.55	H 5 =	621.58
H 6 =	626.33	H 7 =	631.87	H 8 =	638.28	H 9 =	645.62	H 10 =	653.93
H 11 =	663.24	H 12 =	673.57	H 13 =	684.92	H 14 =	697.26	H 15 =	710.54
H 16 =	724.69	H 17 =	735.61	H 18 =	755.18	H 19 =	771.28	H 20 =	787.74
H 21 =	804.42	H 22 =	821.13	H 23 =	837.71	H 24 =	854.00	H 25 =	869.84
H 26 =	885.08	H 27 =	895.60	H 28 =	913.31	H 29 =	926.10	H 30 =	937.92
H 31 =	948.74	H 32 =	958.55	H 33 =	967.33	H 34 =	975.14	H 35 =	981.99
H 36 =	987.96	H 37 =	993.09	H 38 =	997.47	H 39 =	1001.2	H 40 =	1004.3
=	.0	=	.0	=	.0	=	.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 1
Location x/L: 0.85
T(Na-inlet) = 610 F
T(Na-outlet) :
Max = 1100F

PNL 1 LOC=.85 T:IN=610F T:OUT=1045.76 Q/A=0.92821 MW/M2
A21=33.745 A22=112.83 A23=153.92 A24=120.17 A25=63.759

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION =

T:NA IN =	610.00	T:NA OUT=	1045.8	DT: NA =	435.76	T:B NA =	827.88	T:B M =	848.06
DT M-N =	33.745	DT1 =	112.83	DT P-N =	153.92	DT P-M =	120.17	DT2 =	63.759
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.72	N 2 =	616.02	N 3 =	619.96	N 4 =	624.63
N 5 =	630.11	N 6 =	636.48	N 7 =	643.81	N 8 =	652.15	N 9 =	661.55
N 10 =	672.05	N 11 =	683.64	N 12 =	696.33	N 13 =	710.08	N 14 =	724.82
N 15 =	740.47	N 16 =	756.92	N 17 =	774.05	N 18 =	791.70	N 19 =	809.70
N 20 =	827.88	N 21 =	846.06	N 22 =	864.06	N 23 =	881.71	N 24 =	898.84
N 25 =	915.29	N 26 =	930.94	N 27 =	945.68	N 28 =	959.43	N 29 =	972.12
N 30 =	983.71	N 31 =	994.21	N 32 =	1003.6	N 33 =	1012.0	N 34 =	1019.3
N 35 =	1025.6	N 36 =	1031.1	N 37 =	1035.8	N 38 =	1039.7	N 39 =	1043.0
N 40 =	1045.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	614.57	M 1 =	618.27	M 2 =	622.69	M 3 =	627.91	M 4 =	634.01
M 5 =	641.07	M 6 =	649.15	M 7 =	658.30	M 8 =	668.57	M 9 =	679.98
M 10 =	692.51	M 11 =	706.15	M 12 =	720.84	M 13 =	736.49	M 14 =	753.01
M 15 =	770.25	M 16 =	788.07	M 17 =	806.31	M 18 =	824.77	M 19 =	843.27
M 20 =	861.62	M 21 =	879.64	M 22 =	897.14	M 23 =	913.97	M 24 =	929.99
M 25 =	945.07	M 26 =	959.13	M 27 =	972.09	M 28 =	983.93	M 29 =	994.62
M 30 =	1004.2	M 31 =	1012.6	M 32 =	1020.0	M 33 =	1026.4	M 34 =	1031.9
M 35 =	1036.6	M 36 =	1040.5	M 37 =	1043.8	M 38 =	1046.4	M 39 =	1048.6
M 40 =	1050.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	630.83	P 1 =	638.04	P 2 =	646.48	P 3 =	656.25	P 4 =	667.43
P 5 =	680.08	P 6 =	694.25	P 7 =	709.92	P 8 =	727.07	P 9 =	745.60
P 10 =	765.40	P 11 =	786.30	P 12 =	808.10	P 13 =	830.55	P 14 =	853.38
P 15 =	876.30	P 16 =	899.01	P 17 =	921.20	P 18 =	942.57	P 19 =	962.85
P 20 =	981.80	P 21 =	999.21	P 22 =	1014.9	P 23 =	1028.9	P 24 =	1040.9
P 25 =	1051.1	P 26 =	1059.5	P 27 =	1066.2	P 28 =	1071.2	P 29 =	1074.8
P 30 =	1077.1	P 31 =	1078.3	P 32 =	1078.5	P 33 =	1078.1	P 34 =	1077.0
P 35 =	1075.6	P 36 =	1073.9	P 37 =	1072.1	P 38 =	1070.2	P 39 =	1068.4
P 40 =	1066.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	622.20	G 1 =	627.55	G 2 =	633.86	G 3 =	641.21	G 4 =	649.70
G 5 =	659.38	G 6 =	670.32	G 7 =	682.53	G 8 =	696.03	G 9 =	710.78
G 10 =	726.73	G 11 =	743.78	G 12 =	761.80	G 13 =	780.65	G 14 =	800.13
G 15 =	820.04	G 16 =	840.15	G 17 =	860.24	G 18 =	880.07	G 19 =	899.41
G 20 =	918.04	G 21 =	935.77	G 22 =	952.44	G 23 =	967.90	G 24 =	982.06
G 25 =	994.85	G 26 =	1006.2	G 27 =	1016.3	G 28 =	1024.9	G 29 =	1032.3
G 30 =	1038.4	G 31 =	1043.4	G 32 =	1047.5	G 33 =	1050.7	G 34 =	1053.1
G 35 =	1054.9	G 36 =	1056.2	G 37 =	1057.1	G 38 =	1057.6	G 39 =	1057.9
G 40 =	1058.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.00	H 2 =	611.53	H 3 =	614.61	H 4 =	618.33	H 5 =	622.75
H 6 =	627.97	H 7 =	634.07	H 8 =	641.11	H 9 =	649.17	H 10 =	658.29
H 11 =	668.52	H 12 =	679.87	H 13 =	692.33	H 14 =	705.88	H 15 =	720.46
H 16 =	736.00	H 17 =	752.38	H 18 =	769.47	H 19 =	787.14	H 20 =	805.21
H 21 =	823.51	H 22 =	841.84	H 23 =	860.04	H 24 =	877.91	H 25 =	895.28
H 26 =	912.00	H 27 =	927.94	H 28 =	942.96	H 29 =	957.00	H 30 =	969.96
H 31 =	981.83	H 32 =	992.58	H 33 =	1002.2	H 34 =	1010.8	H 35 =	1018.3
H 36 =	1024.8	H 37 =	1030.5	H 38 =	1035.3	H 39 =	1039.3	H 40 =	1042.7
=	.0	=	.0	=	.0	=	.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 1
Location x/L: 0.95
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 1 LOC=.95 T:IN=610F T:OUT=1082.43 Q/A=1.00631 MW/M2
A21=36.199 A22=121.06 A23=165.55 A24=129.35 A25=68.832

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1082.4	DT: NA =	472.43	T:B NA =	846.21	T:B M =	867.87
DT M-N =	36.199	DT1 =	121.06	DT P-N =	165.55	DT P-M =	129.35	DT2 =	68.832
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.95	N 2 =	616.52	N 3 =	620.80	N 4 =	625.86
N 5 =	631.81	N 6 =	638.71	N 7 =	646.65	N 8 =	655.69	N 9 =	665.89
N 10 =	677.27	N 11 =	685.84	N 12 =	703.60	N 13 =	718.50	N 14 =	734.48
N 15 =	751.45	N 16 =	765.29	N 17 =	787.85	N 18 =	806.99	N 19 =	826.50
N 20 =	846.21	N 21 =	865.93	N 22 =	885.44	N 23 =	904.57	N 24 =	923.14
N 25 =	940.98	N 26 =	957.95	N 27 =	973.93	N 28 =	988.83	N 29 =	1002.6
N 30 =	1015.2	N 31 =	1026.5	N 32 =	1036.7	N 33 =	1045.8	N 34 =	1053.7
N 35 =	1060.6	N 36 =	1066.6	N 37 =	1071.6	N 38 =	1075.9	N 39 =	1079.5
N 40 =	1082.4	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	614.90	M 1 =	618.91	M 2 =	623.65	M 3 =	629.33	M 4 =	635.93
M 5 =	643.56	M 6 =	652.30	M 7 =	662.20	M 8 =	673.31	M 9 =	685.66
M 10 =	699.22	M 11 =	713.98	M 12 =	729.88	M 13 =	746.83	M 14 =	764.72
M 15 =	783.40	M 16 =	802.70	M 17 =	822.46	M 18 =	842.47	M 19 =	862.52
M 20 =	882.41	M 21 =	901.95	M 22 =	920.93	M 23 =	939.18	M 24 =	956.56
M 25 =	972.92	M 26 =	988.18	M 27 =	1002.3	M 28 =	1015.1	M 29 =	1026.7
M 30 =	1037.1	M 31 =	1046.3	M 32 =	1054.4	M 33 =	1061.3	M 34 =	1067.3
M 35 =	1072.4	M 36 =	1076.6	M 37 =	1080.2	M 38 =	1083.1	M 39 =	1085.4
M 40 =	1087.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	632.40	P 1 =	640.18	P 2 =	649.29	P 3 =	659.82	P 4 =	671.89
P 5 =	685.55	P 6 =	700.84	P 7 =	717.76	P 8 =	736.28	P 9 =	756.29
P 10 =	777.68	P 11 =	800.26	P 12 =	823.81	P 13 =	848.08	P 14 =	872.76
P 15 =	897.55	P 16 =	922.11	P 17 =	946.12	P 18 =	969.26	P 19 =	991.23
P 20 =	1011.8	P 21 =	1030.7	P 22 =	1047.7	P 23 =	1062.8	P 24 =	1076.0
P 25 =	1087.1	P 26 =	1096.2	P 27 =	1103.5	P 28 =	1109.0	P 29 =	1113.0
P 30 =	1115.6	P 31 =	1116.9	P 32 =	1117.3	P 33 =	1116.9	P 34 =	1115.9
P 35 =	1114.4	P 36 =	1112.6	P 37 =	1110.7	P 38 =	1108.7	P 39 =	1106.7
P 40 =	1104.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	623.09	G 1 =	626.86	G 2 =	635.67	G 3 =	643.60	G 4 =	652.76
G 5 =	663.21	G 6 =	675.01	G 7 =	688.20	G 8 =	702.78	G 9 =	718.71
G 10 =	735.94	G 11 =	754.36	G 12 =	773.84	G 13 =	794.21	G 14 =	815.28
G 15 =	836.81	G 16 =	858.58	G 17 =	880.33	G 18 =	901.80	G 19 =	922.75
G 20 =	942.94	G 21 =	962.17	G 22 =	980.26	G 23 =	997.05	G 24 =	1012.4
G 25 =	1026.3	G 26 =	1038.7	G 27 =	1049.6	G 28 =	1059.1	G 29 =	1067.1
G 30 =	1073.8	G 31 =	1079.4	G 32 =	1083.8	G 33 =	1087.3	G 34 =	1090.0
G 35 =	1092.0	G 36 =	1093.5	G 37 =	1094.4	G 38 =	1095.0	G 39 =	1095.4
G 40 =	1095.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.95	H 2 =	611.71	H 3 =	615.06	H 4 =	619.10	H 5 =	623.91
H 6 =	629.58	H 7 =	636.20	H 8 =	643.85	H 9 =	652.60	H 10 =	662.51
H 11 =	673.61	H 12 =	685.93	H 13 =	699.46	H 14 =	714.16	H 15 =	729.98
H 16 =	746.83	H 17 =	764.59	H 18 =	783.14	H 19 =	802.29	H 20 =	821.88
H 21 =	841.72	H 22 =	861.60	H 23 =	881.31	H 24 =	900.68	H 25 =	919.51
H 26 =	937.62	H 27 =	954.89	H 28 =	971.16	H 29 =	986.36	H 30 =	1000.4
H 31 =	1013.3	H 32 =	1024.9	H 33 =	1035.3	H 34 =	1044.6	H 35 =	1052.7
H 36 =	1059.8	H 37 =	1065.9	H 38 =	1071.1	H 39 =	1075.5	H 40 =	1079.1
=	.0	=	.0	=	.0	=	.0		

PANEL TEMPERATURE DISTRIBUTION

CASE 4

SET 2 Subpanel 2

Solar Flux Distribution: OFF NORMAL

Orifices: None

Sodium Temperatures: T (Na-Inlet) = 610°F

T (Na-Outlet) = 1100°F maximum

(1002.2 to 1100F)

5370F/sjh

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 2
Location x/L: 0.05
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 2 LOC=.05 T:IN=610F T:OUT=1018.49 Q/A=1.08765 MW/M2
A21=38.526 A22=128.87 A23=176.87 A24=138.34 A25=73.925

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN	610.00	T:NA OUT	1018.5	DT: NA	408.49	T:B NA	814.24	T:B M	837.29
DT M-N	38.526	DT1	128.87	DT P-N	176.87	DT P-M	138.34	DT2	73.925
	.0		.0		.0		.0		.0
N	610.00	N 1	612.55	N 2	615.64	N 3	619.34	N 4	623.72
N 5	628.85	N 6	634.82	N 7	641.69	N 8	649.51	N 9	658.32
N 10	668.16	N 11	679.03	N 12	690.93	N 13	703.81	N 14	717.63
N 15	732.31	N 16	747.73	N 17	763.78	N 18	780.32	N 19	797.20
N 20	814.24	N 21	831.29	N 22	848.17	N 23	864.71	N 24	880.76
N 25	896.18	N 26	910.86	N 27	924.67	N 28	937.56	N 29	949.46
N 30	960.33	N 31	970.17	N 32	978.98	N 33	986.80	N 34	993.67
N 35	999.64	N 36	1004.8	N 37	1009.2	N 38	1012.8	N 39	1015.9
N 40	1018.5		.0		.0		.0		.0
	.0		.0		.0		.0		.0
M	615.21	M 1	618.89	M 2	623.26	M 3	628.42	M 4	634.43
M 5	641.36	M 6	649.28	M 7	658.24	M 8	668.26	M 9	679.36
M 10	691.53	M 11	704.73	M 12	718.91	M 13	733.97	M 14	749.81
M 15	766.31	M 16	783.29	M 17	800.61	M 18	818.09	M 19	835.53
M 20	852.77	M 21	869.62	M 22	885.93	M 23	901.54	M 24	916.32
M 25	930.18	M 26	943.04	M 27	954.83	M 28	965.54	M 29	975.15
M 30	983.69	M 31	991.20	M 32	997.73	M 33	1003.3	M 34	1008.1
M 35	1012.1	M 36	1015.5	M 37	1018.2	M 38	1020.5	M 39	1022.3
M 40	1023.7		.0		.0		.0		.0
	.0		.0		.0		.0		.0
P	633.94	P 1	641.64	P 2	650.64	P 3	661.03	P 4	672.89
P 5	686.28	P 6	701.21	P 7	717.67	P 8	735.60	P 9	754.91
P 10	775.44	P 11	797.00	P 12	819.36	P 13	842.25	P 14	865.37
P 15	888.39	P 16	911.00	P 17	932.87	P 18	953.69	P 19	973.19
P 20	991.11	P 21	1007.3	P 22	1021.5	P 23	1033.8	P 24	1044.0
P 25	1052.3	P 26	1058.6	P 27	1063.1	P 28	1066.0	P 29	1067.4
P 30	1067.6	P 31	1066.7	P 32	1065.1	P 33	1062.8	P 34	1060.0
P 35	1057.1	P 36	1054.0	P 37	1050.9	P 38	1047.9	P 39	1045.0
P 40	1042.4		.0		.0		.0		.0
	.0		.0		.0		.0		.0
G	623.93	G 1	629.49	G 2	636.02	G 3	643.61	G 4	652.34
G 5	662.28	G 6	673.47	G 7	685.92	G 8	699.63	G 9	714.55
G 10	730.61	G 11	747.71	G 12	765.69	G 13	784.40	G 14	803.63
G 15	823.17	G 16	842.77	G 17	862.21	G 18	881.25	G 19	899.65
G 20	917.21	G 21	933.74	G 22	949.09	G 23	963.14	G 24	975.80
G 25	987.05	G 26	996.86	G 27	1005.3	G 28	1012.3	G 29	1018.1
G 30	1022.8	G 31	1026.4	G 32	1029.1	G 33	1031.0	G 34	1032.3
G 35	1033.1	G 36	1033.4	G 37	1033.4	G 38	1033.2	G 39	1032.9
G 40	1032.4		.0		.0		.0		.0
	.0		.0		.0		.0		.0
H 1	608.29	H 2	610.51	H 3	613.23	H 4	616.51	H 5	620.44
H 6	625.10	H 7	630.56	H 8	636.90	H 9	644.18	H 10	652.45
H 11	661.75	H 12	672.12	H 13	683.54	H 14	695.99	H 15	709.44
H 16	723.81	H 17	739.01	H 18	754.93	H 19	771.42	H 20	788.34
H 21	805.51	H 22	822.77	H 23	839.94	H 24	856.84	H 25	873.32
H 26	889.21	H 27	904.40	H 28	918.75	H 29	932.17	H 30	944.61
H 31	956.02	H 32	966.37	H 33	975.67	H 34	983.94	H 35	991.22
H 36	997.57	H 37	1003.0	H 38	1007.7	H 39	1011.7	H 40	1015.0
	.0		.0		.0		.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 2
Location x/L: 0.15
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 2 LOC=.15 T:IN=610F T:OUT=1047.01 Q/A=1.16359 MW/M2
A21=40.698 A22=136.16 A23=187.43 A24=146.74 A25=78.680

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1047.0	DT: NA =	437.01	T:B NA =	828.50	T:B M =	852.85
DT M-N =	40.698	DT1 =	136.16	DT P-N =	187.43	DT P-M =	146.74	DT2 =	78.68C
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.73	N 2 =	616.03	N 3 =	619.99	N 4 =	624.67
N 5 =	630.17	N 6 =	636.56	N 7 =	643.90	N 8 =	652.27	N 9 =	661.70
N 10 =	672.22	N 11 =	683.85	N 12 =	696.58	N 13 =	710.36	N 14 =	725.15
N 15 =	740.85	N 16 =	757.35	N 17 =	774.52	N 18 =	792.22	N 19 =	810.27
N 20 =	828.50	N 21 =	846.74	N 22 =	864.79	N 23 =	882.49	N 24 =	899.66
N 25 =	916.16	N 26 =	931.86	N 27 =	946.64	N 28 =	960.43	N 29 =	973.16
N 30 =	984.79	N 31 =	995.31	N 32 =	1004.7	N 33 =	1013.1	N 34 =	1020.5
N 35 =	1026.8	N 36 =	1032.3	N 37 =	1037.0	N 38 =	1041.0	N 39 =	1044.3
N 40 =	1047.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.51	M 1 =	619.43	M 2 =	624.09	M 3 =	629.58	M 4 =	635.99
M 5 =	643.38	M 6 =	651.83	M 7 =	661.39	M 8 =	672.08	M 9 =	683.92
M 10 =	696.91	M 11 =	711.00	M 12 =	726.13	M 13 =	742.22	M 14 =	759.14
M 15 =	776.76	M 16 =	794.92	M 17 =	813.43	M 18 =	832.11	M 19 =	850.77
M 20 =	869.20	M 21 =	887.23	M 22 =	904.69	M 23 =	921.40	M 24 =	937.23
M 25 =	952.08	M 26 =	965.85	M 27 =	978.50	M 28 =	989.98	M 29 =	1000.3
M 30 =	1009.5	M 31 =	1017.5	M 32 =	1024.6	M 33 =	1030.6	M 34 =	1035.7
M 35 =	1040.1	M 36 =	1043.7	M 37 =	1046.6	M 38 =	1049.0	M 39 =	1051.0
M 40 =	1052.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	635.37	P 1 =	643.56	P 2 =	653.13	P 3 =	664.17	P 4 =	676.79
P 5 =	691.02	P 6 =	706.90	P 7 =	724.41	P 8 =	743.50	P 9 =	764.05
P 10 =	785.91	P 11 =	808.87	P 12 =	832.68	P 13 =	857.07	P 14 =	881.70
P 15 =	906.25	P 16 =	930.37	P 17 =	953.70	P 18 =	975.94	P 19 =	996.77
P 20 =	1015.9	P 21 =	1033.2	P 22 =	1048.5	P 23 =	1061.7	P 24 =	1072.7
P 25 =	1081.6	P 26 =	1088.4	P 27 =	1093.3	P 28 =	1096.5	P 29 =	1098.2
P 30 =	1098.5	P 31 =	1097.7	P 32 =	1096.0	P 33 =	1093.6	P 34 =	1090.8
P 35 =	1087.7	P 36 =	1084.4	P 37 =	1081.2	P 38 =	1078.1	P 39 =	1075.1
P 40 =	1072.4	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	624.72	G 1 =	630.62	G 2 =	637.56	G 3 =	645.63	G 4 =	654.92
G 5 =	665.49	G 6 =	677.38	G 7 =	690.63	G 8 =	705.22	G 9 =	721.10
G 10 =	738.20	G 11 =	756.41	G 12 =	775.57	G 13 =	795.51	G 14 =	816.01
G 15 =	836.84	G 16 =	857.76	G 17 =	878.51	G 18 =	898.84	G 19 =	918.51
G 20 =	937.28	G 21 =	954.97	G 22 =	971.42	G 23 =	986.48	G 24 =	1000.1
G 25 =	1012.2	G 26 =	1022.7	G 27 =	1031.8	G 28 =	1039.4	G 29 =	1045.7
G 30 =	1050.8	G 31 =	1054.7	G 32 =	1057.7	G 33 =	1059.8	G 34 =	1061.3
G 35 =	1062.2	G 36 =	1062.6	G 37 =	1062.7	G 38 =	1062.5	G 39 =	1062.2
G 40 =	1061.7	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.23	H 2 =	610.61	H 3 =	613.53	H 4 =	617.06	H 5 =	621.28
H 6 =	626.28	H 7 =	632.14	H 8 =	638.94	H 9 =	646.74	H 10 =	655.61
H 11 =	665.59	H 12 =	676.70	H 13 =	688.93	H 14 =	702.28	H 15 =	716.68
H 16 =	732.07	H 17 =	748.34	H 18 =	765.38	H 19 =	783.02	H 20 =	801.12
H 21 =	819.49	H 22 =	837.95	H 23 =	856.31	H 24 =	874.39	H 25 =	892.00
H 26 =	908.99	H 27 =	925.21	H 28 =	940.55	H 29 =	954.89	H 30 =	968.18
H 31 =	980.36	H 32 =	991.41	H 33 =	1001.3	H 34 =	1010.2	H 35 =	1017.9
H 36 =	1024.7	H 37 =	1030.6	H 38 =	1035.6	H 39 =	1039.8	H 40 =	1043.3
=	.0	=	.0	=	.0	=	.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 2
Location x/L: 0.25
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 2 LOC=.25 T:IN=610F T:OUT=1065.59 Q/A=1.22369 MW/M2
A21=42.418 A22=141.94 A23=195.80 A24=153.38 A25=82.444

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1069.6	DT: NA =	459.59	T:B NA =	839.79	T:B M =	865.17
DT M-N =	42.418	DT1 =	141.94	DT P-N =	195.80	DT P-M =	153.38	DT2 =	82.444
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.87	N 2 =	616.35	N 3 =	620.50	N 4 =	625.43
N 5 =	631.21	N 6 =	637.93	N 7 =	645.65	N 8 =	654.45	N 9 =	664.37
N 10 =	675.44	N 11 =	687.67	N 12 =	701.05	N 13 =	715.55	N 14 =	731.10
N 15 =	747.61	N 16 =	764.96	N 17 =	783.02	N 18 =	801.63	N 19 =	820.62
N 20 =	839.79	N 21 =	858.97	N 22 =	877.96	N 23 =	896.57	N 24 =	914.63
N 25 =	931.98	N 26 =	948.49	N 27 =	964.04	N 28 =	978.54	N 29 =	991.92
N 30 =	1004.2	N 31 =	1015.2	N 32 =	1025.1	N 33 =	1033.9	N 34 =	1041.7
N 35 =	1048.4	N 36 =	1054.2	N 37 =	1059.1	N 38 =	1063.2	N 39 =	1066.7
N 40 =	1065.6	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.74	M 1 =	619.85	M 2 =	624.74	M 3 =	630.50	M 4 =	637.23
M 5 =	644.98	M 6 =	653.85	M 7 =	663.88	M 8 =	675.10	M 9 =	687.53
M 10 =	701.17	M 11 =	715.96	M 12 =	731.86	M 13 =	748.75	M 14 =	766.53
M 15 =	785.04	M 16 =	804.12	M 17 =	823.57	M 18 =	843.21	M 19 =	862.82
M 20 =	882.21	M 21 =	901.18	M 22 =	919.54	M 23 =	937.12	M 24 =	953.79
M 25 =	969.42	M 26 =	983.92	M 27 =	997.24	M 28 =	1009.3	M 29 =	1020.2
M 30 =	1029.9	M 31 =	1038.4	M 32 =	1045.8	M 33 =	1052.2	M 34 =	1057.6
M 35 =	1062.1	M 36 =	1066.0	M 37 =	1069.1	M 38 =	1071.6	M 39 =	1073.7
M 40 =	1075.3	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	636.50	P 1 =	645.08	P 2 =	655.09	P 3 =	666.66	P 4 =	679.87
P 5 =	694.78	P 6 =	711.42	P 7 =	729.76	P 8 =	749.76	P 9 =	771.29
P 10 =	794.20	P 11 =	818.26	P 12 =	843.23	P 13 =	868.80	P 14 =	894.64
P 15 =	920.40	P 16 =	945.71	P 17 =	970.20	P 18 =	993.55	P 19 =	1015.4
P 20 =	1035.6	P 21 =	1053.8	P 22 =	1069.9	P 23 =	1083.8	P 24 =	1095.4
P 25 =	1104.8	P 26 =	1112.0	P 27 =	1117.3	P 28 =	1120.7	P 29 =	1122.5
P 30 =	1122.9	P 31 =	1122.1	P 32 =	1120.4	P 33 =	1118.0	P 34 =	1115.1
P 35 =	1111.9	P 36 =	1108.6	P 37 =	1105.2	P 38 =	1102.0	P 39 =	1098.9
P 40 =	1096.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	625.34	G 1 =	631.52	G 2 =	638.78	G 3 =	647.23	G 4 =	656.96
G 5 =	668.02	G 6 =	680.49	G 7 =	694.36	G 8 =	709.64	G 9 =	726.29
G 10 =	744.21	G 11 =	763.30	G 12 =	783.39	G 13 =	804.30	G 14 =	825.81
G 15 =	847.67	G 16 =	869.63	G 17 =	891.42	G 18 =	912.77	G 19 =	933.44
G 20 =	953.18	G 21 =	971.79	G 22 =	989.10	G 23 =	1005.0	G 24 =	1019.3
G 25 =	1032.0	G 26 =	1043.2	G 27 =	1052.8	G 28 =	1060.9	G 29 =	1067.5
G 30 =	1072.9	G 31 =	1077.1	G 32 =	1080.3	G 33 =	1082.6	G 34 =	1084.2
G 35 =	1085.2	G 36 =	1085.7	G 37 =	1085.8	G 38 =	1085.7	G 39 =	1085.4
G 40 =	1084.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.18	H 2 =	610.70	H 3 =	613.77	H 4 =	617.49	H 5 =	621.94
H 6 =	627.21	H 7 =	633.39	H 8 =	640.55	H 9 =	648.78	H 10 =	658.12
H 11 =	668.63	H 12 =	680.32	H 13 =	693.20	H 14 =	707.25	H 15 =	722.41
H 16 =	738.60	H 17 =	755.72	H 18 =	773.64	H 19 =	792.21	H 20 =	811.24
H 21 =	830.56	H 22 =	849.97	H 23 =	869.27	H 24 =	888.27	H 25 =	906.79
H 26 =	924.64	H 27 =	941.69	H 28 =	957.80	H 29 =	972.88	H 30 =	986.83
H 31 =	999.63	H 32 =	1011.2	H 33 =	1021.7	H 34 =	1030.9	H 35 =	1039.1
H 36 =	1046.2	H 37 =	1052.4	H 38 =	1057.6	H 39 =	1062.0	H 40 =	1065.7
=	.0	=	.0	=	.0	=	.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 2
Location x/L: 0.35
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 2 LOC=.35 T:IN=610F T:OUT=1086.21 C/A=1.26796 MW/M2
A21=43.684 A22=146.19 A23=201.96 A24=156.27 A25=85.216

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1086.2	DT: NA =	476.21	T:B NA =	848.10	T:B M =	874.23
DT M-N =	43.684	DT1 =	146.19	DT F-N =	201.96	DT P-M =	158.27	DT2 =	85.216
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.98	N 2 =	616.58	N 3 =	620.88	N 4 =	625.99
N 5 =	631.98	N 6 =	636.94	N 7 =	646.94	N 8 =	656.06	N 9 =	666.33
N 10 =	677.80	N 11 =	690.48	N 12 =	704.35	N 13 =	719.37	N 14 =	735.48
N 15 =	752.58	N 16 =	770.56	N 17 =	789.28	N 18 =	808.56	N 19 =	828.23
N 20 =	848.10	N 21 =	867.98	N 22 =	887.65	N 23 =	906.93	N 24 =	925.65
N 25 =	943.63	N 26 =	960.73	N 27 =	976.84	N 28 =	991.86	N 29 =	1005.7
N 30 =	1018.4	N 31 =	1029.9	N 32 =	1040.2	N 33 =	1049.3	N 34 =	1057.3
N 35 =	1064.2	N 36 =	1070.2	N 37 =	1075.3	N 38 =	1079.6	N 39 =	1083.2
N 40 =	1086.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.91	M 1 =	620.16	M 2 =	625.22	P 3 =	631.18	M 4 =	638.14
M 5 =	646.16	M 6 =	655.34	M 7 =	665.71	M 8 =	677.32	M 9 =	690.19
M 10 =	704.30	M 11 =	719.62	M 12 =	736.07	M 13 =	753.56	M 14 =	771.97
M 15 =	791.13	M 16 =	810.89	M 17 =	831.04	M 18 =	851.38	M 19 =	871.70
M 20 =	891.79	M 21 =	911.44	M 22 =	930.47	M 23 =	948.69	M 24 =	965.97
M 25 =	982.18	M 26 =	997.22	M 27 =	1011.0	M 28 =	1023.6	M 29 =	1034.9
M 30 =	1044.9	M 31 =	1053.7	M 32 =	1061.4	M 33 =	1068.0	M 34 =	1073.7
M 35 =	1078.4	M 36 =	1082.4	M 37 =	1085.6	M 38 =	1088.3	M 39 =	1090.4
M 40 =	1092.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	637.33	P 1 =	646.19	P 2 =	656.54	P 3 =	668.49	P 4 =	682.14
P 5 =	697.55	P 6 =	714.74	P 7 =	733.70	P 8 =	754.36	P 9 =	776.62
P 10 =	800.30	P 11 =	825.18	P 12 =	851.00	P 13 =	877.44	P 14 =	904.17
P 15 =	930.81	P 16 =	957.00	P 17 =	982.35	P 18 =	1006.5	P 19 =	1029.2
P 20 =	1050.1	P 21 =	1068.9	P 22 =	1085.6	P 23 =	1100.0	P 24 =	1112.1
P 25 =	1121.9	P 26 =	1129.4	P 27 =	1134.9	P 28 =	1138.5	P 29 =	1140.4
P 30 =	1140.9	P 31 =	1140.2	P 32 =	1138.5	P 33 =	1136.0	P 34 =	1133.1
P 35 =	1129.8	P 36 =	1126.4	P 37 =	1122.9	P 38 =	1119.6	P 39 =	1116.5
P 40 =	1113.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	625.80	G 1 =	632.18	G 2 =	639.69	G 3 =	648.41	G 4 =	658.46
G 5 =	669.89	G 6 =	682.77	G 7 =	697.11	G 8 =	712.90	G 9 =	730.10
G 10 =	748.63	G 11 =	768.37	G 12 =	789.15	G 13 =	810.77	G 14 =	833.02
G 15 =	855.64	G 16 =	876.36	G 17 =	900.92	G 18 =	923.03	G 19 =	944.43
G 20 =	964.88	G 21 =	984.17	G 22 =	1002.1	G 23 =	1018.6	G 24 =	1033.4
G 25 =	1046.7	G 26 =	1058.3	G 27 =	1068.2	G 28 =	1076.7	G 29 =	1083.6
G 30 =	1089.2	G 31 =	1093.6	G 32 =	1097.0	G 33 =	1099.4	G 34 =	1101.1
G 35 =	1102.1	G 36 =	1102.7	G 37 =	1102.9	G 38 =	1102.7	G 39 =	1102.4
G 40 =	1102.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.14	H 2 =	610.75	H 3 =	613.95	H 4 =	617.81	H 5 =	622.43
H 6 =	627.90	H 7 =	634.31	H 8 =	641.74	H 9 =	650.27	H 10 =	659.97
H 11 =	670.86	H 12 =	682.99	H 13 =	696.35	H 14 =	710.91	H 15 =	726.63
H 16 =	743.41	H 17 =	761.16	H 18 =	779.73	H 19 =	798.97	H 20 =	818.69
H 21 =	838.71	H 22 =	858.82	H 23 =	878.82	H 24 =	898.50	H 25 =	917.67
H 26 =	936.17	H 27 =	953.82	H 28 =	970.51	H 29 =	986.11	H 30 =	1000.6
H 31 =	1013.8	H 32 =	1025.8	H 33 =	1036.6	H 34 =	1046.2	H 35 =	1054.7
H 36 =	1062.0	H 37 =	1068.4	H 38 =	1073.8	H 39 =	1078.4	H 40 =	1082.2
=	.0	=	.0	=	.0	=	.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 2
Location x/L: 0.45
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 2 LOC=.45 T:IN=610F T:OUT=1096.89 Q/A=1.29640 MW/M2
A21=44.498 A22=148.92 A23=205.91 A24=161.41 A25=86.996

4

ITER NC. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1096.9	DT: NA =	486.89	T:B NA =	853.44	T:B M =	880.06
DT M-N =	44.498	DT1 =	148.92	DT P-N =	205.91	DT P-M =	161.41	DT2 =	86.996
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	613.04	N 2 =	616.72	N 3 =	621.13	N 4 =	626.35
N 5 =	632.47	N 6 =	639.59	N 7 =	647.77	N 8 =	657.09	N 9 =	667.60
N 10 =	679.33	N 11 =	692.28	N 12 =	706.46	N 13 =	721.82	N 14 =	738.29
N 15 =	755.78	N 16 =	774.16	N 17 =	793.30	N 18 =	813.01	N 19 =	833.13
N 20 =	853.44	N 21 =	873.76	N 22 =	893.88	N 23 =	913.59	N 24 =	932.73
N 25 =	951.11	N 26 =	968.60	N 27 =	985.07	N 28 =	1000.4	N 29 =	1014.6
N 30 =	1027.6	N 31 =	1039.3	N 32 =	1049.8	N 33 =	1059.1	N 34 =	1067.3
N 35 =	1074.4	N 36 =	1080.5	N 37 =	1085.8	N 38 =	1090.2	N 39 =	1093.8
N 40 =	1096.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	616.02	M 1 =	620.36	M 2 =	625.53	M 3 =	631.62	M 4 =	638.72
M 5 =	646.92	M 6 =	656.29	M 7 =	666.89	M 8 =	678.75	M 9 =	691.90
M 10 =	706.31	M 11 =	721.96	M 12 =	738.77	M 13 =	756.65	M 14 =	775.46
M 15 =	795.05	M 16 =	815.24	M 17 =	835.84	M 18 =	856.63	M 19 =	877.40
M 20 =	897.94	M 21 =	918.04	M 22 =	937.49	M 23 =	956.13	M 24 =	973.80
M 25 =	990.38	M 26 =	1005.8	M 27 =	1019.9	M 28 =	1032.7	M 29 =	1044.3
M 30 =	1054.6	M 31 =	1063.6	M 32 =	1071.5	M 33 =	1078.2	M 34 =	1084.0
M 35 =	1088.9	M 36 =	1092.9	M 37 =	1096.3	M 38 =	1099.0	M 39 =	1101.2
M 40 =	1102.9	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	637.87	P 1 =	646.91	P 2 =	657.47	P 3 =	669.67	P 4 =	683.60
P 5 =	699.32	P 6 =	716.87	P 7 =	736.22	P 8 =	757.32	P 9 =	780.04
P 10 =	804.22	P 11 =	829.62	P 12 =	855.98	P 13 =	882.99	P 14 =	910.28
P 15 =	937.49	P 16 =	964.24	P 17 =	990.15	P 18 =	1014.8	P 19 =	1038.0
P 20 =	1059.4	P 21 =	1078.6	P 22 =	1095.7	P 23 =	1110.4	P 24 =	1122.8
P 25 =	1132.8	P 26 =	1140.6	P 27 =	1146.2	P 28 =	1149.9	P 29 =	1151.9
P 30 =	1152.5	P 31 =	1151.7	P 32 =	1150.0	P 33 =	1147.6	P 34 =	1144.6
P 35 =	1141.3	P 36 =	1137.8	P 37 =	1134.3	P 38 =	1130.9	P 39 =	1127.7
P 40 =	1124.8	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	626.10	G 1 =	632.61	G 2 =	640.26	G 3 =	649.17	G 4 =	659.42
G 5 =	671.09	G 6 =	684.24	G 7 =	698.87	G 8 =	714.99	G 9 =	732.56
G 10 =	751.48	G 11 =	771.63	G 12 =	792.84	G 13 =	814.93	G 14 =	837.65
G 15 =	860.76	G 16 =	883.98	G 17 =	907.02	G 18 =	929.62	G 19 =	951.49
G 20 =	972.40	G 21 =	992.12	G 22 =	1010.5	G 23 =	1027.3	G 24 =	1042.5
G 25 =	1056.1	G 26 =	1068.0	G 27 =	1078.2	G 28 =	1086.8	G 29 =	1093.9
G 30 =	1099.7	G 31 =	1104.3	G 32 =	1107.7	G 33 =	1110.2	G 34 =	1111.9
G 35 =	1113.0	G 36 =	1113.6	G 37 =	1113.8	G 38 =	1113.7	G 39 =	1113.4
G 40 =	1113.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.12	H 2 =	610.79	H 3 =	614.06	H 4 =	618.02	H 5 =	622.75
H 6 =	628.34	H 7 =	634.90	H 8 =	642.51	H 9 =	651.24	H 10 =	661.15
H 11 =	672.30	H 12 =	684.71	H 13 =	698.37	H 14 =	713.26	H 15 =	729.34
H 16 =	746.51	H 17 =	764.65	H 18 =	783.65	H 19 =	803.32	H 20 =	823.48
H 21 =	843.95	H 22 =	864.51	H 23 =	884.95	H 24 =	905.07	H 25 =	924.67
H 26 =	943.57	H 27 =	961.62	H 28 =	978.67	H 29 =	994.62	H 30 =	1009.4
H 31 =	1022.9	H 32 =	1035.2	H 33 =	1046.2	H 34 =	1056.1	H 35 =	1064.7
H 36 =	1072.2	H 37 =	1078.7	H 38 =	1084.2	H 39 =	1088.9	H 40 =	1092.8
=	.0	=	.0	=	.0	=	.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 2
Location x/L: FULL
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 2 LOC=FULLT:IN=610F T:OUT=1100.0 Q/A=1.30468 MW/M2
A21=44.735 A22=149.71 A23=207.06 A24=162.33 A25=87.514

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1100.0	DT: NA =	490.00	T:B NA =	855.00	T:B M =	881.76
DT M-N =	44.735	DT1 =	149.71	DT F-N =	207.06	DT P-M =	162.33	DT2 =	87.514
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	613.06	N 2 =	616.77	N 3 =	621.20	N 4 =	626.45
N 5 =	632.62	N 6 =	639.76	N 7 =	648.01	N 8 =	657.39	N 9 =	667.97
N 10 =	679.77	N 11 =	692.81	N 12 =	707.08	N 13 =	722.53	N 14 =	739.11
N 15 =	756.71	N 16 =	775.21	N 17 =	794.47	N 18 =	814.31	N 19 =	834.55
N 20 =	855.00	N 21 =	875.45	N 22 =	895.69	N 23 =	915.53	N 24 =	934.79
N 25 =	953.29	N 26 =	970.89	N 27 =	987.47	N 28 =	1002.9	N 29 =	1017.2
N 30 =	1030.2	N 31 =	1042.0	N 32 =	1052.6	N 33 =	1062.0	N 34 =	1070.2
N 35 =	1077.4	N 36 =	1083.5	N 37 =	1088.8	N 38 =	1093.2	N 39 =	1096.9
N 40 =	1100.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	616.05	M 1 =	620.42	M 2 =	625.62	M 3 =	631.74	M 4 =	638.89
M 5 =	647.14	M 6 =	656.57	M 7 =	667.23	M 8 =	679.17	M 9 =	692.39
M 10 =	706.90	M 11 =	722.65	M 12 =	739.56	M 13 =	757.55	M 14 =	776.48
M 15 =	796.19	M 16 =	816.51	M 17 =	837.24	M 18 =	858.16	M 19 =	879.07
M 20 =	899.73	M 21 =	919.96	M 22 =	939.54	M 23 =	958.30	M 24 =	976.08
M 25 =	992.77	M 26 =	1008.3	M 27 =	1022.5	M 28 =	1035.4	M 29 =	1047.0
M 30 =	1057.4	M 31 =	1066.5	M 32 =	1074.4	M 33 =	1081.2	M 34 =	1087.0
M 35 =	1091.9	M 36 =	1096.0	M 37 =	1099.3	M 38 =	1102.1	M 39 =	1104.3
M 40 =	1106.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	638.02	P 1 =	647.12	P 2 =	657.74	P 3 =	670.01	P 4 =	684.02
P 5 =	699.84	P 6 =	717.49	P 7 =	736.96	P 8 =	758.18	P 9 =	781.04
P 10 =	805.36	P 11 =	830.91	P 12 =	857.43	P 13 =	884.60	P 14 =	912.06
P 15 =	939.44	P 16 =	966.35	P 17 =	992.42	P 18 =	1017.3	P 19 =	1040.6
P 20 =	1062.1	P 21 =	1081.5	P 22 =	1098.6	P 23 =	1113.5	P 24 =	1125.9
P 25 =	1136.0	P 26 =	1143.8	P 27 =	1149.5	P 28 =	1153.3	P 29 =	1155.3
P 30 =	1155.8	P 31 =	1155.1	P 32 =	1153.4	P 33 =	1150.9	P 34 =	1147.9
P 35 =	1144.6	P 36 =	1141.1	P 37 =	1137.6	P 38 =	1134.2	P 39 =	1131.0
P 40 =	1128.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	626.18	G 1 =	632.73	G 2 =	640.43	G 3 =	649.39	G 4 =	659.70
G 5 =	671.44	G 6 =	684.66	G 7 =	699.38	G 8 =	715.60	G 9 =	733.27
G 10 =	752.30	G 11 =	772.57	G 12 =	793.92	G 13 =	816.14	G 14 =	839.00
G 15 =	862.25	G 16 =	885.61	G 17 =	908.80	G 18 =	931.53	G 19 =	953.55
G 20 =	974.59	G 21 =	994.44	G 22 =	1012.9	G 23 =	1029.9	G 24 =	1045.2
G 25 =	1058.8	G 26 =	1070.8	G 27 =	1081.1	G 28 =	1089.8	G 29 =	1097.0
G 30 =	1102.8	G 31 =	1107.3	G 32 =	1110.8	G 33 =	1113.4	G 34 =	1115.1
G 35 =	1116.2	G 36 =	1116.8	G 37 =	1117.0	G 38 =	1116.9	G 39 =	1116.6
G 40 =	1116.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.11	H 2 =	610.80	H 3 =	614.10	H 4 =	618.08	H 5 =	622.84
H 6 =	628.47	H 7 =	635.08	H 8 =	642.73	H 9 =	651.52	H 10 =	661.50
H 11 =	672.72	H 12 =	685.21	H 13 =	698.96	H 14 =	713.95	H 15 =	730.13
H 16 =	747.41	H 17 =	765.67	H 18 =	784.79	H 19 =	804.58	H 20 =	824.88
H 21 =	845.48	H 22 =	866.16	H 23 =	886.74	H 24 =	906.98	H 25 =	926.71
H 26 =	945.73	H 27 =	963.89	H 28 =	981.05	H 29 =	997.10	H 30 =	1012.0
H 31 =	1025.6	H 32 =	1037.9	H 33 =	1049.0	H 34 =	1058.9	H 35 =	1067.6
H 36 =	1075.2	H 37 =	1081.7	H 38 =	1087.3	H 39 =	1092.0	H 40 =	1095.9
=	.0	=	.0	=	.0	=	.0		

PANEL TEMPERATURE DISTRIBUTION

CASE 4
SET 3 Subpanel Boundaries

Solar Flux Distribution: OFF NORMAL

Orifices: None

Sodium Temperatures: T (Na-Inlet) = 610°F
T (Na-Outlet) = 1100°F maximum
(652.2 to 1100F)

5370F/sjh

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 1
Location x/L: 0.0 (IN)
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 1 LOC=C T:IN=610F T:OUT=652.24 G/A=0.08998 MW/M2
A21=3.975 A22=13.250 A23=17.263 A24=13.288 A25=6.6630

4

ITER NC. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	652.24	DT: NA =	42.240	T:B NA =	631.12	T:B M =	633.50
DT M-N =	3.9750	DT1 =	13.250	DT P-N =	17.263	DT P-M =	13.288	DT2 =	6.6630
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	61C.26	N 2 =	610.58	N 3 =	610.97	N 4 =	611.42
N 5 =	611.95	N 6 =	612.57	N 7 =	613.28	N 8 =	614.09	N 9 =	615.00
N 10 =	616.01	N 11 =	617.14	N 12 =	618.37	N 13 =	619.70	N 14 =	621.13
N 15 =	622.65	N 16 =	624.24	N 17 =	625.90	N 18 =	627.61	N 19 =	629.36
N 20 =	631.12	N 21 =	632.88	N 22 =	634.63	N 23 =	636.34	N 24 =	638.00
N 25 =	639.59	N 26 =	641.11	N 27 =	642.54	N 28 =	643.87	N 29 =	645.10
N 30 =	646.23	N 31 =	647.24	N 32 =	648.15	N 33 =	648.96	N 34 =	649.67
N 35 =	650.29	N 36 =	65C.82	N 37 =	651.27	N 38 =	651.66	N 39 =	651.98
N 40 =	652.24	=	.0	=	.C	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	610.54	M 1 =	61C.92	M 2 =	611.37	M 3 =	611.90	M 4 =	612.52
M 5 =	613.24	M 6 =	614.06	M 7 =	614.98	M 8 =	616.02	M 9 =	617.17
M 10 =	618.43	M 11 =	61S.79	M 12 =	621.25	M 13 =	622.81	M 14 =	624.45
M 15 =	626.15	M 16 =	627.91	M 17 =	629.7C	M 18 =	631.51	M 19 =	633.31
M 20 =	635.09	M 21 =	636.84	M 22 =	638.52	M 23 =	640.14	M 24 =	641.67
M 25 =	643.10	M 26 =	644.43	M 27 =	645.65	M 28 =	646.76	M 29 =	647.75
M 30 =	648.64	M 31 =	649.41	M 32 =	65C.09	M 33 =	650.67	M 34 =	651.16
M 35 =	651.58	M 36 =	651.93	M 37 =	652.21	M 38 =	652.44	M 39 =	652.63
M 40 =	652.78	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.C	=	.0	=	.0
P =	612.34	P 1 =	613.10	P 2 =	614.00	P 3 =	615.03	P 4 =	616.22
P 5 =	617.55	P 6 =	619.05	P 7 =	620.69	P 8 =	622.49	P 9 =	624.42
P 10 =	626.48	P 11 =	628.65	P 12 =	630.90	P 13 =	633.21	P 14 =	635.55
P 15 =	637.88	P 16 =	64C.18	P 17 =	642.41	P 18 =	644.53	P 19 =	646.53
P 20 =	648.38	P 21 =	65C.06	P 22 =	651.55	P 23 =	652.84	P 24 =	653.93
P 25 =	654.83	P 26 =	655.53	P 27 =	656.05	P 28 =	656.41	P 29 =	656.62
P 30 =	656.70	P 31 =	656.67	P 32 =	656.56	P 33 =	656.38	P 34 =	656.15
P 35 =	655.89	P 36 =	655.62	P 37 =	655.34	P 38 =	655.07	P 39 =	654.81
P 40 =	654.58	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	611.43	G 1 =	612.01	G 2 =	612.68	G 3 =	613.46	G 4 =	614.36
G 5 =	615.39	G 6 =	616.54	G 7 =	617.83	G 8 =	619.24	G 9 =	620.78
G 10 =	622.44	G 11 =	624.21	G 12 =	626.07	G 13 =	628.00	G 14 =	629.98
G 15 =	632.00	G 16 =	634.03	G 17 =	636.04	G 18 =	638.00	G 19 =	639.90
G 20 =	641.72	G 21 =	643.43	G 22 =	645.02	G 23 =	646.47	G 24 =	647.78
G 25 =	648.95	G 26 =	649.96	G 27 =	65C.84	G 28 =	651.57	G 29 =	652.17
G 30 =	652.65	G 31 =	653.03	G 32 =	653.31	G 33 =	653.52	G 34 =	653.65
G 35 =	653.73	G 36 =	653.77	G 37 =	653.77	G 38 =	653.75	G 39 =	653.72
G 40 =	653.67	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	609.83	H 2 =	61C.06	H 3 =	610.34	H 4 =	610.68	H 5 =	611.09
H 6 =	611.57	H 7 =	612.14	H 8 =	612.8C	H 9 =	613.55	H 10 =	614.41
H 11 =	615.37	H 12 =	616.44	H 13 =	617.63	H 14 =	618.92	H 15 =	620.31
H 16 =	621.80	H 17 =	623.37	H 18 =	625.01	H 19 =	626.72	H 20 =	628.47
H 21 =	630.25	H 22 =	632.03	H 23 =	633.8C	H 24 =	635.55	H 25 =	637.25
H 26 =	638.90	H 27 =	64C.46	H 28 =	641.95	H 29 =	643.33	H 30 =	644.62
H 31 =	645.80	H 32 =	646.86	H 33 =	647.82	H 34 =	648.68	H 35 =	649.43
H 36 =	650.08	H 37 =	65C.65	H 38 =	651.13	H 39 =	651.54	H 40 =	651.88
=	.0	=	.0	=	.0	=	.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 1
Location x/L: 1.0 (OUT)
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 1 LOC=1 T:IN=610F T:OUT=1100.0 C/A=1.04374 MW/M2
A21=37.270 A22=124.65 A23=170.76 A24=133.49 A25=71.175

-4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1100.0	DT: NA =	490.00	T:B NA =	855.00	T:B M =	877.29
DT M-N =	37.270	DT1 =	124.65	DT P-N =	170.76	DT P-M =	133.49	DT2 =	71.175
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	613.06	N 2 =	616.77	N 3 =	621.20	N 4 =	626.45
N 5 =	632.62	N 6 =	635.78	N 7 =	648.01	N 8 =	657.39	N 9 =	667.97
N 10 =	679.77	N 11 =	692.81	N 12 =	707.08	N 13 =	722.53	N 14 =	739.11
N 15 =	756.71	N 16 =	775.21	N 17 =	794.47	N 18 =	814.31	N 19 =	834.55
N 20 =	855.00	N 21 =	875.45	N 22 =	895.69	N 23 =	915.53	N 24 =	934.79
N 25 =	953.29	N 26 =	970.89	N 27 =	987.47	N 28 =	1002.9	N 29 =	1017.2
N 30 =	1030.2	N 31 =	1042.0	N 32 =	1052.6	N 33 =	1062.0	N 34 =	1070.2
N 35 =	1077.4	N 36 =	1083.5	N 37 =	1088.8	N 38 =	1093.2	N 39 =	1096.9
N 40 =	1100.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.04	M 1 =	619.19	M 2 =	624.14	M 3 =	629.98	M 4 =	636.81
M 5 =	644.72	M 6 =	653.77	M 7 =	664.02	M 8 =	675.53	M 9 =	688.32
M 10 =	702.37	M 11 =	717.67	M 12 =	734.14	M 13 =	751.71	M 14 =	770.24
M 15 =	789.60	M 16 =	809.62	M 17 =	830.10	M 18 =	850.84	M 19 =	871.64
M 20 =	892.27	M 21 =	912.53	M 22 =	932.22	M 23 =	951.16	M 24 =	969.19
M 25 =	986.18	M 26 =	1002.0	M 27 =	1016.6	M 28 =	1030.0	M 29 =	1042.0
M 30 =	1052.8	M 31 =	1062.4	M 32 =	1070.7	M 33 =	1078.0	M 34 =	1084.2
M 35 =	1089.5	M 36 =	1093.9	M 37 =	1097.6	M 38 =	1100.6	M 39 =	1103.1
M 40 =	1105.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	633.11	P 1 =	641.15	P 2 =	650.56	P 3 =	661.45	P 4 =	673.93
P 5 =	686.05	P 6 =	703.87	P 7 =	721.37	P 8 =	740.51	P 9 =	761.21
P 10 =	783.34	P 11 =	806.70	P 12 =	831.08	P 13 =	856.19	P 14 =	881.74
P 15 =	907.41	P 16 =	932.84	P 17 =	957.72	P 18 =	981.69	P 19 =	1004.5
P 20 =	1025.8	P 21 =	1045.4	P 22 =	1063.1	P 23 =	1078.8	P 24 =	1092.4
P 25 =	1104.0	P 26 =	1113.5	P 27 =	1121.1	P 28 =	1126.9	P 29 =	1131.1
P 30 =	1133.8	P 31 =	1135.3	P 32 =	1135.7	P 33 =	1135.3	P 34 =	1134.3
P 35 =	1132.8	P 36 =	1131.0	P 37 =	1129.1	P 38 =	1127.0	P 39 =	1125.0
P 40 =	1123.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	623.48	G 1 =	625.44	G 2 =	636.48	G 3 =	644.68	G 4 =	654.14
G 5 =	664.95	G 6 =	677.16	G 7 =	690.80	G 8 =	705.87	G 9 =	722.35
G 10 =	740.18	G 11 =	759.24	G 12 =	779.40	G 13 =	800.49	G 14 =	822.30
G 15 =	844.60	G 16 =	867.15	G 17 =	889.68	G 18 =	911.93	G 19 =	933.65
G 20 =	954.59	G 21 =	974.54	G 22 =	993.31	G 23 =	1010.7	G 24 =	1026.7
G 25 =	1041.2	G 26 =	1054.1	G 27 =	1065.4	G 28 =	1075.2	G 29 =	1083.6
G 30 =	1090.6	G 31 =	1096.4	G 32 =	1101.1	G 33 =	1104.8	G 34 =	1107.6
G 35 =	1109.7	G 36 =	1111.2	G 37 =	1112.3	G 38 =	1112.9	G 39 =	1113.3
G 40 =	1113.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.94	H 2 =	611.81	H 3 =	615.25	H 4 =	619.49	H 5 =	624.48
H 6 =	630.37	H 7 =	637.25	H 8 =	645.20	H 9 =	654.28	H 10 =	664.57
H 11 =	676.10	H 12 =	688.88	H 13 =	702.92	H 14 =	718.18	H 15 =	734.60
H 16 =	752.08	H 17 =	770.52	H 18 =	789.75	H 19 =	809.62	H 20 =	829.94
H 21 =	850.52	H 22 =	871.13	H 23 =	891.58	H 24 =	911.66	H 25 =	931.18
H 26 =	949.96	H 27 =	967.85	H 28 =	984.73	H 29 =	1000.5	H 30 =	1015.0
H 31 =	1028.4	H 32 =	1040.4	H 33 =	1051.2	H 34 =	1060.8	H 35 =	1069.2
H 36 =	1076.6	H 37 =	1082.9	H 38 =	1088.3	H 39 =	1092.8	H 40 =	1096.6
=	.0	=	.0	=	.0	=	.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 2
Location x/L: 0.0 (OUT)
T(Na-inlet) = 610 F
T(Na-outlet) :
Max = 1100F

PNL 2 LOC=0 T:IN=610F T:OUT=1002.0 Q/A=1.04374 MW/M2
A21=37.270 A22=124.65 A23=170.76 A24=133.49 A25=71.175

A

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1002.0	DT: NA =	392.00	T:B NA =	806.00	T:B M =	828.29
DT M-N =	37.270	DT1 =	124.65	DT P-N =	170.76	DT P-M =	133.49	DT2 =	71.175
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	612.45	N 2 =	615.41	N 3 =	618.96	N 4 =	623.16
N 5 =	628.09	N 6 =	633.82	N 7 =	640.41	N 8 =	647.91	N 9 =	656.37
N 10 =	665.81	N 11 =	676.25	N 12 =	687.66	N 13 =	700.03	N 14 =	713.29
N 15 =	727.37	N 16 =	742.17	N 17 =	757.58	N 18 =	773.45	N 19 =	789.64
N 20 =	806.00	N 21 =	822.36	N 22 =	838.55	N 23 =	854.42	N 24 =	869.83
N 25 =	884.63	N 26 =	898.71	N 27 =	911.97	N 28 =	924.34	N 29 =	935.75
N 30 =	946.19	N 31 =	955.63	N 32 =	964.09	N 33 =	971.59	N 34 =	978.18
N 35 =	983.91	N 36 =	988.84	N 37 =	993.04	N 38 =	996.59	N 39 =	999.55
N 40 =	1002.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	615.04	M 1 =	618.58	M 2 =	622.79	M 3 =	627.75	M 4 =	633.52
M 5 =	640.19	M 6 =	647.81	M 7 =	656.42	M 8 =	666.06	M 9 =	676.73
M 10 =	688.42	M 11 =	701.11	M 12 =	714.73	M 13 =	729.20	M 14 =	744.42
M 15 =	760.26	M 16 =	776.57	M 17 =	793.21	M 18 =	809.98	M 19 =	826.73
M 20 =	843.27	M 21 =	859.44	M 22 =	875.08	M 23 =	890.05	M 24 =	904.23
M 25 =	917.52	M 26 =	929.84	M 27 =	941.14	M 28 =	951.40	M 29 =	960.61
M 30 =	968.79	M 31 =	975.98	M 32 =	982.23	M 33 =	987.60	M 34 =	992.17
M 35 =	996.01	M 36 =	999.20	M 37 =	1001.8	M 38 =	1004.0	M 39 =	1005.7
M 40 =	1007.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	633.11	P 1 =	640.54	P 2 =	649.21	P 3 =	659.21	P 4 =	670.64
P 5 =	683.53	P 6 =	697.91	P 7 =	713.76	P 8 =	731.03	P 9 =	749.62
P 10 =	769.39	P 11 =	790.14	P 12 =	811.66	P 13 =	833.68	P 14 =	855.92
P 15 =	878.06	P 16 =	899.80	P 17 =	920.82	P 18 =	940.83	P 19 =	959.55
P 20 =	976.76	P 21 =	992.26	P 22 =	1005.9	P 23 =	1017.7	P 24 =	1027.5
P 25 =	1035.3	P 26 =	1041.3	P 27 =	1045.6	P 28 =	1048.3	P 29 =	1049.6
P 30 =	1049.8	P 31 =	1048.9	P 32 =	1047.2	P 33 =	1044.9	P 34 =	1042.3
P 35 =	1039.3	P 36 =	1036.3	P 37 =	1033.3	P 38 =	1030.4	P 39 =	1027.6
P 40 =	1025.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	623.48	G 1 =	628.83	G 2 =	635.12	G 3 =	642.44	G 4 =	650.85
G 5 =	660.43	G 6 =	671.20	G 7 =	683.19	G 8 =	696.39	G 9 =	710.76
G 10 =	726.22	G 11 =	742.68	G 12 =	759.98	G 13 =	777.98	G 14 =	796.48
G 15 =	815.26	G 16 =	834.11	G 17 =	852.79	G 18 =	871.07	G 19 =	888.74
G 20 =	905.59	G 21 =	921.45	G 22 =	936.17	G 23 =	949.64	G 24 =	961.77
G 25 =	972.52	G 26 =	981.90	G 27 =	989.93	G 28 =	996.66	G 29 =	1002.2
G 30 =	1006.6	G 31 =	1010.0	G 32 =	1012.6	G 33 =	1014.4	G 34 =	1015.6
G 35 =	1016.2	G 36 =	1016.5	G 37 =	1016.5	G 38 =	1016.3	G 39 =	1015.9
G 40 =	1015.5	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.33	H 2 =	610.45	H 3 =	613.05	H 4 =	616.20	H 5 =	619.96
H 6 =	624.42	H 7 =	629.65	H 8 =	635.72	H 9 =	642.69	H 10 =	650.62
H 11 =	659.54	H 12 =	669.47	H 13 =	680.42	H 14 =	692.36	H 15 =	705.26
H 16 =	719.04	H 17 =	733.62	H 18 =	748.89	H 19 =	764.71	H 20 =	780.94
H 21 =	797.43	H 22 =	813.99	H 23 =	830.47	H 24 =	846.70	H 25 =	862.52
H 26 =	877.78	H 27 =	892.36	H 28 =	906.14	H 29 =	919.04	H 30 =	930.99
H 31 =	941.94	H 32 =	951.89	H 33 =	960.83	H 34 =	968.77	H 35 =	975.77
H 36 =	981.87	H 37 =	987.13	H 38 =	991.63	H 39 =	995.43	H 40 =	998.61
=	.0	=	.0	=	.0	=	.0		

CASE # 4

Solar Flux: OFF-NORMAL
Orifices: NO
Sub-Panel: 2
Location x/L: 1.0 (IN)
T(Na-inlet) = 610 F
T(Na-outlet) : Max = 1100F

PNL 2 LOC=1 T:IN=610F T:OUT=1100.0 Q/A=1.30468 MW/M2
A21=44.735 A22=149.71 A23=207.06 A24=162.33 A25=87.514

4

ITER NO. 2. GREATEST TEMPERATURE CHANGE PER ITERATION = .0 CRITICAL NODE = 2

T:NA IN =	610.00	T:NA OUT=	1100.0	DT: NA =	490.00	T:B NA =	855.00	T:B M =	881.76
DT M-N =	44.735	DT1 =	149.71	DT P-N =	207.06	DT P-M =	162.33	DT2 =	87.514
=	.0	=	.0	=	.0	=	.0	=	.0
N =	610.00	N 1 =	613.06	N 2 =	616.77	N 3 =	621.20	N 4 =	626.45
N 5 =	632.62	N 6 =	639.78	N 7 =	648.01	N 8 =	657.39	N 9 =	667.97
N 10 =	679.77	N 11 =	692.81	N 12 =	707.08	N 13 =	722.53	N 14 =	739.11
N 15 =	756.71	N 16 =	775.21	N 17 =	794.47	N 18 =	814.31	N 19 =	834.55
N 20 =	855.00	N 21 =	875.45	N 22 =	895.69	N 23 =	915.53	N 24 =	934.79
N 25 =	953.29	N 26 =	970.89	N 27 =	987.47	N 28 =	1002.9	N 29 =	1017.2
N 30 =	1030.2	N 31 =	1042.0	N 32 =	1052.6	N 33 =	1062.0	N 34 =	1070.2
N 35 =	1077.4	N 36 =	1083.5	N 37 =	1088.8	N 38 =	1093.2	N 39 =	1096.9
N 40 =	1100.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
M =	616.05	M 1 =	620.42	M 2 =	625.62	M 3 =	631.74	M 4 =	638.89
M 5 =	647.14	M 6 =	656.57	M 7 =	667.23	M 8 =	679.17	M 9 =	692.39
M 10 =	706.90	M 11 =	722.65	M 12 =	739.56	M 13 =	757.55	M 14 =	776.48
M 15 =	796.19	M 16 =	816.51	M 17 =	837.24	M 18 =	858.16	M 19 =	879.07
M 20 =	899.73	M 21 =	915.96	M 22 =	939.54	M 23 =	958.30	M 24 =	976.08
M 25 =	992.77	M 26 =	1008.3	M 27 =	1022.5	M 28 =	1035.4	M 29 =	1047.0
M 30 =	1057.4	M 31 =	1066.5	M 32 =	1074.4	M 33 =	1081.2	M 34 =	1087.0
M 35 =	1091.9	M 36 =	1096.0	M 37 =	1099.3	M 38 =	1102.1	M 39 =	1104.3
M 40 =	1106.1	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
P =	638.02	P 1 =	647.12	P 2 =	657.74	P 3 =	670.01	P 4 =	684.02
P 5 =	699.84	P 6 =	717.49	P 7 =	736.96	P 8 =	758.18	P 9 =	781.04
P 10 =	805.36	P 11 =	830.91	P 12 =	857.43	P 13 =	884.60	P 14 =	912.06
P 15 =	939.44	P 16 =	966.35	P 17 =	992.42	P 18 =	1017.3	P 19 =	1040.6
P 20 =	1062.1	P 21 =	1081.5	P 22 =	1098.6	P 23 =	1113.5	P 24 =	1125.9
P 25 =	1136.0	P 26 =	1143.8	P 27 =	1149.5	P 28 =	1153.3	P 29 =	1155.3
P 30 =	1155.8	P 31 =	1155.1	P 32 =	1153.4	P 33 =	1150.9	P 34 =	1147.9
P 35 =	1144.6	P 36 =	1141.1	P 37 =	1137.6	P 38 =	1134.2	P 39 =	1131.0
P 40 =	1128.0	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
G =	626.18	G 1 =	632.73	G 2 =	640.43	G 3 =	649.39	G 4 =	659.70
G 5 =	671.44	G 6 =	684.66	G 7 =	699.38	G 8 =	715.60	G 9 =	733.27
G 10 =	752.30	G 11 =	772.57	G 12 =	793.92	G 13 =	816.14	G 14 =	839.00
G 15 =	862.25	G 16 =	885.61	G 17 =	908.80	G 18 =	931.53	G 19 =	953.55
G 20 =	974.59	G 21 =	994.44	G 22 =	1012.9	G 23 =	1029.9	G 24 =	1045.2
G 25 =	1058.8	G 26 =	1070.8	G 27 =	1081.1	G 28 =	1089.8	G 29 =	1097.0
G 30 =	1102.8	G 31 =	1107.3	G 32 =	1110.8	G 33 =	1113.4	G 34 =	1115.1
G 35 =	1116.2	G 36 =	1116.8	G 37 =	1117.0	G 38 =	1116.9	G 39 =	1116.6
G 40 =	1116.2	=	.0	=	.0	=	.0	=	.0
=	.0	=	.0	=	.0	=	.0	=	.0
H 1 =	608.11	H 2 =	610.80	H 3 =	614.10	H 4 =	618.08	H 5 =	622.84
H 6 =	628.47	H 7 =	635.08	H 8 =	642.73	H 9 =	651.52	H 10 =	661.50
H 11 =	672.72	H 12 =	685.21	H 13 =	698.96	H 14 =	713.95	H 15 =	730.13
H 16 =	747.41	H 17 =	765.67	H 18 =	784.79	H 19 =	804.58	H 20 =	824.88
H 21 =	845.48	H 22 =	866.16	H 23 =	886.74	H 24 =	906.98	H 25 =	926.71
H 26 =	945.73	H 27 =	963.89	H 28 =	981.05	H 29 =	997.10	H 30 =	1012.0
H 31 =	1025.6	H 32 =	1037.9	H 33 =	1049.0	H 34 =	1058.9	H 35 =	1067.6
H 36 =	1075.2	H 37 =	1081.7	H 38 =	1087.3	H 39 =	1092.0	H 40 =	1095.9
=	.0	=	.0	=	.0	=	.0		

ADD-3 TUBE-MANIFOLD TAP THERMAL MODEL SETUP

Of special interest for transient thermal stress analysis is the location of the tube-manifold wall joint. A stress model (nodes and elements) had been set up. The coordinates of the nodes had been established. These coordinates are then to be used as input to the STAMP computer program which sets up a nodal-connector network for use with the TAP computer program. Figures Add-III-1 and Add-III-2 show the geometry and the node/element model of the joint area. Table Add-III-1 shows the STAMP input data.

The analysis was suspended prior to completion. This model data is recorded here for later use.

5370F/sjh

FIGURE Add-III-1

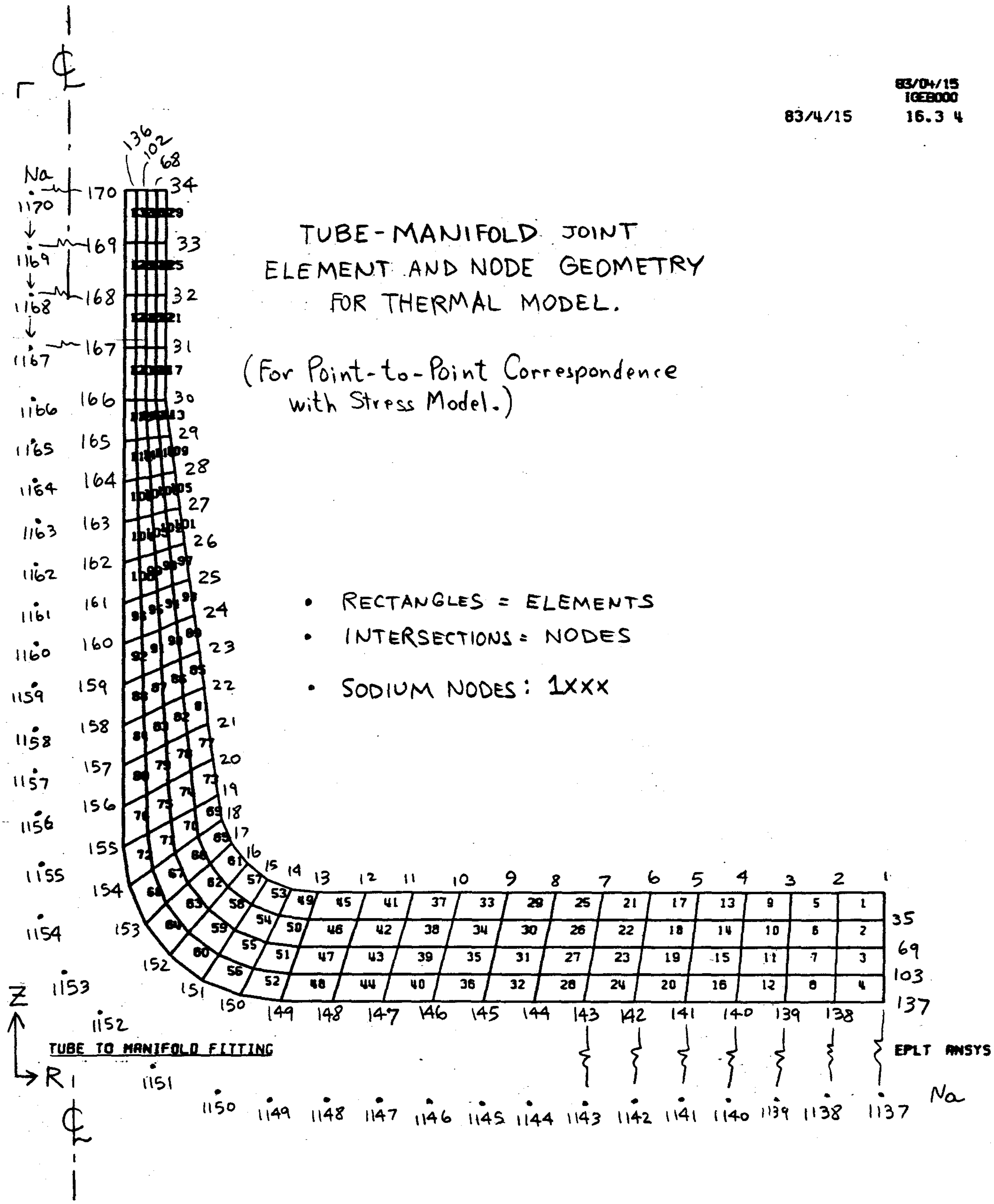


FIGURE Add-III-2

TUBE-MANIFOLD JOINT

STAMP OUT-PUT GEOMETRY

- RECTANGLES = ELEMENTS
- INTERSECTIONS = NODES

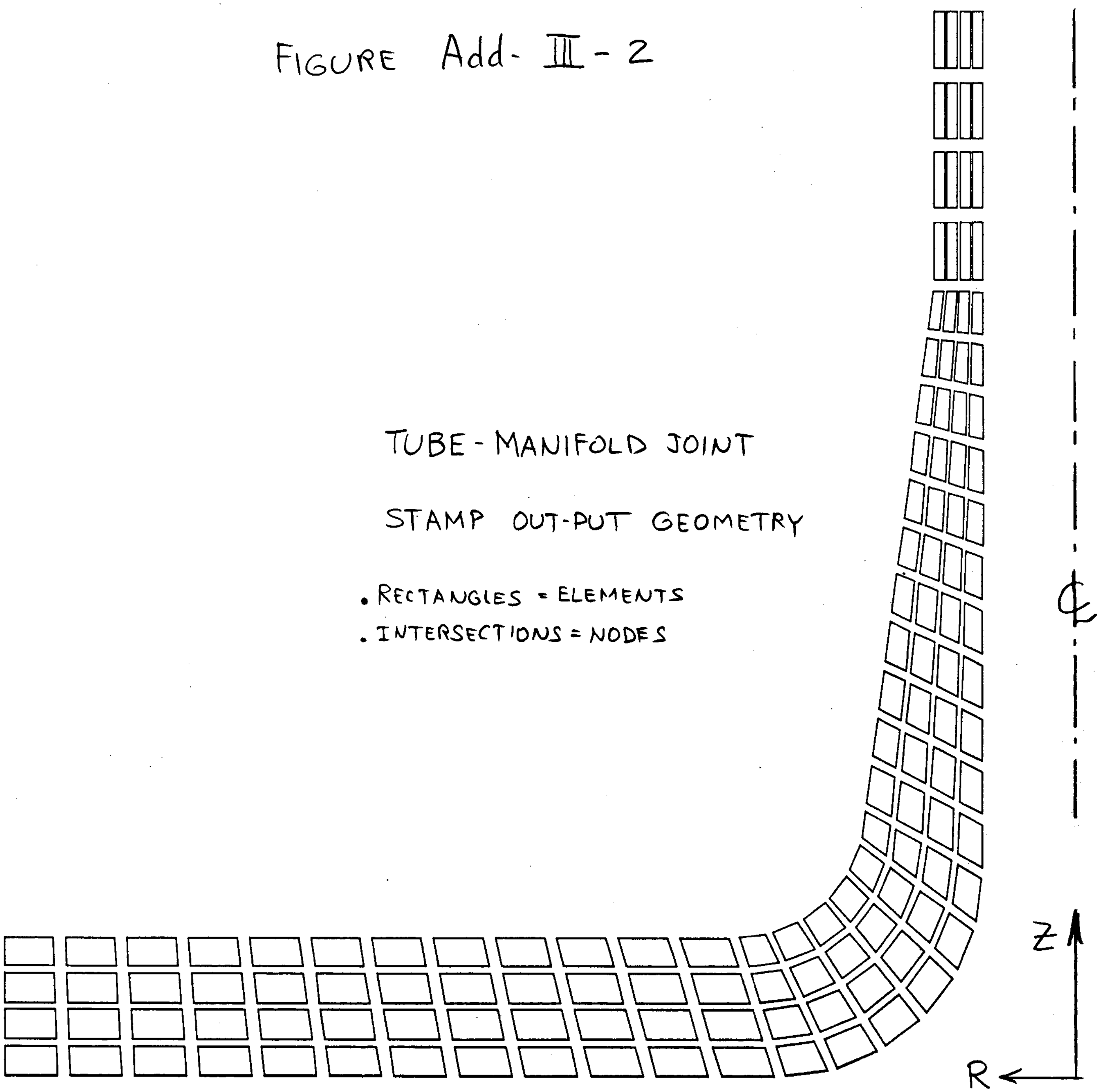


TABLE Add-III-1 (a)

"STAMP" INPUT

SHEET 1 OF 2

(TO GENERATE TAP NETWORK)

NODAL COORDINATES (Z, R)

170 NODES (STEEL)

132 ELEMENTS

NODES # ELEM

170 132 0 0 ← BODY OF REVOLUTION

Node	Z	R
1	Z=.13400	R=1.2500
2	.13400	1.1925
3	.13400	1.1350
4	.13400	1.0775
5	.13400	1.0200
6	.13400	.96250
7	.13400	.90500
8	.13400	.84750
9	.13400	.79000
10	.13400	.73250
11	.13400	.67500
12	.13400	.61750
13	.13400	.56000
14	.13809	.52894
15	.15008	.50000
16	.16915	.47515
17	.19400	.45608
18	.22294	.44409
19	.25400	.44000
20	.29818	.43409
21	.34236	.42818
22	.38655	.42227
23	.43073	.41636
24	.47491	.41045
25	.51909	.40455
26	.56327	.39864
27	.60745	.39273
28	.65164	.38682
29	.69582	.38091
30	.74000	.37500
31	.80500	.37500
32	.87000	.37500
33	.93500	.37500
34	1.0000	.37500
35	.10050	1.2500
36	.10050	1.1916
37	.10050	1.1332
38	.10050	1.0748
39	.10050	1.0163
40	.10050	.95792
41	.10050	.89950
42	.10050	.84108
43	.10050	.78267
44	.10050	.72425
45	.10050	.66583
46	.10050	.60742
47	.10050	.54900
48	.10519	.51341
49	.11892	.48025
50	.14077	.45177
51	.16925	.42992
52	.20241	.41619
53	.23800	.41150
54	.28364	.40707
55	.32927	.40264
56	.37491	.39820
57	.42055	.39377
58	.46618	.38934
59	.51182	.38491
60	.55745	.38048
61	.60309	.37605
62	.64873	.37161
63	.69436	.36718
64	.74000	.36275
65	.80500	.36275
66	.87000	.36275
67	.93500	.36275
68	1.0000	.36275
69	.06700	1.2500
70	.06700	1.1907
71	.06700	1.1313
72	.06700	1.0720
73	.06700	1.0127
74	.06700	.95333
75	.06700	.89400
76	.06700	.83467
77	.06700	.77533
78	.06700	.71600
79	.06700	.65667
80	.06700	.59733
81	.06700	.53800
82	.07228	.49788
83	.08777	.46050
84	.11240	.42840
85	.14450	.40377
86	.18188	.38828
87	.22200	.38300

Node	Z	R
88	.26909	.38005
89	.31618	.37709
90	.36327	.37414
91	.41036	.37118
92	.45745	.36823
93	.50455	.36527
94	.55164	.36232
95	.59873	.35936
96	.64582	.35641
97	.69291	.35345
98	.74000	.35050
99	.80500	.35050
100	.87000	.35050
101	.93500	.35050
102	1.0000	.35050
103	.03350	1.2500
104	.03350	1.1898
105	.03350	1.1295
106	.03350	1.0693
107	.03350	1.0090
108	.03350	.94875
109	.03350	.88850
110	.03350	.82825
111	.03350	.76800
112	.03350	.70775
113	.03350	.64750
114	.03350	.58725
115	.03350	.52700
116	.03938	.48235
117	.05661	.44075
118	.08402	.40502
119	.11975	.37761
120	.16135	.36038
121	.20600	.35450
122	.25455	.35302
123	.30309	.35155
124	.35164	.35007
125	.40018	.34859
126	.44873	.34711
127	.49727	.34564
128	.54582	.34416
129	.59436	.34268
130	.64291	.34120
131	.69145	.33973
132	.74000	.33825
133	.80500	.33825
134	.87000	.33825
135	.93500	.33825
136	1.0000	.33825
137	0.0	1.2500
138	0.0	1.1888
139	0.0	1.1277
140	0.	1.0665
141	0.	1.0053
142	0.	.94417
143	0.	.88300
144	0.	.82183
145	0.	.76067
146	0.	.69950
147	0.	.63833
148	0.	.57717
149	0.	.51600
150	.00647	.46682
151	.02546	.42100
152	.05565	.38165
153	.09500	.35146
154	.14082	.33247
155	.19000	.32600
156	.24000	.32600
157	.29000	.32600
158	.34000	.32600
159	.39000	.32600
160	.44000	.32600
161	.49000	.32600
162	.54000	.32600
163	.59000	.32600
164	.64000	.32600
165	.69000	.32600
166	.74000	.32600
167	.80500	.32600
168	.87000	.32600
169	.93500	.32600
170	1.0000	.32600

NO

TABLE Add-III-1 (b)

"STAMP" INPUT (TO GENERATE TAP NETWORK)

SHEET 2 OF 2

• ELEMENT CARDS

- Na → STEEL CONNECTORS

1=ELEM	1	2	36	35
2	35	36	70	69
3	69	70	104	103
4	138	137	103	104
5	2	3	37	36
6	36	37	71	70
7	70	71	105	104
8	139	138	104	105
9	3	4	38	37
10	37	38	72	71
11	71	72	106	105
12	140	139	105	106
13	4	5	39	38
14	38	39	73	72
15	72	73	107	106
16	141	140	106	107
17	5	6	40	39
18	39	40	74	73
19	73	74	108	107
20	142	141	107	108
21	6	7	41	40
22	40	41	75	74
23	74	75	109	108
24	143	142	108	109
25	7	8	42	41
26	41	42	76	75
27	75	76	110	109
28	144	143	109	110
29	8	9	43	42
30	42	43	77	76
31	76	77	111	110
32	145	144	110	111
33	9	10	44	43
34	43	44	78	77
35	77	78	112	111
36	146	145	111	112
37	10	11	45	44
38	44	45	79	78
39	78	79	113	112
40	147	146	112	113
41	11	12	46	45
42	45	46	80	79
43	79	80	114	113
44	148	147	113	114
45	12	13	47	46
46	46	47	81	80
47	80	81	115	114
48	149	148	114	115
49	13	14	48	47
50	47	48	82	81
51	81	82	116	115
52	150	149	115	116
53	14	15	49	48
54	48	49	83	82
55	82	83	117	116
56	151	150	116	117
57	15	16	50	49
58	49	50	84	83
59	83	84	118	117
60	152	151	117	118
61	16	17	51	50
62	50	51	85	84
63	84	85	119	118
64	153	152	118	119
65	17	18	52	51
66	51	52	86	85
67	85	86	120	119
68	154	153	119	120
69	18	19	53	52
70	52	53	87	86
71	86	87	121	120
72	155	154	120	121
73	19	20	54	53
74	53	54	88	87
75	87	88	122	121
76	156	155	121	122
77	20	21	55	54
78	54	55	89	88
79	88	89	123	122
80	157	156	122	123
81	21	22	56	55
82	55	56	90	89
83	89	90	124	123
84	158	157	123	124
85	22	23	57	56
86	56	57	91	90
87	90	91	125	124
88	159	158	124	125
89	23	24	58	57
90	57	58	92	91
91	91	92	126	125
92	160	159	125	126
93	24	25	59	58
94	58	59	93	92
95	92	93	127	126
96	161	160	126	127
97	25	26	60	59
98	59	60	94	93
99	93	94	128	127
100	162	161	127	128
101	26	27	61	60
102	60	61	95	94
103	94	95	129	128
104	163	162	128	129
105	27	28	62	61
106	61	62	96	95
107	95	96	130	129
108	164	163	129	130
109	28	29	63	62
110	62	63	97	96
111	96	97	131	130
112	165	164	130	131
113	29	30	64	63
114	63	64	98	97
115	97	98	132	131
116	166	165	131	132
117	30	31	65	64
118	64	65	99	98
119	98	99	133	132
120	167	166	132	133
121	31	32	66	65
122	65	66	100	99
123	99	100	134	133
124	168	167	133	134
125	32	33	67	66
126	66	67	101	100
127	100	101	135	134
128	169	168	134	135
129	33	34	68	67
130	67	68	102	101
131	101	102	136	135
132	170	169	135	136

1137=Na	137=Steel
1138	138
1139	139
1140	140
1141	141
1142	142
1143	143
1144	144
1145	145
1146	146
1147	147
1148	148
1149	149
1150	150
1151	151
1152	152
1153	153
1154	154
1155	155
1156	156
1157	157
1158	158
1159	159
1160	160
1161	161
1162	162
1163	163
1164	164
1165	165
1166	166
1167	167
1168	168
1169	169
1170	170
-1	

0.0	0.35	0.30	0.80
Z_{min}	Z_{max}	R_{min}	R_{max}

Rockwell International
Energy Systems Group

SUPPORTING DOCUMENT

GO NO.	S/A NO.	PAGE 1 OF	TOTAL PAGES	REV LTR/CHG NO (SEE SUMMARY OF CHG)	NUMBER
09479	13120	168	168	NC	079TI000001

PROGRAM TITLE
Solar Central Receiver Power PLant - Carrizo Plains, Unit No. 1

DOCUMENT TITLE
Preliminary Design Structural Analysis - Carrizo Plains Solar Receiver Subsystem

DOCUMENT TYPE
Technical Information

KEY NOUNS

ORIGINAL ISSUE DATE

REL. DATE 3-14-83 RK

PREPARED BY/DATE — W. R. Castle — DEPT 731 — MAIL ADDR LB30

APPROVALS — H. M. Minami, Jr. — DATE 3/10/83

IR&D PROGRAM? YES ☐ NO ☐
IF YES, ENTER TPA NO.

DISTRIBUTION

*	NAME	MAIL ADDR
	H. Minami, Jr.	LB30
*	E. Mouradian	LB30
	L. Rico	LB30
	B. Katz	LA19
*	A. Ullman	LA19
*	L. Glasgow	LA19
	J. Ives	LA19
	T. Anderson	LB26
*	J. Miller	LA19
	T. Springer	LA21
*	T. Johnson (4)	LA19
*	W. Propes	LB30
*	C. Wahnsiedler	LB30
*	W. Castle (3)	LB30

* COMPLETE DOCUMENT
NO ASTERISK, TITLE PAGE/SUMMARY OF CHANGE PAGE ONLY

ABSTRACT

This report documents the Preliminary Design analysis of the Carrizo Plains Receiver Subsystem. The analysis was performed in accordance with the requirements of the Rockwell International Receiver Specification N10049.

Basic Code analyses were performed to demonstrate the gross structural integrity of the overall receiver subsystem under design condition loadings. Analyses of critical components of the receiver under combined loading were also performed.

Further analyses are required to verify the structural adequacy of the entire receiver subsystem design.

FORM 734-C REV. 12-79

TABLE OF CONTENTS

TABLES

FIGURES

DRAWINGS

1.0 INTRODUCTION

The receiver subsystem is one of the most critical components in the 30MWe solar central power station which is to be constructed at the Carrizo Plains site, approximately 66 miles North of Santa Barbara in San Luis Obispo County, California. This report documents the receiver subsystem stress analyses and evaluations performed, to date, during the Preliminary Design phase of the program.

The evaluations contained in this report are intended to demonstrate that the proposed design configuration satisfies the gross requirements of the various structural design Codes for the conditions contained in the receiver Design Specification (Reference 1). The structural criteria, design requirements, and the specific areas of the design evaluated to date are presented in the report. In addition, areas which require further analyses are identified. This report will be updated as the design continues its evolution through the Preliminary and Final Design phases.

2.0 SUMMARY

The receiver subsystem sits atop the tower structure in the center of a field of mirrored helostats which focus and concentrate the rays of the sun on the receiver panels. The panels consist of an array of stainless steel tubes in which liquid sodium flows, collecting the solar heat. The main components of the receiver subsystem are the panel tubes, the inlet and outlet headers, the tube support tangs, the panel support hatbands, the support rods, and the receiver support frame steel structure. A description of the receiver design is presented in Section 3.1 of this report.

The structural design conditions specified for the receiver subsystem consist of internal pressure, deadweight, seismic, and wind loadings. The design temperature of the sodium pressure boundary components is 1050°F. The structural criteria to be used for the sodium containing pressure boundary are Section VIII of the ASME Boiler and Pressure Vessel Code, and Section B31.1 of the ANSI Power Piping Code. Supplementary creep-fatigue criteria are also applied to the high temperature sodium pressure boundary using the methodology of ASME Code Case N-47. The frame steel receiver support structure is designed in accordance with AISC Manual of Steel Construction. Details of the structural criteria and design loading combinations are contained in Sections 3.2 and 3.3 of this report.

The analyses and evaluations performed to date indicate that the proposed receiver design configuration satisfies the gross structural requirements and criteria described above. The detail analyses performed are presented in the Appendices to this report for the following receiver components:

1. Panel Sodium Tubes
2. Tube Support Tangs
3. Panel Support Band (Hatbands)

4. Panel Support Rods
5. Inlet and Outlet Headers
6. Receiver Support Box and Truss

The analyses of these components under the specified loading combinations, and the evaluations performed in accordance with the appropriate structural criteria are summarized in Table 1. All design margins are positive, which demonstrates the feasibility of the overall design concept.

Although the overall design has been shown to meet the gross structural design requirements, additional analyses are required to complete the structural evaluation and to confirm the structural integrity of the receiver subsystem. The following areas require additional or new analysis:

1. Header Structural Analysis
    a. Inlet and Outlet Headers - ASME Section VIII
    b. Inlet and Outlet Headers - Header to Tube Transition
2. Transient Analysis
    a. Analyze thermal transient conditions for the receiver tubes and headers
3. Receiver Life Evaluation
    a. Evaluate the creep-fatigue damage fractions for the receiver subsystem
4. Tube Support Tangs
    a. Additional analyses for beam column effects
5. Inboard Receiver Panel Analyses
    a. Analyze the inboard receiver panels for normal and off-normal flux distributions
6. Receiver Support Structure
    a. Aanalze the support structure for the receiver panel
7. Shipping and Handling Analyses

TABLE 1

SUMMARY OF RESULTS

Component	Type of Loading	Material	Criteria	Stress Calculated	Values Allowable	Design Margin	Ref. Page
Sodium Tubes	Pressure	SS316	Section VIII	100 psi	2000 psi	High	61
Sodium Tubes (Thermal Window)	Thermal Expansion	SS316	ANSI B31.1	17320 psi	18900 psi	0.09	95
Sodium Tubes (Thermal Window)	Thermal Expansion + Sustained Loads	SS316	ANSI B31.1	17943 psi	33400 psi	0.86	95
Sodium Tubes (Shaded Area)	Thermal Expansion	SS316	ANSI B31.1	11790 psi	18900 psi	0.60	96
Sodium Tubes (Shaded Area)	Thermal Expansion + Sustained Loads	SS316	ANSI B31.1	15280psi	33400 psi	1.18	96
Tangs	DW + TE + + Seis + Wind	SS304	AISC	0.66	1.00	0.51	107
Hatbands	DW + TE + Seis + Wind	ASTMA 366	AISC	0.39	1.00	1.56	116
Support Rods	DW + TE + Seis + Wind	ASTMA 519	AISC	1720 psi	11900 psi	5.93	120
Inlet and Outlet Headers	DW + TE + + Seis + Wind	SS316	ANSI B31.1	7130 psi	18900 psi	1.65	123
Support Box Section	DW + TE + + Seis + Wind	SS304	AISC	0.74	1.00	0.35	129
Support Truss	DW + TE + + Seis + Wind	ASTM A36	AISC	0.29	1.00	2.45	134

3.0 DISCUSSION

The following section describes the structural criteria, loading combinations, material properties, material allowable stresses and the methods of analysis.

3.1 Design Description

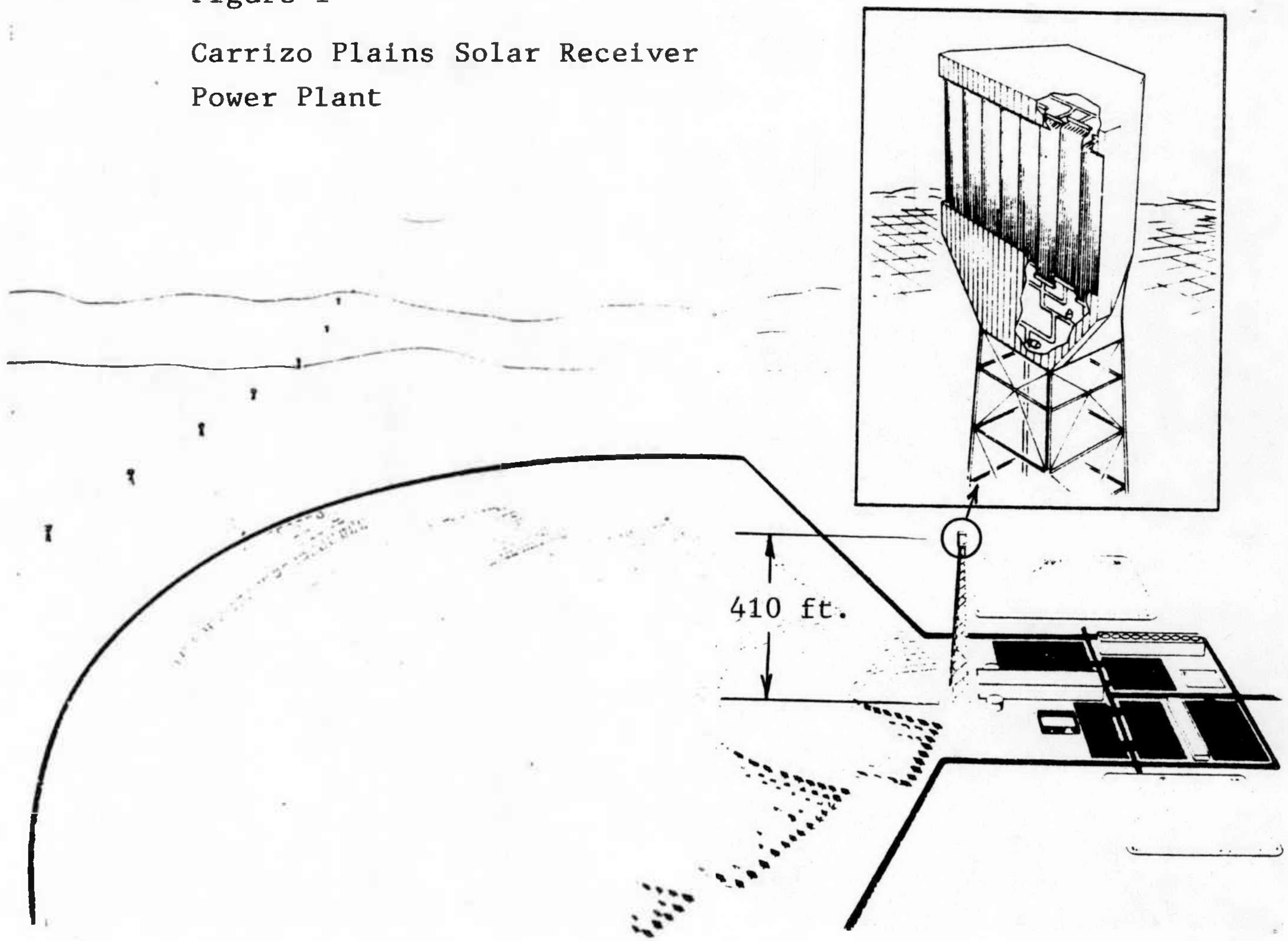
The receiver and its support structure are located atop a 365 foot steel truss type tower. The mid-plane height of the receiver is at 410 feet above ground level, as shown in Figure 1. The receiver assembly consists of eight panels approximately 52 feet in width and 50 feet in height. The receiver aperture (thermal flux window) is approximately 40 feet in height and extends from approximately 4 feet above the lower sodium inlet header of the panel to approximately 6 feet below the sodium outlet header. Each panel consists of 102 Type 316 stainless steel tubes with a diameter of 0.75 inches and a wall thickness of 0.049 inches.

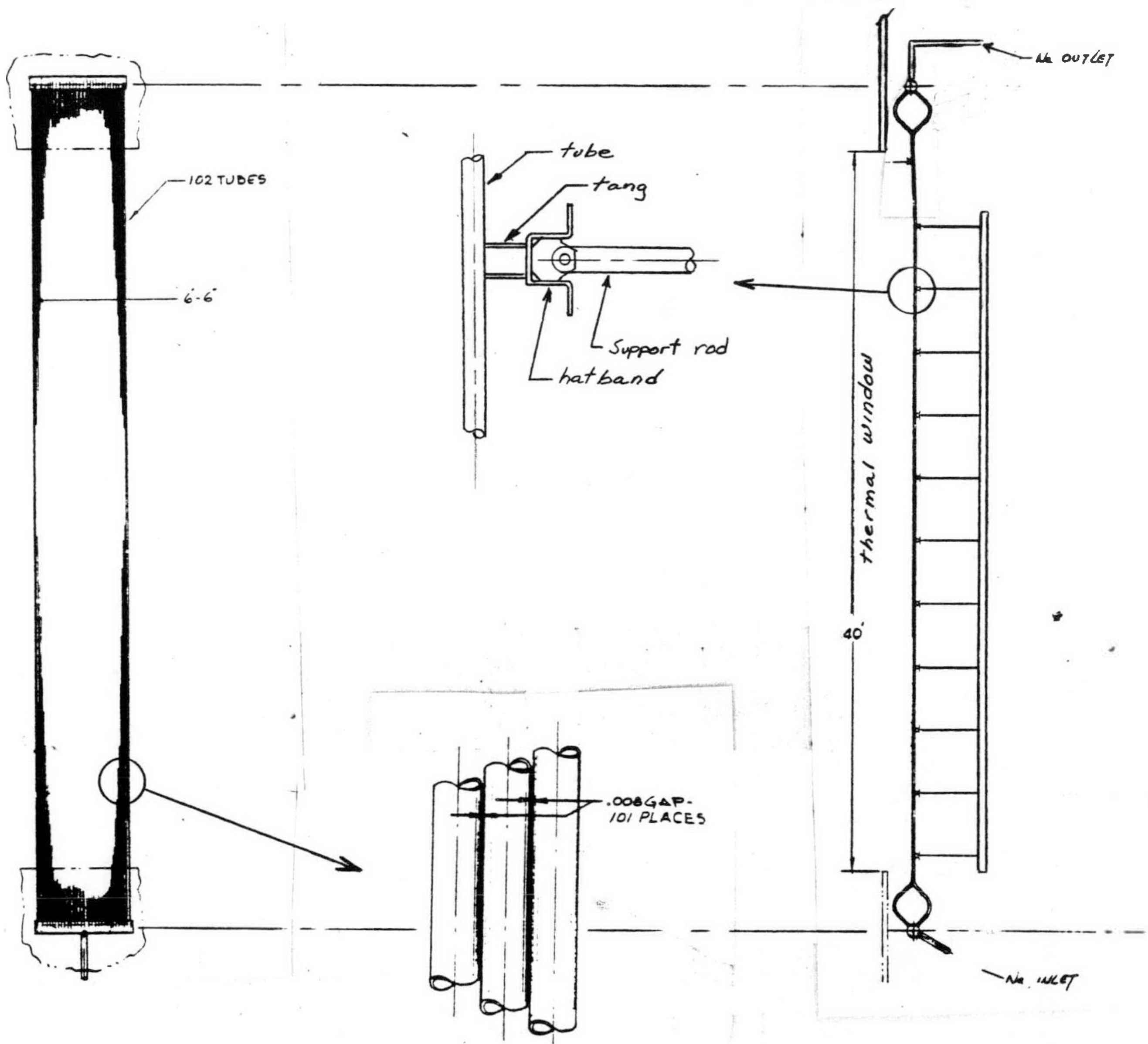
The sodium tubes are supported by 0.105 inch diameter rods (tangs) which are attached to "hatband" type support sections. The "hatband" sections are connected to tie rods (free to translate in the direction of thermal growth) that are attached to the rigid structure of the strong back of the receiver. Details of this tube support system are shown in Figure 2 and the enclosed design layout drawings.

The sodium tubes interface at both the upper and lower ends with 6.0 inch diameter headers with a wall thickness of 0.375 inches. The headers are supported in the horizontal planes but are free to move vertically. The inlet and outlet headers are shown in the enclosed layout drawings.

Figure 1

Carrizo Plains Solar Receiver Power Plant

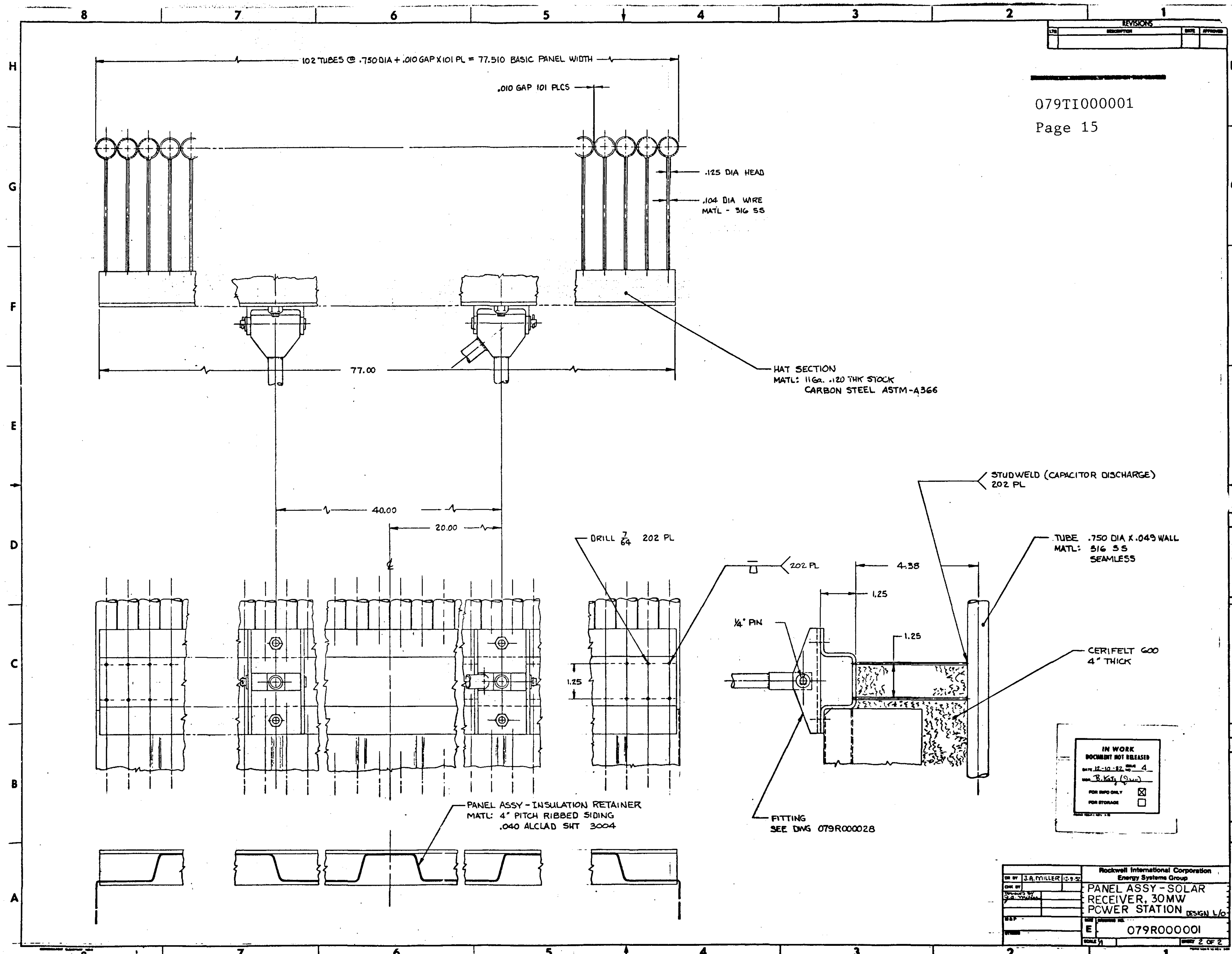


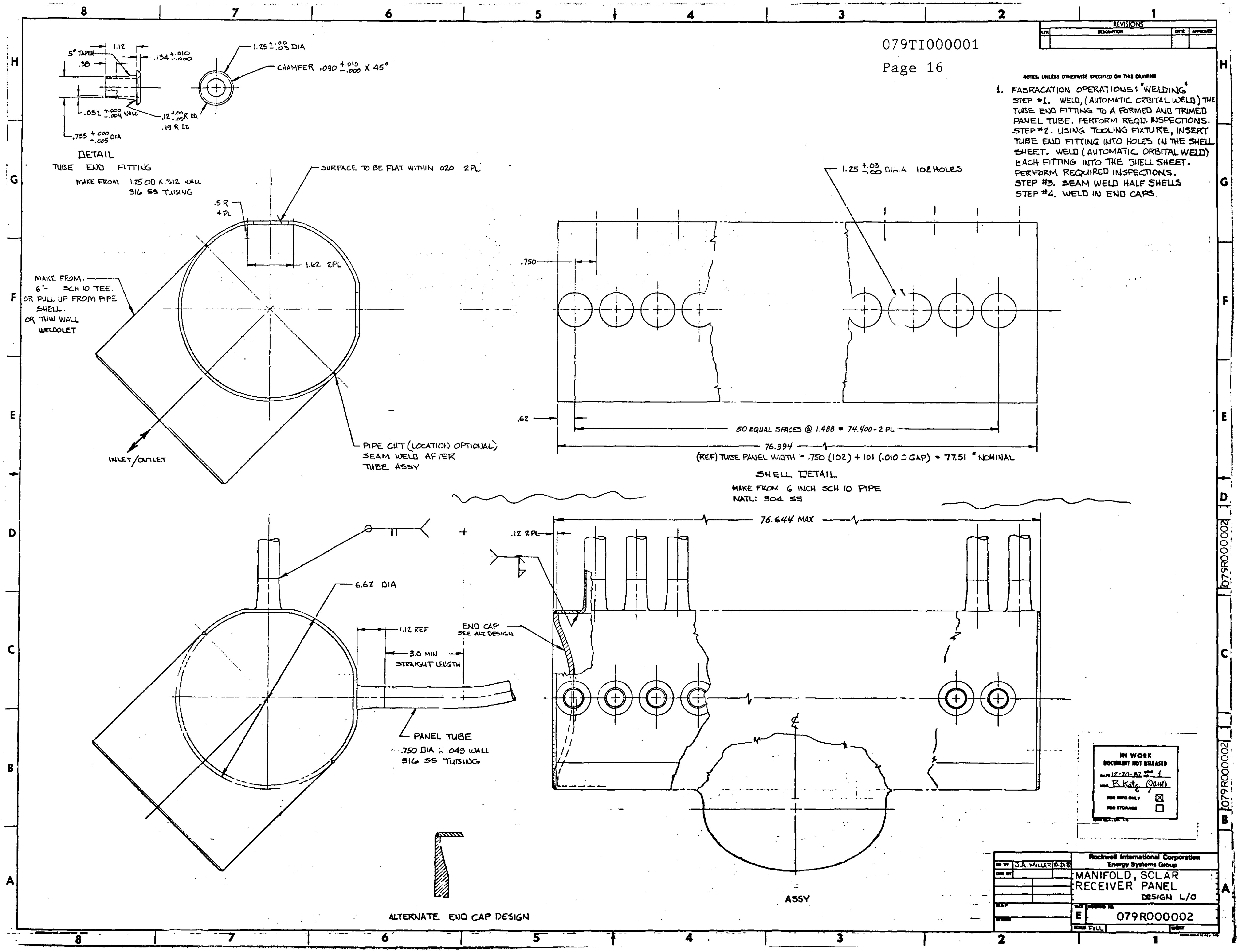


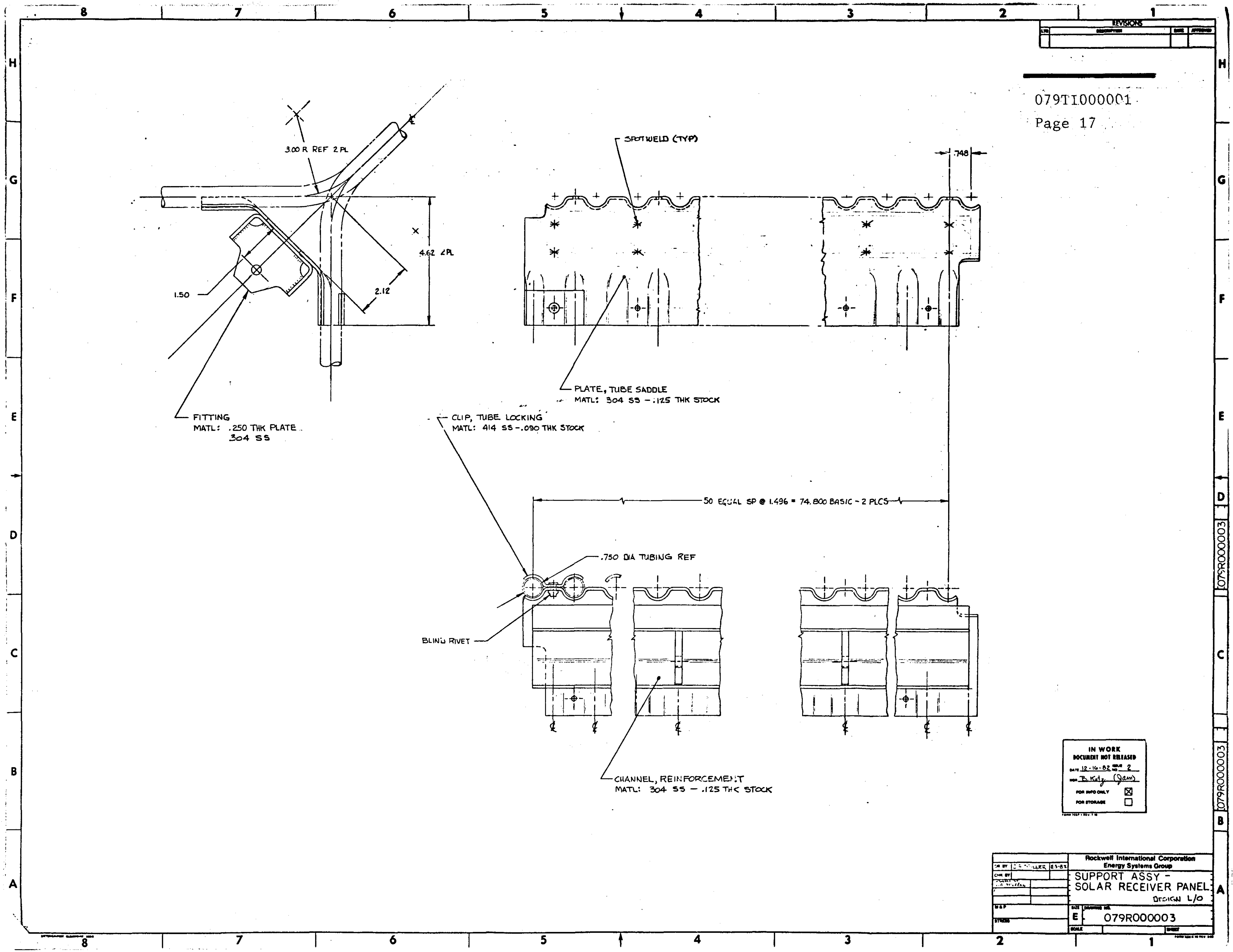
CARRIZO PLAINS SOLAR RECEIVER DETAILS

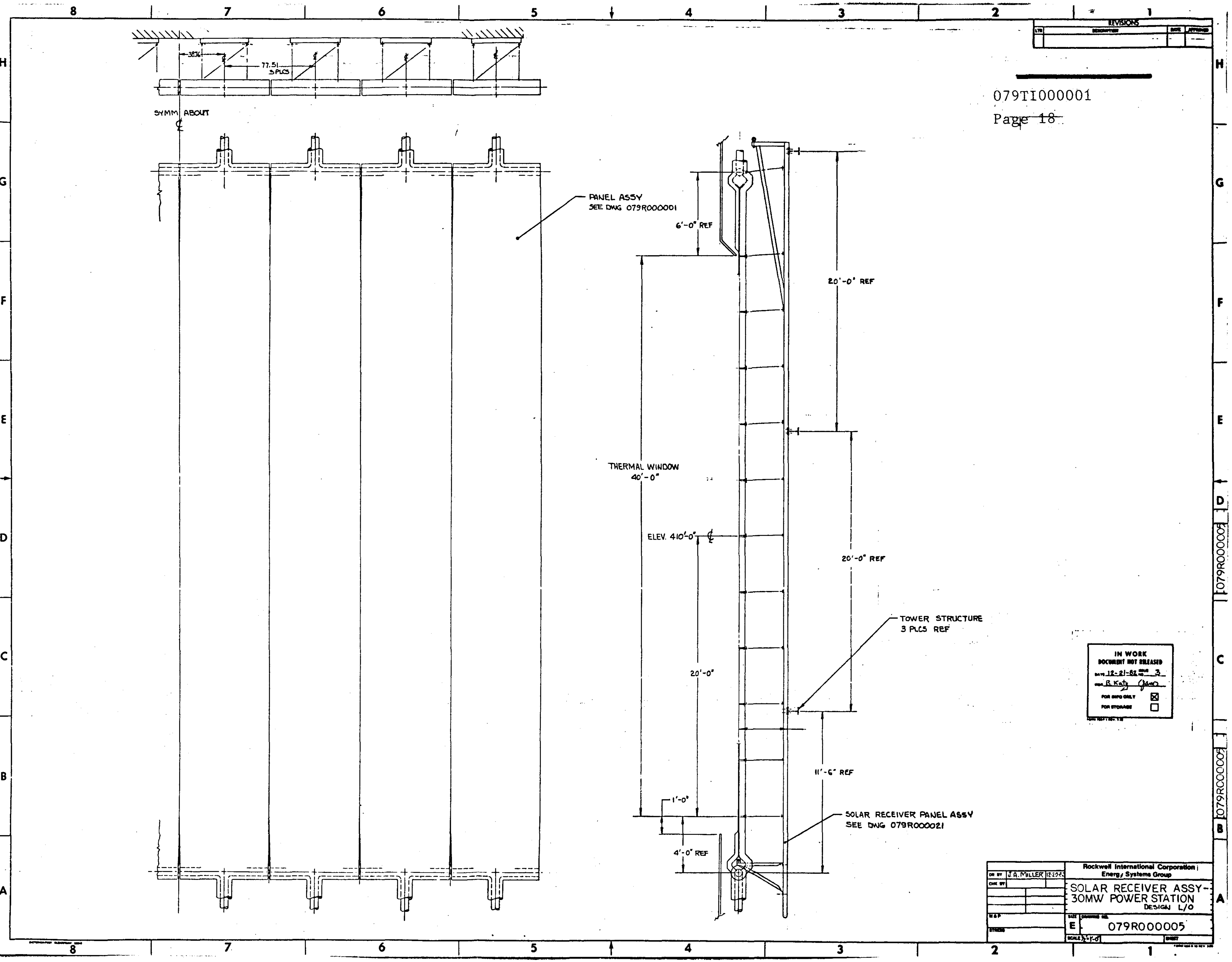
Figure 2

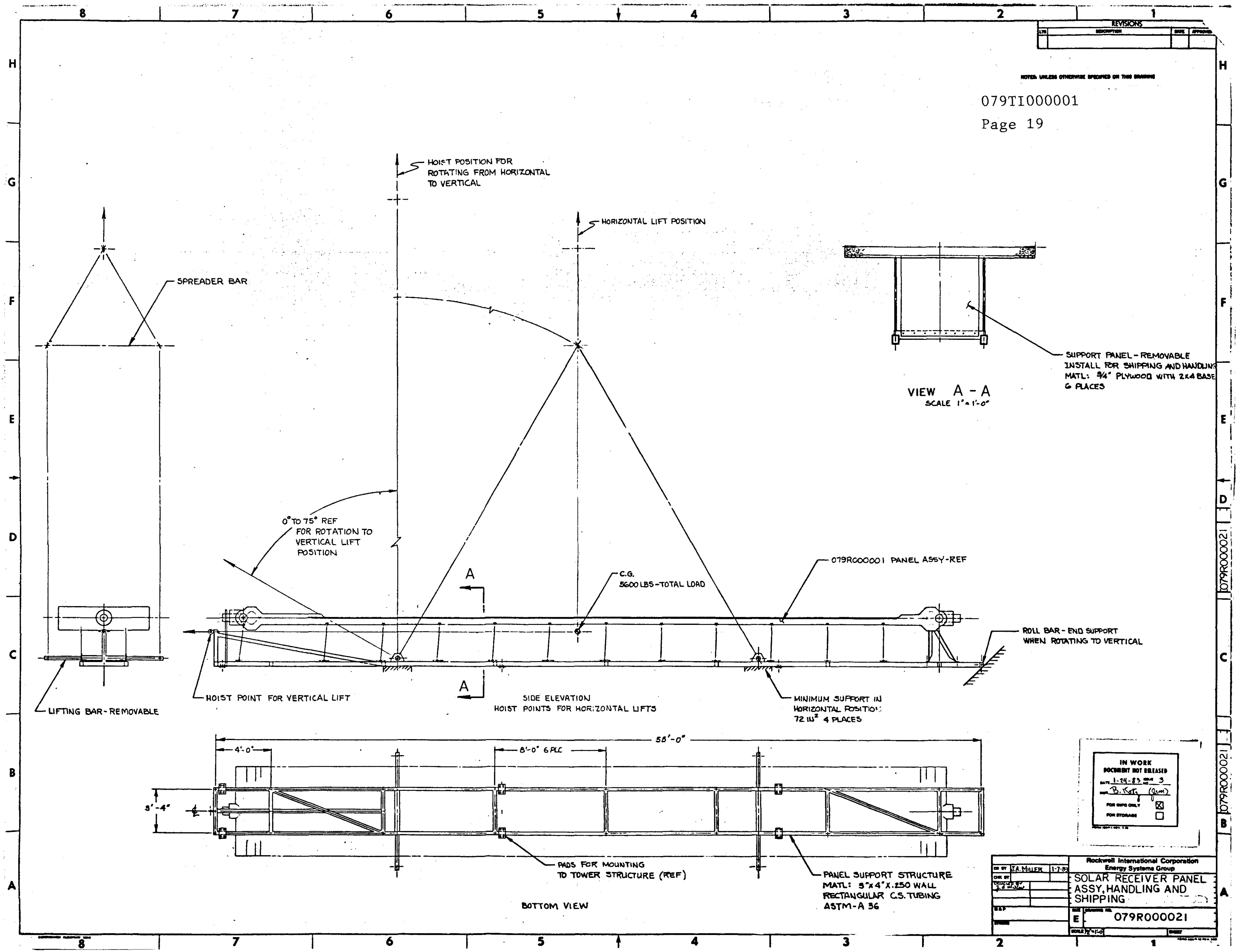

REVISIONS
NOTES: UNLESS OTHERWISE SPECIFIED ON THIS DRAWING
76.50 BASIC REF
.010 GAP BETWEEN TUBES
SUPPORT COVER, INSULATION
MATL: RIBBED SIDING; 4" PITCH - .040 TK
INSULATION
MATL: CERAFELT 600; 6 LBS/FT³ X 5" TK
72.51
40.00 REF
VIEW A - A
HEATER RODS
TYPICAL FOR BOTH ENDS
NO 10 RIVNUT & SCREW
3.50
2.85
TIE BAR ASSY
SEE DWG 079R000028
42.00
PANEL SUPPORT - INTERFACE REF
10.00 BASIC
PANEL SUPPORT ASSY
MATL: STRUCTURAL TEE 5 x 2½ x .31
ASTM-A36
5.625 REF
SEE DETAIL ON SH 2
45° REF
PANEL SUPPORT CHANNEL
SEE DWG 079R000003
3.00 R
MANIFOLD ASSY
SEE DWG 079R000002
15.0 REF
12.00 REF
TOP OF WINDOW REF
.25" STEEL PLATE-REF
INSULATION BOARD 1½" THICK, REF
600.00"
528.0"
480.0"
432.0"
384.0"
336.0"
288.0"
240.0"
192.0"
144.0"
96.0"
48.0"
Rockwell International Corporation
Energy Systems Group
079R000001
J A MILLER
PANEL ASSY - SOLAR RECEIVER, 30MW FOWER STATION
SHEET 1 OF 2


102 TUBES @ .750 DIA + .010 GAP X 101 PL = 77.510 BASIC PANEL WIDTH
.010 GAP 101 PLCS
.125 DIA HEAD
.104 DIA WIRE
MATL - 316 SS
77.00
HAT SECTION
MATL: 11 Ga. .120 THK STOCK
CARBON STEEL ASTM-A366
STUDWELD (CAPACITOR DISCHARGE)
202 PL
40.00
20.00
DRILL 7/64 202 PL
202 PL
4.38
1.25
1/4" PIN
1.25
1.25
TUBE .750 DIA X .049 WALL
MATL: 316 SS
SEAMLESS
CERIFELT 600
4" THICK
FITTING
SEE DWG 079R000028
PANEL ASSY - INSULATION RETAINER
MATL: 4" PITCH RIBBED SIDING
.040 ALCLAD SHT 3004
IN WORK
DOCUMENT NOT RELEASED
FOR INFO ONLY
FOR STORAGE
REVISIONS
J.A. MILLER
Rockwell International Corporation
Energy Systems Group
PANEL ASSY - SOLAR
RECEIVER, 30MW
POWER STATION
DESIGN L/O
E
079R000001
SHEET 2 OF 2
079R000001


DETAIL
TUBE END FITTING
MAKE FROM 1.25 OD X .312 WALL 316 SS TUBING
5° TAPER
1.12
.38
.134 +.010 -.000
1.25 +.00 -.03 DIA
CHAMFER .090 +.010 -.000 X 45°
.052 +.000 -.004 WALL
.12 +.00 -.03 R OD
.19 R ID
.755 +.000 -.005 DIA
SURFACE TO BE FLAT WITHIN .020 2 PL
.5 R 4 PL
1.62 2 PL
MAKE FROM: 6" SCH 10 TEE. OR PULL UP FROM PIPE SHELL. OR THIN WALL WELDOLET
INLET/OUTLET
PIPE CUT (LOCATION OPTIONAL) SEAM WELD AFTER TUBE ASSY
1.25 +.03 -.00 DIA 102 HOLES
.750
.62
50 EQUAL SPACES @ 1.488 = 74.400 - 2 PL
76.394
(REF) TUBE PANEL WIDTH = .750 (102) + 101 (.010 GAP) = 77.51" NOMINAL
SHELL DETAIL
MAKE FROM 6 INCH SCH 10 PIPE
MATL: 304 SS
NOTES: UNLESS OTHERWISE SPECIFIED ON THIS DRAWING
1. FABRACATION OPERATIONS: "WELDING"
STEP #1. WELD, (AUTOMATIC ORBITAL WELD) THE TUBE END FITTING TO A FORMED AND TRIMED PANEL TUBE. PERFORM REQD. INSPECTIONS.
STEP #2. USING TOOLING FIXTURE, INSERT TUBE END FITTING INTO HOLES IN THE SHELL SHEET. WELD (AUTOMATIC ORBITAL WELD) EACH FITTING INTO THE SHELL SHEET. PERFORM REQUIRED INSPECTIONS.
STEP #3. SEAM WELD HALF SHELLS
STEP #4. WELD IN END CAPS.
REVISIONS
6.62 DIA
1.12 REF
3.0 MIN STRAIGHT LENGTH
PANEL TUBE
.750 DIA X .049 WALL 316 SS TUBING
END CAP SEE ALT DESIGN
.12 2 PL
76.644 MAX
ALTERNATE END CAP DESIGN
ASSY
IN WORK
DOCUMENT NOT RELEASED
FOR INFO ONLY ☒
FOR STORAGE ☐
J.A. MILLER
Rockwell International Corporation
Energy Systems Group
MANIFOLD, SOLAR RECEIVER PANEL DESIGN L/O
E 079R000002
SCALE FULL
079R000002


3.00 R REF 2 PL
4.62 2 PL
1.50
2.12
FITTING
MATL: .250 THK PLATE
304 SS
SPOTWELD (TYP)
.748
PLATE, TUBE SADDLE
MATL: 304 SS - .125 THK STOCK
CLIP, TUBE LOCKING
MATL: 414 SS - .090 THK STOCK
50 EQUAL SP @ 1.496 = 74.800 BASIC - 2 PLCS
.750 DIA TUBING REF
BLIND RIVET
CHANNEL, REINFORCEMENT
MATL: 304 SS - .125 THK STOCK
REVISIONS
IN WORK
DOCUMENT NOT RELEASED
DATE 12-16-82 ISSUE NO. 2
FOR INFO ONLY
FOR STORAGE
079R000003
Rockwell International Corporation
Energy Systems Group
SUPPORT ASSY -
SOLAR RECEIVER PANEL
DESIGN L/O
E
079R000003


REVISIONS
SYMM ABOUT ℄
38¾
77.51
3 PLCS
PANEL ASSY
SEE DWG 079R000001
6'-0" REF
20'-0" REF
THERMAL WINDOW
40'-0"
ELEV. 410'-0" ℄
20'-0" REF
20'-0"
TOWER STRUCTURE
3 PLCS REF
11'-6" REF
1'-0"
4'-0" REF
SOLAR RECEIVER PANEL ASSY
SEE DWG 079R000021
IN WORK
DOCUMENT NOT RELEASED
12-21-82 3
B. Katz
FOR INFO ONLY
FOR STORAGE
J.A. MILLER
Rockwell International Corporation
Energy Systems Group
SOLAR RECEIVER ASSY--
30MW POWER STATION
DESIGN L/O
E
079R000005
079R000005


REVISIONS
HOIST POSITION FOR ROTATING FROM HORIZONTAL TO VERTICAL
HORIZONTAL LIFT POSITION
SPREADER BAR
SUPPORT PANEL - REMOVABLE INSTALL FOR SHIPPING AND HANDLING MATL: 3/4" PLYWOOD WITH 2X4 BASE 6 PLACES
VIEW A - A
SCALE 1" = 1'-0"
0° TO 75° REF FOR ROTATION TO VERTICAL LIFT POSITION
079R000001 PANEL ASSY-REF
C.G. 5600 LBS-TOTAL LOAD
A
A
ROLL BAR - END SUPPORT WHEN ROTATING TO VERTICAL
LIFTING BAR - REMOVABLE
HOIST POINT FOR VERTICAL LIFT
SIDE ELEVATION
HOIST POINTS FOR HORIZONTAL LIFTS
MINIMUM SUPPORT IN HORIZONTAL POSITION 72 IN² 4 PLACES
4'-0"
8'-0" 6 PLC
55'-0"
5'-4"
PADS FOR MOUNTING TO TOWER STRUCTURE (REF)
PANEL SUPPORT STRUCTURE MATL: 5"x4"x.250 WALL RECTANGULAR C.S. TUBING ASTM-A 36
BOTTOM VIEW
IN WORK
DOCUMENT NOT RELEASED
FOR INFO ONLY
FOR STORAGE
T.A. MILLER
Rockwell International Corporation
Energy Systems Group
SOLAR RECEIVER PANEL ASSY, HANDLING AND SHIPPING
E
079R000021

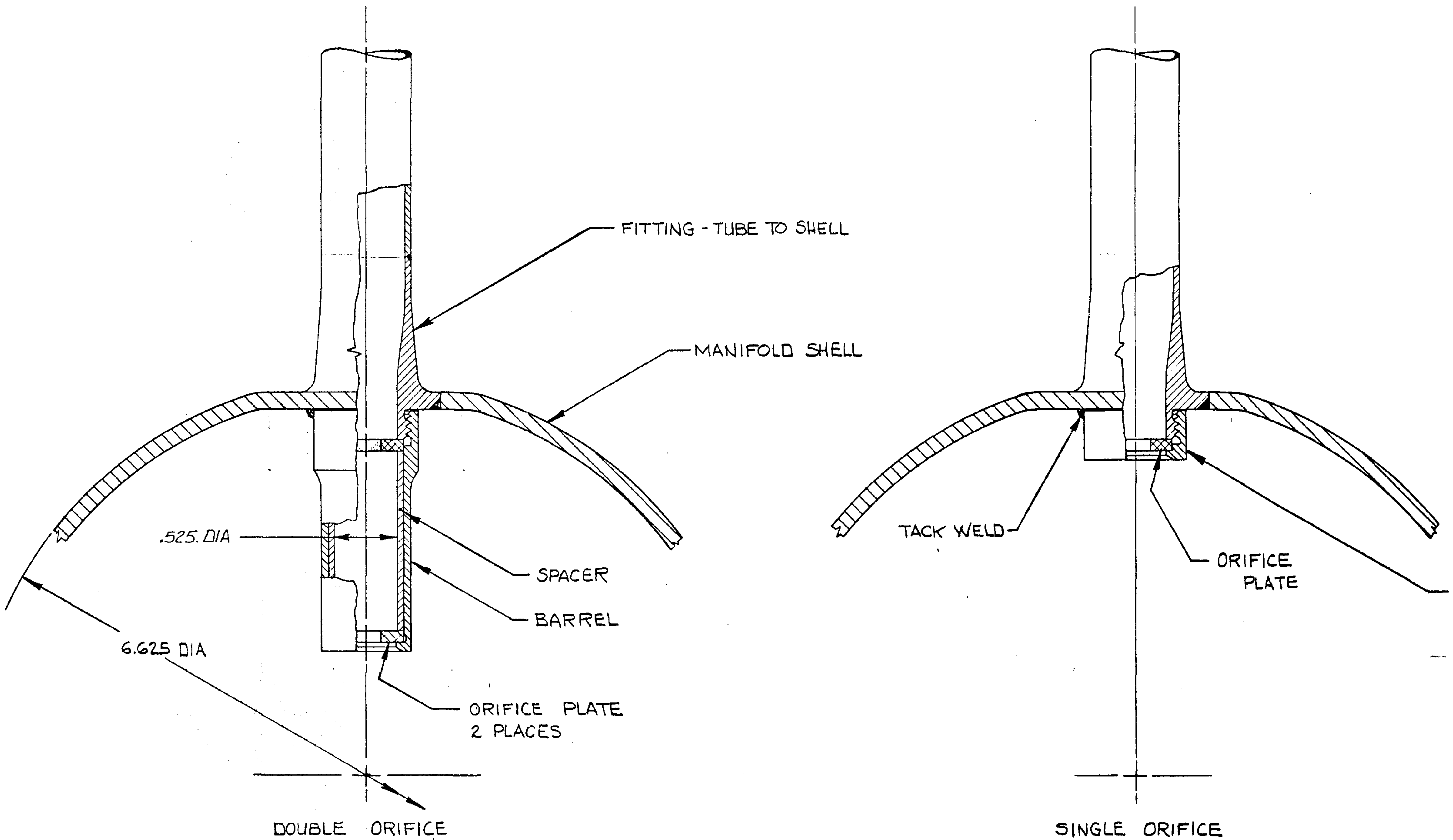
REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

079TI000001

Page 20

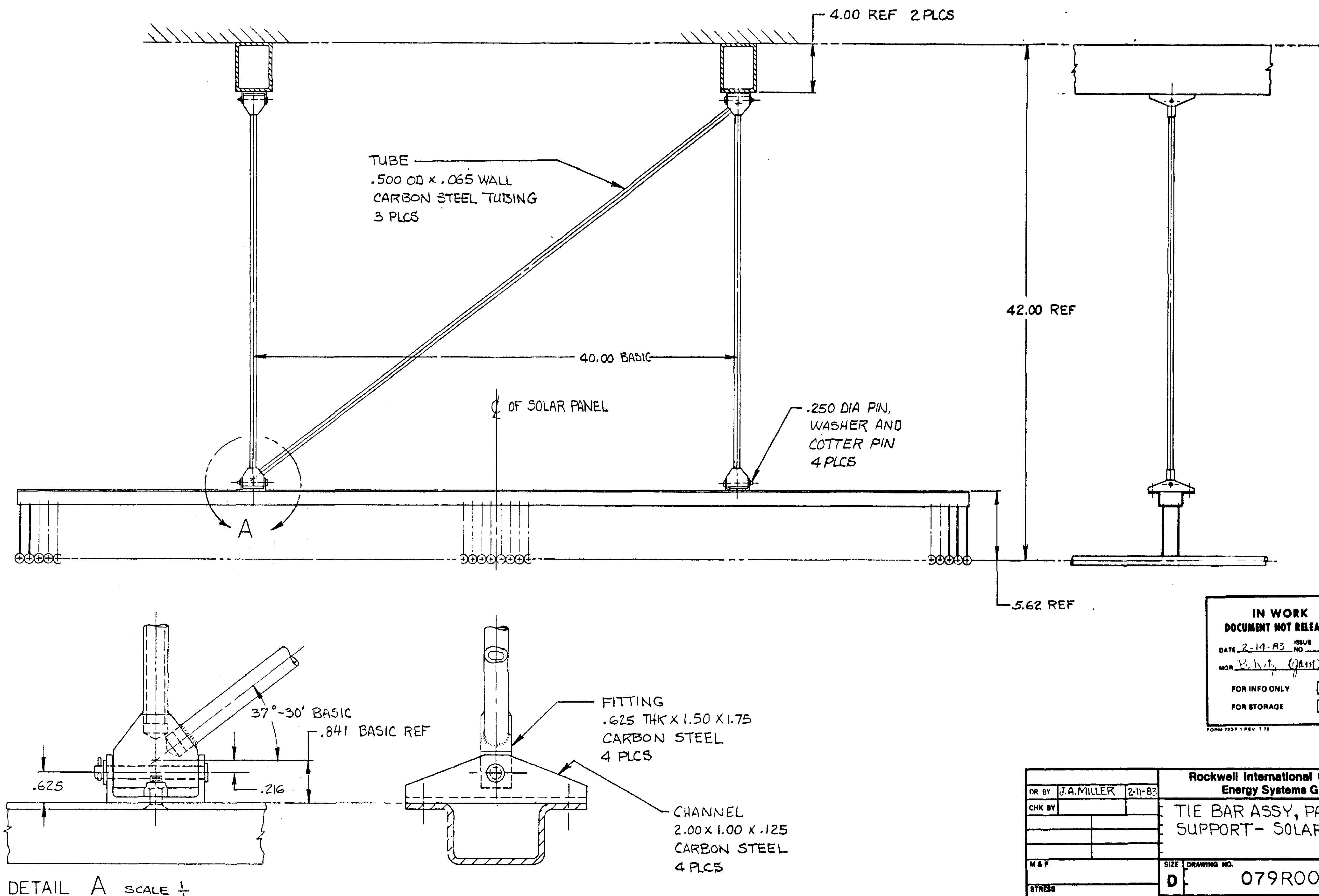
NOTES: UNLESS OTHERWISE SPECIFIED ON THIS DRAWING



IN WORK
DOCUMENT NOT RELEASED
DATE 1-17-83 ISSUE NO. 2
MGR B. Katz (Jam)
FOR INFO ONLY ☒
FOR STORAGE ☐

DR BY J.A. MILLER 1-14-83	Rockwell International Corporation Energy Systems Group
CHK BY	COOLANT FLOW ORIFICE ASSY - SOLAR RECEIVER PANEL
M&P	SIZE D DRAWING NO. 079R000025
STRESS	SCALE 2X1 SHEET

079R000025



IN WORK
DOCUMENT NOT RELEASED
DATE 2-14-83 ISSUE NO. 1
MGR
FOR INFO ONLY ☒
FOR STORAGE ☐

DR BY	J.A. MILLER	2-11-83	Rockwell International Corporation Energy Systems Group
CHK BY			TIE BAR ASSY, PANEL SUPPORT - SOLAR RECEIVER DESIGN L/O
M & P			SIZE D DRAWING NO. 079R000028
STRESS			SCALE 1/8=1 & 1/1 SHEET

079R000028

3.2 Structural Criteria

3.2.1 Environmental Requirements

The enviromental requirements contained in the receiver subsystem specification (Reference 1), are shown in Table 2.

3.2.1.1 Seismic Design Basis

The receiver subsystem is designed to withstand seismic loads derived from the following horizontal and vertical earthquake force formulae:

Horizontal Load = 0.04W
Vertical Load = 2/3[0.40W] = 0.27W
Where: W = Structural and fluid weight (lbs)

The seismic loads are assumed to act in two horizontal directions and in the vertical direction, simultaneously. The rationale for the application of the above static seismic coefficients is given below:

The Uniform Building Code (Reference 2) provides the following formula for establishing the total lateral force (V) acting on a cantilever type building structure as a function of its weight (W):

$$V = ZIKCSW$$

where Z,I,K,C,S are factors related to the location, foundation, design configuration, importance, etc., of the structure. For the Carrizo Plains location (seismic zone 4), the formula has the value of:

$$V = 0.21W$$

In this formula, the factor ZIKCS may be used as a measure of the equivalent static seismic acceleration at the foundation of the structure.

TABLE 2

ENVIRONMENTAL REQUIREMENTS

Minimum temperature, °C (°F)	-18 (0)
Maximum temperature, °C (°F)	45 (110)
Maximum operating wind (including gusts),[a] m/s (mph)	13.3 (30)
Maximum survival wind (including gusts),[a] m/s (mph)	40 (90)
Seismic environment	Zone 4
Survival earthquake horizontal & vertical acceleration, g	0.4 (equipment) 0.25 (civil)
Maximum dust devil wind speed, m/s (mph)	18 (45)
Maximum static snow load, Pa (lb/ft^2)	24 (0.5)
Maximum snow deposition weight, m/day (in./day)	0.2 (4)
Average annual rainfall, mm (in.)	88 (8.8)
Maximum 24-h rainfall, mm (in.)	TBD (TBD)
Hail maximum diameter, mm (in.)	25 (1)
Hail ice deposit, mm (in.)	25 (1)
Hail specific gravity	0.9
Hail maximum terminal velocity, m/s (fps)	23 (75)

[a]At reference height of 10 m (32.8 ft)

A summary of the natural frequency and response spectrum analysis results for a tower of simular size to that proposed for the Carrizo Plains site is contained in Reference 3. Based on the results presented in Figure 6 and Tablè 2 of Reference 3, a tower amplification factor of 1.57 is indicated when the SRSS acceleration at the centroid of the receiver (0.263g) is compared to the 0.15g zero period ground acceleration (ZPGA).
Hence, using a ground acceleration (ZPGA) of 0.21 and an amplification factor of 1.57, the following formula is obtained:

$$\text{Horizontal Load} = 0.21W[1.57] = 0.33W$$

The horizontal load factor of 0.40 used for Carrizo Plains is thus conservative based upon the above rationale.

3.2.1.2 Wind Design Basis

From the receiver subsystem specification, the following wind velocities at 32.8 feet above grade are used in the evaluation of the receiver subsystem:

Maximum Operating Wind, V_{30} = 30mph
Maximum Survival Wind, V_{90} = 90mph

The effective wind velocity pressures on the receiver panels at the midplane height of 410 feet are calculated using the methods presented in ANSI A58.1-1972 (Reference 4). Based on the calculations in Section 6 of the document, the effective wind pressures at the receiver elevation are:

Maximum Operating Wind, p_{30} = 5.07psf
Maximum Survival Wind, p_{90} = 54.0psf

Survival Design Wind Pressure Derivation

Design Wind Velocity = 90 mph

From equation 6.3.4 of ANSI A58.1, the effective velocity pressure is:

$$q_{30}\ (90\text{mph}) = 0.00256\ (90)^2 = 20.736\ \text{psf}$$

The effective velocity pressures of winds for buildings and structures, q_f, at various heights above ground are computed in accordance with the following formulas:

$$q_f = K_z G_f q_{30}$$

where: K_z = Velocity pressure coefficient which depends upon the type of exposure and height, z, above ground

G_f = Gust factors which depend upon the type of exposure and dynanic response

The receiver is assumed to be located in a Type C exposure, therefore from Figure A2 of Reference 4

$$K_z = 2.20$$

The calculation of the gust factor is presented below:

Receiver Mid-Height = 410 feet

Receiver Width = 52 feet

Fundamental Natural Frequency = 10.49Hz

Damping Ratio, = 0.01

Type of Exposure = C

Reference Velocity at 30 feet, V_{30} = 90 mph

From Figure A3

K_{30} = 1.00

K_{410} = 2.20

From Figure A3

$T[2h/3] = 0.12$

From Figure A4

$1.12\sqrt{K_{30}}\,[V_{30}]/f = 1.12\sqrt{1.0}\,[90]/10.49 = 9.609$

Therefore, P, the gust power factor = 0.02

From Figure A5

$0.88fh/V_{30}\sqrt{K_h} = 0.88[10.49][410]/[90]\sqrt{2.2} = 28.35$

$h/c = 410/52 = 7.88$

Therefore, F, the gust correlation factor = 10^{-4}

From Figure A6

S, the structure size factor = 0.82

Substituting in Equation A3

$$\sigma\sqrt{P} = 1.7[.12]\left[\frac{.785[0.02][10^{-4}]}{0.01} + \frac{.82}{1+.002[52]}\right]^{.5}$$

$$= 0.1758$$

Substituting in Equation A2

$G_f = .65 + 1.95[.1758] = 0.99$

The minimum allowable gust response factor is 1.0

The effective velocity wind pressure at 410 feet is:

$q_f = K_z G_f q_{30} = 2.2[1.0][20.736] = 45.6$ psf

From Table 5, the effective velocity pressure for parts and portions of buildings and structures, q_p, for exposure C will conservatively use for the receiver survival pressure

$q_f = 54$ psf @ 450 feet = 0.375 psi

Maximum Design Operating Wind

Operating wind design velocity = 30 mph

q_{30} (30mph) = $0.00256[30]^2 = 2.304$ psf

$q_f = K_z G_f q_{30}$

Where: $K_z = 2.20$ (From 90mph analysis)

$G_f = 1.00$ (From 90mph analysis)

$q_f = 2.20[1.0][2.304] = 5.07$ psf $= 0.0352$ psi

Nominal Design Wind

Nominal wind design velocity = 8 mph

q_{30} (8 mph) = $.00256[8]^2 = 0.164$ psf

$q_f = K_z G_f q_{30} = 2.20[1.0][0.164] = 0.361$ psf

3.2.2 Code Requirements

3.2.2.1 Pressure Boundary Analysis Requirements

3.2.2.1.1 ASME Section VIII Requirements (Reference 5)

The receiver tubes, inlet header and the outlet header shall meet the design requirements of ASME, Section VIII, Division 1. The loadings to be considered shall include pressure, deadweight, seismic and wind. Thermal expansion loads are not required to be included in the Section VIII analysis, but will be considered in the structural criteria of Section 3.2.2.1.3. Allowable stresses for the ASME Section VIII evaluations are presented in Section 3.6.2 of this report

3.2.2.1.2 ANSI B31.1 Analysis Requirements (Reference6)

The receiver tubes, inlet header and the outlet header shall meet the design requirements of ANSI B31.1-1977 Edition for Power Piping. The loadings to be considered shall include pressure, deadweight, seismic, wind, and restrained thermal expansion. The allowable stresses for the various sustained and occasional loadings are specified in Section 3.6.1 of this report.

3.2.2.1.3 Code Case N-47

The receiver tubes, inlet header and outlet header fatigue and creep damage evaluations shall be performed using ASME Code Case N-47 (Reference 7) as a guide. The creep-fatigue damage fraction allowables are presented in Section 3.6.3 of this report.

3.2.2.2 Non Pressure Boundary Requirements AISC (Reference 8)

The receiver subsystem, except for the pressure boundary components shall be designed in accordance with the American Institute of Steel Construction (AISC). Material yield and ultimate strength properties shall be obtained from accepted sources such as the Military Standardization Handbook (Mil-Hdbk 5B).

3.3 Loading Combinations

The following loading combinations have been used in the evaluation of the receiver subsystem.

3.3.1 Sodium Tubes and Headers

a) Section VIII Analysis
   - Design Pressure (100psi)
   - Design Temperature (1050°F)
   - Design Wind (30mph)
   - Design Seismic (0.40g)

b) ANSI B31.1 Analysis
   - Pressure (30psi)
   - Temperature (610 to 1050°F)
   - Wind (30mph)
   - Seismic (0.40g)
   - Thermal Expansion
   - Thermal Gradients

3.3.2 Balance of Receiver Subsystem

a) AISC Analysis
   - Temperature (200°F)
   - Wind (30mph)
   - Seismic (0.40g)
   - Thermal Expansion

3.4 Thermal Environments

The Carrizo Plains receiver panels are designed for a peak incident flux limit of 1.2 MW_t/m^2. The design operating temperatures for the receiver are 610^{o}F sodium inlet and 1050^{o}F sodium outlet.

Figures 3 and 4 show the reference vertical flux distribution in the thermal window area and the reference lateral flux distribution across the 8 individual panels.

Based upon these figures, thermal analysis, Reference 10, was performed to determine the temperature profiles in the individual receiver tubes. Three areas were investigated in the thermal analysis:

1) Outboard edge, panel number 1
2) Inboard edge, Panel number 1
3) Full Load tube

The results of the thermal analysis are summarized graphically in Figures 5 through 7 and in tabular form in Tables 3 through 5.

The above temperatures were used as a basis for the structural evaluation of the receiver tubes.

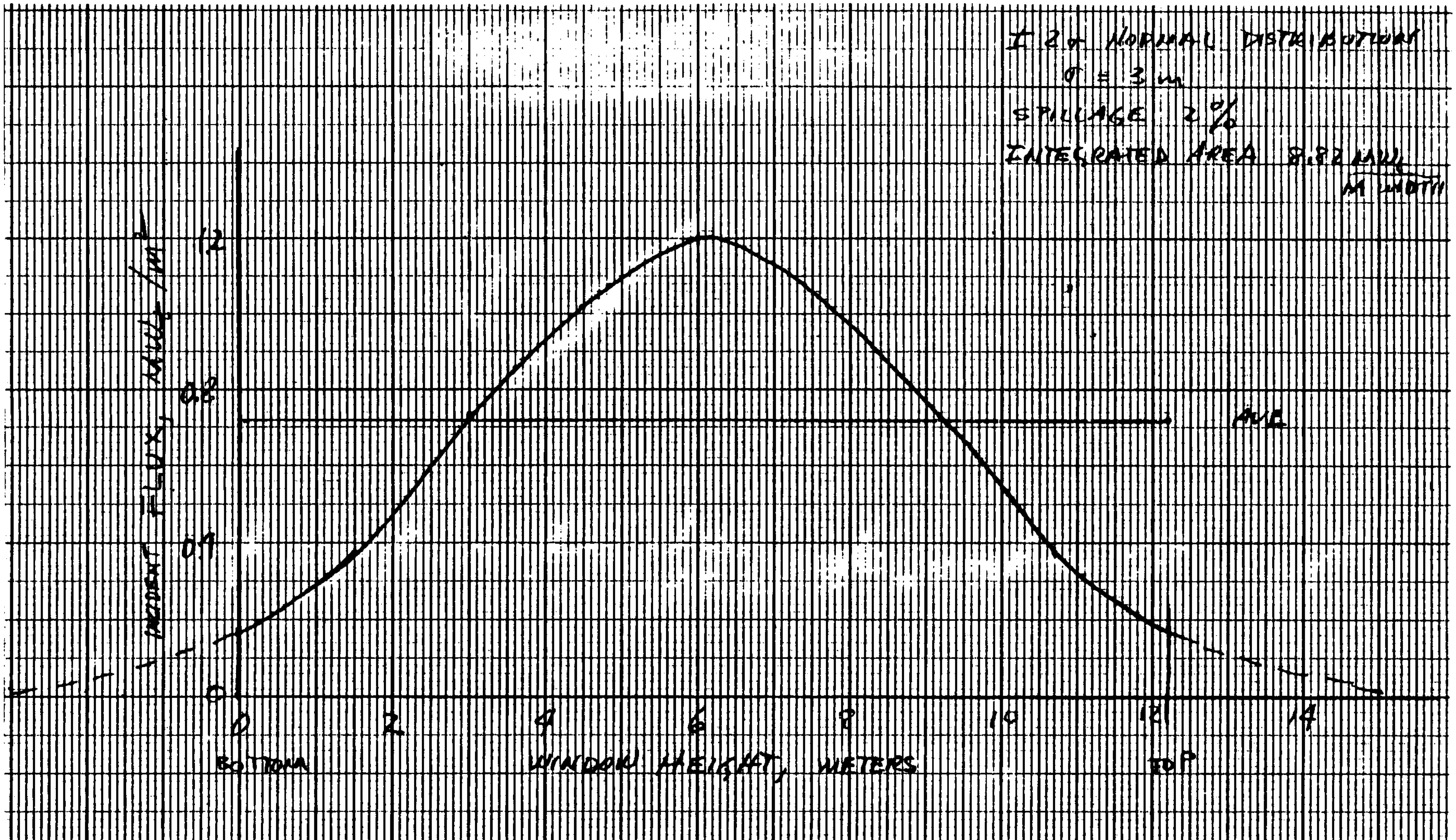


FIGURE 3 REFERENCE VERTICAL FLUX DISTRIBUTION - 30 MWe SOLAR PLANT

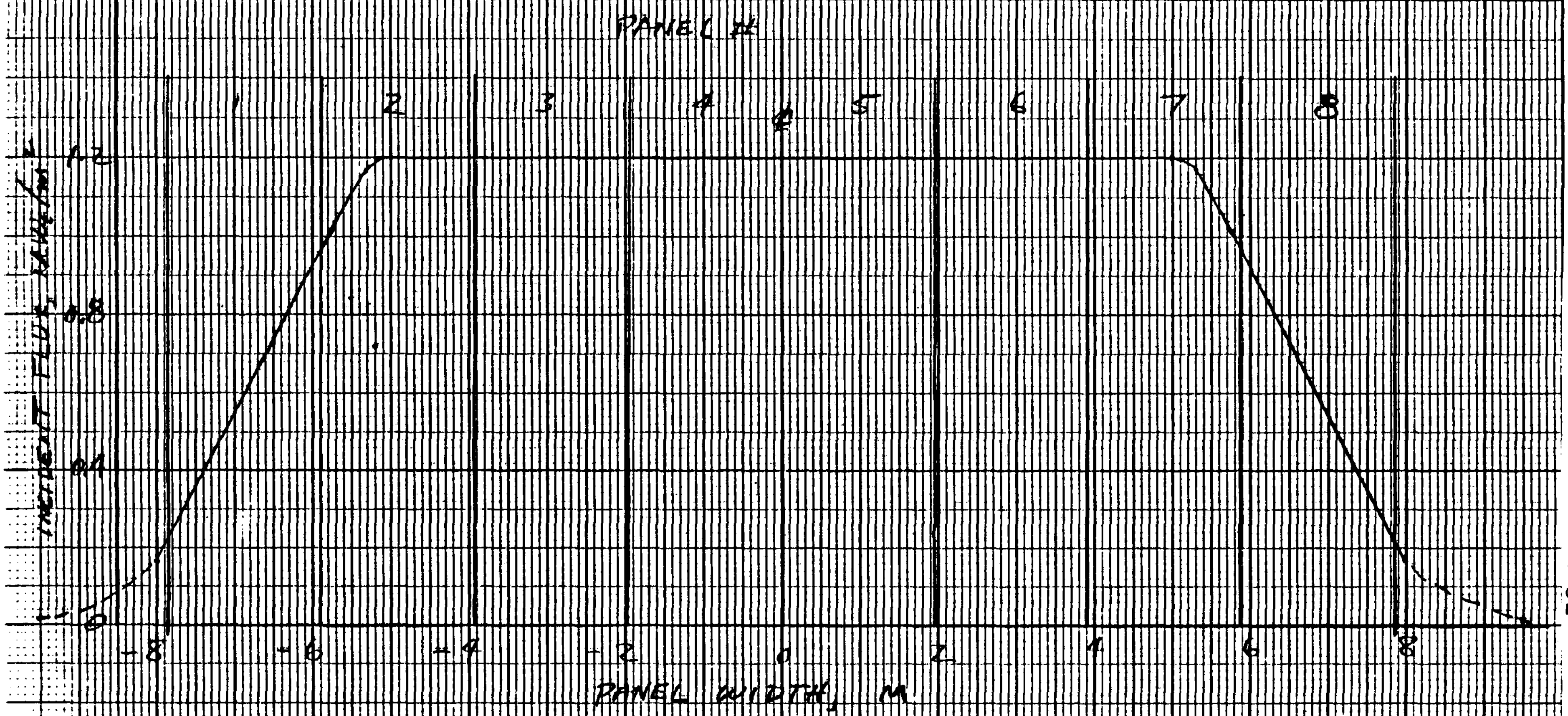


FIGURE 4 REFERENCE LATERAL FLUX DISTRIBUTION - 30 MWe SOLAR PLANT

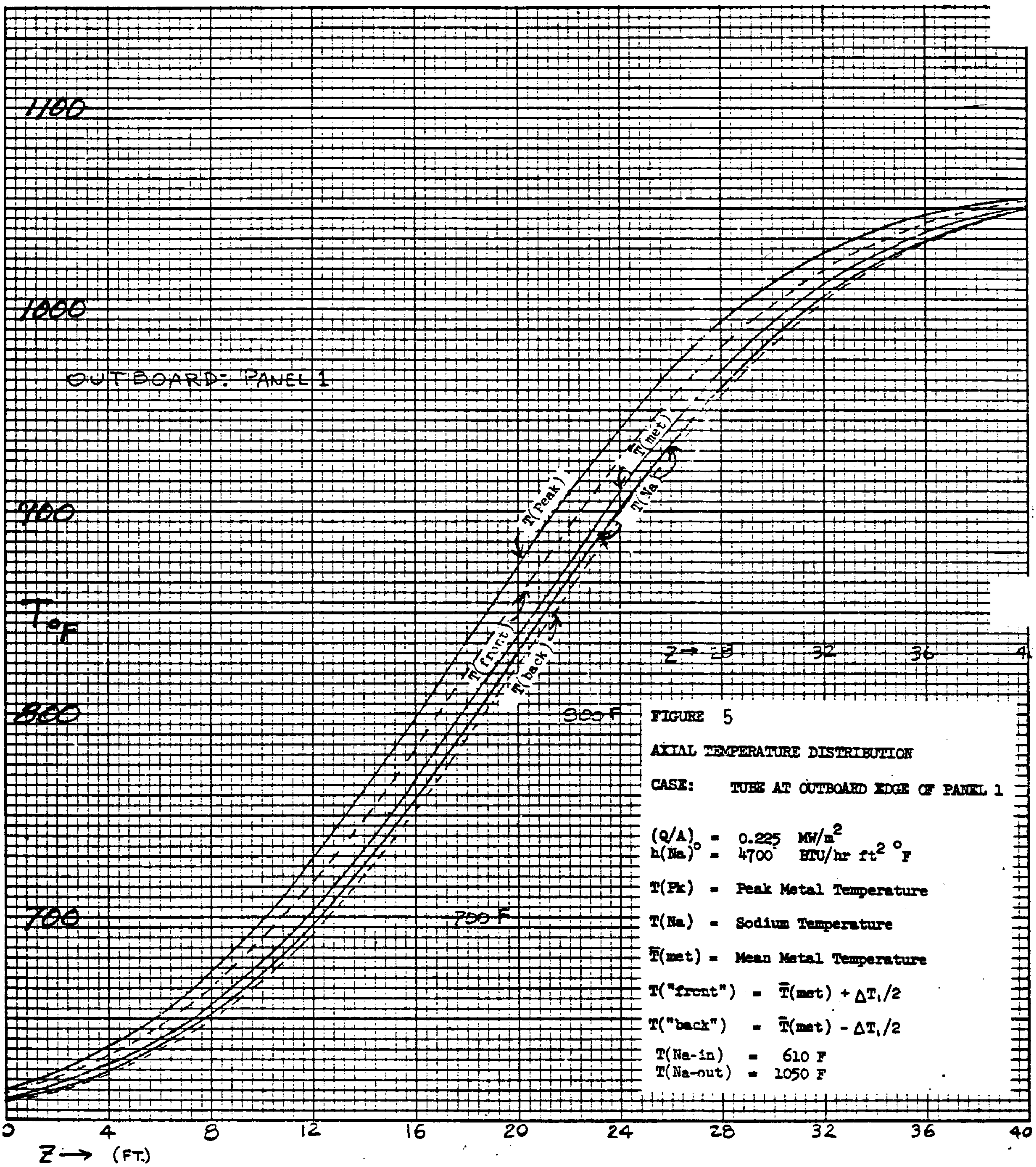


FIGURE 5

AXIAL TEMPERATURE DISTRIBUTION

CASE: TUBE AT OUTBOARD EDGE OF PANEL 1

$(Q/A)_o$ = 0.225 MW/m^2
$h(Na)^o$ = 4700 $BTU/hr\ ft^2\ ^oF$

T(Pk) = Peak Metal Temperature

T(Na) = Sodium Temperature

$\bar{T}$(met) = Mean Metal Temperature

T("front") = $\bar{T}(met) + \Delta T_1/2$

T("back") = $\bar{T}(met) - \Delta T_1/2$

T(Na-in) = 610 F
T(Na-out) = 1050 F

Table 3

CASE: OUTBOARD PANEL 1

$(Q/A)_0 = 0.225 \frac{MW}{m^2}$

(21) $(\bar{T}_{MET} - T_{Na})_{℄} = 9.94°$
(22) $(\Delta T_1)_{℄} = 33.133°$
(23) $(T_{PK} - T_{Na})_{℄} = 43.17°$
(24) $(T_{PK} - \bar{T}_{MET})_{℄} = 33.23°$
(25) $(\Delta T_2)_{℄} = 16.662°$

⓪ Z	① $T_{Na}(z)$ SODIUM	② $\Phi(z)$	③ $\bar{T}_{MET}(z)$	④ $\Delta T_1(z)$	⑤ $\frac{\Delta T_1}{2}$	⑥ T(z) "FRONT"	⑦ T(z) "BACK"	⑧ $T_{PEAK}(z)$	⑨ $(T_{PK} - \bar{T}_{MET})(z)$	⑩ $\Delta T_2(z)$
0	610.00	.135335	611.35	4.48	2.24	613.59	609.10	615.84	4.50	2.25
1	612.75	.164474	614.38	5.45	2.72	617.11	611.66	619.85	5.47	2.74
2	616.08	.197899	618.05	6.56	3.28	621.33	614.77	624.62	6.58	3.30
3	620.06	.235746	622.40	7.81	3.91	626.31	618.50	630.24	7.83	3.93
4	624.77	.278037	627.53	9.21	4.61	632.14	622.93	636.77	9.24	4.63
5	630.31	.324652	633.54	10.76	5.38	638.92	628.16	644.33	10.79	5.41
6	636.74	.375311	640.47	12.44	6.22	646.69	634.25	652.94	12.47	6.25
7	644.14	.429557	648.41	14.23	7.12	655.53	641.29	662.68	14.27	7.16
8	652.56	.486752	657.40	16.13	8.06	665.46	649.33	673.57	16.17	8.11
9	662.05	.546074	667.48	18.09	9.05	676.52	658.43	685.62	18.15	9.10
10	672.65	.606531	678.68	20.10	10.05	688.73	668.63	698.83	20.16	10.11
11	684.36	.666977	690.99	22.10	11.05	702.04	679.94	713.15	22.16	11.11
12	697.17	.726149	704.39	24.06	12.03	716.42	692.36	728.52	24.13	12.10
13	711.05	.782705	718.83	25.93	12.97	731.80	705.86	744.84	26.01	13.04
14	725.94	.835270	734.24	27.68	13.84	748.08	720.41	762.00	27.76	13.92
15	741.74	.882497	750.51	29.24	14.62	765.13	735.89	779.84	29.33	14.70
16	758.35	.923116	767.53	30.59	15.29	782.82	752.23	798.20	30.68	15.38
17	775.65	.955997	785.15	31.68	15.84	800.99	769.32	816.92	31.77	15.93
18	793.46	.980199	803.20	32.48	16.24	819.44	786.96	835.78	32.57	16.33
19	811.64	.995012	821.53	32.97	16.48	838.01	805.05	854.59	33.06	16.58
20	830.00	1.00	839.94	33.13	16.57	856.51	823.37	873.17	33.23	16.66
21	848.36	.995012	858.27	32.97	16.48	874.75	841.79	891.33	33.06	16.58
22	866.54	.980199	876.28	32.48	16.24	892.52	860.04	908.86	32.57	16.33
23	884.35	.955997	893.85	31.68	15.84	909.69	878.02	925.62	31.77	15.93
24	901.65	.923116	910.83	30.59	15.29	926.12	895.53	941.50	30.68	15.38
25	918.26	.882497	927.03	29.24	14.62	941.65	912.41	956.36	29.33	14.70
26	934.06	.835270	942.36	27.68	13.84	956.20	928.53	970.12	27.76	13.92
27	948.95	.782705	956.73	25.93	12.97	969.70	943.76	982.74	26.01	13.04
28	962.83	.726149	970.05	24.06	12.03	982.08	958.02	994.18	24.13	12.10
29	975.64	.666977	982.27	22.10	11.05	993.32	971.22	1004.43	22.16	11.11
30	987.35	.606531	993.38	20.10	10.05	1003.43	983.33	1013.53	20.16	10.11
31	997.95	.546074	1003.38	18.09	9.05	1012.42	994.33	1021.52	18.15	9.10
32	1007.44	.486752	1012.28	16.13	8.06	1020.34	1004.21	1028.45	16.17	8.11
33	1015.86	.429557	1020.13	14.23	7.12	1027.25	1013.01	1034.40	14.27	7.16
34	1023.26	.375311	1026.94	12.44	6.22	1033.21	1020.77	1039.46	12.47	6.25
35	1029.69	.324652	1032.92	10.76	5.38	1038.30	1027.54	1043.71	10.79	5.41
36	1035.23	.278037	1037.99	9.21	4.61	1042.60	1033.39	1047.23	9.24	4.63
37	1039.94	.235746	1042.28	7.81	3.91	1046.19	1038.38	1050.12	7.83	3.93
38	1043.92	.197899	1045.89	6.56	3.28	1049.17	1042.61	1052.46	6.58	3.30
39	1047.25	.164474	1048.88	5.45	2.72	1051.61	1046.16	1054.35	5.47	2.74
40	1050.00	.135335	1051.35	4.48	2.24	1053.59	1049.10	1055.84	4.50	2.25

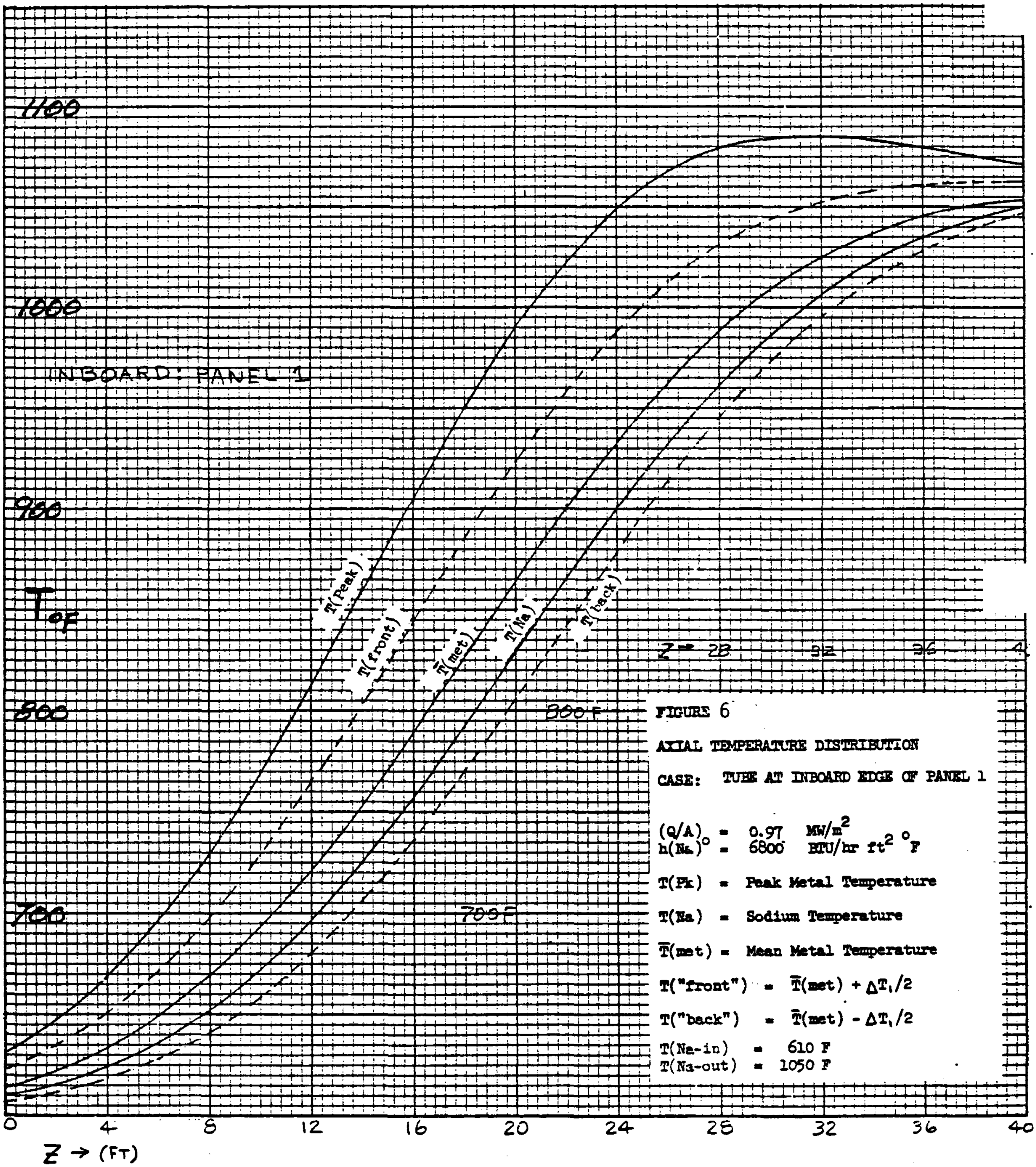


FIGURE 6

AXIAL TEMPERATURE DISTRIBUTION

CASE: TUBE AT INBOARD EDGE OF PANEL 1

$(Q/A)_o$ = 0.97 MW/m^2
$h(Na)^o$ = 6800 BTU/hr ft^2 °F

T(Pk) = Peak Metal Temperature

T(Na) = Sodium Temperature

$\overline{T}$(met) = Mean Metal Temperature

T("front") = $\overline{T}$(met) + $\Delta T_1/2$

T("back") = $\overline{T}$(met) - $\Delta T_1/2$

T(Na-in) = 610 F
T(Na-out) = 1050 F

Table 4

CASE: INBOARD: PANEL 1

$(Q/A)_o$ = 0.97 MW/m²

(21) $(\bar{T}_{MET} - T_{Na})_℄$ = 35.16°
(22) $(\Delta T_1)_℄$ = 117.57°
(23) $(T_{PK} - T_{Na})_℄$ = 160.50°
(24) $(T_{PK} - \bar{T}_{MET})_℄$ = 125.34°
(25) $(\Delta T_2)_℄$ = 66.558°

z	(1) $T_{Na}(z)$ SODIUM	(2) $\phi(z)$	(3) $\bar{T}_{MET}(z)$	(4) $\Delta T_1(z)$	(5) $\frac{\Delta T_1}{2}$	(6) $T(z)$ "FRONT"	(7) $T(z)$ "BACK"	(8) $T(z)$ PEAK	(9) $(T_{PK} - \bar{T}_{MET})$	(10) $\Delta T_2(z)$
0	610.0	.135335	614.76	15.91	7.96	622.71	606.80	631.72	16.96	9.01
1	612.75	.164474	618.53	19.34	9.67	628.20	608.86	639.15	20.62	10.95
2	616.08	.197899	623.04	23.27	11.63	634.67	611.40	647.84	24.80	13.17
3	620.06	.235746	628.35	27.72	13.86	642.21	614.49	657.90	29.55	15.69
4	624.77	.278037	634.55	32.69	16.34	650.89	618.20	669.39	34.85	18.51
5	630.31	.324652	641.72	38.17	19.08	660.81	622.64	682.42	40.69	21.61
6	636.74	.375311	649.94	44.13	22.06	672.00	627.87	696.98	47.04	24.98
7	644.14	.429557	659.24	50.50	25.25	684.49	633.99	713.08	53.84	28.59
8	652.56	.486752	669.67	57.23	28.61	698.29	641.06	730.68	61.01	32.40
9	662.05	.546074	681.25	64.20	32.10	713.35	649.15	749.69	68.44	36.35
10	672.65	.606531	693.98	71.31	35.65	729.63	658.32	770.00	76.02	40.37
11	684.36	.666977	707.81	78.42	39.21	747.02	668.60	791.41	83.60	44.39
12	697.17	.726149	722.71	85.37	42.69	765.40	680.02	813.73	91.02	48.33
13	711.05	.782705	738.57	92.02	46.01	784.58	692.56	836.67	98.10	52.10
14	725.94	.835270	755.31	98.20	49.10	804.41	706.21	860.00	104.69	55.59
15	741.74	.882497	772.77	103.76	51.88	824.65	720.89	883.38	110.61	58.74
16	758.35	.923116	790.81	108.53	54.27	845.07	736.54	906.51	115.70	61.44
17	775.65	.955997	809.26	112.40	56.20	865.46	753.06	929.09	119.82	63.63
18	793.46	.980199	827.92	115.24	57.62	885.54	770.30	950.78	122.86	65.24
19	811.64	.995012	846.62	116.98	58.49	905.12	788.13	971.34	124.71	66.23
20	830.00	1.00	865.16	117.57	58.79	923.95	806.38	990.50	125.34	66.56
21	848.36	.995012	883.34	116.98	58.49	941.84	824.85	1008.06	124.71	66.23
22	866.54	.980199	901.00	115.24	57.62	958.62	843.38	1023.86	122.86	65.24
23	884.35	.955997	917.96	112.40	56.20	974.16	861.76	1037.79	119.82	63.63
24	901.65	.923116	934.11	108.53	54.27	988.37	879.84	1049.81	115.70	61.44
25	918.26	.882497	949.29	103.76	51.88	1001.17	897.41	1059.90	110.61	58.74
26	934.06	.835270	963.43	98.20	49.10	1012.53	914.33	1068.12	104.69	55.59
27	948.95	.782705	976.47	92.02	46.01	1022.48	930.46	1074.57	98.10	52.10
28.	962.83	.726149	988.36	85.37	42.69	1031.05	945.67	1079.38	91.02	48.33
29	975.64	.666977	999.09	78.42	39.21	1038.30	959.88	1082.69	83.60	44.39
30	987.35	.606531	1008.68	71.31	35.65	1044.33	973.02	1084.70	76.02	40.37
31	997.95	.546074	1017.15	64.20	32.10	1049.25	985.05	1085.59	68.44	36.35
32	1007.44	.486752	1024.55	57.23	28.61	1053.17	995.94	1085.56	61.01	32.40
33	1015.86	.429557	1030.96	50.50	25.25	1056.21	1005.71	1084.80	53.84	28.59
34	1023.26	.375311	1036.46	44.13	22.06	1058.52	1014.39	1083.50	47.04	24.98
35	1029.69	.324652	1041.10	38.17	19.08	1060.19	1022.02	1081.80	40.69	21.61
36	1035.23	.278037	1045.00	32.69	16.34	1061.35	1028.66	1079.85	34.85	18.51
37	1039.94	.235746	1048.23	27.72	13.86	1062.09	1034.37	1077.78	29.55	15.69
38	1043.92	.197899	1050.88	23.27	11.63	1062.51	1039.24	1075.68	24.80	13.17
39	1047.25	.164474	1053.03	19.34	9.67	1062.70	1043.36	1073.65	20.62	10.95
40	1050.00	.135335	1054.76	15.91	7.96	1062.71	1046.80	1071.72	16.96	9.01

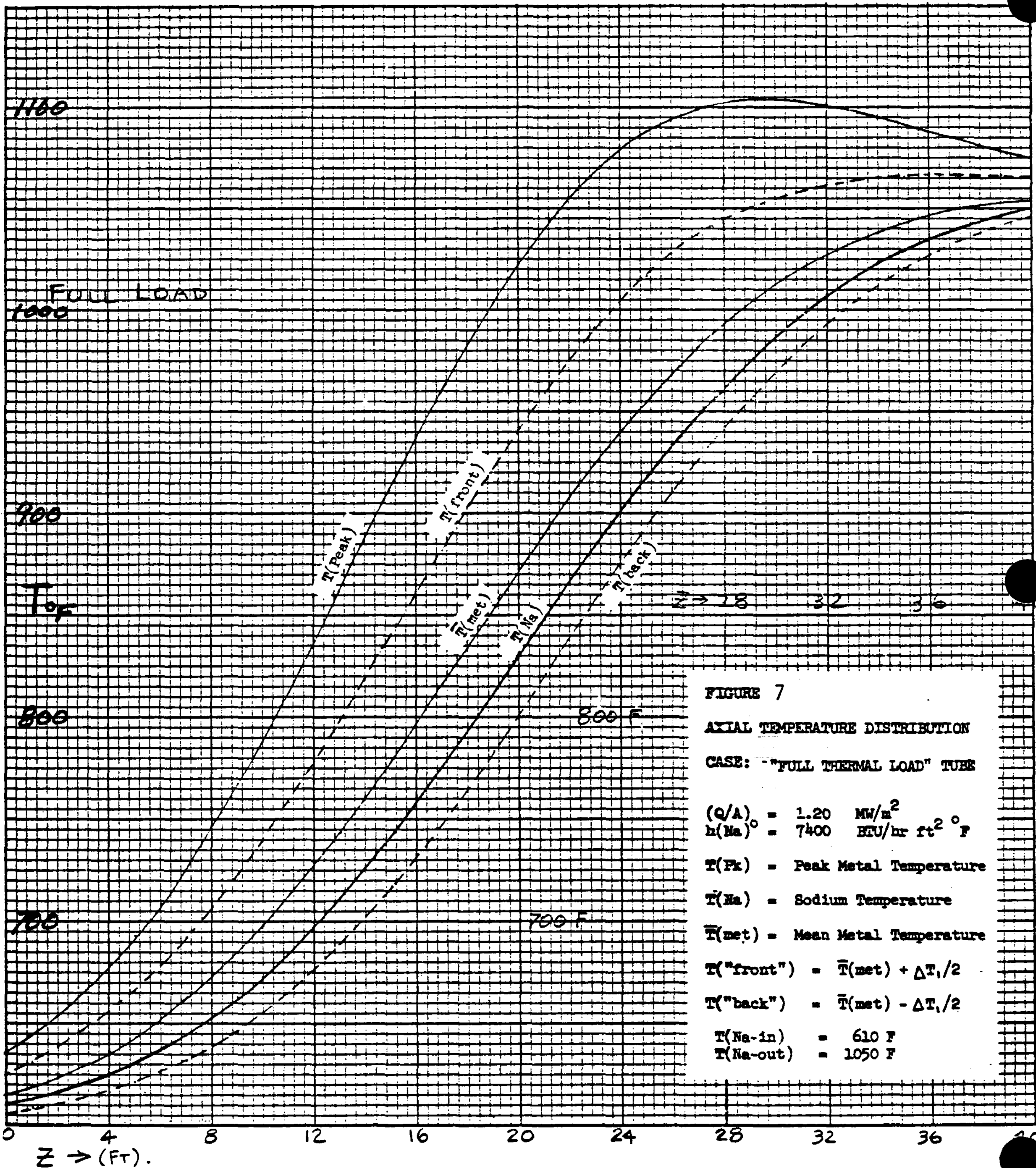


FIGURE 7

AXIAL TEMPERATURE DISTRIBUTION

CASE: "FULL THERMAL LOAD" TUBE

$(Q/A)_o$ = 1.20 MW/m^2
$h(Na)^o$ = 7400 BTU/hr ft^2 °F

T(Pk) = Peak Metal Temperature

T(Na) = Sodium Temperature

$\bar{T}$(met) = Mean Metal Temperature

T("front") = $\bar{T}$(met) + $\Delta T_1/2$

T("back") = $\bar{T}$(met) - $\Delta T_1/2$

T(Na-in) = 610 F
T(Na-out) = 1050 F

Table 5

CASE: "FULL LOAD" TUBE

$(Q/A)_0 = 1.20\ MW/m^2$

(21) $(\bar{T}_{MET} - T_{Na})_{℄} = 41.74$
(22) $(\Delta T_1)_{℄} = 139.66$
(23) $(T_{PK} - T_{Na})_{℄} = 192.50$
(24) $(T_{PK} - \bar{T}_{MET})_{℄} = 150.76$
(25) $(\Delta T_2)_{℄} = 80.98$

(0) Z LOCATION (FT)	(1) $T_{Na}(z)$ SODIUM	(2) $\phi(z)$ NORMALIZED ALTITUDE OF CURVE	(3) $\bar{T}_{MET}(z)$ MEAN METAL TEMP	(4) $\Delta T_1(z)$	(5) $\Delta T_1 / 2$	(6) $T(z)$ "FRONT"	(7) $T(z)$ "BACK"	(8) $T_{PEAK}(z)$	(9) $(T_{PK} - \bar{T}_{MET})(z)$	(10) $\Delta T_2(z)$
0	610.00	.135335	615.65	18.90	9.45	625.10	606.20	636.05	20.40	10.96
1	612.75	.164474	619.62	22.97	11.49	631.10	608.13	644.41	24.80	13.32
2	616.08	.197899	624.34	27.64	13.82	638.16	610.52	654.18	29.84	16.03
3	620.06	.235746	629.90	32.92	16.46	646.36	613.44	665.44	35.55	19.09
4	624.77	.278037	636.38	38.83	19.42	655.79	616.96	678.29	41.93	22.52
5	630.31	.324652	643.86	45.34	22.67	666.53	621.19	692.81	48.96	26.29
6	636.74	.375311	652.41	52.42	26.21	678.61	626.20	708.99	56.60	30.39
7	644.14	.429557	662.07	59.99	30.00	692.07	632.07	726.83	64.78	34.79
8	652.56	.486752	672.88	67.98	33.99	706.87	638.89	746.26	73.40	39.42
9	662.05	.546074	684.84	76.26	38.13	722.98	646.71	767.17	82.35	44.22
10	672.65	.606531	697.97	84.71	42.35	740.32	655.61	789.91	91.46	49.12
11	684.36	.666977	712.20	93.15	46.58	758.77	665.62	812.75	100.58	54.01
12	697.17	.726149	727.48	101.41	50.71	778.19	676.77	836.95	109.50	58.80
13	711.05	.782705	743.72	109.31	54.66	798.38	689.06	861.72	118.03	63.38
14	725.94	.835270	760.80	116.65	58.33	819.13	702.48	886.73	125.96	67.64
15	741.74	.882497	778.57	123.25	61.62	840.20	716.95	911.62	133.08	71.46
16	758.35	.923116	796.88	128.92	64.46	861.34	732.42	936.05	139.21	74.75
17	775.65	.955997	815.55	133.51	66.76	882.31	748.80	959.68	144.16	77.42
18	793.46	.980199	834.37	136.89	68.45	902.82	765.93	982.15	147.81	79.38
19	811.64	.995012	853.17	138.96	69.48	922.65	783.69	1003.18	150.05	80.58
20	830.00	1.00	871.74	139.66	69.83	941.57	801.91	1022.50	150.76	80.98
21	848.36	.995012	889.89	138.96	69.48	959.37	820.41	1039.90	150.05	80.58
22	866.54	.980199	907.45	136.89	68.45	975.90	839.01	1055.23	147.81	79.38
23	884.35	.955997	924.25	133.51	66.76	991.01	857.50	1068.38	144.16	77.42
24	901.65	.923116	940.18	128.92	64.46	1004.64	875.72	1079.35	139.21	74.75
25	918.26	.882497	955.10	123.25	61.62	1016.72	893.47	1088.14	133.08	71.46
26	934.06	.835270	968.92	116.65	58.33	1027.25	910.60	1094.85	125.96	67.64
27	948.95	.782705	981.62	109.31	54.66	1036.28	926.96	1099.62	118.03	63.38
28	962.83	.726149	993.14	101.41	50.71	1043.85	942.93	1102.61	109.50	58.80
29	975.64	.666977	1003.48	93.15	46.58	1050.05	956.90	1104.03	100.58	54.01
30	987.35	.606531	1012.67	84.71	42.35	1055.02	970.31	1104.11	91.46	49.12
31	997.95	.546074	1020.74	76.26	38.13	1058.88	982.61	1103.07	82.35	44.22
32	1007.44	.486752	1027.76	67.98	33.99	1061.75	993.77	1101.14	73.40	39.42
33	1015.86	.429557	1033.79	59.99	30.00	1063.79	1003.79	1098.55	64.78	34.79
34	1023.26	.375311	1038.93	52.42	26.21	1065.13	1012.72	1095.51	56.60	30.39
35	1029.69	.324652	1043.24	45.34	22.67	1065.91	1020.57	1092.19	48.96	26.29
36	1035.23	.278037	1046.84	38.83	19.42	1066.25	1027.42	1088.75	41.93	22.52
37	1039.94	.235746	1049.78	32.92	16.46	1066.24	1033.32	1085.32	35.55	19.09
38	1043.92	.197899	1052.18	27.64	13.82	1066.00	1038.36	1082.02	29.84	16.03
39	1047.25	.164474	1054.12	22.97	11.49	1065.60	1042.63	1078.91	24.80	13.32
40	1050.00	.135335	1055.65	18.90	9.45	1065.10	1046.20	1076.05	20.40	10.96

3.5 Material Properties

The properties for the materials of construction of the receiver subsystem are presented in Table 6. References for the properties are also presented.

Material Properties

Table 6

Component	Material	Temp. °F	F_y ksi	F_{ult} ksi	E ksi	α in/in°F	
Sodium Tubes	ASME SA-213TP316 Stainless Steel	610-1050	See Fig. 8		See Fig. 8	See Fig. 9	
Tangs	ASTM Type 304 Stainless Steel	200-1050	25.8				
Hatbands	ASTM A366 Carbon Steel	R.T.	28.0				
Support Rods	ASTM A519 (1020) Low Alloy Steel	R.T.	28.0				
Headers	ASME TP 316 Stainless Steel	610-1050	See Fig. 8		See Fig. 8	See Fig. 9	
Support Beams	ASTM Type 304 Stainless Steel	200	25.0				
Support Truss	ASTM A36 Carbon Steel	R.T.	36.0				

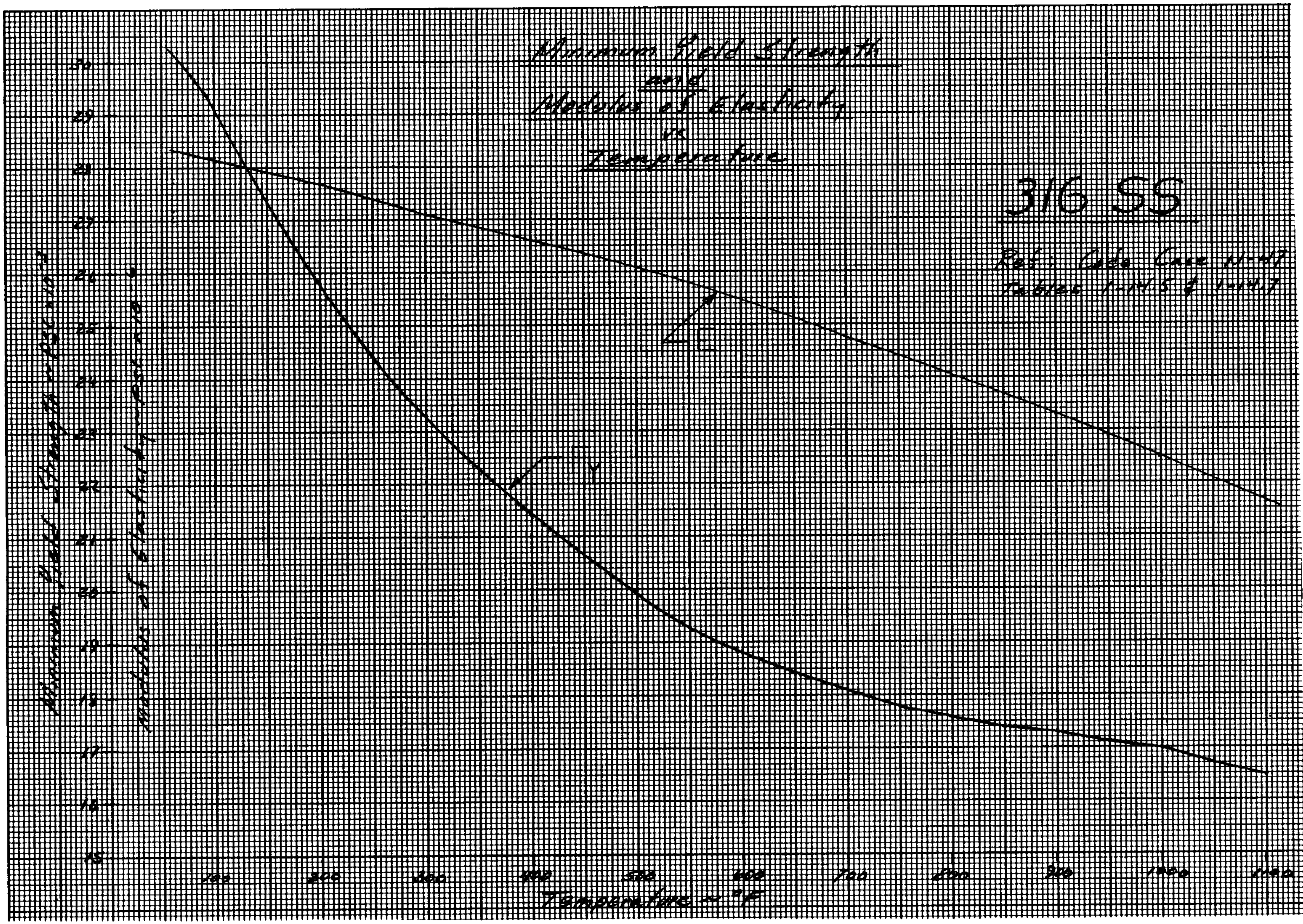
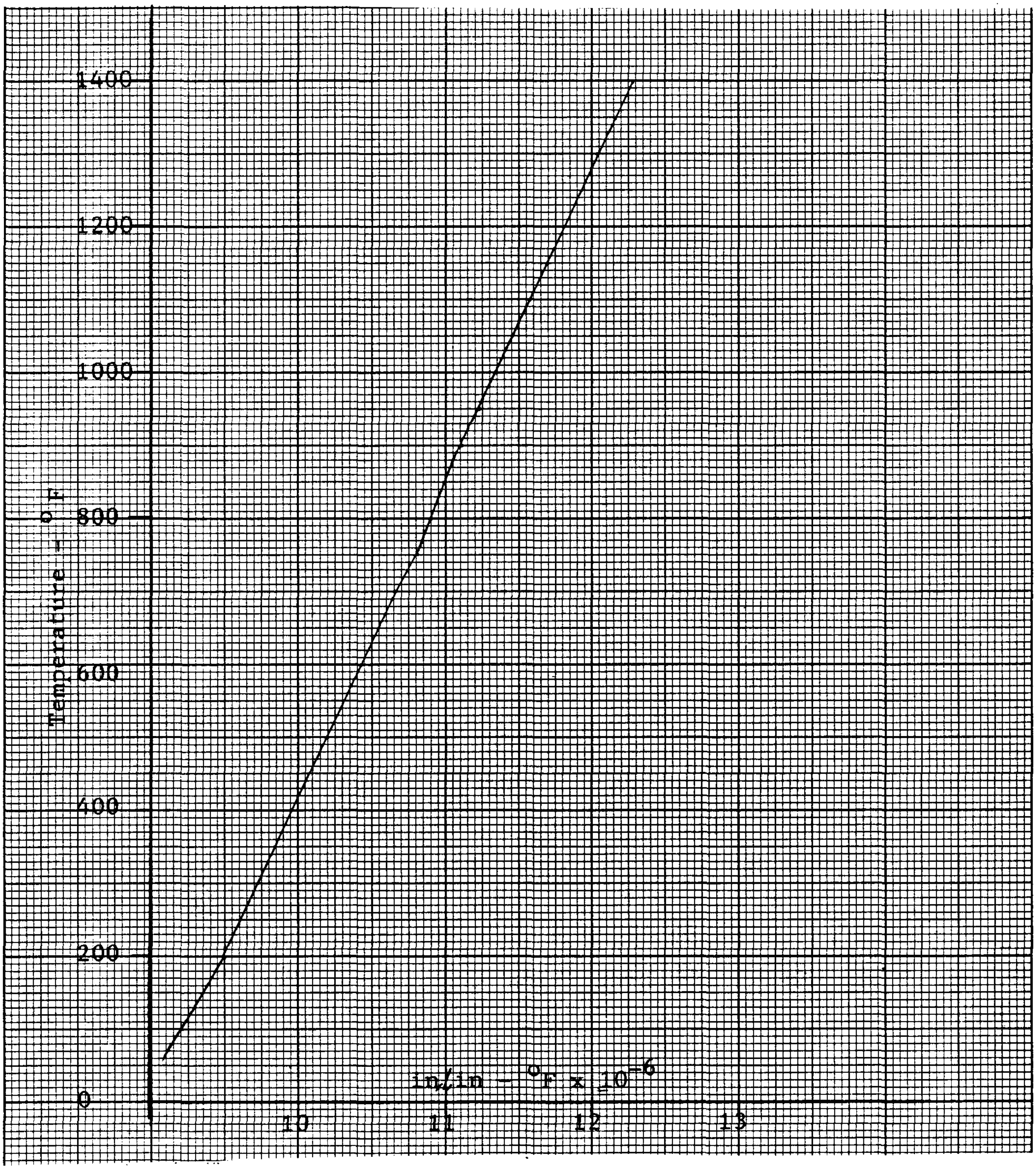

Minimum Yield Strength
and
Modulus of Elasticity
vs
Temperature
316 SS
Ref: Code Case N-47
Tables I-14.5 & I-14.7
E
Y
100
200
300
400
500
600
700
800
900
1000
1100
Temperature ~ °F

Figure 8



Instantaneous Coefficient of Thermal Expansion

Figure 9

3.6 Allowable Stresses

3.6.1 ANSI B31.1 Power Piping Stress Allowables

The requirements of either Equation 13A or Equation 14 in section 104.8.3 shall be met:

a. Thermal Expansion (S_E)

$$S_E = \frac{iMc}{Z} = S_A$$

where: i = Stress Intensification Factor (Appendix D) The product, 0.75i, shall never be taken as less than 1.0

Z = Section Modulus, in^3

Mc = Range of resultant moments due to thermal expansion

S_A = The allowable stress range for expansion stresses

b. Thermal Expansion + Sustained Loads

The effects of pressure, weight, and other sustained loads and thermal expansion must meet the requirements of Equation 14

$$S_{TE} = \frac{PDo}{4t_n} + \frac{.75iMa}{Z} + \frac{iMc}{Z} \leq S_H + S_A$$

where: p = Internal Design Presure, psig

Do = Outside diameter of pipe, inches

t_n = Nominal wall thickness, inches

Ma = Resultant moment loading on cross-section due to weight and other sustained loads, inch-pounds

S_h = Basic material allowable stress at maximum temperature from allowable stress tables, psi

The allowable stresses for the receiver tubes vary depending if the tube is in the thermal window area or if it is in the shielded area with trace heating at 425°F. The allowable stresses are obtained from Reference 6 , ANSI B31.1.1-1977 Appendix A, Table A-3.

Thermal Window Area

Temperature °F	S_h ksi	S_a ksi	$S_a + S_h$ ksi
-20 to 100	18.70	19.64	38.34
200	18.70	19.64	38.34
300	18.30	19.57	37.87
400	18.00	19.51	37.51
500	17.90	19.50	37.40
600	17.00	19.34	36.34
650	16.60	19.27	35.87
700	16.30	19.22	35.52
750	16.00	19.16	35.16
800	15.80	19.13	34.93
850	15.70	19.11	34.81
900	15.50	19.08	34.58
950	15.40	19.06	34.36
1000	15.30	19.04	34.34
1050	14.50	18.90	33.40
1100	12.40	18.53	30.93

Shielded Area

Temperature °F	S_h ksi	S_a ksi	$S_a + S_h$ ksi
-20 to 100	18.70	28.05	46.75
200	18.70	28.05	46.75
300	18.30	27.95	46.25
400	18.00	27.88	45.88
500	17.90	27.85	45.75
600	17.00	27.63	44.63
650	16.60	27.53	44.13
700	16.30	27.45	43.75
750	16.00	27.38	43.38
800	15.80	27.33	43.13
850	15.70	27.30	43.00
900	15.50	27.25	42.75
950	15.40	27.23	42.63
1000	15.30	27.20	42.50
1050	14.50	27.00	41.50
1100	12.40	26.48	38.88

The allowable stresses are based upon the following ANSI B31.1 equations:

$$S_a = f[1.25S_c + 0.25S_h]$$

where: S_c = Basic material allowable stress at cold temperature from the allowable stress tables

S_h = Basic material allowable stress at (hot) temperature from the allowable stress tables

f = Stress range reduction factor for cyclic conditions for total number, N, of full temperature cycles over total number of years during which system is expected to be in operation, from Table 102.3.2,C of ANSI B31.1

The value of "f" for the thermal window area and the shielded area is given below:

Thermal Window Area

Number of cycles for 30 years are:

22,000 full range ....70^oF to 1050^oF

28,000 hold periods ....610^oF to 1050^oF

The equivalent full temperature cycles is

$$N = N_E + r_1^{\,5} N_1$$

where: N_E = Number of cycles at full temperature change ΔT_E for which expansion stress S_E has been calculated.

N_1 = Number of cycles at lesser temperature changes ΔT_1

$$r_1 = \frac{\Delta T_1}{\Delta T_E}$$

N_E = 22,000 cycles

N_1 = 28,000 cycles

T_E = 980^oF

T_1 = 440^oF

$$r_1 = \frac{440}{980} = 0.449$$

$N = 22{,}000 + [.449]^5[28{,}000] = 22{,}510$ cycles

From Table 102.3.2,c, of ANSI B 31.1, f = 0.70

Shielded Area

Number of cycles for 30 years are:

50,000 partial range*..............425°F to 1050°F

$$r_1 = \frac{\Delta T_1}{\Delta T_E} = \frac{1050 - 425}{1050 - 70} = \frac{625}{980} = .638$$

$N = [.638]^5[50{,}000] = 5285$ cycles

From Table 102.3.2,c, of ANSI B31.1, f = 1.0

* Trace heated Area

3.6.2 ASME Section VIII Allowable Stresses

Maximum allowable stress values in Tension for High Alloy Steel
Material: SA-213 TP316 Smls Tube, 16Cr-12Ni-2Mo
Reference: ASME Section VIII, Division 1, Table UHA-23

Yield Strengh @ Room Temperature = 30 ksi
Tensile Strengh @ Room Temperature = 75 ksi

Temperature °F	Allowable Stress KSI
-20 to 100	18.80
200	18.80
300	18.40
400	18.10
500	18.00
600	17.00
650	16.70
700	16.30
750	16.10
800	15.90
850	15.70
900	15.50
950	15.40
1000	15.30
1050	14.50
1100	12.40

3.6.3 Creep-Fatigue Damage Fraction Allowables

The receiver tubes creep-fatigue evaluations for life predictions are based on the criteria presented in ASME Code Case N-47 (Reference 7)

The tube stresses are evaluated for accumulated creep and fatigue damage including hold time and strain rate effects. For a design to be acceptable, the creep and fatigue damage fraction shall satisfy the following relation:

$$\Sigma\left(\frac{n}{N_d}\right) + \Sigma\left(\frac{t}{T_d}\right) \leq D \leq 1.0$$

Where D = Total creep-fatigue damage fraction
n = Number of applied cycles of loading
N_d = Number of design allowable cycles
T_d = Allowable time at a given stress intensity or at a given effective stress (for inelastic analysis)

The number of applied cycles of loading is shown in Figure 10. The total number of cycles is 50,000. Of this number, 22,000 cycles are for startup/shutdown for 30 years while 28,000 cycles are for low power operation.

Figures 11 and 12 present the design creep stress to rupture curve and the design fatigue curve. From the ASME Criteria document (Reference 9), the design stress values were obtained from the best fit curves by applying a factor of two on stress or a factor of twenty on cycles, whichever was more conservative at each point. For the Carrizo Plains Solar Receiver it is felt that the conservative factor used for Nuclear Plants is not required. Therefore, the allowable design values used

Carrizo Plains Solar Receiver
Cyclic Histogram
Figure 10

① Dry Preheat - 10 minutes
② Fill - 2 minutes
③ Power Buildup - 5 minutes
④ Operating - 441 minutes
⑤ Cool Down - 5 minutes
⑥ Hold - 10 minutes
⑦ Drain - 2 minutes
⑧ Cool Down - 30 minutes

Number Startup/Shutdown Cycles per 30 years = 22000

Number Low Power Cycles per 30 Year = 28000

Operating Hours per Day = 10

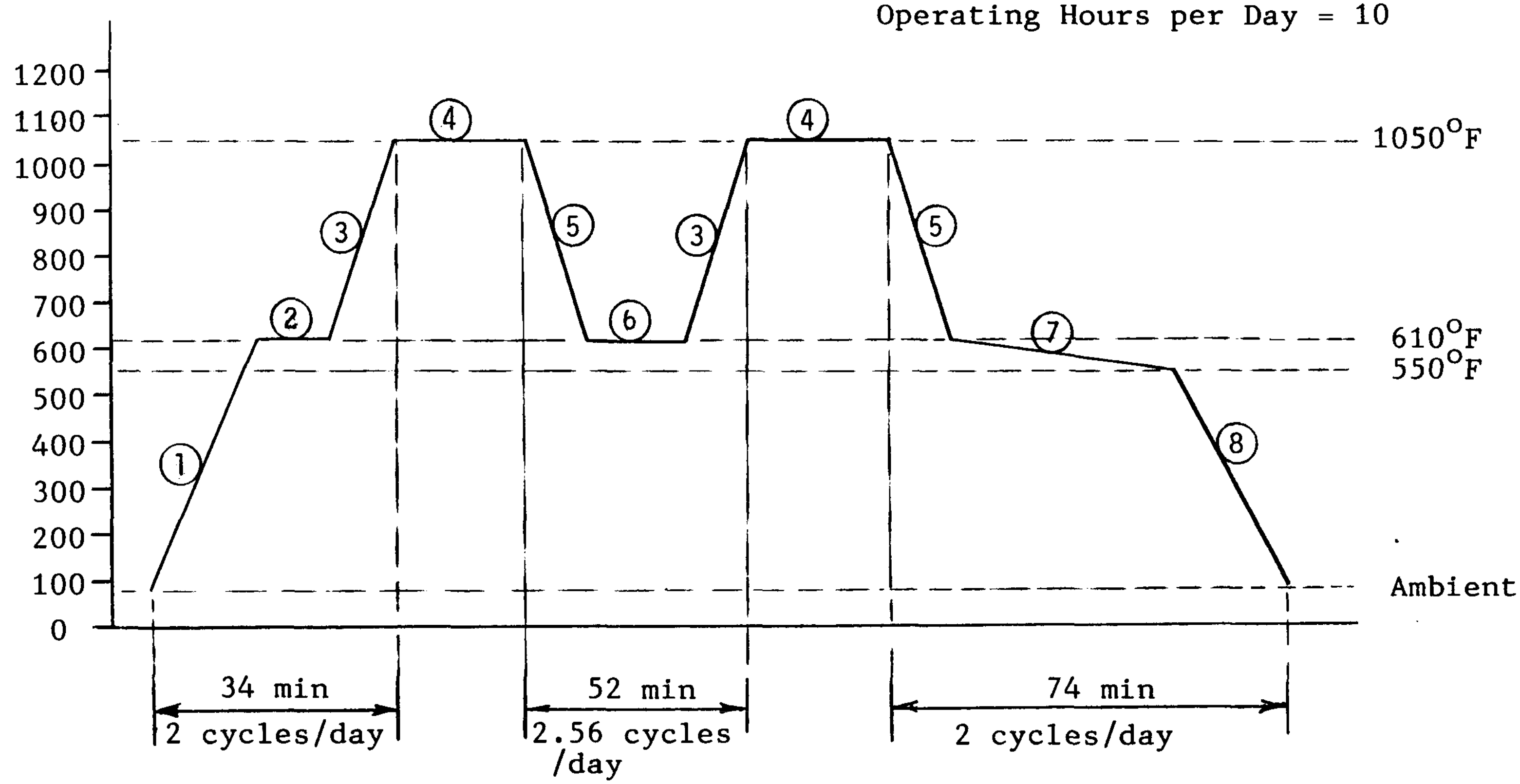


Table I-14.6B

Expected Minimum Stress-to-Rupture Values, 1000 psi
Type 316 SS

Temp., °F	1 hr	10 hr	30 hr	10^2 hr	3×10^2 hr	10^3 hr	3×10^3 hr	10^4 hr	3×10^4 hr	10^5 hr	3×10^5 hr
800	64.5	64.5	64.5	64.5	64.5	64.5	64.5	64.5	64.5	64.5	64.5
850	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	60	56	52
900	62.2	62.2	62.2	62.2	62.1	62	58	54.1	48	42.6	38
950	60	60	60	60	56	51.6	46.5	42.6	37.5	32.4	28.3
1000	58.5	58.5	55	51.7	47	42.1	37.5	33.6	28.8	24.6	21
1050	56	52.9	47.5	43.4	38.2	34.4	30.2	26.4	22.3	18.8	16
1100	53.5	45.1	40	36.4	32.2	28.1	24.2	20.8	17.3	14.3	11.7
1150	46.5	38.4	34	30.5	26.6	23.0	19.5	16.4	13.4	10.9	8.8
1200	40	32.7	29	25.6	22	18.8	15.6	12.9	10.3	8.3	6.7
1250	35	27.8	24.3	21.4	18.1	15.4	12.7	10.2	8.1	6.3	4.9
1300	30	23.7	20.8	18.0	15	12.5	10.0	8.0	6.2	4.8	3.7
1350	26	20.0	17.5	15.0	12.7	10.4	8.2	6.4	4.9	3.6	2.7
1400	22.5	17.1	14.8	12.4	10.2	8.4	6.6	5.0	3.8	2.8	2.1
1450	19.5	14.6	12.6	10.5	8.6	6.8	5.2	3.9	2.9	2.1	1.5
1500	17	12.5	10.6	8.8	7.2	5.6	4.2	3.1	2.3	1.6	1.2

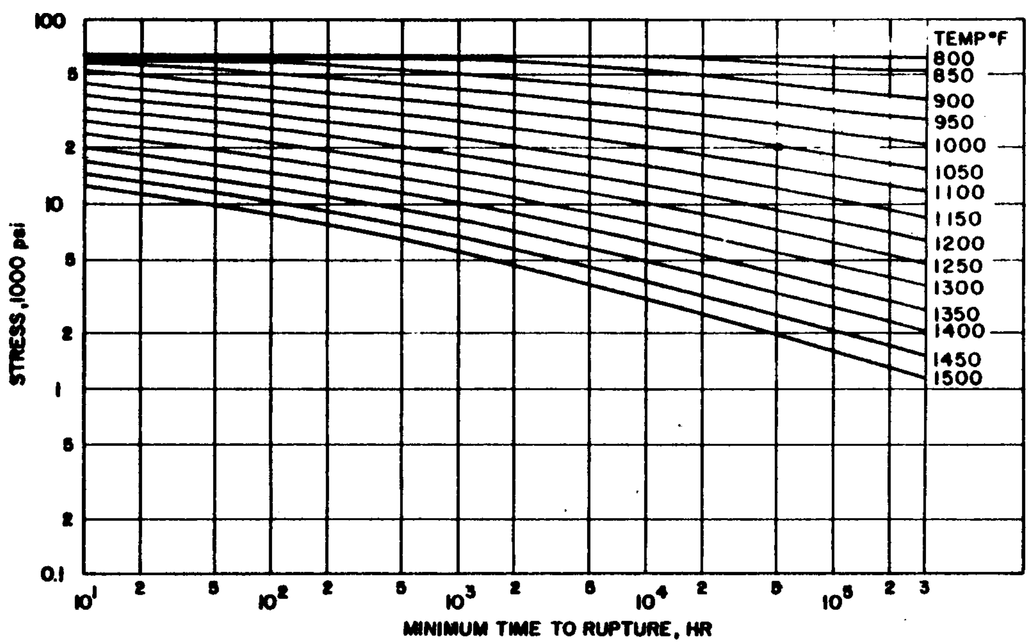


Fig. I-14.6B Stress-to-rupture (minimum)

ıre 11

CASES OF ASME BOILER AND PRESSURE VESSEL CODE

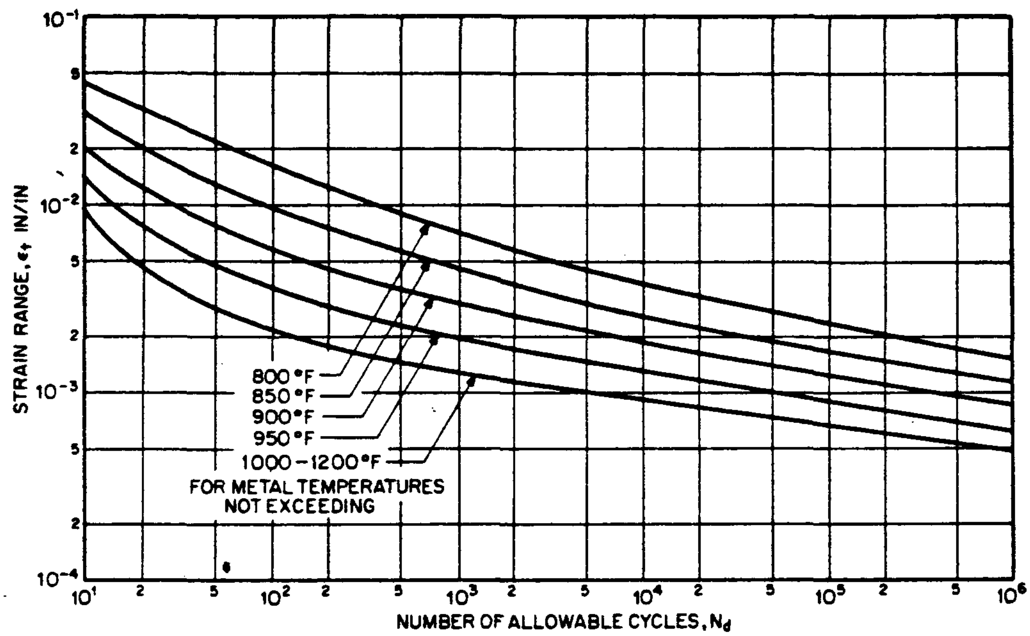


Fig. T–1430-1A,1B Design fatigue strain range, ϵ_t, 304 SS and 316 SS – elastic analysis

Table T–1430-1A, 1B

Design Fatigue Strain Range, ϵ_t, for 304 SS and 316 SS (Elastic Analysis)

N_d Number of Cycles	ϵ_t, Strain Range (in./in.) at Temperature				
	800 F	850 F	900 F	950 F	1000-1200 F
10^1	.0448	.0303	.0201	.0137	.00915
2×10^1	.0318	.020	.0124	.0078	.00472
4×10^1	.0231	.0145	.00867	.0051	.00322
10^2	.0168	.00982	.00587	.00355	.00212
2×10^2	.0125	.00772	.00469	.0028	.00174
4×10^2	.00956	.00612	.00387	.0024	.00152
10^3	.00711	.00462	.00304	.00198	.00129
2×10^3	.00576	.00382	.00257	.00173	.00114
4×10^3	.00476	.00322	.00222	.00153	.00104
10^4	.00376	.00261	.00186	.0013	.000922
2×10^4	.00316	.00222	.00164	.00116	.000842
4×10^4	.00269	.00202	.00144	.00106	.000762
10^5	.00224	.00162	.00122	.000899	.000662
2×10^5	.00196	.00147	.00108	.000799	.000602
4×10^5	.00176	.00131	.000966	.000719	.000544
10^6	.00151	.00112	.000826	.000619	.000482

Figure 12

in this report for creep-fatigue damage calculations will be based on a factor of safety of 4.0 rather than 20.

$$N_d' = 5N_d$$

$$T_d' = 5T_d$$

3.7 Methods of Analysis

The analysis of the Carrizo Plains receiver subsystem is performed in accordance with the requirements of the ASME Code, Section VIII, ANSI B31.1 and the AISC Code.

Finite element analysis was used extensively in the evaluation of the receiver subsystem stresses. Three finite element models were used in the Preliminary Design of the receiver. The models are described briefly in this section of the report and in detail in Section 6.2.

(1) Receiver Subsystem Model: The SAP V finite element model includes the sodium tubes, tangs, hatbands, support rods, manifolds, inlet and outlet piping, and the support truss. Loadings considered include deadweight, thermal expansion, seismic, and wind.

(2) Single Tube Model: This model was used to determine the receiver loading due to a temperature differential between the flux side of the receiver tube and the back side of the tube.

(3) Tube Cross-section Model: This model was used to determine the effects of the through the wall gradient and across the tube gradient for the purpose of determining the creep-fatigue damage fraction life evaluations. This model considered the inelastic behavior of the sodium tubes.

In most cases, the loads from the finite element models were considered to be added absolutely (conservative) since loads due to seismic and wind may be a variable direction condition.

4.0 CONCLUSIONS

The structural evaluations of the Carrizo Plains Receiver Subsystem contained in this report demonstrates that the proposed Preliminary Design Configuration satisfies the gross requirements of the structural criteria and loading conditions contained in the Receiver Design Specification. However, additional analyses are required to verify the structural adequacy of the entire subsystem design for all of the loading and transient conditions anticipated. The additional analyses required are itemized in Section 2.0 of this report and will be performed during the remaining Preliminary and Final Design phases of the project.

5.0 REFERENCES

1. Receiver Subsystem Solar Central Power Plant, Carrizo Plains Unit 1 Design Specification N10049, Prepared by T.L. Johnson, Rockwell International, Energy Systems Group, 8900 Desoto Ave., Canoga Park, Ca. 91304
2. Uniform Building Code (UBC), 1979 Edition, International Conference of Building Officials, Whittier, Ca.
3. Receiver Tower Trade Study, Solar Repowering Study, Permian Basin - Unit No. 1, TESCO, A.W. McKenzie to T.H. Springer, Sterns Rodger Letter C-23147-16, Dated January 24, 1980
4. American National Standard Code For Minimum Design Loads in Buildings and other Structures, ANSI A58.1-1972 Edition, American National Standard Institute, Inc., 1430 Broadway New York, N.Y. 10018
5 ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Pressure Vessels, 1980 Edition, American Society of Mechanical Engineers, United Engineering Center, 345 East 47th St., New York, N.Y. 10017
6. American National Standard Code For Pressure Piping, ANSI B31.1-1977 Edition, American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y., 10017
7. ASME Boiler and Pressure Vessel Code, Code Case N-47, Nuclear Components, 1980 Edition, American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y. 10017
8. Manual of Steel Construction, Eighth Edition, American Institute of Steel Construction, Inc., 400 North Michigan Ave., Chicago, Ill., 60611

9. Criteria of the ASME Boiler and Pressure Vessel Code For Design by Analysis in Sections III and VIII, Division 2, American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y. 10017

10. Report 079TI000002, Thermal Analysis of Central Receiver for Preliminary Design Phase, Prepared by E. Mourdian, Rockwell International, Energy Systems Group, Dated March, 1983

11. Report N036TI6300007, "SAP V Users Manual", A.P.Gelman and A. Hromjak, Atomics International, November, 1976

12. ANSYS Engineering Analysis System Users Manual, November, 1977, Swanson Analysis Systems Inc., P.O. Box 65, Houston, Pennsylvania, 15342

13. Nuclear Systems Materials Handbook, TID 26666, Supporting Documentation for Design Data, Hanford Engineering Development Laboratory P.O. Box 1970 Richland, WA 99352

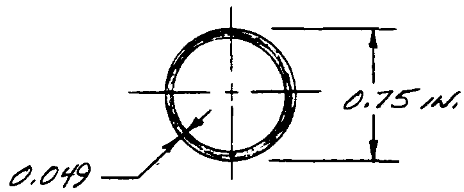
6.0 APPENDICES

APPENDIX 6.1

ASME Section VIII Analysis

RECEIVER TUBES ~ SECTION VIII ANALYSIS

SUMMARY



Material 316SS (SA-213 TP316)
Design Pressure : 100 psi
Design Temperature : 1050 °F

① Internal Pressure

Allowable Pressure = 2000 psi Circumferential
4640 psi Longitudinal
Design Pressure = 100 psi

D.M. = High

② Standard Hydrostatic Test Pressure

P_{Test} = 194 psi @ Room Temperature

③ Longitudinal Compression Stress Allowable

$F_{compression}$ = 10,000 psi @ 1050 °F
= 12,000 psi @ 610 °F

④ External Pressure Stress Allowable

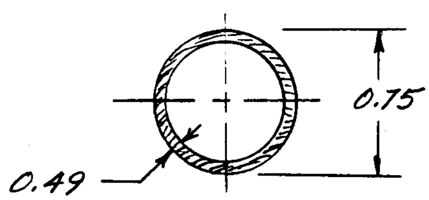
P_a = 784 psi @ 1050 °F

RECEIVER TUBES ~ SECTION VIII ANALYSIS

① Internal Pressure

UG-31 Tubes, and Pipe When Used as Tubes or Shells.

The required wall thickness for tubes and pipe under internal pressure shall be determined in accordance with the rules for shells in UG-27. The applicable stress values given in the stress tables for welded tubes and pipe shall be used instead of the factor SE in the formulas of UG-27. No increase in these stress values shall be allowed for the performance of radiography.



Material : 316 SS (SA-213 TP316)
Design Pressure : 100 psi
Design Temperature : 1050°F

a) Circumferential stress

$$P = \frac{St}{R + 0.6t}$$

where : S = 14,500 psi @ 1050°F
Table UHA-23
t = 0.049 in.
R = 0.326 in.

$$P = \frac{14500(.049)}{0.326 + 0.6(.049)} = 2000 \text{ psi}$$

$$D.M. = \frac{2000}{100} - 1 = \underline{\underline{High}}$$

RECEIVER TUBES ~ SECTION VIII ANALYSIS

① Internal Pressure ~ Cont'd.

b) Longitudinal Stress

$$P = \frac{2St}{R - 0.4t}$$

$$= \frac{2(14500)(0.049)}{0.326 - 0.4(0.049)} = 4640 \text{ psi}$$

$$D.M. = \frac{4640}{100} - 1 = \underline{\underline{High}}$$

② Standard Hydrostatic Test

UG-99 The hydrostatic test pressure shall be at least equal to 1.5 times the maximum allowable working pressure (design pressure) multiplied by the lowest ratio of the stress value S for the test temperature on the vessel to the stress value S for the design temperature.

$$P_{TEST} = 1.5\, P_{DESIGN} \left[\frac{S_{R.T}}{S_{DES.\ TEMP}} \right]$$

where: $P_{DESIGN} = 100$ psi

$S_{RT} = 18800$ psi } Ref 5
$S_{DESIGN\ TEMP} = 14500$ psi } UHA-23

$$P_{TEST} = 1.5(100)\left(\frac{18800}{14500}\right) = 194 \text{ psi}$$

PREPARED BY: Castle	Rockwell International Energy Systems Group	PAGE NO. 63 OF
CHECKED BY:		079TI000001 REPORT NO.
DATE: 10-19-82		MODEL NO.

RECEIVER TUBES ~ SECTION VIII ANALYSIS

③ Maximum Allowable Longitudinal Compressive Stress

UG-23 (b) The allowable longitudinal compressive stress shall be the smaller of the following values

a) The maximum allowable tensile value from UHA-23: $S = 14500$ psi @ 1050°F

b) The value of the factor B

$t = 0.049$ in

$R_o = 0.375$ in.

$E = 22.1 \times 10^6$ psi Ref: Code Case N-47

$$A = \frac{0.125}{(R_o/t)} = \frac{0.125}{(.375/.049)} = 0.0163$$

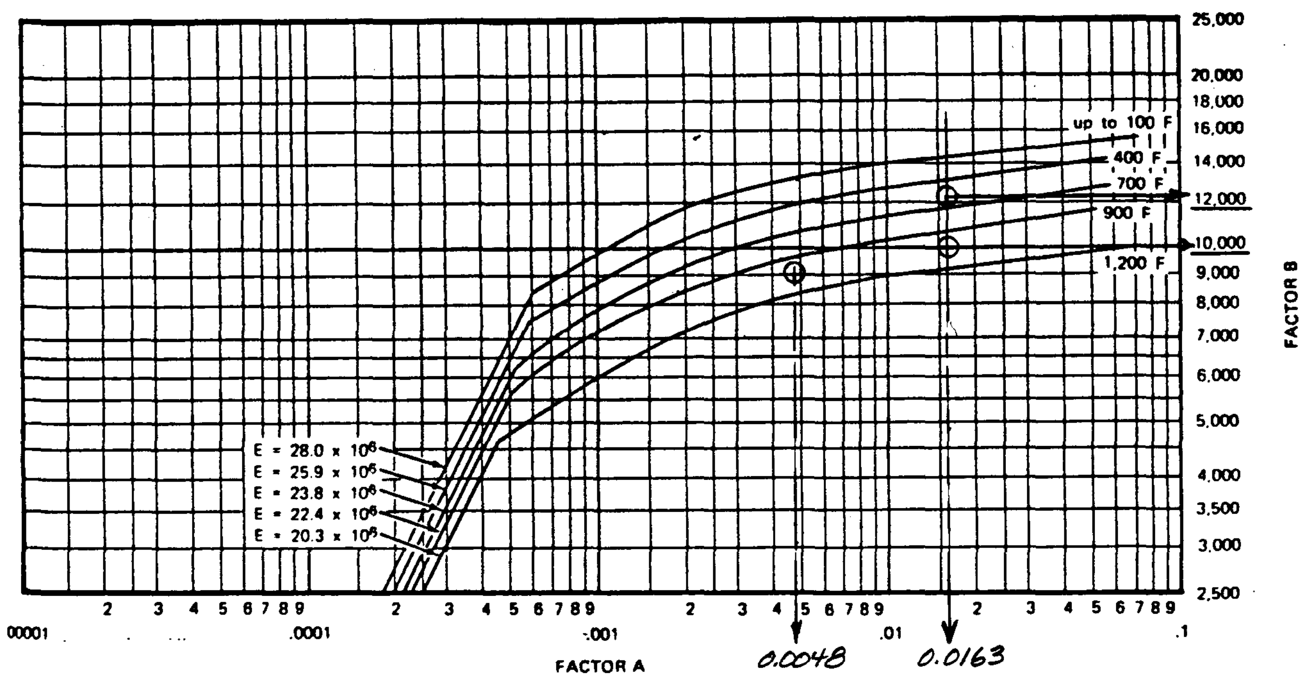


FIG. UHA-28.2 CHART FOR DETERMINING SHELL THICKNESS OF CYLINDRICAL AND SPHERICAL VESSELS UNDER EXTERNAL PRESSURE WHEN CONSTRUCTED OF AUSTENITIC STEEL [18 CR-8 NI + MO, TYPE 316; 18 CR-8 NI + TI, TYPE 321; 18 CR-8 NI + CB, TYPE 347; 25 CR-12 NI, TYPE 309 (THROUGH 1100 F ONLY); 25 CR-20 NI, TYPE 310; AND 17 CR, TYPE 430B STAINLESS STEEL (THROUGH 700 F ONLY)] (NOTE 8)

RECEIVER TUBES ~ SECTION VIII ANALYSIS

③ Maximum Allowable Longitudinal Compressive Stress ~ Cont'd

From Figure UHA-28.2 :

Factor B = 10,000 psi @ 1050°F
= 12,000 psi @ 610°F

The maximum direct (membrane) stress due to any combination of loadings listed in UG-22 that are expected to occur simultaneously during normal operation of the vessel shall not exceed the Factor B.

④ Thickness of Shells and Tubes Under External Pressure - UG 28

$$\frac{D_o}{t} \geq 10 = \frac{0.75}{0.049} = 15.31$$

where : D_o = Outside Diameter of tube
t = Tube thickness

$$\frac{L}{D_o} = \frac{4(12)}{0.75} = 64.0$$

where : L = Length between tube supports

From Figure UGO-28.0 (next page)

Factor A = 0.0048

From Figure UHA-28.2 (previous page)

Factor B = 9000

The maximum allowable pressure, P_a, is :

$$P_a = \frac{4B}{3(D_o/t)} = \frac{4(9000)}{3(15.31)} = 784 \text{ psi}$$

RECEIVER TUBES ~ SECTION VIII ANALYSIS

④ Thickness of Shells and Tubes Under External Pressure ~ Cont'd

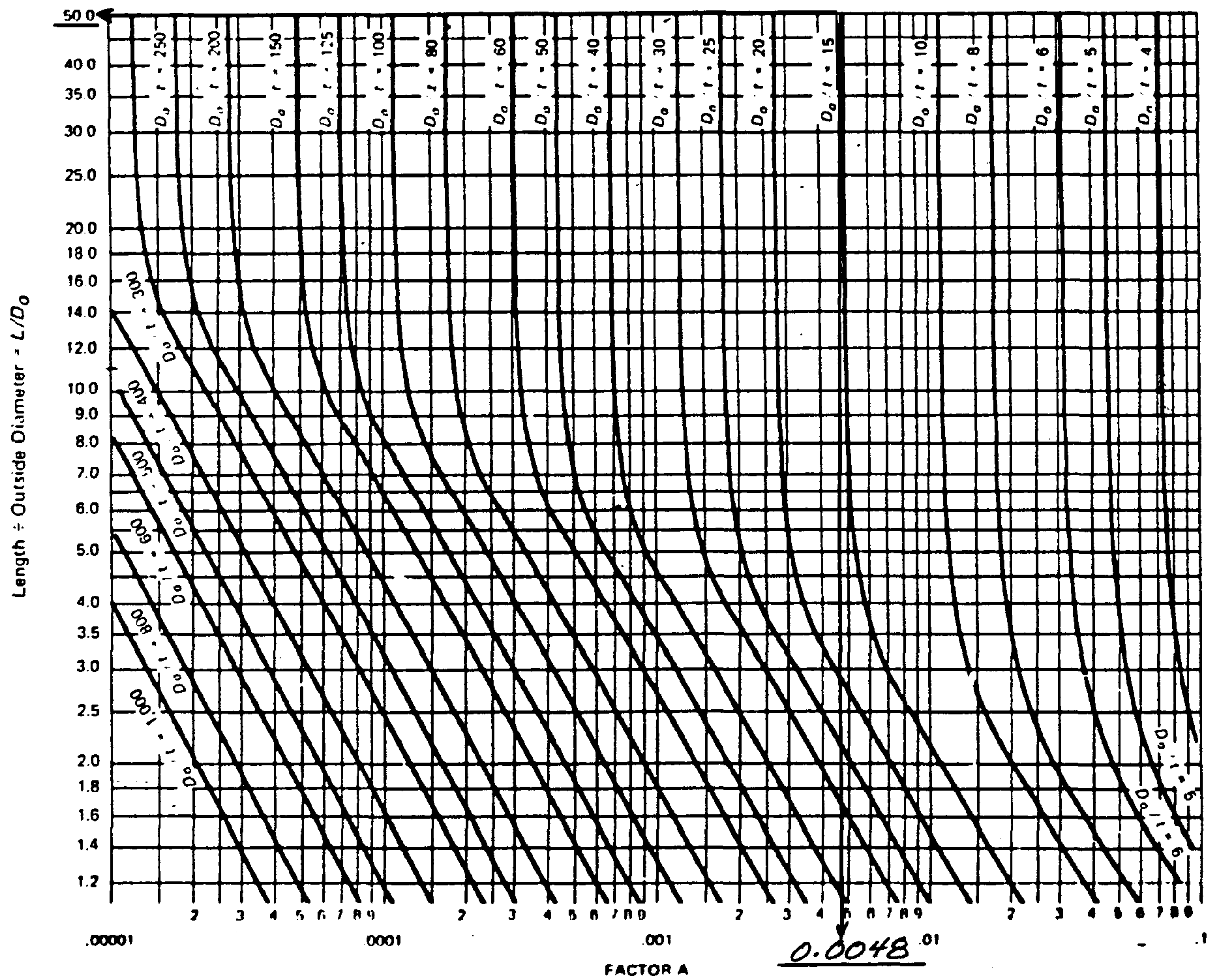


FIG. UGO-28.0 GEOMETRIC CHART FOR CYLINDRICAL VESSELS UNDER EXTERNAL OR COMPRESSIVE LOADING (FOR ALL MATERIALS)

APPENDIX 6.2

Finite Element Model Descriptions

RECEIVER SUBSYSTEM MODEL

An edge panel of the receiver subsystem was modeled in detail to determine the loading effects of deadweight, thermal expansion, seismic and wind environments. This model was also used to evaluate the dynamic characteristics of the panel.

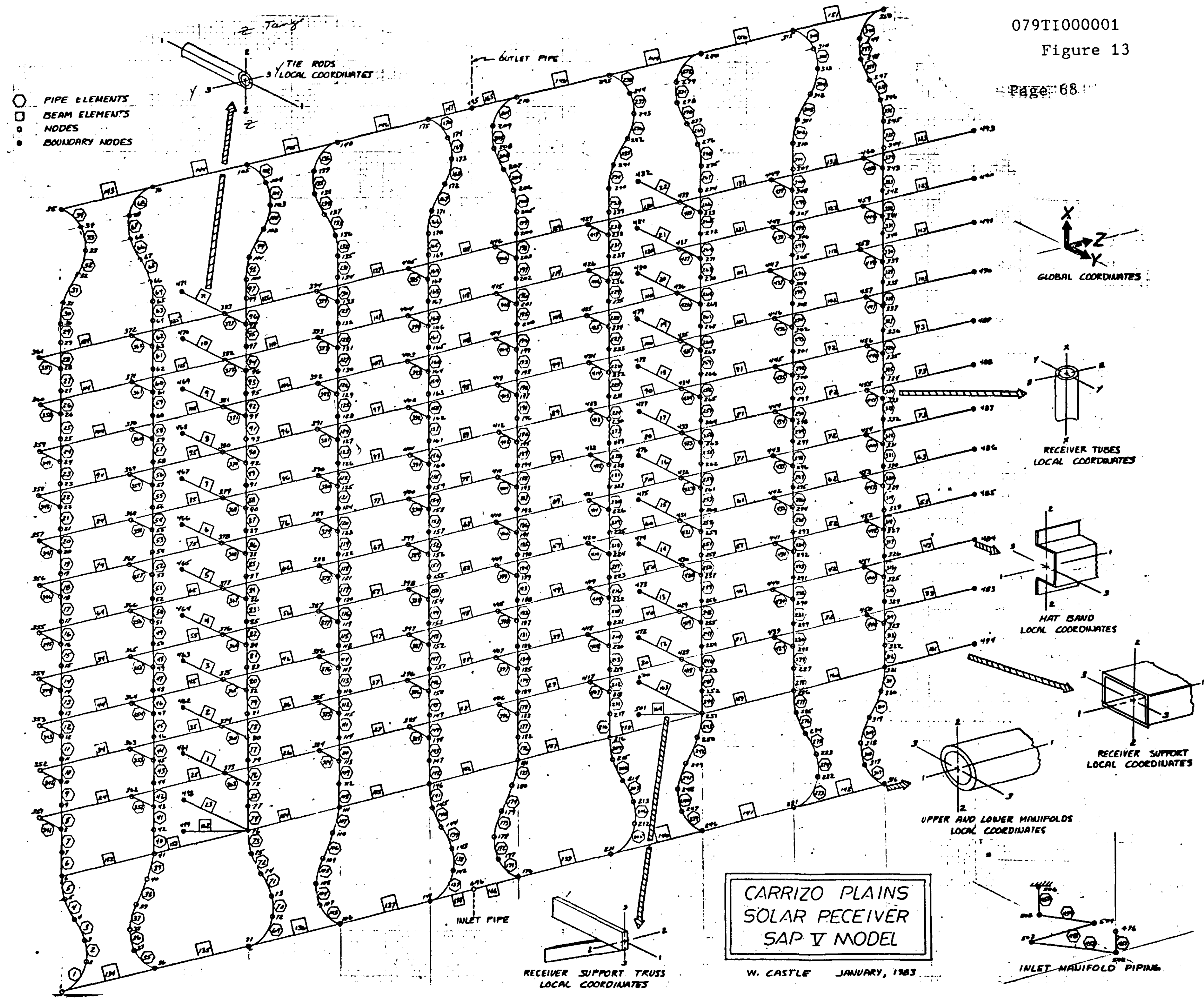
The SAP V finite element code (Reference 11) was used to perform the evaluation. The model contains 520 nodes and 631 elements. Two types of elements are used in the model.

Type 2 ... Three dimensional Beam Elements: Forces (axial and shear) and moments (bending and torsion are calculated (in local beam coordinate system) for each beam element. Gravity loadings in each coordinate direction and specified fixed end forces form the basic element load conditions.

Type 12 .. Three Dimensional Straight or Curved Pipe Elements: Axial and shear forces, torque and bending moments are calculated for each beam element. Gravity loadings in the global (X,Y,Z) directions, uniform temperature changes (computed from input nodal temperatures), and extensional effects due to internal pressure form the basic member loading conditions.

The following components and their element type are included in the model and are shown in Figure 13.

Component	Element Type
Sodium Tubes	12
Tangs	12
Hatbands	2
Support Rods	2
Panel Support Box	2


PIPE ELEMENTS
BEAM ELEMENTS
NODES
BOUNDARY NODES
TIE RODS LOCAL COORDINATES
OUTLET PIPE
GLOBAL COORDINATES
RECEIVER TUBES LOCAL COORDINATES
HAT BAND LOCAL COORDINATES
RECEIVER SUPPORT LOCAL COORDINATES
UPPER AND LOWER MANIFOLDS LOCAL COORDINATES
INLET PIPE
RECEIVER SUPPORT TRUSS LOCAL COORDINATES
CARRIZO PLAINS
SOLAR RECEIVER
SAP V MODEL
W. CASTLE JANUARY, 1983
INLET MANIFOLD PIPING

Panel Support Truss	2
Inlet and Outlet Header Pipe	12
Headers	2

Since it was not practical to model each of the 102 tubes and 2244 tangs in each panel, every 10th tube was modeled and each set of tangs was modeled as one tang.

The inlet and outlet header sodium piping was included in the model to evaluate the thermal growth restraint they produce on the receiver panel.

The nodal temperatures for the thermal expansion evaluation are obtained from Reference 10. The thermal profiles for the edge panel from Reference 10, are shown in Figures 5 and 6. At a given elevation, the temperature profile was assumed to vary lineraly from the tube at the outboard edge of panel 1 to the tube at the inboard edge of panel 1. Temperatures from the inlet header to the thermal window and from the thermal window to the outlet header were assumed to be constant at 610°F and 1050°F respectively.

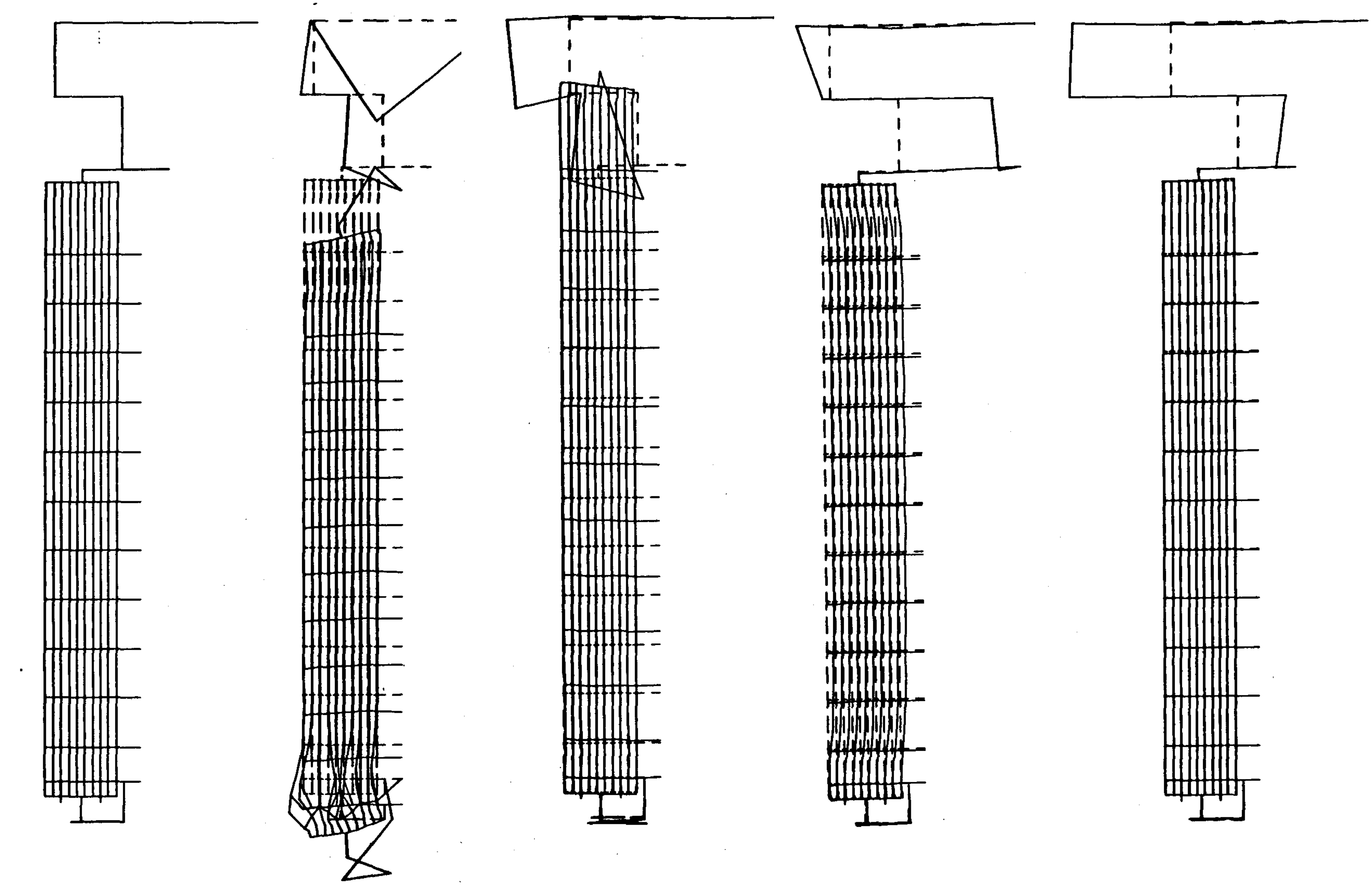
The earthquake loading was performed by inputing gravity factors of 0.40 in the planes lateral and normal to the panel and 0.27 in the vertical plane. The earthquake was conservatively assumed to act in three directions simultaneously. The earthquake design basis is presented in Section 3.2.1.1 of this report.

The wind loading was performed by inputing a gravity factor of 0.653 in the direction normal to the panel. The wind design basis is presented in Section 3.2.1.2 of this report and the gravity factor of 0.653 is derived on page 83 of this report. The wind loading considered for the analysis is the maximum operating design wind of 30mph. The 90mph wind was evaluated separately and found not to be as severe as the deadweight, thermal expansion, seismic and 30mph wind combination presented in this report.

The SAP V model section property calculations are shown on pages 75 through 83 of this Appendix.

Undeformed and deformed modal shape plots of the SAP V analysis for deadweight, thermal expansion, seismic and wind are shown in Figures 14, 15, and 16. The solid lines in the plots represent the undeformed model shape while the dashed lines represent the deformed modal shape.

Figure 14
CARRIZO PLAINS RECEIVER PANEL
UNDEFORMED AND DEFORMED SHAPES



Undeformed   Dead Weight   Thermal Expansion   Seismic   Wind

Figure 15

CARRIZO PLAINS RECEIVER PANEL

UNDEFORMED AND DEFORMED SHAPES

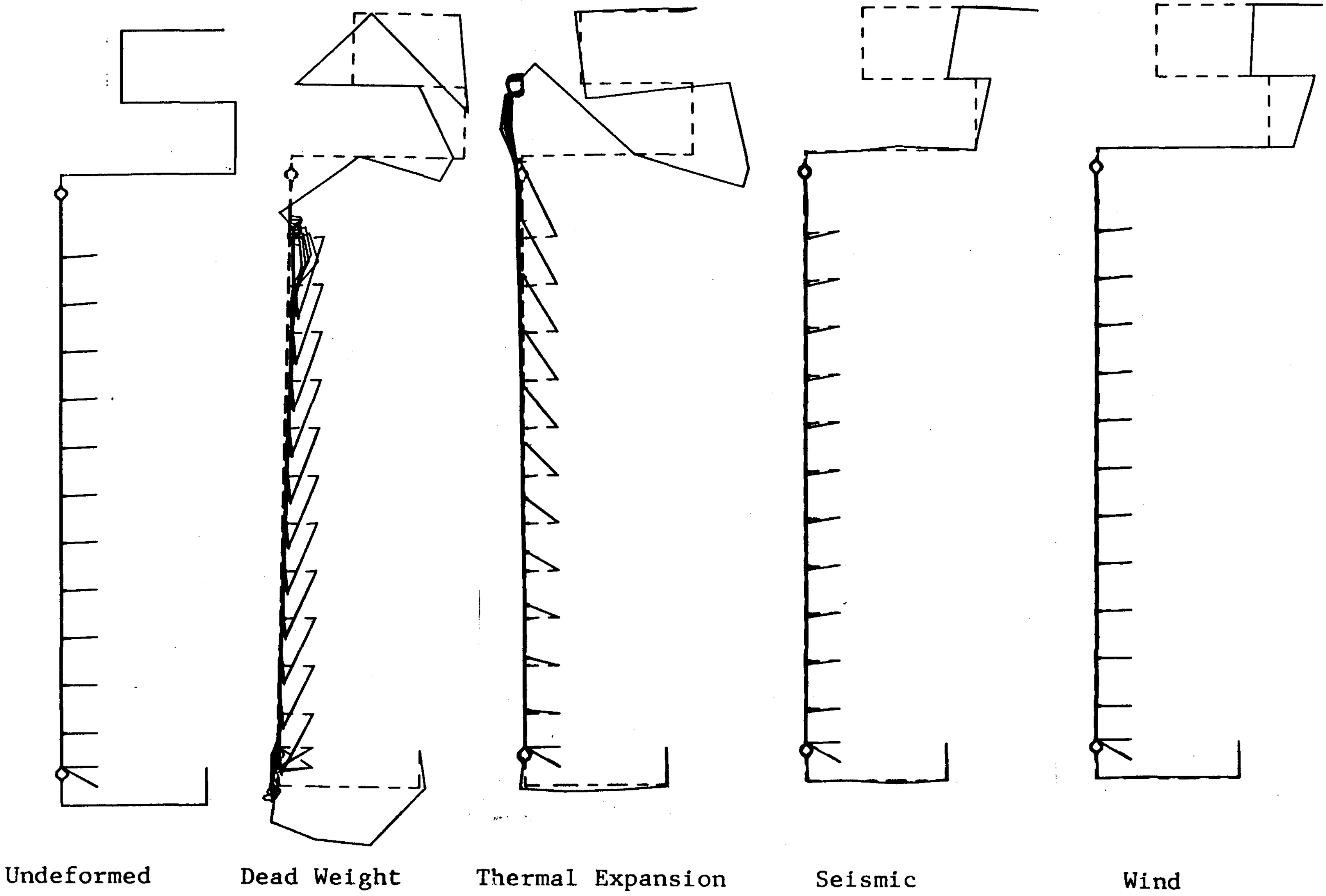
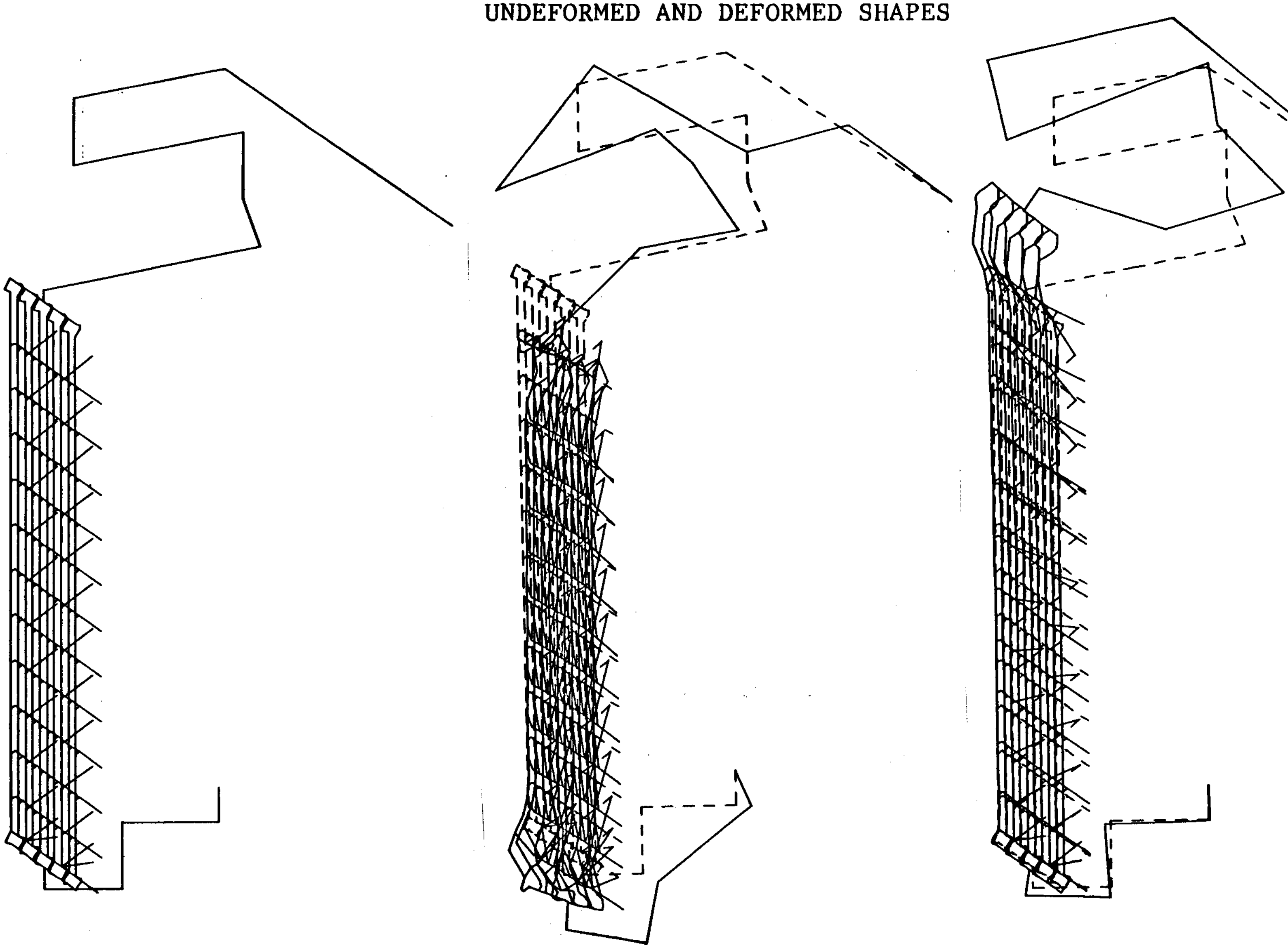


Figure 16

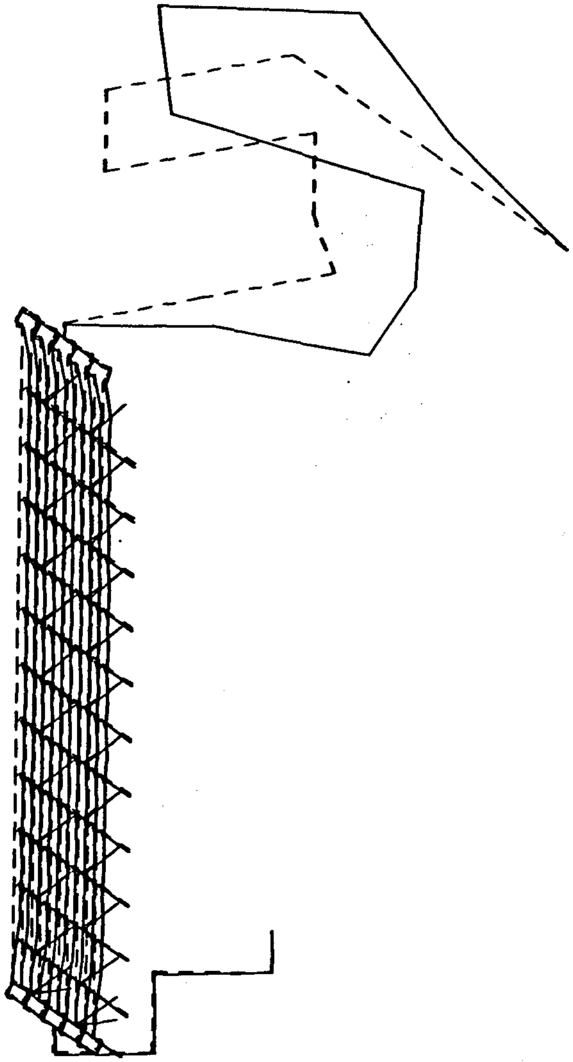
CARRIZO PLAINS RECEIVER PANEL

UNDEFORMED AND DEFORMED SHAPES

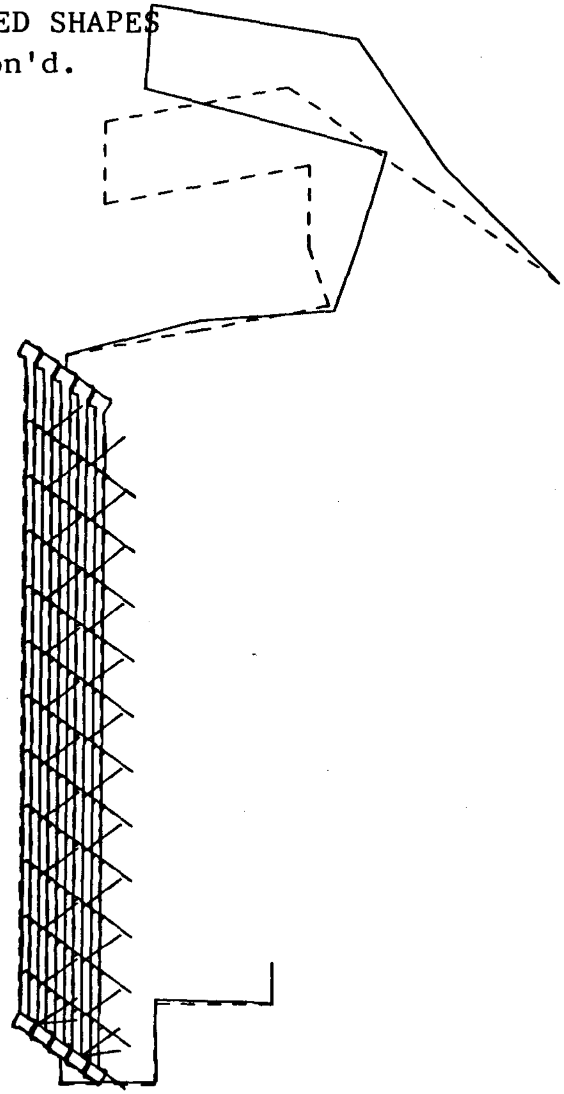


Undeformed   Dead Weight   Thermal Expansion

CARRIZO PLAINS RECEIVER PANAL
UNDEFORMED AND DEFORMED SHAPES
Figure 16 Con'd.



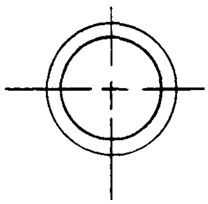
Seismic



Wind

CARRIZO PLAINS RECEIVER PANEL

Tube Section Properties



$D_o = 0.75$ in.

$t_w = .049$ in.

$A = 0.108 \text{ in}^2$

$I = 0.0067 \text{ in}^4$

Model Tube represents 10.2 tubes ∴

Model Area $= 10.2(0.108) = 1.102 \text{ in}^2$

Inertia $= 10.2(.0067) = .0683 \text{ in}^4$

Input a tube diameter and thickness that will give the proper inertia. Adjust the density to give the proper weight

Use a 1.5" ϕ tube, $t_w = 0.058$

$A = 0.26275 \text{ in}^2$

$I = 0.0684 \text{ in}^4$ ✓

Area inside actual tube

$= \pi(.326)^2 = 0.334 \text{ in}^2$

sodium density $= 0.03 \text{ lbs/in}^3$

wt sodium per unit length for 10.2 tubes

$= .334(.03)(10.2) = 0.102$ lbs/in

Metal area actual tube

$= 0.108 \text{ in}^2$

wt metal per unit length for 10.2 tubes

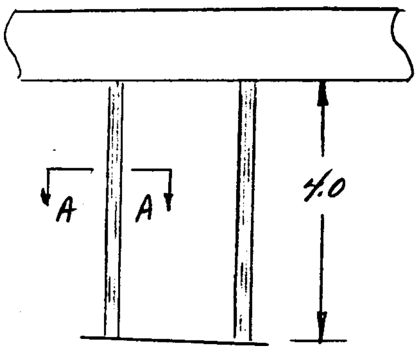
$= .108(.283)(10.2) = 0.312$

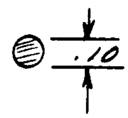
Model density $= .102 + .312 = 0.414$ lbs/in.

N 152-R-2 REV. 8-78

CARRIZO PLAINS RECEIVER PANEL

Tang Section Properties





section AA

$A = \pi(.05)^2 = .00785\ in^2$

$I = .25\pi R^4$

$= .25\pi(.05)^4 = 4.9 \times 10^{-6}$

For 10.2 tubes there are 2(10.2) = 20.4 tangs

$I = 4.9\times10^{-6} \times 20.4 = 1.0\times10^{-4}\ in^4$

Use .250"ϕ $\times\ t_w = 0.022$

$I = 1.03\times10^{-4}\ in^4$

$A = 0.1576\ in^2$

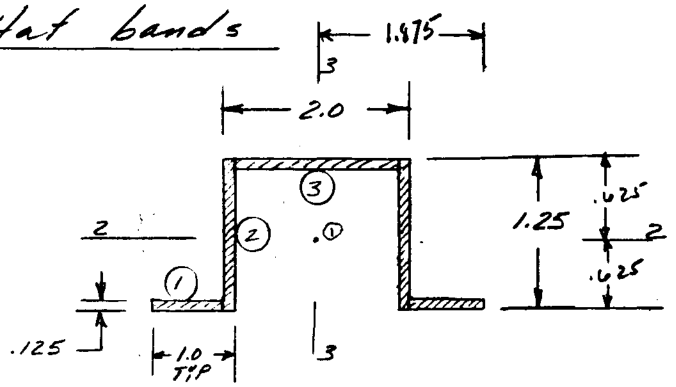
Actual Area = 20.4 (.00785) = 0.160 in^2

wt/unit length = 20.4(.0078)(1.0)(.286) = .0455 lb/in

CARRIZO PLAINS RECEIVER PANEL
SAP IV SECTION PROPERTIES

Hat bands

3.75



$$A = .125\left[2(.875) + 1.75 + 2(1.25)\right] = 0.75 \text{ in}^2$$

$$I_{22} = \frac{.25(1.25)^3}{12} + 2\left[.125(1.75)(.5625)^2\right] = 0.179 \text{ in}^4$$

$$I_{33} = \frac{.125(1.75)^3}{12} + 2\left[.125(1.25)(.9375)^2 + .125(.875)(1.4375)^2\right]$$

$$= .0558 + 2\left[.137 + .226\right] = 0.782 \text{ in}^4$$

$$A_{s22} = .125(2+2) = 0.50 \text{ in}^2$$

$$A_{s33} = 2(1.25)(.125) = .3125 \text{ in}^2$$

Torsional Constant

① $b/t = .875/.125 = 7 \qquad \beta = .303$

$R = 2(.303)(.875)(.125)^3 = .001$

② $b/t = 1.25/.125 = 10 \qquad \beta = .313$

$R = 2(.313)(1.25)(.125)^3 = .0015$

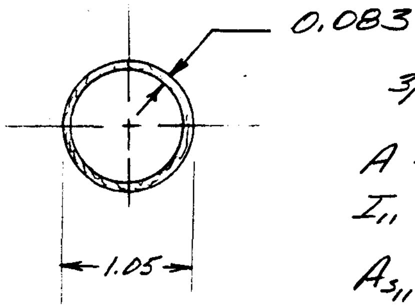
③ $b/t = 1.75/.125 = 14 \qquad \beta = .333$

$R = .333(1.75)(.125)^3 = .0011$

$\Sigma R = .0036 = J$

CARRIZO PLAINS RECEIVER PANEL
SAP V SECTION PROPERTIES

Support Rods



3/4" ϕ sch 10s pipe

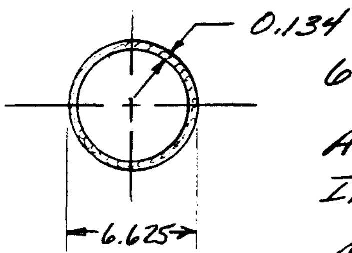
$A = 0.252 \ in^2$

$I_{11} = I_{22} = 0.0297 \ in^4$

$A_{s_{11}} = A_{s_{22}} = \frac{A}{K} = \frac{0.252}{1.885} = 0.134 \ in^2$

$J = 2\pi r^3 t = 2I_{11} = 0.0594 \ in^4$

Manifolds



6" ϕ sch 10 pipe

$A = 2.733 \ in^2$

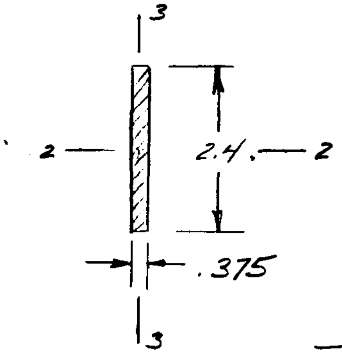
$I_{11} = I_{22} = 14.40 \ in^4$

$A_{s_{11}} = A_{s_{22}} = \frac{A}{K} = \frac{2.733}{1.885} = 1.45 \ in^2$

$J = 2I_{11} = 2(14.4) = 28.8 \ in^4$

CARRIZO PLAINS RECEIVER PANEL
SAP V SECTION PROPERTIES

Panel Support Beam Truss



$A = 2.4(.375) = 0.90 \text{ in}^2$

$I_{33} = \frac{2.4(.375)^3}{12} = 0.011 \text{ in}^4$

$I_{22} = \frac{.375(2.4)^3}{12} = 0.432 \text{ in}^4$

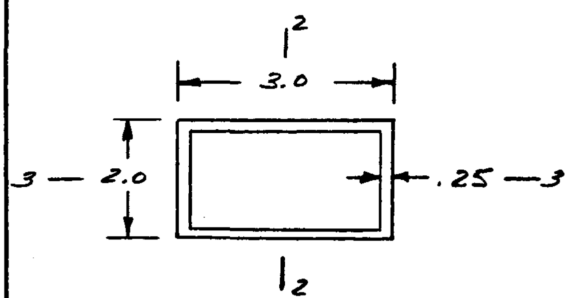
$A_s = A_s = 2.4(.375)/1.177 = 0.765 \text{ in}^2$

Torsional Constant

$b/t = 2.4/.375 = 6.4 \quad \beta \doteq 0.301$

$J = 0.301(2.4)(.375)^2 = 0.102 \text{ in}^3$

Panel Support Beam



From AISC Manual

$A = 2.09 \text{ in}^2$
$I_{22} = 2.21 \text{ in}^4$
$I_{33} = 1.15 \text{ in}^4$

$A_{s22} = 2(2.0)(.25) = 1.0 \text{ in}^2$
$A_{s33} = 2(3.0)(.25) = 1.5 \text{ in}^2$

Torsional Constant

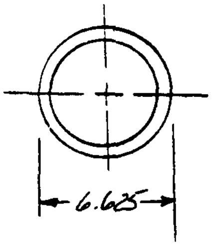
$J = \frac{2b^2h^2t^2}{t(b+t)} = \frac{2(1.75)^2(2.75)^2(.25)^2}{.25(1.75+2.75)} = 2.57$

where $b = 1.75$ in
$h = 2.75$ in
$t = .25$

CARRIZO PLAINS RECEIVER

INLET PIPING SECTION PROPERTIES

6 inch Sch 40 C.S. Pipe with Sodium



$t_{wall} = 0.280$ in
$ID = 6.065$ in
$A_{inside} = 28.89$ in^2
$A_{metal} = 5.58$
$w = 18.97$ lbs/ft $= 1.58$ lbs/in
$I = 28.14$ in^4

wt sodium per unit length

$w_s = 28.89(1.0)(.03) = 0.867$ lbs/in.

Model wt $= w + w_s = 1.58 + .867 = 2.45$ lbs/in.

CARRIZO PLAINS RECEIVER PANEL

SAP V MODEL PROPERTIES

Upper and Lower Manifold Density

6" ϕ Sch 10 pipe with sodium

Inside Area = 31.70 in^2

Sodium density = 0.03 lbs/in^3

wt sodium = 31.7 × .03 = 0.951 lbs/in

wt pipe = 9.29 lbs/ft = 0.774 lbs/in

Total weight (pipe + sodium) = .951 + .774 = 1.725 lbs/in

Metal Area = 2.733 in^2

Model density = $\frac{1.725}{2.733}$ = 0.631 lbs/in^3

PREPARED BY: Castle	Rockwell International Energy Systems Group	PAGE NO. 82 OF
CHECKED BY:		079TI000001 REPORT NO.
DATE: Jan 7, 83		MODEL NO.

SAP V Panel Pressure

Total Receiver weight = 3050 lbs

Hat bands

$A = 0.75\ in^2$

l / band = 96.63 − 3.87 = 92.76 in

No. bands = 11

wt = .75(92.76)(11)(.286) = 220 lbs.

Tie Rods

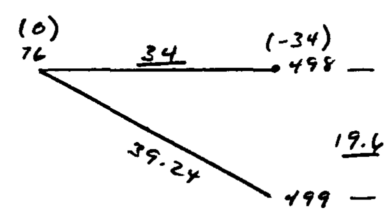
$A = 0.252\ in^2$

l = 34.0 − 4 = 30 in

No rods = 22

wt = .252(30)(22)(.286) = 48 lbs

Support Truss



$A = .90\ in^2$

l = 34 + 39.24 = 73.24 in

No truss = 2

wt = .90(73.24)(2)(.286) = 38 lbs.

Manifold

$\rho = .631$

A = 2.733

l = 73.44 − 3.87 = 69.57 in

No manifold = 2

wt = 2.733(69.57)(2)(.631) = 240 lbs.

Receiver Support

$A = 1.044\ in^2$

l = 96.63 − 3.87 = 92.76 in

wt = 1.044(92.76)(.286) = 28 lbs

SAP IV Panel Pressure

Total wt beam elements

$= 220 + 48 + 38 + 240 + 28 = 574$ lbs

Total pipe element wt

$= 3050 - 574 = 2476$ lbs.

Panel Pressure $= 0.0352$ psi for 30 mph wind

Total force pressure $= 600(76.5)(.0352) = 1616$ lbs.

Pressure factor for model

$$= \frac{1616}{2476} = \underline{\underline{0.653}}$$

Panel Pressure $= 0.375$ psi for 90 mph wind

Total force pressure $= 600(76.5)(.375) = 17213$ lbs.

Pressure factor for model

$$= \frac{17213}{2476} = 6.95$$

6.2.2 Single Tube Model

To evaluate the sodium tube and tang stresses due to the effects of a temperature differential from the flux side of the tube and the back insulated side, an ANSYS model was developed.

The model consists of a representation of a single tube of the receiver subsystem and the eleven sets of tangs supporting the sodium tubes. The model is shown in Figure 17 .

The sodium tubes are modeled using the ANSYS STIFF 20 straight pipe element and the tangs are modeled using the ANSYS 3D elastic bar element. The input data listing for the model is presented is Appendix 6.2 of this report.

The temperature profiles along the length of the tube were obtained using the T(front) curve of Figure 7 and the T(back) curve of Figure 7.

The tube and tang loads obtained from this model were supperimposed with the receiver subsystem model results to obtain the complete loading on the individual components of the receiver subsystem.

The tube and tang loads and stresses obtained from the single tube model are shown in Table 97 (tubes) and Table 102 (tangs).

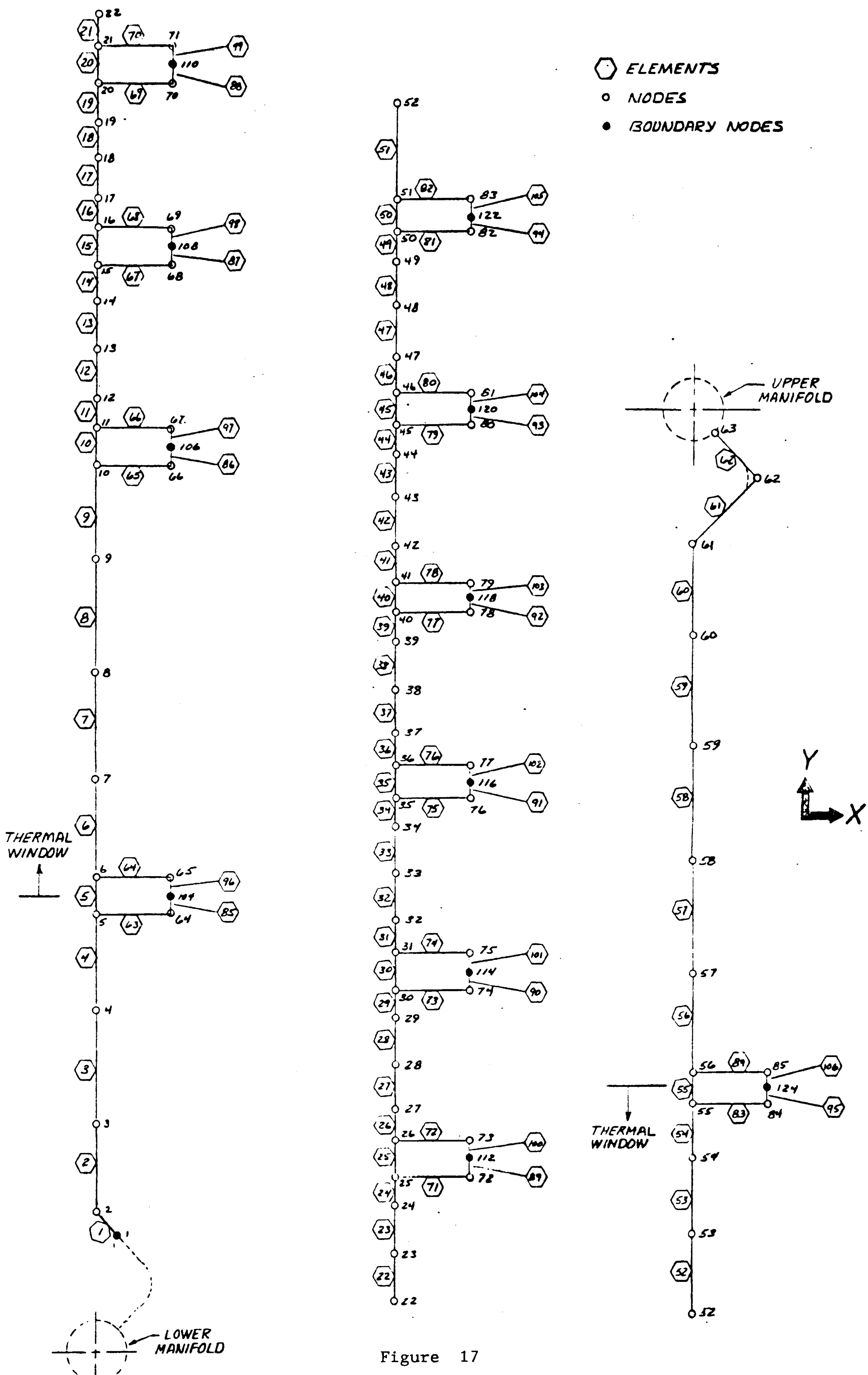
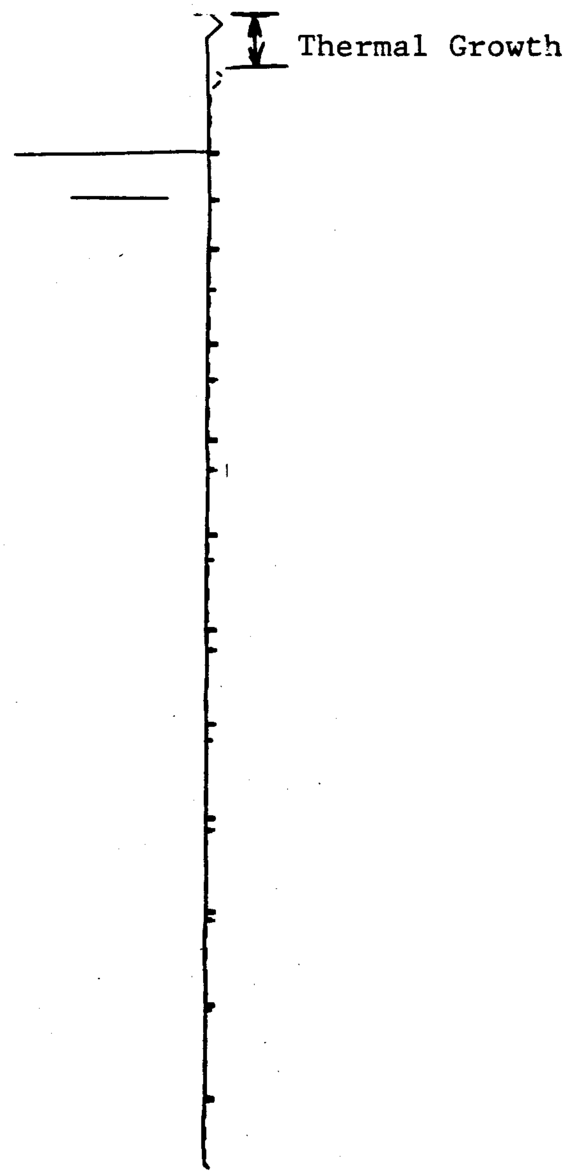


Figure 17

W. PROPES JANUARY 1983

CARRIZO PLAINS
SOLAR RECEIVER
ANSYS MODEL



CARIZZO SOLAR RECEIVER-(DWG.NO.079000001)-SINGLE TUBE-THERMAL LOADING

Figure 18
Carrizo Solar Receiver Single Tube Model CRT

6.2.3 Tube Cross-Section Model

To determine the creep-fatigue life evaluation of the Carrizo Plains Receiver tubes, a model of a single tube was constructed using the ANSYS Computer Code (Reference 12). A two dimensional isoparametric element with the axisymmetric modeling option (STIFF 42) was used to evaluate the tube. A meshplot of the cross-section of the tube is shown in Figure 19, and the thermal nodal map is shown in Figure 20.

Since the sodium tube is modeled as an axisymmetric model with a radius of 100 inches, it is possible to have the same effects as a generalized plane strain representation of a straight tube. This modeling technique was used since the ANSYS Code does not have a two dimensional generalized plain strain element available.

The temperature profile used in the analysis represents the maximum temperature gradients across the tube for a full thermal load at the tube mid-height. The temperature profile is shown in Figure 21 and Table 7, and was obtained from Reference 10. Temperature dependent material properties for the Type 316 Stainless Steel tube was obtained from the Nuclear Systems Material Handbook (Reference 13).

The creep equation for annealed Type 316 Stainless Steel available in the ANSYS Code is described in the Nuclear Systems Material Handbook.

The cyclic thermal history of the receiver tubes used in the analysis is shown in Figure 10.

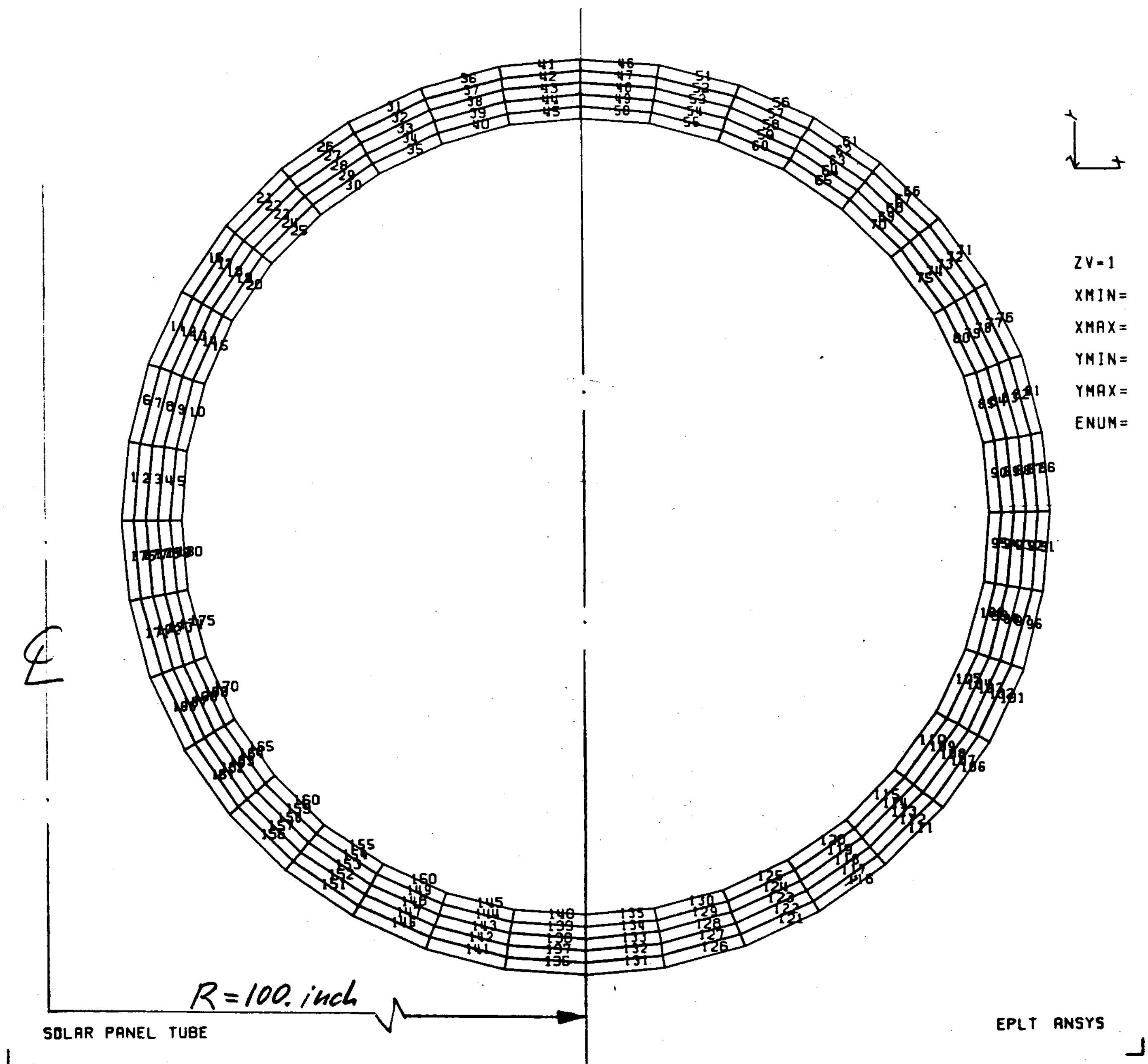


Figure 19

Meshplot of the Tube Cross-Section

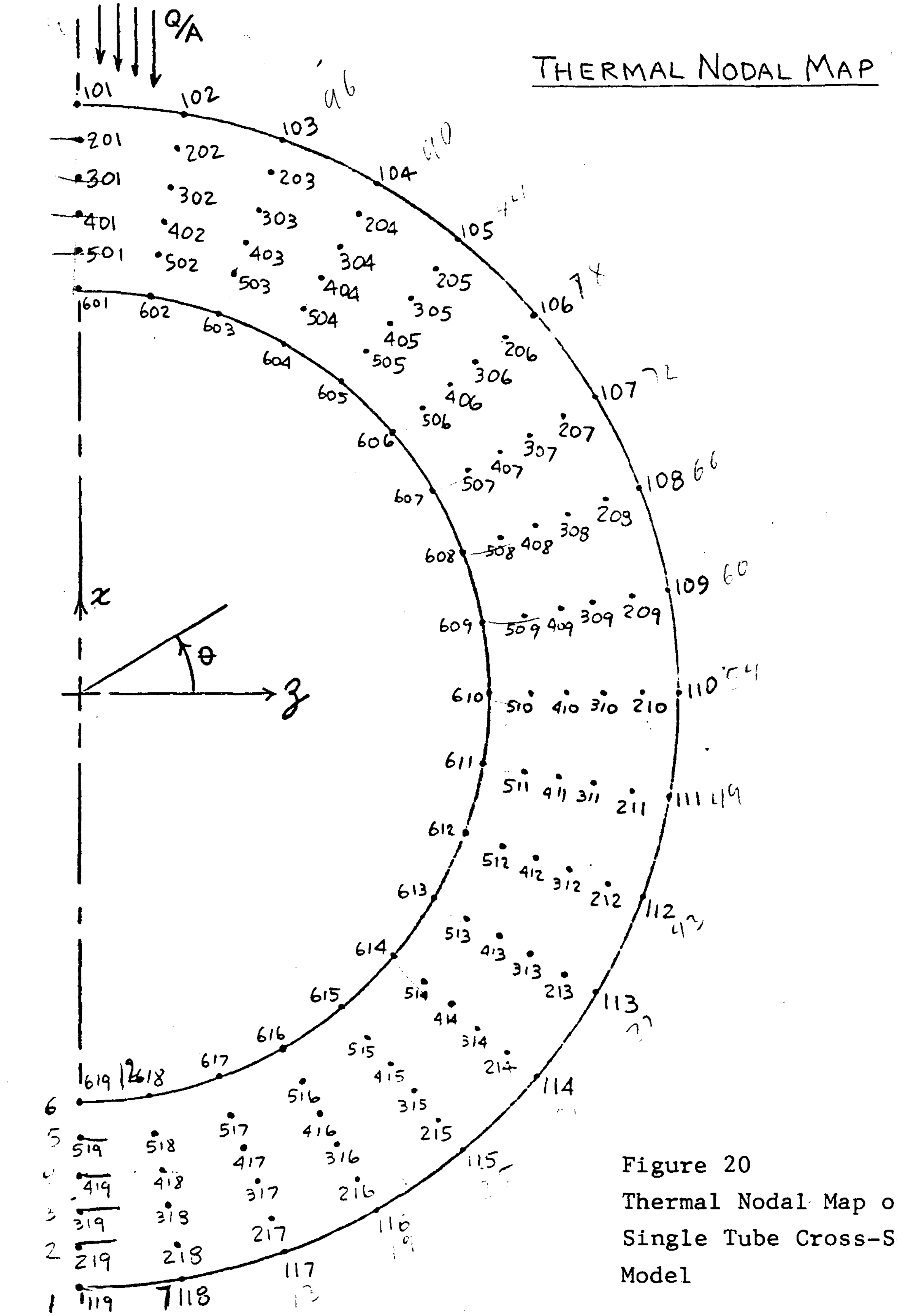
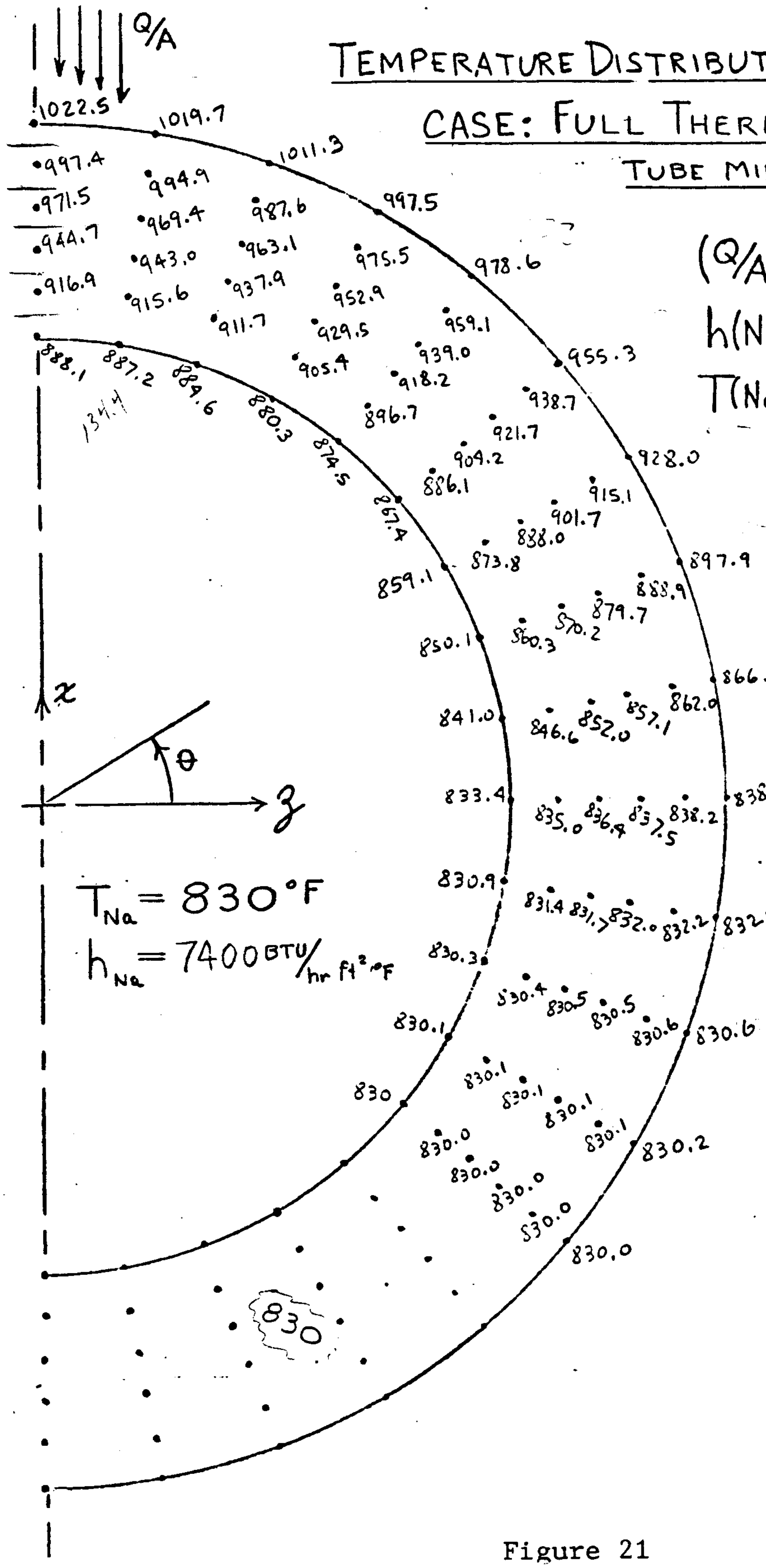


Figure 20
Thermal Nodal Map of the Single Tube Cross-Section Model

TEMPERATURE DISTRIBUTION MAP

CASE: FULL THERMAL LOAD

TUBE MID-HEIGHT (Z = 20 FT)



$(Q/A)_o = 1.20 \ \frac{MW}{m^2}$ (COSINE LOADING)

$h(Na) = 7400 \ BTU/hr\ ft^2\ °F$

$T(Na) = 830°F$

$T_{PEAK} = 1022.5°$

$\bar{T}_{MET} = 871.74°$

$\Delta T_1 = 139.66°$

$\Delta T_2 = 80.98°$

$T_{PK} - \bar{T}_{MET} = \frac{\Delta T_1}{2} + \Delta T_2 = 150.81°$

$T_{PK} - T_{Na} = 192.5°$

$T_{\text{"FRONT"}} = \bar{T} + \frac{\Delta T_1}{2} = 941.57°$

$T_{\text{"BACK"}} = \bar{T} - \frac{\Delta T_1}{2} = 801.91°$

$S_1 = \frac{E\alpha\Delta T_1}{2} = 18.575 \ PSI$

$S_2 = E\alpha\Delta T_2 = 21.541 \ PSI$

$S_{TOT} = S_1 + S_2 = 40.116 \ PSI$

$D_o = 3/4"$ SS: 316

$t_{WALL} = 0.049"$ $E\alpha = 266 \ \frac{PSI}{°F}$

Figure 21

The results of the creep-fatigue evaluation of the sodium tube are not complete at this time. The results of this accessment will be included in the next revision to this report.

APPENDIX 6.3

Tube Stress Analysis

CARRIZO PLAINS SOLAR RECEIVER
SODIUM TUBES

The analysis results for the stresses in the sodium tubes indicate that the highest stresses in the thermal window area occur at element 61J of the receiver system model and at element 240I in the shaded tube area. The stress calculations for both areas are shown below.

The loads on the sodium tubes include the effects of deadweight, thermal expansion, seismic, wind, and the ΔT from the flux side of the panel to the back side. All loads are conservatively added absolutely.

From the system receiver model, the loads due to deadweight, thermal expansion, seismic and wind are:

Element 61, Node 63 (Thermal Window Area)

Load		D.W.	T.E.	Seismic	Wind	Total
P_1	lbs	51	321	25	11	408
P_2	lbs	0	8	4	7	19
P_3	lbs	0	0	4	0	4
M_1	in-lbs	0	1	43	1	45
M_2	in-lbs	2	21	32	1	56
M_3	in-lbs	10	334	47	86	477

Element 240, Node 247 (Shaded Area)

Load		D.W.	T.E.	Seismic	Wind	Total
P_1	lbs	43	139	5	0	187
P_2	lbs	88	350	28	28	494
P_3	lbs	1	61	15	3	80
M_1	in-lbs	2	168	49	7	226
M_2	in-lbs	5	330	87	20	442
M_3	in-lbs	311	2073	135	145	2664

CARRIZO PLAINS SOLAR RECEIVER
SODIUM TUBES

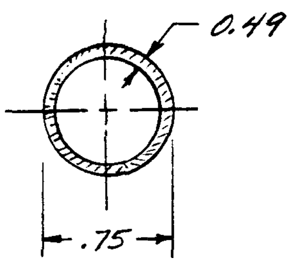
From the single tube model, the sodium tube loads for the thermal window and shaded areas are:

Thermal Window Area (Ele 55, Node 55)

$P_1 = 1.0$ lbs
$P_2 = 0$
$P_3 = 0$
$M_1 = 0$
$M_2 = 0$
$M_3 = 20$ in-lbs

The loads in the shaded area of the tube due to the flux ΔT are very small and will not be considered.

Sodium Tube Section Properties



$A = 0.108 \text{ in}^2$
$I = 0.0067 \text{ in}^4$
$J = 2I = 0.0134 \text{ in}^4$
$$Z = \frac{I}{c} = \frac{.0067}{.375} = 0.0179 \text{ in}^3$$

Sodium Tube stresses

The system receiver model loads are for 10 tubes ∴ all loads will be divided by 10 in calculating the stresses.

Pressure Stress - Axial

The operating pressure is 30 psi

$$\sigma_{axial} = \frac{Pr}{2t} = \frac{30(.375)}{2(.049)} = 115 \text{ psi}$$

CARRIZO PLAINS SOLAR RECEIVER
SODIUM TUBES

Thermal Window Area Stresses

For thermal expansion stresses per ANSI B31.1

$$S_E = \frac{i M_c}{z} \le S_A$$

where: $i = 1.0$

$$M_c = \left[M_1^2 + M_2^2 + M_3^2\right]^{1/2}$$
$$= \left[(1)^2 + (2.1)^2 + (53.4)^2\right]^{1/2}$$
$$53.45 \text{ in-lbs}$$
$$z = 0.0179 \text{ in}^3$$

$$S_E = \frac{53.45}{.0179} = 2986 \text{ psi}$$

$$S_A @ 1050°F = 18900 \text{ psi}$$

$$D.M. = \frac{18900}{2986} - 1 = \underline{\underline{5.33}}$$

For thermal expansion + sustained loads per ANSI B31.1

$$S_{TE} = \frac{PD_o}{4t_m} + \frac{.75 i M_A}{z} + \frac{i M_c}{z} \le S_h + S_a$$

where: $P = 30$ psi
$D_o = 0.75$ in
$t_n = 0.049$ in
$i = 10$
$z = 0.0179$ in^3

$$M_A = \left[(4.4)^2 + (3.5)^2 + (14.3)^2\right]^{1/2}$$
$$= 15.37 \text{ in-lbs}$$
$$M_c = 53.45 \text{ in-lbs}$$

$$S_{TE} = \frac{30(.75)}{4(.049)} + \frac{15.37}{.0179} + \frac{53.37}{.0179} = 3955 \text{ psi}$$

$$S_h + S_A @ 1050°F = 33400 \text{ psi}$$

$$D.M. = \frac{33400}{3955} - 1 = \underline{\underline{7.45}}$$

CARRIZO PLAINS SOLAR RECEIVER
SODIUM TUBES

Thermal Window Area Stresses ~ cont'd

Check the tubes in an area where the thermal stresses are maximum for the flux ΔT. From page 98, the highest stress occures at element 30, Node 30 in the single tube model

$$M_3 = 309 \text{ in-lbs}$$

From the receiver system model (ele 187)

$$M_1 = .51 \text{ in-lbs}$$
$$M_2 = .01 \text{ in-lbs}$$
$$M_3 = 5.72 \text{ in-lbs}$$

$$S_E = \frac{i M_c}{Z} \le S_A$$

where: $M_c = \left[(.051)^2 + (.001)^2 + (309.57)^2\right]^{1/2}$
$= 310 \text{ in-lbs}$

$$S_E = \frac{310}{.0179} = 17320 \text{ psi}$$

$$S_A @ 1050°F = 18900 \text{ psi}$$

$$D.M. = \frac{18900}{17320} - 1 = \underline{0.09}$$

From Element 52 of the receiver system model the D.W + Seismic + wind loads are

$$M_1 = 1.84 \text{ in-lbs}$$
$$M_2 = 31.27 \text{ in-lbs}$$
$$M_3 = 85.29 \text{ in-lbs}$$

$$M_A = \left[(.184)^2 + (3.127)^2 + (8.529)^2\right]^{1/2} = 9.086 \text{ in-lbs}$$

$$S_{TE} = \frac{30(.75)}{4(.049)} + 17320 + \frac{9.086}{0.0179} = 17943 \text{ psi}$$

$$S_a + S_h = 33,400 \text{ psi}$$

$$D.M. = \frac{33400}{17943} - 1 = \underline{0.86}$$

CARRIZO PLAINS SOLAR RECEIVER
SODIUM TUBES

Shaded Area Tube Stresses

For thermal expansion stresses per ANSI B31.1

$$S_E = \frac{i M_c}{Z} \leq S_A$$

where: $i = 1.0$

$$M_c = \left[(16.8)^2 + (33.0)^2 + (207.3)^2\right]^{1/2}$$

$$= 211 \text{ in-lbs}$$

$$Z = 0.0179 \text{ in}^3$$

$$S_E = \frac{211}{0.0179} = 11790 \text{ psi}$$

$$S_E @ 1050°F = 18900 \text{ psi}$$

$$D.M. = \frac{18900}{11790} - 1 = \underline{\underline{0.60}}$$

For thermal Expansion + Sustained loads

$$S_{TE} = \frac{P_o D_o}{4 t_n} + \frac{.75 i M_A}{Z} + \frac{i M_c}{Z} \leq S_h + S_a$$

where: $p = 30 \text{ psi}$

$D_o = .75 \text{ in}$

$t_n = 0.049 \text{ in}$

$$M_A = \left[(5.8)^2 + (11.2)^2 + (59.1)^2\right]^{1/2}$$

$$= 60.4 \text{ in-lbs}$$

$M_c = 211 \text{ in-lbs}$

$$S_{TE} = \frac{30(.75)}{4(.049)} + \frac{60.4}{.0179} + \frac{211}{.0179} = 15280 \text{ psi}$$

$$S_h + S_A @ 1050°F = 33400 \text{ psi}$$

$$D.M. = \frac{33400}{15280} - 1 = \underline{\underline{1.18}}$$

CARRIZO PLAINS SOLAR RECEIVER

Single Tube Model Tube Stresses

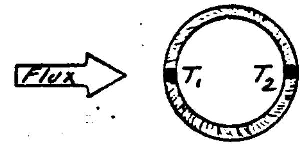


Table 7

Ele	Node	T_1 °F	T_2 °F	ΔT °F	Bending Stress psi	Displacement in.
1	1	610	610	0	5	0
2	2	610	610	0	92	-.0134
3	3	610	610	0	517	-.0224
4	4	610	610	0	1033	-.0258
5	5	610	610	0	1522	-.0147
6	6	629	617	12	1601	-.0124
7	7	635	620	15	2531	.0019
8	8	642	626	16	3512	.0021
9	9	650	632	18	4493	-.0061
10	10	655	635	20	5423	-.0134
11	11	660	639	21	5516	-.0139
12	12	673	647	26	6256	-.0163
13	13	684	657	27	7038	-.0173
14	14	699	667	32	7820	-.0166
15	15	706	673	33	8561	-.0141
16	16	715	679	36	8689	-.0139
17	17	730	691	39	9756	-.0140
18	18	750	705	45	10882	-.0139
19	19	767	719	48	12008	-.0142
20	20	777	728	49	13077	-.0152
21	21	787	735	52	13181	-.0150
22	22	808	751	57	14034	-.0129
23	23	830	769	61	14933	-.0108
24	24	850	786	64	15833	-.0122
25	25	860	796	64	16688	-.0161
26	26	872	807	65	16742	-.0164
27	27	891	825	66	16921	-.0173
28	28	914	843	71	17110	-.0136
29	29	930	861	69	17299	-.0132

CARRIZO PLAINS SOLAR RECEIVER

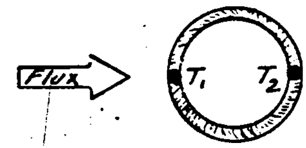


Table 7 ~ Cont'd

Ele	Node	T_1 °F	T_2 °F	ΔT °F	Bending Stress PSI	Displacement in.
30	30	940	871	69	17482	-.0176
31	31	950	881	69	17469	-.0180
32	32	966	899	67	17129	-.0206
33	33	984	916	68	16770	-.0204
34	34	997	932	65	16411	-.0199
35	35	1004	940	64	16077	-.0196
36	36	1010	947	63	16008	-.0194
37	37	1023	961	62	15200	-.0154
38	38	1033	975	58	14348	-.0132
39	39	1041	987	54	13495	-.0161
40	40	1045	993	52	12694	-.0207
41	41	1048	999	49	12585	-.0214
42	42	1053	1008	45	11538	-.0243
43	43	1057	1016	41	10433	-.0247
44	44	1060	1024	36	9328	-.0240
45	45	1061	1027	34	8288	-.0223
46	46	1063	1030	33	8182	-.0222
47	47	1065	1035	30	7419	-.0206
48	48	1066	1040	26	6616	-.0214
49	49	1066	1045	21	5812	-.0238
50	50	1066	1046	20	5058	-.0232
51	51	1066	1049	17	4957	-.0228
52	52	1066	1050	16	4026	-.0150
53	53	1066	1052	14	3044	-.0056
54	54	1065	1053	12	2062	-.0055
55	55	1050	1050	0	1139	-.0220
56	56	1050	1050	0	1066	-.0249
57	57	1050	1050	0	812	-.0429
58	58	1050	1050	0	544	-.0483

PREPARED BY: Castle

CHECKED BY:

DATE: Jan 26, 1983

Rockwell International
Energy Systems Group

019 TI000001
REPORT NO.

MODEL NO.

CARRIZO PLAINS SOLAR RECEIVER

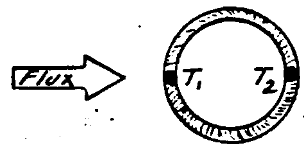


Table 7 Cont'd

Ele	Node	T_1 °F	T_2 °F	ΔT °F	Bending Stress psi	Displacement in.
59	59	1050	1050	0	277	-.0442
60	60	1050	1050	0	9	-.0353
61	61	1050	1050	0	214	-.0277
62	62	1050	1050	0	371	-.0459
62	63	1050	1050	0	477	0

APPENDIX 6.4

Tang Stress Analysis

CARRIZO PLAINS SOLAR RECEIVER
PANEL TANGS

Tang Stresses

The highest tang loads occur at model element 351. This element represents the tang nearest the outlet header and the edge tube.

From the system receiver model the loads on the tangs due to deadweight, thermal expansion, seismic and wind are:

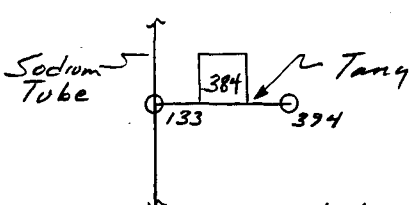
Element 384, Nodes 133 and 394

Case	Node	LBS			in-lbs		
		PX	PY	PZ	MX	MY	MZ
1	133	1.20	.17	2.31	.03	8.21	.34
	394	1.20	.17	2.31	.03	.67	.34
2	133	38.30	2.35	7.67	.57	20.73	3.58
	394	38.30	2.35	7.67	.57	9.93	5.83
3	133	9.56	8.88	1.24	.02	4.81	15.34
	394	9.56	8.88	1.24	.02	.04	20.32
4	133	16.61	.03	.91	.01	3.99	0
	394	16.61	.03	.91	.01	.37	.13

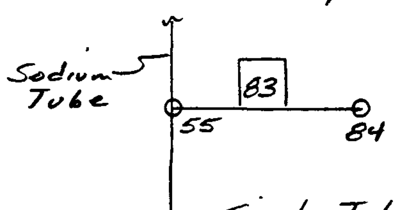
From the single tube model the tang loads due to the ΔT from the flux side of the panel to the back side are:

Element 83, Node 55 $\quad P_x = -.526$ lbs
$\quad M_y = -.1187$ in-lbs

Node 84 $\quad P_x = -.526$ lbs
$\quad M_y = -.1245$ in-lbs



System Model



Single Tube Model

CARRIZO PLAINS SOLAR RECEIVER
TANG LOADS AND STRESSES

The tang loads and stresses summarized below are from the single tube model described in Section 6.2.2 of this report. This model represents the effects of the temperature differential between the front (flux) side of the sodium tube and the back side of the tube. These loads and stresses must be combined with the deadweight, thermal expansion, seismic and wind tang loads in order to determine the complete tang loading.

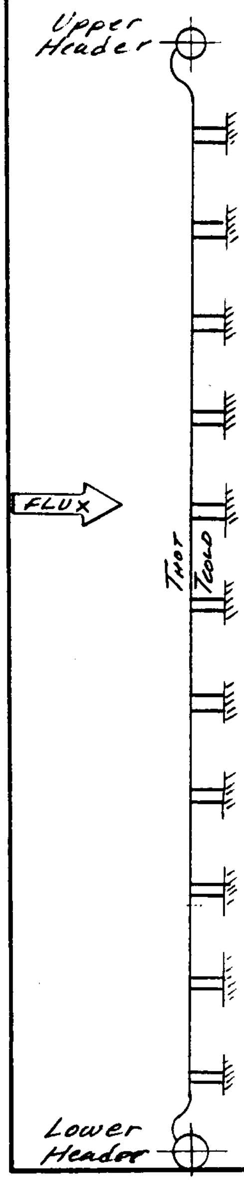
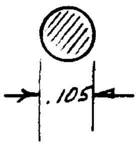


Table 8

Tang Element	Tang Nodes	Axial Load-Lbs.	Axial Stress-psi
84	56-85	.526	61.9
83	55-84	.526	61.9
82	51-83	-.131	15.5
81	50-82	-.131	15.5
80	46-81	.222	26.1
79	45-80	.222	26.1
78	41-79	-.186	21.9
77	40-78	-.186	21.9
76	36-77	-.363	42.8
75	35-76	-.363	42.8
74	31-75	-.403	47.5
73	30-74	-.403	47.5
72	26-73	-.523	61.6
71	25-72	-.523	61.6
70	21-71	-.167	19.6
69	20-70	-.167	19.6
68	16-69	-.148	17.4
67	15-68	.655	77.1
66	11-67	-.147	17.2
65	10-66	-.147	17.2
64	6-65	.342	40.3
63	5-64	.342	40.3

CARRIZO PLAINS SOLAR RECEIVER
PANEL TANGS

Tang Section Properties



Material : 304 stainless Steel

$F_y = 30{,}000$ psi

$A = \pi(.0525)^2 = 0.00866 \ in^2$

$I = .25\pi(.0525)^4 = 6\times10^{-6} \ in^4$

$r = \sqrt{\frac{I}{A}} = 0.0262 \ in$

Buckling Allowable

Assume the average temperature of the tang is 400°F

$F_y = 21400$ psi

$E = 26.6\times10^6$ psi

From AISC, section 1.5.1.3

$$F_a = \frac{\left[1 - \frac{(Kl/r)^2}{2C_c^2}\right]F_y}{\frac{5}{3} + \frac{3(Kl/r)}{8C_c} + \frac{(Kl/r)^3}{8C_c^3}}$$

From table C1.8.1 case a, $K = 0.65$

Tang length = 4.0 inches

$$\frac{Kl}{r} = \frac{0.65(4)}{.0262} = 99.2$$

$$C_c = \sqrt{\frac{2\pi^2 E}{F_y}} = \sqrt{\frac{2\pi^2(26.6\times10^6)}{21400}} = 156.6$$

$$F_a = \frac{\left[1 - \frac{(99.2)^2}{2(156.6)^2}\right]\left[21400\right]}{\frac{5}{3} + \frac{3(99.2)}{8(156.6)} + \frac{(99.2)^3}{8(156.6)^3}} = 8836 \text{ psi}$$

$P_{allowable} = F_a A =$

$= 8836(.00866) = 76.5$ lbs.

CARRIZO PLAINS SOLAR RECEIVER PANEL TANGS

Allowable Bending Stresses

Two allowables are required since the tang end attached to the sodium tube will be hotter than the tang end at the hatband.

$T_{tube\ end} = 1050°F$

$T_{hatband\ end} = 200°F$

From AISC, Section 1.5.1.4.1

$F_b = 0.66\ F_y$

F_y @ 1050°F = 16700 psi
@ 200°F = 25800 psi

F_b @ 1050°F = 0.66(16700) = 11022 psi

F_b @ 200°F = 0.66(25800) = 17028 psi

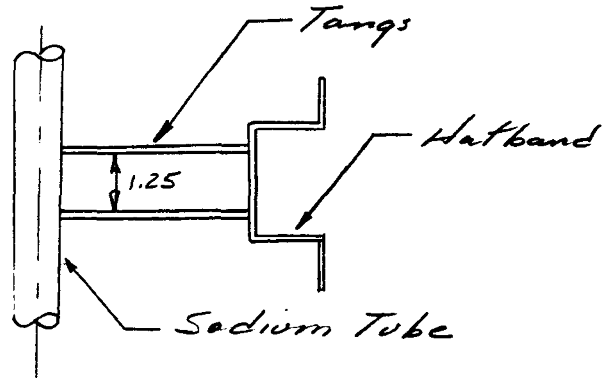
From AISC, Section 1.5.6, the allowable stresses may be increased 1/3 above the values otherwise provided when produced by wind or seismic loading provided the required section computed on this basis is not less than that required for the design dead and live load, computed without the 1/3 stress increase.

F_b @ 1050°F = 1.33 (11022) = 14660 psi

F_b @ 200°F = 1.33(17028) = 22650 psi

CARRIZO PLAINS SOLAR RECEIVER
PANEL TANGS

Tang Stresses ~ Cont'd.



For the receiver system model element 384 represents 20 tangs, therefore, the loads in the table on the previous page will be divided by 20. The single tube model loads represent the loads on one tang, therefore, they will not be factored.

Stresses Due To D.W. + Thermal Expansion + ΔT At Node 133

$$P_x = \frac{1.2 + 38.3}{20} + .526 = 2.50 \text{ lbs}$$

$$P_y = \frac{.17 + 2.35}{20} = .126 \text{ lbs}$$

$$P_z = \frac{2.31 + 7.67}{20} = .499 \text{ lbs}$$

$$M_x = \frac{.03 + .57}{10} = .06 \text{ in-lbs}$$

$$M_y = \frac{8.21 + 20.73}{10} = 2.89 \text{ in-lbs}$$

$$M_z = \frac{.34 + 3.58}{20} + .1187 = .31 \text{ in-lbs}$$

$$\sigma_x = \frac{P_x}{A} + \frac{M_y}{1.25A}$$

$$= \frac{2.50}{.00866} + \frac{2.89}{1.25(.00866)} = 556 \text{ psi}$$

CARRIZO PLAINS SOLAR RECEIVER
PANEL TANGS

Tang Stresses ~ Cont'd

$$\sigma_Y = \frac{P_Y}{A} + \frac{M_x}{1.25\,A}$$

$$= \frac{.126}{.00866} + \frac{.06}{1.25(.00866)} = 20.1\ psi$$

$$\sigma_z = \frac{P_z}{A} = \frac{.499}{.00866} = 57.6\ psi$$

$$\sigma_{y\text{-}z} = (\sigma_Y^2 + \sigma_z^2)^{1/2} = 61.\ psi$$

$$\sigma_{bending} = \frac{M_z c}{I} = \frac{.31\ (.0525)}{6\times10^{-6}} = 2713\ psi$$

Combined Stress D.M (AISC, Section 1.6-2)

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \le 1.0$$

$$\frac{556}{8836} + \frac{2713}{11022} = 0.309$$

$$D.M. = \frac{1}{0.309} - 1 = \underline{\underline{2.24}}$$

Shear D.M

$$F_v = 0.4\,F_y = 0.4(16700) = 6680\ psi$$

$$D.M. = \frac{6680}{61} - 1 = \underline{\underline{High}}$$

Stresses Due to D.W. + Thermal Expansion + ΔT + Seismic + Wind at Node 133

$$P_x = \frac{1.2 + 38.3 + 9.56 + 16.61}{20} + .526 = 3.81\ lbs$$

$$P_y = \frac{.17 + 2.35 + 8.88 + .03}{20} = 0.57\ lbs$$

$$P_z = \frac{2.31 + 7.67 + 1.24 + .91}{20} = 0.61\ lbs$$

$$M_x = \frac{.03 + .57 + .02 + .01}{10} = 0.063\ in\text{-}lbs$$

CARRIZO PLAINS SOLAR RECEIVER
PANEL TANGS

Tang Stresses ~ Cont'd

$$M_y = \frac{8.21+20.73+4.81+3.99}{10} + .12 = 3.89 \text{ in-lbs}$$

$$M_z = \frac{.34+3.58+15.34+0}{20} = 0.96 \text{ in-lbs}$$

$$\sigma_x = \frac{P_x}{A} + \frac{M_y}{1.25A} = \frac{3.81}{.00866} + \frac{3.89}{1.25(.00866)} = 799 \text{ psi}$$

$$\sigma_y = \frac{P_y}{A} + \frac{M_x}{1.25A} = \frac{.57}{.00866} + \frac{.063}{1.25(.00866)} = 72 \text{ psi}$$

$$\sigma_z = \frac{P_z}{A} = \frac{.61}{.00866} = 70 \text{ psi}$$

$$\sigma_{yz} = (\sigma_y^2 + \sigma_z^2)^{1/2} = 100 \text{ psi}$$

$$\sigma_{bending} = \frac{M_z c}{I} = \frac{.96(.0525)}{6\times10^{-6}} = 8400 \text{ psi}$$

Combined Stress D.M

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \le 1.0$$

$$\frac{799}{8836} + \frac{8400}{14660} = 0.66$$

$$D.M. = \frac{1}{0.66} - 1 = \underline{\underline{0.51}}$$

Shear Design Margin

$F_v = 6680$ psi
$f_{yz} = 141$ psi

$$D.M. = \frac{6680}{100} - 1 = \underline{\underline{High}}$$

Stresses Due to D.W. + Thermal Expansion + ΔT
At Node 394

$P_x = 2.50$ lbs

$P_y = .126$ lbs

CARRIZO PLAINS SOLAR RECEIVER
PANEL TANGS

Tang Stresses ~ Cont'd

$P_z = .499$ lbs

$M_x = .06$ in-lbs

$M_y = \frac{.67 + 9.93}{10} + .12 = 1.18$ in-lbs

$M_z = \frac{.34 + 5.83}{20} = .31$ in-lbs

$\sigma_x = \frac{P_x}{A} + \frac{M_y}{1.25A} = \frac{2.50}{.00866} + \frac{1.18}{1.25(.00866)} = 398$ psi

$\sigma_y = \frac{P_y}{A} \quad \frac{M_x}{1.25A} = \frac{.126}{.00866} + \frac{.06}{1.25(.00866)} = 20$ psi

$\sigma_z = \frac{P_z}{A} = \frac{.499}{.008666} = 58$ psi

$\sigma_{yz} = (\sigma_y^2 + \sigma_z^2)^{1/2} = 61$ psi

$\sigma_{bending} = \frac{M_z c}{I} = \frac{.31(.0525)}{6 \times 10^{-6}} = 2713$ psi

Combined Stress Design Margin

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \le 1.0$$

$$\frac{398}{8836} + \frac{2713}{17028} = 0.204$$

$$D.M. = \frac{1}{.204} - 1 = \underline{\underline{3.89}}$$

Stresses Due to D.W. + Thermal Expansion + ΔT + Seismic + Wind at Node 394

$P_x = 3.81$ lbs

$P_y = .57$ lbs

$P_z = .61$ lbs

CARRIZO PLAINS SOLAR RECEIVER
PANEL TANGS

Tang Stresses ~ Cont'd

$$M_x = .063 \text{ in-lbs}$$

$$M_y = \frac{.67+9.93+.04+.37}{10} + .12 = 1.22 \text{ in-lbs}$$

$$M_z = \frac{.34+5.83+20.32+.13}{20} = 1.33 \text{ in-lbs}$$

$$\sigma_x = \frac{P_x}{A} + \frac{M_y}{1.25A} = \frac{3.81}{.00866} + \frac{1.22}{1.25(.00866)} = 553 \text{ psi}$$

$$\sigma_y = \frac{P_y}{A} + \frac{M_x}{1.25A} = \frac{.57}{.00866} + \frac{.063}{1.25(.00866)} = 72 \text{ psi}$$

$$\sigma_z = \frac{P_z}{A} = \frac{.61}{.00866} = 70 \text{ psi}$$

$$\sigma_{yz} = (\sigma_y^2 + \sigma_z^2)^{1/2} = 100 \text{ psi}$$

$$\sigma_{bending} = \frac{M_z c}{I} = \frac{1.33(.0525)}{6\times10^{-6}} = 11640 \text{ psi}$$

Combined Stress Design Margin

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \le 1.0$$

$$\frac{553}{8836} + \frac{11640}{22650} = 0.58$$

$$D.M. = \frac{1}{.58} - 1 = \underline{\underline{0.73}}$$

Shear Design Margin

$$\sigma_{xz} =$$

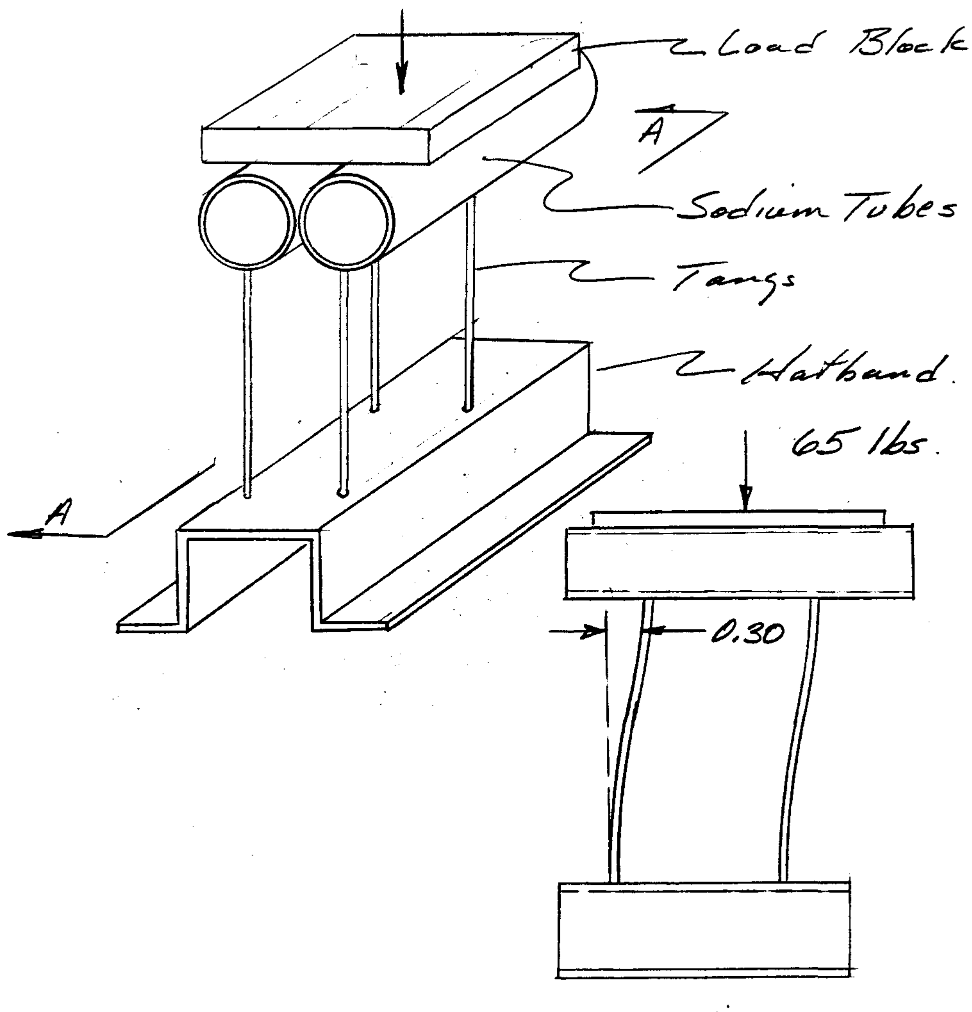
$$F_v = .4(25800) = 10320 \text{ psi}$$

$$D.M. = \frac{10320}{100} - 1 = \underline{\underline{\text{High}}}$$

CARRIZO PLAINS SOLAR RECEIVER PANEL TANGS

Buckling Strength

In order to evaluate the buckling strength of the sodium support tangs a test was conducted. This test was performed to evaluate Sandias concerns about a prebent tang in compression. A sketch of the test set-up is shown below.



Section AA

CARRIZO PLAINS SOLAR RECEIVER

The tangs were permanently displaced 0.30 inches, as shown is Section AA, prior to the test. In this configuration, lead weights were loaded onto the tubes. The maximum load applied was 65 lbs. At this load the tangs were supporting the load without buckling.

The results of This test indicate that the tangs with an offset of 0.30 inch (far in excess to that expected during operation) can support 65 lbs. or 16.3 lbs per tang.

The maximum expected load on the tang is approximately 6 lbs, therefore a factor of safety of 2.7 is indicated.

APPENDIX 6.5

Hatband Stress Analysis

CARRIZO PLAINS SOLAR RECEIVER
PANEL SUPPORT HAT BANDS

The analysis results for the stresses in the panel support hat bands indicate that the highest stresses occur in the next from top hat-band near the outlet header.

The loads on the hat bands include the effects of deadweight, thermal expansion, seismic, wind, and the ΔT from the flux side of the panel to the back side. All loads are conservatively added absolutely.

From the system receiver model, the loads due to deadweight, thermal expansion, seismic and wind are:

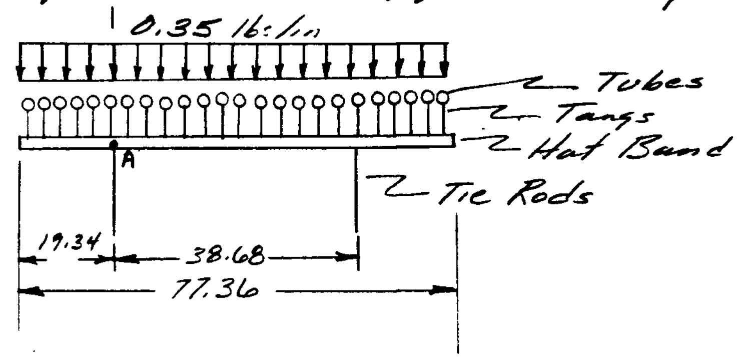
Element 120_J, Node 437

Load		D.W.	T.E.	Seismic	Wind	Total
P_1	lbs	.20	12.58	61.5	.0	64.3
P_2	lbs	.65	2.98	.45	1.15	5.23
P_3	lbs	.65	43.46	18.15	20.35	82.61
M_1	in-lbs	1.48	3.08	.19	.73	5.48
M_2	in-lbs	16.74	1326	127	143.2	1613
M_3	in-lbs	28.99	233	14.67	8.38	285

From the single tube model the tang loads for elements 81 and 82 combined is 0.263 lbs. for a single tube. Since there are 1.33 tubes per inch the ΔT thermal condition loads up the hat band with 1.33 x 0.263 = 0.35 lbs/inch. The maximum hat band stress will be calculated for the 0.35 lbs/inch and added absolutely to the stresses from the receiver system model.

CARRIZO PLAINS SOLAR RECEIVER
PANEL SUPPORT HAT BANDS

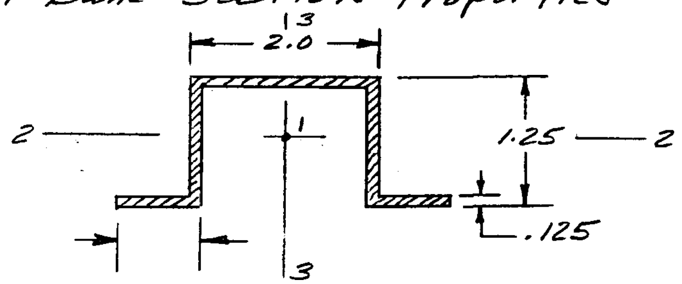
Each panel is supported by two tie rods.



Assuming a 19.34 in long cantilever beam the maximum moment occur at point A.

$$M_2 = \frac{wl^2}{2} = \frac{0.35(19.34)^2}{2} = 65 \text{ in-lbs.}$$

Hat Band Section Properties



Material: Carbon Steel
ASTM - A366

$A = 0.75 \text{ in}^2$
$I_{22} = 0.179 \text{ in}^4$
$I_{33} = 0.782 \text{ in}^4$
$As_{22} = 0.50 \text{ in}^2$
$As_{33} = 0.3125 \text{ in}^2$
Torsional Constant
$R = 0.0036$

Hat band Stresses

$$\sigma_{axial} = \frac{P_1}{A} = \frac{64.3}{0.75} = 86 \text{ psi}$$

$$\sigma_{shear} = \frac{P_2}{A_2} + \frac{P_3}{A_3} + \frac{M_1 t}{R}$$

$$= \frac{5.23}{.50} + \frac{82.61}{.3125} + \frac{5.48(.125)}{.0036} = 465 \text{ psi}$$

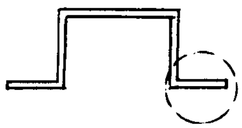
$$\sigma_{bending}(2\text{-}2) = \frac{M_2(c)}{I_{22}} = \frac{(1613+65)(.625)}{0.179} = 5860 \text{ psi}$$

$$\sigma_{bending}(3\text{-}3) = \frac{M_3 c}{I_{33}} = \frac{285(1.875)}{0.782} = 683 \text{ psi}$$

CARRIZO PLAINS SOLAR RECEIVER
PANEL SUPPORT HAT BANDS

Allowable Buckling Loads (AISC)

From AISC Section 1.9.1.2 "Unstiffened elements subject to axial compression or compression due to bending shall be considered as fully effective when the ratio of width to thickness is not greater than the following:

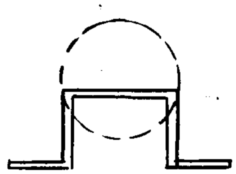


$$\frac{95}{\sqrt{F_y}} = \frac{95}{\sqrt{28}} = 17.95$$

$$\frac{b}{t} = \frac{1.0}{.125} = 8.0$$

$$b/t < \frac{95}{\sqrt{28}} \quad \therefore \text{ Flange Fully Effective}$$

From AISC Section 1.9.2 "Stiffened elements subject to axial compression or to uniform compression due to bending shall be considered as fully effective when the ratio of width to thickness is not greater than the following:



$$\frac{238}{\sqrt{F_y}} = \frac{238}{\sqrt{28}} = 45$$

$$\frac{b}{t} = \frac{2.0}{.125} = 16$$

$$\frac{b}{t} < \frac{238}{\sqrt{28}} \quad \therefore \text{ Web fully Effective}$$

Allowable Stresses

$$\sigma_a = .6(F_{Ty}) = .6(28) = 16{,}800 \text{ psi}$$

$$\sigma_b = .6(F_{Ty}) = 16800 \text{ psi}$$

CARRIZO PLAINS SOLAR RECEIVER
PANEL SUPPORT HAT BANDS

For combined axial compression and bending

$$\frac{f_a}{F_a} + \frac{f_{b2}}{F_{b2}} + \frac{f_{b3}}{F_{b3}} \leq 1.0$$

$$\frac{86}{16800} + \frac{5860}{16800} + \frac{683}{16800} = 0.39$$

$$D.M. = \frac{1.0}{0.39} - 1 = \underline{\underline{1.56}}$$

APPENDIX 6.6

Support Rod Stress Analysis

CARRIZO PLAINS SOLAR RECEIVER
PANEL SUPPORT TIE RODS

The analysis results for the stresses in the panel support tie rods indicate that the highest stresses occur in the tie rod nearest the inlet header.

The loads on the tie rods include the effects of deadweight, thermal expansion, seismic, wind, and the ΔT from the flux side of the panel to the back side. All loads are conservatively added absolutely.

From the system receiver model the loads due to deadweight, thermal expansion, seismic and wind are:

Element 12, Nodes 428 - 472

Load		D.W.	T.E.	SEISMIC	WIND	TOTAL
P_1	lbs	4.23	321	30.55	42.0	398
P_2	lbs	—	—	—	—	—
P_3	lbs	—	—	—	—	—
M_1	in-lbs	0.50	.07	0.67	0.07	1.31
M_2	in-lbs	—	—	—	—	—
M_3	in-lbs	—	—	—	—	—

From the single tube model, the tie rod load for elements 63 and 64 combined is 0.684 lbs for one tube. Since one tie rod must react the loads of 1/2 panel (51 tubes), the tie rod axial load is:

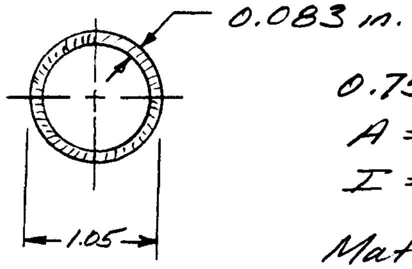
$$P_{\Delta T} \text{ axial} = 51(.684) = 35.0 \text{ lbs}$$

The total tie rod axial load is:

$$P_T' = 398 + 35.0 = 433 \text{ lbs}.$$

CARRIZO PLAINS SOLAR RECEIVER
PANEL SUPPORT TIE RODS

Tie Rod Section Properties



0.75 in ¢ Schedule 10S pipe

$A = 0.252\ in^2$

$I = 0.0297\ in^4 \qquad c = .525\ in$

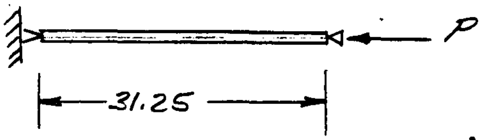
Material: Low Alloy Steel
ASTM-A-519
(Fy = 28 KSI for 1020 Annealed)

Tie Rod Stresses

$$\sigma_{axial} = \frac{P_T'}{A} = \frac{433}{0.252} = 1720\ psi$$

$$\sigma_{Torsion} = \frac{M_1 c}{2I} = \frac{1.31(.525)}{2(.0297)} = 12\ psi$$

Allowable Buckling Load (AISC)



$$F_a = \frac{\left[1 - \frac{(K\ell/r)^2}{2(C_c)^2}\right] F_y}{\frac{5}{3} + \frac{3(K\ell/r)}{8C_c} - \frac{(K\ell/r)^3}{8C_c^3}}$$

$$C_c = \sqrt{\frac{2\pi^2 E}{F_y}} = \sqrt{\frac{2\pi^2(29 \times 10^6)}{28000}} = 143$$

$$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{.0297}{.252}} = .343\ in$$

$$\frac{K\ell}{r} = \frac{1.0(31.25)}{.343} = 91.0$$ (K from AISC Table C1.8.1)

$$F_a = \frac{\left[1 - \frac{(91)^2}{2(143)^2}\right] 28000}{\frac{5}{3} + \frac{3(91)}{8(143)} - \frac{(91)^3}{8(143)^3}} = 11920\ psi$$

PREPARED BY: Castle	Rockwell International Energy Systems Group	PAGE NO. 120 OF
CHECKED BY:		079TI000001 REPORT NO.
DATE: Feb 7, 1983		MODEL NO.

CARRIZO PLAINS SOLAR RECEIVER
PANEL SUPPORT TIE RODS

σ_{allow} (Compression or tension) $= .6 F_{TY}$

$= .60(28000) = 16800$ psi

$$D.M = \frac{11920}{1720} - 1 = 5.93$$

AXIAL Buckling

σ_{allow} (Torsion) $= .4 F_{Y}$

$= .4(28000) = 11200$ psi

$$D.M. = \frac{11200}{.12} - 1 = \text{High}$$

APPENDIX 6.7

Header Stress Analysis

CARRIZO PLAINS SOLAR RECEIVER
INLET AND OUTLET HEADERS

The analysis results for the stresses in the inlet and outlet headers are summarized in Table. A typical evaluation method to obtain the results is shown below.

The loads on the headers include the effects of deadweight, thermal expansion, seismic, wind and the ΔT from the flux side of the panel to the back side. All loads are conservatively added absolutely.

From the receiver system model, the loads due to deadweight, thermal expansion, seismic and wind are:

Element 147, Node 495

Load	D.W.	T.E.	Seis.	Wind	Total
P_1 (lbs)	1	177	2	1	
P_2 (lbs)	8	556	19	5	
P_3 (lbs)	3	1134	8	5	
M_1 (in-lbs)	0	7629	435	707	
M_2 (in-lbs)	79	26270	173	112	
M_3 (in-lbs)	221	14370	55	98	

From the single tube model, the sodium tube loads (interection of the manifold) are:

P_1 = .39 lbs (Neglect) M_1 = 0
P_2 = 0 M_2 = 0
P_3 = 0 M_3 = 8.38 in-lbs

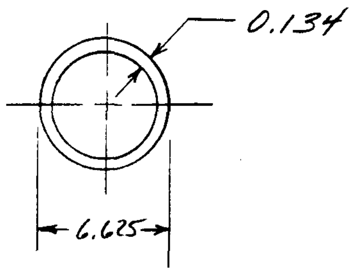
M_3 = 8.38 for 1 tube
For one-forth of the 102 tubes

Note: M_3 tube = M_1 Header

$$M_1 = 8.38\left(\frac{102}{4}\right) = 214 \text{ in-lbs}$$

CARRIZO PLAINS SOLAR RECEIVER
INLET AND OUTLET HEADERS

Header Section Properties



6"ϕ Sch 10 pipe

$A = 2.733 \ in^2$

$I = 14.40 \ in^4$

$J = 2I = 28.8 \ in^4$

$Z = 4.347 \ in^3$

Header Stresses

For thermal expansion stresses per ANSI B31.1

$$S_E = \frac{i M_c}{Z} \le S_A$$

where: $i = 1.0$

$Z = 4.347 \ in^3$

$$M_c = \left[M_1^2 + M_2^2 + M_3^2 \right]^{1/2}$$

$$= \left[(7629)^2 + (26270)^2 + (14584)^2 \right]^{1/2}$$

$$= 31000 \ in\text{-}lbs$$

$$S_E = \frac{31000}{4.347} = 7130 \ psi$$

S_A @ 1050°F = 18900 psi

$$D.M. = \frac{18900}{7130} - 1 = \underline{\underline{1.65}}$$

For thermal expansion + sustained loads per ANSI B31.1

$$S_{TE} = \frac{P D_o}{4 t_m} + \frac{.75 i M_A}{Z} + \frac{i M_c}{Z} \le S_h + S_a$$

where: $P = 30 \ psi$

$D_o = 6.625 \ in$

$t_m = .134$

CARRIZO PLAINS SOLAR RECEIVER
INLET AND OUTLET HEADERS

$Z = 4.347 \text{ in}^3$

$i = 1.0$

$M_A = \left[(1142)^2 + (364)^2 + (374)^2 \right]^{1/2} = 1256 \text{ in-lbs}$

$M_C = 31000 \text{ in-lbs}$

$$S_{TE} = \frac{30(6.625)}{4(.134)} + \frac{1256}{4.347} + \frac{31000}{4.347} = 7790 \text{ psi}$$

$S_h + S_A$ @ 1050°F = 33400 psi

$$D.M. = \frac{33400}{7790} - 1 = \underline{\underline{3.29}}$$

APPENDIX 6.8

Support Beam Stress Analysis

CARRIZO PLAINS SOLAR RECEIVER
RECEIVER SUPPORT BOX

The analysis results for the stresses in the support box member indicate that the highest stresses occur in Element 161 at the inboard edge of the panel.

The loads on the support box includes the effects of dead weight, thermal expansion, seismic, wind and the ΔT from the flux side of the panel to the back side. All loads are conservatively added absolutely.

From the system receiver model, the loads due to dead weight, thermal expansion, seismic and wind are:

Element 153, Node 76

Load	D.W.	T.E.	Seismic	Wind	Total
P_1 (lbs)	-17	132	40	3	192
P_2 (lbs)	539	157	191	8	895
P_3 (lbs)	26	505	46	22	599
M_1 (in-lbs)	229	537	84	54	904
M_2 (in-lbs)	268	-5058	359	230	5915
M_3 (in-lbs)	5110	392	1752	49	7303

From the single tube model the support box loads for element 1, Node 1 are

$P_2 = .76$ lbs
$M_1 = 1.63$ in-lbs

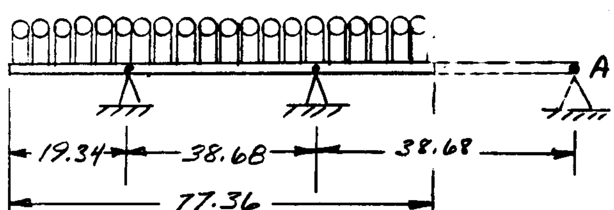
Since there are 1.33 tubes per inch, the thermal condition loads up the support box with the following loads

$P_2 = 1.33(.76) = 1.01$ lbs/in
$M_1 = 1.33(1.63) = 2.17$ in-lbs/in

CARRIZO PLAINS SOLAR RECEIVER
RECEIVER SUPPORT BOX

The maximum box beam stress will be calculated for the ΔT loads and added absolutely to the stresses from the receiver system model.

The box beam is supported at two locations at 1/4 span for each panel as shown below



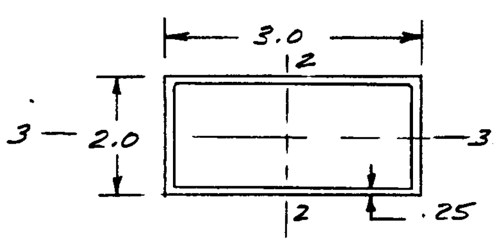
Assuming a 38.68 in long fixed-fixed beam, the maximum loads occur at point A

$$P_2 = 38.68(1.01) = 39.0 \text{ lbs}$$

$$M_3 = \frac{P_2 l}{12} = \frac{39(38.68)}{12} = 126 \text{ in-lbs}$$

$$M_1 = 2.17(38.68)/2 = 42 \text{ in-lbs}$$

Support box Section Properties



$A = 2.09 \text{ in}^2$
$I_{22} = 2.21 \text{ in}^4$
$I_{33} = 1.15 \text{ in}^4$
$A_{s22} = 1.0 \text{ in}^2$
$A_{s33} = 1.5 \text{ in}^2$
$[A] = 2.5(1.5) = 3.75 \text{ in}^2$

Material: 304 S.S.

Support Box Stresses

$$\sigma_{axial} = \frac{P_1}{A} = \frac{192}{2.09} = 92 \text{ psi}$$

CARRIZO PLAINS SOLAR RECEIVER
RECEIVER SUPPORT BOX

Support Box Stresses ~ Contd

$$\sigma_{shear} = \frac{P_2}{A_2} + \frac{P_3}{A_3} + \frac{M_1}{2[A]t}$$

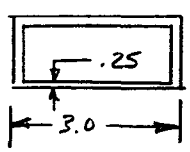
$$= \frac{934}{1.0} + \frac{599}{1.5} + \frac{946}{2(3.75)(.25)} = 1838 \text{ psi}$$

$$\sigma_{bending}(2\text{-}2) = \frac{M_2 c}{I_{22}} = \frac{5915(1.5)}{1.15} = 7715 \text{ psi}$$

$$\sigma_{bending}(3\text{-}3) = \frac{M_3 c}{I_{33}} = \frac{(7303+126)(1)}{2.21} = 3360 \text{ psi}$$

Allowable Buckling Loads

From AISC Section 1.9.2 "Stiffened elements subject to axial compression or to uniform compression due to bending shall be considered as fully effective when the ratio of width to thickness is not greater than the following



$$\frac{238}{\sqrt{F_y}} = \frac{238}{\sqrt{25}} = 47.6$$

$$\frac{b}{t} = \frac{3.0}{.25} = 12$$

$$\frac{b}{t} < \frac{238}{\sqrt{25}} \therefore \text{Web Fully Effective}$$

Allowable stresses

$$\sigma_a = .6F_{TY} = .6(25000) = 15000 \text{ psi}$$

$$\sigma_b = .6F_{TY} = 15000 \text{ psi}$$

$$\sigma_s = .4F_{TY} = .4(25000) = 10000 \text{ psi}$$

For combined axial compression and bending

$$\frac{f_a}{F_a} + \frac{f_{b22}}{F_b} + \frac{f_{b33}}{F_b} < 1$$

CARRIZO PLAINS SOLAR RECEIVER
RECEIVER SUPPORT BOX

$$\frac{92}{15000} + \frac{7715}{15000} + \frac{3360}{15000} = 0.74$$

$$D.M. = \frac{1}{.74} - 1 = \underline{\underline{0.35}}$$

For a shear stress of 1284

$$D.M. = \frac{10000}{1838} - 1 = \underline{\underline{4.44}}$$

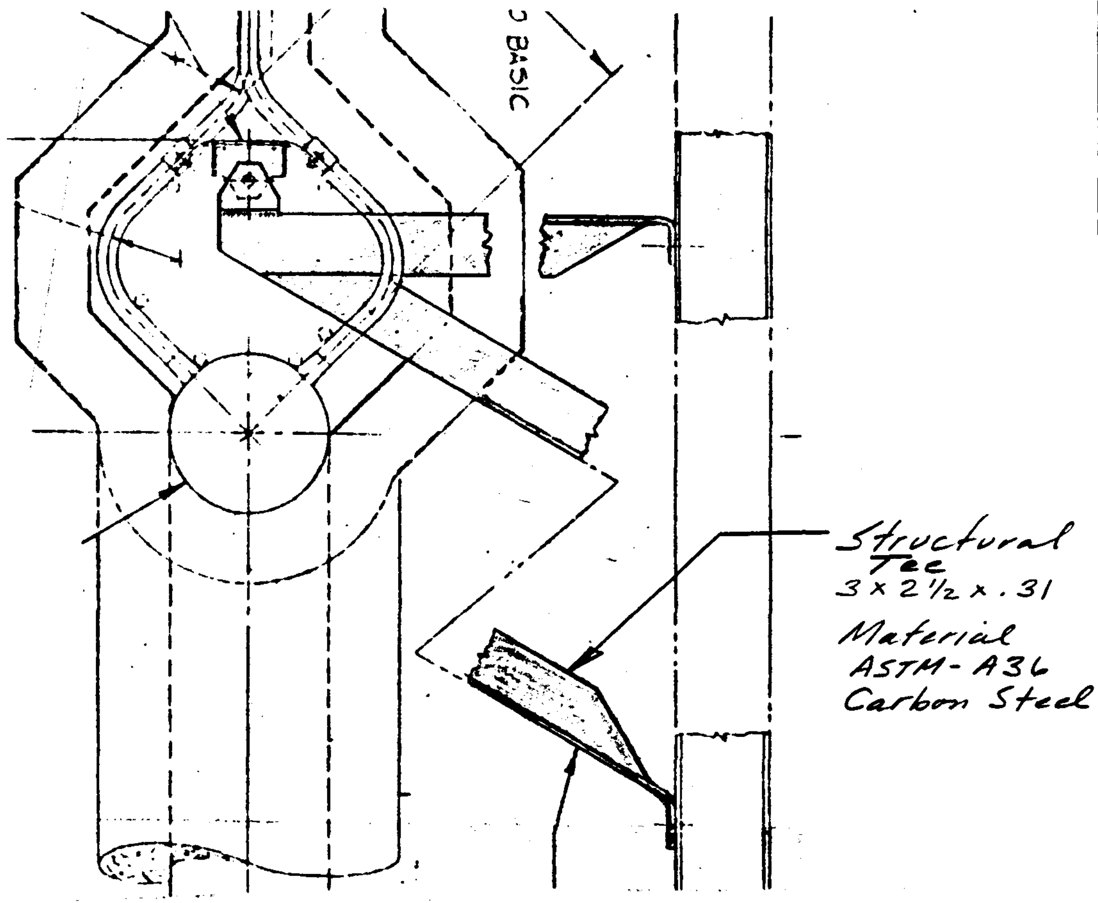
APPENDIX 6.9

Support Truss Stress Analysis

PREPARED BY: Castle	Rockwell International Energy Systems Group	PAGE NO. 131 OF
CHECKED BY:		079TI000001 REPORT NO.
DATE: Feb 8, 1983		MODEL NO.

CARRIZO PLAINS SOLAR RECEIVER

PANEL SUPPORT TRUSS



Each of the 8 receiver panels is supported by 2 truss supports located at the ¼ points on the panel.

The loads on the trusses include the effects of dead weight, thermal expansion, seismic, wind, and the ΔT from the flux side of the panel to the back side. All loads are conservatively added absolutely.

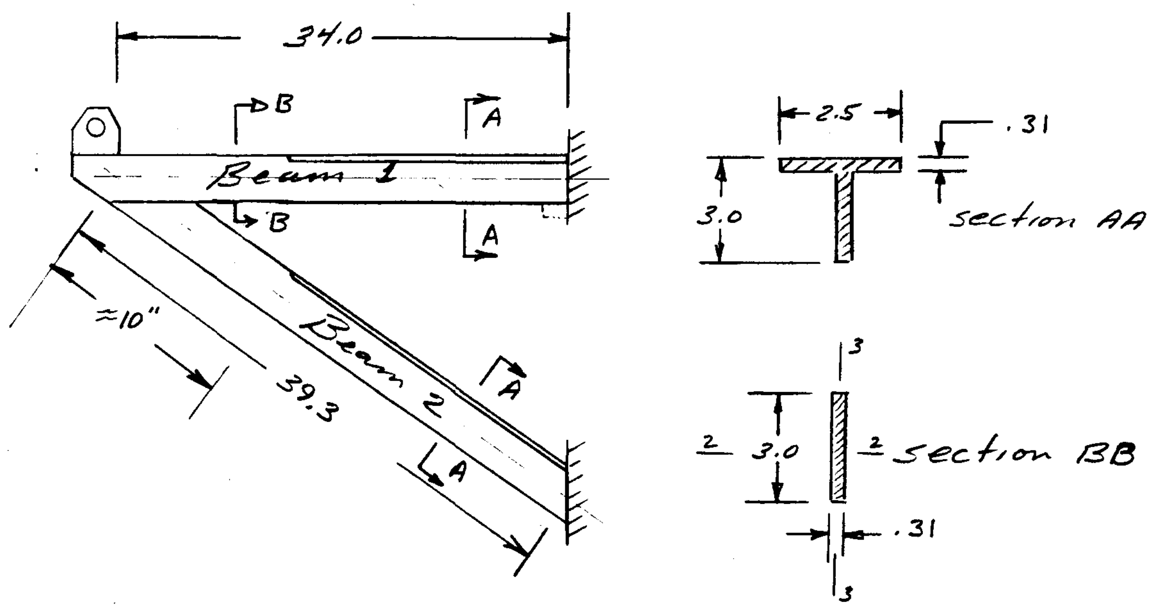
CARRIZO PLAINS SOLAR RECEIVER
PANEL SUPPORT TRUSS

From the system receiver model, the loads due to deadweight, thermal expansion, seismic and wind are:

ELE	NODE	LOAD	D.W.	T.E.	Seis.	Wind	Total
23	76 I	P_1	2862	1716	879	44	5501
		M_1	4	0	4	1	9
		M_3	0	12	1	1	14
	498 J	P_1	2862	1716	879	44	5501
		M_1	4	0	4	1	9
		M_3	0	6	0	0	6
162	76 I	P_1	3343	154	1125	35	4657
		M_1	3	5	3	0	11
		M_3	2	9	1	1	13
	499 J	P_1	3343	154	1125	35	4657
		M_1	3	5	3	0	11
		M_3	1	4	1	1	7
163	251 I	P_1	2457	1773	527	8	4765
		M_1	11	1	5	0	17
		M_3	2	14	0	0	16
	500 J	P_1	2457	1773	527	8	4765
		M_1	11	1	5	0	17
		M_3	1	7	0	0	8
164	251 I	P_1	2932	27	737	130	3826
		M_1	9	4	4	0	17
		M_3	4	11	2	0	17
	501 J	P_1	2932	27	737	130	3826
		M_1	9	4	4	0	17
		M_3	4	6	1	0	11

Note: P = lbs
M = in-lbs.

CARRIZO PLAINS SOLAR RECEIVER
PANEL SUPPORT TRUSS



The highest loads occur for beam elements 23 and 162. Conservatively use the following loads

$P_1 = 5501$ lbs $M_1 = 11$ in-lbs $M_3 = 14$ in-lbs.

For the cross-section BB

$$A = 3(.31) = 0.93 \text{ in}^2$$

$$I_{33} = \frac{3(.31)^3}{12} = .0074 \text{ in}^4$$

$$\sigma_{axial} = \frac{5501}{.93} = 5915 \text{ psi}$$

$$\sigma_{bending} = \frac{M_3 c}{I} = \frac{14(.155)}{.0074} = 293 \text{ psi}$$

$$\sigma_{Torsion} = \frac{3M_1}{bt^2} = \frac{(81)}{3(.31)^2} = 281 \text{ psi}$$

CARRIZO PLAINS SOLAR RECEIVER
PANEL SUPPORT TRUSS

For ASTM A-36 Carbon Steel

$F_y = 36000$ psi
$F_a = .6\,(36000) = 21600$ psi
$F_b = 21600$ psi

Check Buckling allowable

$$P_{CR} = \frac{\pi^2 EI}{l^2}$$ (Roark 4th Ed, Table XV)

where: $E = 29 \times 10^6$
$I = .0074$ in^4
$l = 10$ in.

$$P_{CR} = \frac{\pi^2 (29\times10^6)(.0074)}{(10)^2} = 21180 \text{ lbs}$$

$$\sigma_{CR} = \frac{P_{CR}}{A} = \frac{21180}{.93} = 22775 \text{ psi}$$

$22775 > 21600$ ∴ Buckling Not Critical

Combined Stress Design Margin

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \leq 1.0$$

$$\frac{5915}{21600} + \frac{293}{21600} = 0.29$$

$$D.M. = \frac{1}{.29} - 1 = \underline{\underline{2.45}}$$

Note: Section AA is adequate by inspection.

APPENDIX 6.10

Finite Element Model Input Data Listings

P R O G R A M   I N P U T   D A T A

ESG CARRIZO PLAINS SOLAR RECEIVER PANEL - W. CASTLE - JANUARY 1983

520	3	4		1	1	3	
1			0.00	0.00		3.87	
2			2.34	2.34		3.87	610.
3			5.03	5.03		3.87	610.
4			7.15	5.75		3.87	610.
5			9.27	5.03		3.87	610.
6			14.36	0.00		3.87	610.
7			31.00	0.00		3.87	610.
8			48.00	0.00		3.87	611.5
9			72.00	0.00		3.87	619.7
10			96.	0.00		3.87	627.9
11			120.	0.00		3.87	643.0
12			144.	0.00		3.87	658.
13			168.	0.00		3.87	681.7
14			192.	0.00		3.87	705.3
15			216.	0.00		3.87	737.
16			240.	0.00		3.87	768.7
17			264.	0.00		3.87	805.
18			288.	0.00		3.87	841.2
19			312.	0.00		3.87	876.6
20			336.	0.00		3.87	912.
21			360.	0.00		3.87	941.5
22			384.	0.00		3.87	971.0
23			408.	0.00		3.87	992.
24			432.	0.00		3.87	1012.9
25			456.	0.00		3.87	1025.6
26			480.	0.00		3.87	1038.3
27			504.	0.00		3.87	1044.9
28			528.	0.00		3.87	1051.5
29			556.82	0.00		3.87	1050.
30			585.64	0.00		3.87	1050.
31			590.73	5.03		3.87	1050.
32			592.85	5.75		3.87	1050.
33			594.97	5.03		3.87	1050.
34			597.66	2.34		3.87	1050.
35			600.	0.00		3.87	1050.
36			0.	0.00		11.60	610.
37			2.34	-2.34		11.60	610.
38			5.03	-5.03		11.60	610.
39			7.15	-5.75		11.60	610.
40			9.27	-5.03		11.60	610.
41			14.36	0.00		11.60	610.
42			31.00	0.00		11.60	610.
43			48.	0.00		11.60	611.8
44			72.	0.00		11.60	620.2
45			96.	0.00		11.60	628.6
46			120.	0.00		11.60	643.9
47			144.	0.00		11.60	659.2
48			168.	0.00		11.60	683.2
49			192.	0.00		11.60	707.1
50			216.	0.00		11.60	739.0
51			240.	0.00		11.60	770.9
52			264.	0.00		11.60	807.3
53			288.	0.00		11.60	843.6
54			312.	0.00		11.6	878.9
55			336.	0.00		11.6	914.2
56			360.	0.00		11.6	943.5

SAP V RECEIVER SYSTEM

MODEL INPUT DATA LISTING

57	384.	0.00	11.60	972.7
58	408.	0.00	11.60	993.4
59	432.	0.00	11.60	1014.1
60	456.	0.00	11.60	1026.6
61	480.	0.00	11.60	1039.
62	504.	0.00	11.60	1045.4
63	528.	0.00	11.60	1051.8
64	556.82	0.00	11.60	1050.
65	585.64	0.00	11.60	1050.
66	590.73	-5.03	11.60	1050.
67	592.85	-5.75	11.60	1050.
68	594.97	-5.03	11.60	1050.
69	597.66	-2.34	11.60	1050.
70	600.00	0.00	11.60	1050.
71	0.00	0.00	19.33	610.
72	2.34	2.34	19.33	610.
73	5.03	5.03	19.33	610.
74	7.15	5.75	19.33	610.
75	9.27	5.03	19.33	610.
76	14.36	0.00	19.33	610.
77	31.00	0.00	19.33	610.
78	48.00	0.00	19.33	612.2
79	72.	0.00	19.33	620.8
80	96.	0.00	19.33	629.3
81	120.	0.00	19.33	644.9
82	144.	0.00	19.33	660.5
83	168.	0.00	19.33	684.8
84	192.	0.00	19.33	709.0
85	216.	0.00	19.33	741.2
86	240.	0.00	19.33	773.4
87	264.	0.00	19.33	809.9
88	288.	0.00	19.33	846.3
89	312.	0.00	19.33	881.5
90	336.	0.00	19.33	916.7
91	360.	0.00	19.33	945.7
92	384.	0.00	19.33	974.6
93	408.	0.00	19.33	995.0
94	432.	0.00	19.33	1015.4
95	456.	0.00	19.33	1027.6
96	480.	0.00	19.33	1039.7
97	504.	0.00	19.33	1046.
98	528.	0.00	19.33	1052.2
99	556.82	0.00	19.33	1050.
100	585.64	0.00	19.33	1050.
101	590.73	5.03	19.33	1050.
102	592.85	5.75	19.33	1050.
103	594.97	5.03	19.33	1050.
104	597.66	2.34	13.33	1050.
105 1 1	600.00	0.00	19.33	1050.
106	0.00	0.00	27.06	610.
107	2.34	-2.34	27.06	610.
108	5.03	-5.03	27.06	610.
109	7.15	-5.75	27.06	610.
110	9.27	-5.03	27.06	610.
111	14.36	0.00	27.06	610.
112	31.00	0.00	27.06	610.
113	48.00	0.00	27.06	612.5
114	72.	0.00	27.06	621.3
115	96.	0.00	27.06	630.
116	120.	0.00	27.06	645.9
117	144.	0.00	27.06	661.7
118	168.	0.00	27.06	686.3

079TI000001
Page 137

119	192.	0.00	27.06	710.8
120	216.	0.00	27.06	743.3
121	240.	0.00	27.06	775.7
122	264.	0.00	27.06	812.6
123	288.	0.00	27.06	848.8
124	312.	0.00	27.06	883.9
125	336.	0.00	27.06	919.
126	360.	0.00	27.06	947.8
127	384.	0.00	27.06	976.5
128	408.	0.00	27.06	996.5
129	432.	0.00	27.06	1016.6
130	456.	0.00	27.06	1028.5
131	480.	0.00	27.06	1040.4
132	504.	0.00	27.06	1046.5
133	528.	0.00	27.06	1052.5
134	556.82	0.00	27.06	1050.0
135	585.64	0.00	27.06	1050.
136	590.73	-5.03	27.06	1050.
137	592.85	-5.75	27.06	1050.
138	594.97	-5.03	27.06	1050.
139	597.66	-2.34	27.06	1050.
140	600.00	0.00	27.06	1050.
141	0.00	0.00	34.79	610.
142	2.34	2.34	34.79	610.
143	5.03	5.03	34.79	610.
144	7.15	5.75	34.79	610.
145	9.27	5.03	34.79	610.
146	14.36	0.00	34.79	610.
147	31.	0.00	34.79	610.
148	48.	0.00	34.79	612.9
149	72.	0.00	34.79	621.8
150	96.	0.00	34.79	630.7
151	120.	0.00	34.79	646.8
152	144.	0.00	34.79	662.9
153	168.	0.00	34.79	687.8
154	192.	0.00	34.79	712.6
155	216.	0.00	34.79	745.3
156	240.	0.00	34.79	778.0
157	264.	0.00	34.79	814.7
158	288.	0.00	34.79	851.3
159	312.	0.00	34.79	886.3
160	336.	0.00	34.79	921.3
161	360.	0.00	34.79	949.8
162	384.	0.00	34.79	978.3
163	408.	0.00	34.79	998.1
164	432.	0.00	34.79	1017.8
165	456.	0.00	34.79	1029.5
166	480.	0.00	34.79	1041.1
167	504.	0.00	34.79	1047.
168	528.	0.00	34.79	1052.9
169	556.82	0.00	34.79	1050.
170	585.64	0.00	34.79	1050.
171	590.73	5.03	34.79	1050.
172	592.85	5.75	34.79	1050.
173	594.97	5.03	34.79	1050.
174	597.66	2.34	34.79	1050.
175	600.00	0.00	34.79	1050.
176	0.00	0.00	42.52	610.
177	2.34	-2.34	42.52	610.
178	5.03	-5.03	42.5	610.
17	7.15	-5.75	42	610.
18	9.27	-5.03	42	610.

079TI000001
Page 138.

181	14.36	0.00	42.52	610.
182	31.	0.00	42.52	610.
183	48.	0.00	42.52	613.2
184	72.	0.00	42.52	622.3
185	96.	0.00	42.52	631.4
186	120.	0.00	42.52	647.8
187	144.	0.00	42.52	664.2
188	168.	0.00	42.52	689.4
189	192.	0.00	42.52	714.5
190	216.	0.00	42.52	747.4
191	240.	0.00	42.52	780.3
192	264.	0.00	42.52	817.1
193	288.	0.00	42.52	853.8
194	312.	0.00	42.52	888.7
195	336.	0.00	42.52	923.6
196	360.	0.00	42.52	951.9
197	384.	0.00	42.52	980.1
198	408.	0.00	42.52	999.6
199	432.	0.00	42.52	1019.0
200	456.	0.00	42.52	1030.5
201	480.	0.00	42.52	1041.9
202	504.	0.00	42.52	1047.6
203	528.	0.00	42.52	1053.2
204	556.82	0.00	42.52	1050.
205	585.64	0.00	42.52	1050.
206	590.73	-5.03	42.52	1050.
207	592.85	-5.75	42.52	1050.
208	594.97	-5.03	42.52	1050.
209	597.66	-2.34	42.52	1050.
210	600.	0.00	42.52	1050.
211	0.00	0.00	50.25	610.
212	2.34	2.34	50.25	610.
213	5.03	5.03	50.25	610.
214	7.15	5.75	50.25	610.
215	9.27	5.03	50.25	610.
216	14.36	0.00	50.25	610.
217	31.	0.00	50.25	610.
218	48.	0.00	50.25	613.6
219	72.	0.00	50.25	622.9
220	96.	0.00	50.25	632.1
221	120.	0.00	50.25	648.8
222	144.	0.00	50.25	665.4
223	168.	0.00	50.25	690.9
224	192.	0.00	50.25	716.3
225	216.	0.00	50.25	749.5
226	240.	0.00	50.25	782.7
227	264.	0.00	50.25	819.5
228	288.	0.00	50.25	856.3
229	312.	0.00	50.25	891.2
230	336.	0.00	50.25	926.
231	360.	0.00	50.25	954.
232	384.	0.00	50.25	982.
233	408.	0.00	50.25	1001.2
234	432.	0.00	50.25	1020.3
235	456.	0.00	50.25	1031.5
236	480.	0.00	50.25	1042.6
237	504.	0.00	50.25	1048.1
238	528.	0.00	50.25	1053.6
239	556.82	0.00	50.25	1050.
240	585.64	0.00	50.25	1050.
241	590.73	5.03	50.25	1050.
242	592.85	5.75	50.25	1050.

243		594.97	5.03	50.25	1050.
244		597.66	2.34	50.25	1050.
245		600.	0.00	50.25	1050.
246		0.00	0.00	57.98	610.
247		2.34	-2.34	57.98	610.
248		5.03	-5.03	57.98	610.
249		7.15	-5.75	57.98	610.
250		9.27	-5.03	57.98	610.
251		14.36	0.00	57.98	610.
252		31.	0.00	57.98	610.
253		48.	0.00	57.98	613.9
254		72.	0.00	57.98	623.4
255		96.	0.00	57.98	632.8
256		120.	0.00	57.98	649.7
257		144.	0.00	57.98	666.6
258		168.	0.00	57.98	692.4
259		192.	0.00	57.98	718.1
260		216.	0.00	57.98	751.6
261		240.	0.00	57.98	785.
262		264.	0.00	57.98	822.
263		288.	0.00	57.98	858.9
264		312.	0.00	57.98	893.6
265		336.	0.00	57.98	928.3
266		360.	0.00	57.98	956.1
267		384.	0.00	57.98	983.8
268		408.	0.00	57.98	1002.7
269		432.	0.00	57.98	1021.5
270		456.	0.00	57.98	1032.4
271		480.	0.00	57.98	1043.3
272		504.	0.00	57.98	1048.6
273		528.	0.00	57.98	1053.9
274		556.82	0.00	57.98	1050.
275		585.64	0.00	57.98	1050.
276		590.73	-5.03	57.98	1050.
277		592.85	-5.75	57.98	1050.
278		594.97	-5.03	57.98	1050.
279		597.66	-2.34	57.98	1050.
280	1 1	600.	0.00	57.98	1050.
281		0.00	0.00	65.71	610.
282		2.34	2.34	65.71	610.
283		5.03	5.03	65.71	610.
284		7.15	5.75	65.71	610.
285		9.27	5.03	65.71	610.
286		14.36	0.00	65.71	610.
287		31.0	0.00	65.71	610.
288		48.	0.00	65.71	614.3
289		72.	0.00	65.71	623.9
290		96.	0.00	65.71	633.5
291		120.	0.00	65.71	650.7
292		144.	0.00	65.71	667.8
293		168.	0.00	65.71	693.9
294		192.	0.00	65.71	720.
295		216.	0.00	65.71	753.7
296		240.	0.00	65.71	787.3
297		264.	0.00	65.71	824.4
298		288.	0.00	65.71	861.4
299		312.	0.00	65.71	896.
300		336.	0.00	65.71	930.6
301		360.	0.00	65.71	958.1
302		384.	0.00	65.7	985.6
303		408.	0.00	65.7	1004.2
304		432.	0.00	65.7	1022.7

305	456.	0.00	65.71	1033.4
306	480.	0.00	65.71	1044.
307	504.	0.00	65.71	1049.2
308	528.	0.00	65.71	1054.3
309	556.82	0.00	65.71	1050.
310	585.64	0.00	65.71	1050.
311	590.73	5.03	65.71	1050.
312	592.85	5.75	65.71	1050.
313	594.97	5.03	65.71	1050.
314	597.66	2.34	65.71	1050.
315	600.	0.00	65.71	1050.
316	0.00	0.00	73.44	610.
317	2.34	-2.34	73.44	610.
318	5.03	-5.03	73.44	610.
319	7.15	-5.75	73.44	610.
320	9.27	-5.03	73.44	610.
321	14.36	0.00	73.44	610.
322	31.	0.00	73.44	610.
323	48.	0.00	73.44	614.6
324	72.	0.00	73.44	624.4
325	96.	0.00	73.44	634.2
326	120.	0.00	73.44	651.7
327	144.	0.00	73.44	669.1
328	168.	0.00	73.44	695.5
329	192.	0.00	73.44	721.8
330	216.	0.00	73.44	755.8
331	240.	0.00	73.44	789.7
332	264.	0.00	73.44	826.8
333	288.	0.00	73.44	863.9
334	312.	0.00	73.44	898.5
335	336.	0.00	73.44	933.
336	360.	0.00	73.44	960.2
337	384.	0.00	73.44	987.4
338	408.	0.00	73.44	1005.7
339	432.	0.00	73.44	1023.9
340	456.	0.00	73.44	1034.3
341	480.	0.00	73.44	1044.7
342	504.	0.00	73.44	1049.7
343	528.	0.00	73.44	1054.6
344	556.82	0.00	73.44	1050.
345	585.64	0.00	73.44	1050.
346	590.73	-5.03	73.44	1050.
347	592.85	-5.75	73.44	1050.
348	594.97	-5.03	73.44	1050.
349	597.66	-2.34	73.44	1050.
350	600.	0.00	73.44	1050.
351	48.	-4.00	3.87	200.
352	96.	-4.00	3.87	200.
353	144.	-4.00	3.87	200.
354	192.	-4.00	3.87	200.
355	240.	-4.00	3.87	200.
356	288.	-4.00	3.87	200.
357	336.	-4.00	3.87	200.
358	384.	-4.00	3.87	200.
359	432.	-4.0	3.87	200.
360	480.	-4.0	3.87	200.
361	528.	-4.0	3.87	200.
362	48.	-4.0	11.60	200.
363	96.	-4.0	11.60	200.
364	144.	-4.0	11.60	200.
365	192.	-4.0	11.60	200.
366	240.	-4.0	11.60	200.

367	288.	-4.0	11.60	200.
368	336.	-4.0	11.60	200.
369	384.	-4.0	11.60	200.
370	432.	-4.0	11.60	200.
371	480.	-4.0	11.60	200.
372	528.	-4.0	11.60	200.
373	48.	-4.0	19.33	200.
374	96.	-4.0	19.33	200.
375	144.	-4.0	19.33	200.
376	192.	-4.0	19.33	200.
377	240.	-4.0	19.33	200.
378	288.	-4.0	19.33	200.
379	336.	-4.0	19.33	200.
380	384.	-4.0	19.33	200.
381	432.	-4.0	19.33	200.
382	480.	-4.00	19.33	200.
383	528.	-4.0	19.33	200.
384	48.	-4.0	27.06	200.
385	96.	-4.0	27.06	200.
386	144.	-4.0	27.06	200.
387	192.	-4.0	27.06	200.
388	240.	-4.0	27.06	200.
389	288.	-4.0	27.06	200.
390	336.	-4.0	27.06	200.
391	384.	-4.0	27.06	200.
392	432.	-4.0	27.06	200.
393	480.	-4.0	27.06	200.
394	528.	-4.0	27.06	200.
395	48.	-4.0	34.79	200.
396	96.	-4.0	34.79	200.
397	144.	-4.0	34.79	200.
398	192.	-4.0	34.79	200.
399	240.	-4.0	34.79	200.
400	288.	-4.0	34.79	200.
401	336.	-4.0	34.79	200.
402	384.	-4.0	34.79	200.
403	432.	-4.0	34.79	200.
404	480.	-4.0	34.79	200.
405	528.	-4.0	34.79	200.
406	48.	-4.0	42.52	200.
407	96.	-4.00	42.52	200.
408	144.	-4.00	42.52	200.
409	192.	-4.00	42.52	200.
410	240.	-4.00	42.52	200.
411	288.	-4.00	42.52	200.
412	336.	-4.00	42.52	200.
413	384.	-4.00	42.52	200.
414	432.	-4.00	42.52	200.
415	480.	-4.00	42.52	200.
416	528.	-4.00	42.52	200.
417	48.	-4.00	50.25	200.
418	96.	-4.00	50.25	200.
419	144.	-4.00	50.25	200.
420	192.	-4.00	50.25	200.
421	240.	-4.00	50.25	200.
422	288.	-4.00	50.25	200.
423	336.	-4.00	50.25	200.
424	384.	-4.00	50.25	200.
425	432.	-4.00	50.25	200.
426	480.	-4.00	50.2[illegible]	200.
427	528.	-4.00	50.2[illegible]	200.
428	48.	-4.00	57.9[illegible]	200.

429							96.	-4.00	57.98	200.
430							144.	-4.0	57.98	200.
431							192.	-4.0	57.98	200.
432							240.	-4.0	57.98	200.
433							288.	-4.0	57.98	200.
434							336.	-4.0	57.98	200.
435							384.	-4.0	57.98	200.
436							432.	-4.0	57.98	200.
437							480.	-4.0	57.98	200.
438							528.	-4.0	57.98	200.
439							48.	-4.0	65.71	200.
440							96.	-4.0	65.71	200.
441							144.	-4.0	65.71	200.
442							192.	-4.0	65.71	200.
443							240.	-4.0	65.71	200.
444							288.	-4.0	65.71	200.
445							336.	-4.0	65.71	200.
446							384.	-4.0	65.71	200.
447							432.	-4.0	65.71	200.
448							480.	-4.0	65.71	200.
449							528.	-4.0	65.71	200.
450							48.	-4.0	73.44	200.
451							96.	-4.0	73.44	200.
452							144.	-4.0	73.44	200.
453							192.	-4.0	73.44	200.
454							240.	-4.0	73.44	200.
455							288.	-4.00	73.44	200.
456							336.	-4.00	73.44	200
457							384.	-4.00	73.44	200.
458							432.	-4.00	73.44	200.
459							480.	-4.00	73.44	200.
460							528.	-4.00	73.44	200.
461	1	1	1		1		48.14	-34.00	19.33	100.
462	1	1	1		1		96.28	-34.00	19.33	100.
463	1	1	1		1		144.43	-34.00	19.33	100.
464	1	1	1		1		192.59	-34.00	19.33	100.
465	1	1	1		1		240.77	-34.00	19.33	100.
466	1	1	1		1		288.97	-34.00	19.33	100.
467	1	1	1		1		337.19	-34.00	19.33	100.
468	1	1	1		1		385.44	-34.00	19.33	100.
469	1	1	1		1		433.69	-34.00	19.33	100.
470	1	1	1		1		481.96	-34.00	19.33	100.
471	1	1	1		1		530.23	-34.00	19.33	100.
472	1	1	1		1		48.14	-34.00	57.98	100.
473	1	1	1		1		96.28	-34.00	57.98	100.
474	1	1	1		1		144.43	-34.00	57.98	100.
475	1	1	1		1		192.59	-34.00	57.98	100.
476	1	1	1		1		240.77	-34.00	57.98	100.
477	1	1	1		1		288.97	-34.00	57.98	100.
478	1	1	1		1		337.19	-34.00	57.98	100.
479	1	1	1		1		385.44	-34.00	57.98	100.
480	1	1	1		1		433.69	-34.00	57.98	100.
481	1	1	1		1		481.96	-34.00	57.98	100.
482	1	1	1		1		530.23	-34.00	57.98	100.
483		1	1	1	1	1	48.	-4.00	96.63	200.
484		1	1	1	1	1	96.	-4.00	96.63	200.
485		1	1	1	1	1	144.	-4.00	96.63	200.
486		1	1	1	1	1	192.	-4.00	96.63	200.
487		1	1	1	1	1	240.	-4.00	96.63	200.
488		1	1	1	1	1	288.	-4.00	96.63	200.
489		1	1	1	1	1	336.	-4.00	96.63	200.
490		1	1	1	1	1	384.	-4.00	96.63	200.

491		1	1	1	1	1	432.	-4.00	96.63	200.
492		1	1	1	1	1	480.	-4.00	96.63	200.
493		1	1	1	1	1	528.	-4.00	96.63	200.
494	1	1	1	1	1		14.36	0.00	96.63	200.
495							600.	0.00	39.00	1050.
496							0.00	0.00	39.00	610.
497	1	1	1	1	1	1	610.	7.00	39.00	70.
498	1	1	1	1	1	1	14.36	-34.00	19.33	100.
499	1	1	1	1	1	1	-5.24	-34.00	19.33	100.
500	1	1	1	1	1	1	14.36	-34.00	57.98	100.
501	1	1	1	1	1	1	-5.24	-34.00	57.98	100.
502							-24.00	0.00	39.00	610.
503							-24.00	-42.00	81.00	610.
504							-24.00	-92.90	30.10	610.
505							-24.00	-143.90	81.10	610.
506	1	1	1	1	1	1	12.00	-143.90	81.10	610.
507							612.00	0.00	39.00	1050.
508							612.00	-147.20	124.00	1050.
509							612.00	-173.70	78.10	1050.
510							684.00	-173.70	78.10	1050.
511							684.00	-59.40	12.10	1050.
512							756.00	-59.40	12.10	1050.
513							756.00	-161.60	71.10	1050.
514							756.00	-161.60	191.10	1050.
515	1	1	1	1	1	1	756.00	-161.60	311.10	1050.
516							612.00	-73.60	81.50	1050.
517	1	1	1	1	1	1	622.00	-73.60	81.50	1050.
518	1	1	1	1	1	1	694.00	-173.70	78.10	1050.
519	1	1	1	1	1	1	766.00	-59.40	12.10	1050.
520	1	1	1	1	1	1	766.00	-161.60	191.10	1050.

12 465 2 13 5

1 13 RECEIVER TUBES, TANGS, RODS

70.	28.3E6	.3	9.11E-6
100.	28.3E6	.3	9.21E-6
200.	27.7E6	.3	9.50E-6
300.	27.1E6	.3	9.73E-6
400.	26.6E6	.3	9.99E-6
500.	26.1E6	.3	10.20E-6
600.	25.4E6	.3	10.43E-6
700.	24.8E6	.3	10.66E-6
800.	24.1E6	.3	10.90E-6
900.	23.3E6	.3	11.11E-6
1000.	22.5E6	.3	11.35E-6
1100.	21.7E6	.3	11.58E-6
1200.	20.9E6	.3	11.81E-6

2 9 INLET PIPING

70.	27.9E6	.3	6.07E-6
100.	27.8E6	.3	6.22E-6
200.	27.7E6	.3	6.38E-6
300.	27.4E6	.3	6.60E-6
400.	27.0E6	.3	6.82E-6
500.	26.4E6	.3	7.02E-6
600.	25.7E6	.3	7.23E-6
700.	24.8E6	.3	7.44E-6
800.	23.4E6	.3	7.65E-6

1	1.50	.058	20.4	.4140	RECEIVER TUBES
2	0.25	.022	20.4	.0455	RECEIVER TANGS
3	6.00	.250	2.0	.1000	TUBE AT MANIFOLD
4	6.625	.280	2.0	2.4500	INLET PIPE
5	[illegible]2.750	.375	2.0	7.5200	OUTLET PI[illegible]2IN

-.270

-.400 -.653

079TI00001
Page 144

FORM 126 7-82

.400

1.00

1	1	2	1	3	70.
2	2	3	1	1	70.
3	3	4	1	1	70.
4	4	5	1	1	70.
5	5	6	1	1	70.
6	6	7	1	1	70.
7	7	8	1	1	70.
8	8	9	1	1	70.
9	9	10	1	1	70.
10	10	11	1	1	70.
11	11	12	1	1	70.
12	12	13	1	1	70.
13	13	14	1	1	70.
14	14	15	1	1	70.
15	15	16	1	1	70.
16	16	17	1	1	70.
17	17	18	1	1	70.
18	18	19	1	1	70.
19	19	20	1	1	70.
20	20	21	1	1	70.
21	21	22	1	1	70.
22	22	23	1	1	70.
23	23	24	1	1	70.
24	24	25	1	1	70.
25	25	26	1	1	70.
26	26	27	1	1	70.
27	27	28	1	1	70.
28	28	29	1	1	70.
29	29	30	1	1	70.
30	30	31	1	1	70.
31	31	32	1	1	70.
32	32	33	1	1	70.
33	33	34	1	1	70.
34	34	35	1	3	70.
35	36	37	1	3	70.
36	37	38	1	1	70.
37	38	39	1	1	70.
38	39	40	1	1	70.
39	40	41	1	1	70.
40	41	42	1	1	70.
41	42	43	1	1	70.
42	43	44	1	1	70.
43	44	45	1	1	70.
44	45	46	1	1	70.
45	46	47	1	1	70.
46	47	48	1	1	70.
47	48	49	1	1	70.
48	49	50	1	1	70.
49	50	51	1	1	70.
50	51	52	1	1	70.
51	52	53	1	1	70.
52	53	54	1	1	70.
53	54	55	1	1	70.
54	55	56	1	1	70.
55	56	57	1	1	70.
56	57	58	1	1	70.
57	58	59	1	1	70.
58	59	60	1	1	70.
59	60	61	1	1	70.

FORM 126-P-120 NEW 7 82

60	61	62	1	1	70.
61	62	63	1	1	70.
62	63	64	1	1	70.
63	64	65	1	1	70.
64	65	66	1	1	70.
65	66	67	1	1	70.
66	67	68	1	1	70.
67	68	69	1	1	70.
68	69	70	1	3	70.
69	71	72	1	3	70.
70	72	73	1	1	70.
71	73	74	1	1	70.
72	74	75	1	1	70.
73	75	76	1	1	70.
74	76	77	1	1	70.
75	77	78	1	1	70.
76	78	79	1	1	70.
77	79	80	1	1	70.
78	80	31	1	1	70.
79	81	82	1	1	70.
80	82	83	1	1	70.
81	83	84	1	1	70.
82	84	85	1	1	70.
83	85	86	1	1	70.
84	86	87	1	1	70.
85	87	88	1	1	70.
86	88	89	1	1	70.
87	89	90	1	1	70.
88	90	91	1	1	70.
89	91	92	1	1	70.
90	92	93	1	1	70.
91	93	94	1	1	70.
92	94	95	1	1	70.
93	95	96	1	1	70.
94	96	97	1	1	70.
95	97	98	1	1	70.
96	98	99	1	1	70.
97	99	100	1	1	70.
98	100	101	1	1	70.
99	101	102	1	1	70.
100	102	103	1	1	70.
101	103	104	1	1	70.
102	104	105	1	3	70.
103	106	107	1	3	70.
104	107	108	1	1	70.
105	108	109	1	1	70.
106	109	110	1	1	70.
107	110	111	1	1	70.
108	111	112	1	1	70.
109	112	113	1	1	70.
110	113	114	1	1	70.
111	114	115	1	1	70.
112	115	116	1	1	70.
113	116	117	1	1	70.
114	117	118	1	1	70.
115	118	119	1	1	70.
116	119	120	1	1	70.
117	120	121	1	1	70.
118	121	122	1	1	70.
119	[illegible]	123	1	1	70.
120	[illegible]	124	1	1	70.
121		125	1	1	70.

079TI000001
Page 146

122		126	1	1	70.
123	126	127	1	1	70.
124	127	128	1	1	70.
125	128	129	1	1	70.
126	129	130	1	1	70.
127	130	131	1	1	70.
128	131	132	1	1	70.
129	132	133	1	1	70.
130	133	134	1	1	70.
131	134	135	1	1	70.
132	135	136	1	1	70.
133	136	137	1	1	70.
134	137	138	1	1	70.
135	138	139	1	1	70.
136	139	140	1	3	70.
137	141	142	1	3	70.
138	142	143	1	1	70.
139	143	144	1	1	70.
140	144	145	1	1	70.
141	145	146	1	1	70.
142	146	147	1	1	70.
143	147	148	1	1	70.
144	148	149	1	1	70.
145	149	150	1	1	70.
146	150	151	1	1	70.
147	151	152	1	1	70.
148	152	153	1	1	70.
149	153	154	1	1	70.
150	154	155	1	1	70.
151	155	156	1	1	70.
152	156	157	1	1	70.
153	157	158	1	1	70.
154	158	159	1	1	70.
155	159	160	1	1	70.
156	160	161	1	1	70.
157	161	162	1	1	70.
158	162	163	1	1	70.
159	163	164	1	1	70.
160	164	165	1	1	70.
161	165	166	1	1	70.
162	166	167	1	1	70.
163	167	168	1	1	70.
164	168	169	1	1	70.
165	169	170	1	1	70.
166	170	171	1	1	70.
167	171	172	1	1	70.
168	172	173	1	1	70.
169	173	174	1	1	70.
170	174	175	1	3	70.
171	176	177	1	3	70.
172	177	178	1	1	70.
173	178	179	1	1	70.
174	179	180	1	1	70.
175	180	181	1	1	70.
176	181	182	1	1	70.
177	182	183	1	1	70.
178	183	184	1	1	70.
179	184	185	1	1	70.
180	185	186	1	1	70.
181	186	187	1	1	70.
182	187	188	1	1	70.
183	188	189	1	1	70.

184	189	190	1	1	70.
185	190	191	1	1	70.
186	191	192	1	1	70.
187	192	193	1	1	70.
188	193	194	1	1	70.
189	194	195	1	1	70.
190	195	196	1	1	70.
191	196	197	1	1	70.
192	197	198	1	1	70.
193	198	199	1	1	70.
194	199	200	1	1	70.
195	200	201	1	1	70.
196	201	202	1	1	70.
197	202	203	1	1	70.
198	203	204	1	1	70.
199	204	205	1	1	70.
200	205	206	1	1	70.
201	206	207	1	1	70.
202	207	208	1	1	70.
203	208	209	1	1	70.
204	209	210	1	3	70.
205	211	212	1	3	70.
206	212	213	1	1	70.
207	213	214	1	1	70.
208	214	215	1	1	70.
209	215	216	1	1	70.
210	216	217	1	1	70.
211	217	218	1	1	70.
212	218	219	1	1	70.
213	219	220	1	1	70.
214	220	221	1	1	70.
215	221	222	1	1	70.
216	222	223	1	1	70.
217	223	224	1	1	70.
218	224	225	1	1	70.
219	225	226	1	1	70.
220	226	227	1	1	70.
221	227	228	1	1	70.
222	228	229	1	1	70.
223	229	230	1	1	70.
224	230	231	1	1	70.
225	231	232	1	1	70.
226	232	233	1	1	70.
227	233	234	1	1	70.
228	234	235	1	1	70.
229	235	236	1	1	70.
230	236	237	1	1	70.
231	237	238	1	1	70.
232	238	239	1	1	70.
233	239	240	1	1	70.
234	240	241	1	1	70.
235	241	242	1	1	70.
236	242	243	1	1	70.
237	243	244	1	1	70.
238	244	245	1	3	70.
239	246	247	1	3	70.
240	247	248	1	1	70.
241	248	249	1	1	70.
242	249	250	1	1	70.
243	[illegible]	251	1	1	70.
244	[illegible]	252	1	1	70.
245	[illegible]	253	1	1	70.

246		254	1	1	70.
247	254	255	1	1	70.
248	255	256	1	1	70.
249	256	257	1	1	70.
250	257	258	1	1	70.
251	258	259	1	1	70.
252	259	260	1	1	70.
253	260	261	1	1	70.
254	261	262	1	1	70.
255	262	263	1	1	70.
256	263	264	1	1	70.
257	264	265	1	1	70.
258	265	266	1	1	70.
259	266	267	1	1	70.
260	267	268	1	1	70.
261	268	269	1	1	70.
262	269	270	1	1	70.
263	270	271	1	1	70.
264	271	272	1	1	70.
265	272	273	1	1	70.
266	273	274	1	1	70.
267	274	275	1	1	70.
268	275	276	1	1	70.
269	276	277	1	1	70.
270	277	278	1	1	70.
271	278	279	1	1	70.
272	279	280	1	3	70.
273	281	282	1	3	70.
274	282	283	1	1	70.
275	283	284	1	1	70.
276	284	285	1	1	70.
277	285	286	1	1	70.
278	286	287	1	1	70.
279	287	288	1	1	70.
280	288	289	1	1	70.
281	289	290	1	1	70.
282	290	291	1	1	70.
283	291	292	1	1	70.
284	292	293	1	1	70.
285	293	294	1	1	70.
286	294	295	1	1	70.
287	295	296	1	1	70.
288	296	297	1	1	70.
289	297	298	1	1	70.
290	298	299	1	1	70.
291	299	300	1	1	70.
292	300	301	1	1	70.
293	301	302	1	1	70.
294	302	303	1	1	70.
295	303	304	1	1	70.
296	304	305	1	1	70.
297	305	306	1	1	70.
298	306	307	1	1	70.
299	307	308	1	1	70.
300	308	309	1	1	70.
301	309	310	1	1	70.
302	310	311	1	1	70.
303	311	312	1	1	70.
304	312	313	1	1	70.
305	313	314	1	1	70.
306	314	315	1	3	70.
307	316	317	1	3	70.

308	317	318	1	1	70.
309	318	319	1	1	70.
310	319	320	1	1	70.
311	320	321	1	1	70.
312	321	322	1	1	70.
313	322	323	1	1	70.
314	323	324	1	1	70.
315	324	325	1	1	70.
316	325	326	1	1	70.
317	326	327	1	1	70.
318	327	328	1	1	70.
319	328	329	1	1	70.
320	329	330	1	1	70.
321	330	331	1	1	70.
322	331	332	1	1	70.
323	332	333	1	1	70.
324	333	334	1	1	70.
325	334	335	1	1	70.
326	335	336	1	1	70.
327	336	337	1	1	70.
328	337	338	1	1	70.
329	338	339	1	1	70.
330	339	340	1	1	70.
331	340	341	1	1	70.
332	341	342	1	1	70.
333	342	343	1	1	70.
334	343	344	1	1	70.
335	344	345	1	1	70.
336	345	346	1	1	70.
337	346	347	1	1	70.
338	347	348	1	1	70.
339	348	349	1	1	70.
340	349	350	1	3	70.
341	8	351	1	2	70.
342	10	352	1	2	70.
343	12	353	1	2	70.
344	14	354	1	2	70.
345	16	355	1	2	70.
346	18	356	1	2	70.
347	20	357	1	2	70.
348	22	358	1	2	70.
349	24	359	1	2	70.
350	26	360	1	2	70.
351	28	361	1	2	70.
352	43	362	1	2	70.
353	45	363	1	2	70.
354	47	364	1	2	70.
355	49	365	1	2	70.
356	51	366	1	2	70.
357	53	367	1	2	70.
358	55	368	1	2	70.
359	57	369	1	2	70.
360	59	370	1	2	70.
361	61	371	1	2	70.
362	63	372	1	2	70.
363	78	373	1	2	70.
364	80	374	1	2	70.
365	82	375	1	2	70.
366	84	376	1	2	70.
367	[illegible]	377	1	2	70.
368	[illegible]	378	1	2	70.
369	0	379	1	2	70.

370		380	1	2	70.
371	94	381	1	2	70.
372	96	382	1	2	70.
373	98	383	1	2	70.
374	113	384	1	2	70.
375	115	385	1	2	70.
376	117	386	1	2	70.
377	119	387	1	2	70.
378	121	388	1	2	70.
379	123	389	1	2	70.
380	125	390	1	2	70.
381	127	391	1	2	70.
382	129	392	1	2	70.
383	131	393	1	2	70.
384	133	394	1	2	70.
385	148	395	1	2	70.
386	150	396	1	2	70.
387	152	397	1	2	70.
388	154	398	1	2	70.
389	156	399	1	2	70.
390	158	400	1	2	70.
391	160	401	1	2	70.
392	162	402	1	2	70.
393	164	403	1	2	70.
394	166	404	1	2	70.
395	168	405	1	2	70.
396	183	406	1	2	70.
397	185	407	1	2	70.
398	187	408	1	2	70.
399	189	409	1	2	70.
400	191	410	1	2	70.
401	193	411	1	2	70.
402	195	412	1	2	70.
403	197	413	1	2	70.
404	199	414	1	2	70.
405	201	415	1	2	70.
406	203	416	1	2	70.
407	218	417	1	2	70.
408	220	418	1	2	70.
409	222	419	1	2	70.
410	224	420	1	2	70.
411	226	421	1	2	70.
412	228	422	1	2	70.
413	230	423	1	2	70.
414	232	424	1	2	70.
415	234	425	1	2	70.
416	236	426	1	2	70.
417	238	427	1	2	70.
418	253	428	1	2	70.
419	255	429	1	2	70.
420	257	430	1	2	70.
421	259	431	1	2	70.
422	261	432	1	2	70.
423	263	433	1	2	70.
424	265	434	1	2	70.
425	267	435	1	2	70.
426	269	436	1	2	70.
427	271	437	1	2	70.
428	273	438	1	2	70.
429	288	439	1	2	70.
430	290	440	1	2	70.
431	292	441	1	2	70.

FORM 120-P-170 NEW 7-82

432	294	442	1	2		70.			
433	296	443	1	2		70.			
434	298	444	1	2		70.			
435	300	445	1	2		70.			
436	302	446	1	2		70.			
437	304	447	1	2		70.			
438	306	448	1	2		70.			
439	308	449	1	2		70.			
440	323	450	1	2		70.			
441	325	451	1	2		70.			
442	327	452	1	2		70.			
443	329	453	1	2		70.			
444	331	454	1	2		70.			
445	333	455	1	2		70.			
446	335	456	1	2		70.			
447	337	457	1	2		70.			
448	339	458	1	2		70.			
449	341	459	1	2		70.			
450	343	460	1	2		70.			
451	496	502	2	4		70.			
452	502	503	2	4		70.			
453	503	504	2	4		70.			
454	504	505	2	4		70.			
455	505	506	2	4		70.			
456	495	507	1	4		70.			
457	507	516	1	4		70.			
458	508	503	1	4		70.			
459	509	510	1	4		70.			
460	510	511	1	4		70.			
461	511	512	1	4		70.			
462	512	513	1	4		70.			
463	513	514	1	5		70.			
464	514	515	1	5		70.			
465	516	508	1	4		70.			
7	4								
	1.		1.		1.		1.		
510	518				1				
512	519				1				
514	520				1				
516	517				1				
2	166	5		6					
1		27.7E6		.3			.283		
2		22.1E6		.3			.631		
3		25.4E6		.3			.631		
4		27.7E6		.3			.283		
5		25.4E6		.3			.283		
6		27.7E6		.3			.283		
1		.252		.134		.134	.0594	.0297	.0297
2		2.733		1.450		1.450	28.8000	14.4000	14.4000
3		.750		.500		.313	.0036	.1790	.7820
4		2.090		1.000		1.500	2.5700	2.2100	1.1500
5		.900		.765		.765	.1020	.4320	.0110
	-1.				-.27				
					-.40				
					.40				
1	373	461	472	1	1			11	
2	374	462	473	1	1			11	
3	375	463	474	1	1			11	
4	376	464	475	1	1			11	
5	[illegible]	465	476	1	1			11	
6	[illegible]	466	477	1	1			11	
7	[illegible]	467	478	1	1			11	

079TI000001 Page 152

8	380	468	479	1	1	11	
9	381	469	480	1	1	11	
10	382	470	481	1	1	11	
11	383	471	482	1	1	11	
12	428	472	461	1	1	11	
13	429	473	462	1	1	11	
14	430	474	463	1	1	11	
15	431	475	464	1	1	11	
16	432	476	465	1	1	11	
17	433	477	466	1	1	11	
18	434	478	467	1	1	11	
19	435	479	468	1	1	11	
20	436	480	469	1	1	11	
21	437	481	470	1	1	11	
22	438	482	471	1	1	11	
23	76	498	251	6	5		1
24	351	362	352	4	3		
25	362	373	352	4	3		
26	373	384	352	4	3		
27	384	395	352	4	3		
28	395	406	352	4	3		
29	406	417	352	4	3		
30	417	428	352	4	3		
31	428	439	352	4	3		
32	439	450	352	4	3		
33	450	483	352	4	3		1
34	352	363	351	4	3		
35	363	374	351	4	3		
36	374	385	351	4	3		
37	385	396	351	4	3		
38	396	407	351	4	3		
39	407	418	351	4	3		
40	418	429	351	4	3		
41	429	440	351	4	3		
42	440	451	351	4	3		
43	451	484	351	4	3		1
44	353	364	351	4	3		
45	364	375	351	4	3		
46	375	386	351	4	3		
47	386	397	351	4	3		
48	397	408	351	4	3		
49	408	419	351	4	3		
50	419	430	351	4	3		
51	430	441	351	4	3		
52	441	452	351	4	3		
53	452	485	351	4	3		1
54	354	365	351	4	3		
55	365	376	351	4	3		
56	376	387	351	4	3		
57	387	398	351	4	3		
58	398	409	351	4	3		
59	409	420	351	4	3		
60	420	431	351	4	3		
61	431	442	351	4	3		
62	442	453	351	4	3		
63	453	486	351	4	3		1
64	355	366	351	4	3		
65	366	377	351	4	3		
66	377	388	351	4	3		
67	388	399	351	4	3		
68	399	410	351	4	3		
69	410	421	351	4	3		

70	421	432	351	4	3	
71	432	443	351	4	3	
72	443	454	351	4	3	
73	454	487	351	4	3	1
74	356	367	351	4	3	
75	367	378	351	4	3	
76	378	389	351	4	3	
77	389	400	351	4	3	
78	400	411	351	4	3	
79	411	422	351	4	3	
80	422	433	351	4	3	
81	433	444	351	4	3	
82	444	455	351	4	3	
83	455	488	351	4	3	1
84	357	368	351	4	3	
85	368	379	351	4	3	
86	379	390	351	4	3	
87	390	401	351	4	3	
88	401	412	351	4	3	
89	412	423	351	4	3	
90	423	434	351	4	3	
91	434	445	351	4	3	
92	445	456	351	4	3	
93	456	489	351	4	3	1
94	358	369	351	4	3	
95	369	380	351	4	3	
96	380	391	351	4	3	
97	391	402	351	4	3	
98	402	413	351	4	3	
99	413	424	351	4	3	
100	424	435	351	4	3	
101	435	446	351	4	3	
102	446	457	351	4	3	
103	457	490	351	4	3	1
104	359	370	351	4	3	
105	370	381	351	4	3	
106	381	392	351	4	3	
107	392	403	351	4	3	
108	403	414	351	4	3	
109	414	425	351	4	3	
110	425	436	351	4	3	
111	436	447	351	4	3	
112	447	458	351	4	3	
113	458	491	351	4	3	1
114	360	371	351	4	3	
115	371	382	351	4	3	
116	382	393	351	4	3	
117	393	404	351	4	3	
118	404	415	351	4	3	
119	415	426	351	4	3	
120	426	437	351	4	3	
121	437	448	351	4	3	
122	448	459	351	4	3	
123	459	492	351	4	3	1
124	361	372	351	4	3	
125	372	383	351	4	3	
126	383	394	351	4	3	
127	394	405	351	4	3	
128	405	416	351	4	3	
129	[illegible]	427	351	4	3	
130	[illegible]	[illegible]	351	4	3	
131	[illegible]	[illegible]	351	4	3	

FORM 125-P-130

132	449	460	351	4	3	
133	460	493	351	4	3	1
134	1	36	6	3	2	
135	36	71	6	3	2	
136	71	106	6	3	2	
137	106	141	6	3	2	
138	141	496	6	3	2	
139	176	211	6	3	2	
140	211	246	6	3	2	
141	246	281	6	3	2	
142	281	316	6	3	2	
143	35	70	6	2	2	
144	70	105	6	2	2	
145	105	140	6	2	2	
146	140	175	6	2	2	
147	175	210	6	2	2	
148	210	245	6	2	2	
149	245	280	6	2	2	
150	280	315	6	2	2	
151	315	350	6	2	2	
152	6	41	7	5	4	
153	41	76	7	5	4	
154	76	111	7	5	4	
155	111	146	7	5	4	
156	146	181	7	5	4	
157	181	216	7	5	4	
158	216	251	7	5	4	
159	251	286	7	5	4	
160	286	321	7	5	4	
161	321	494	7	5	4	
162	76	499	251	6	5	
163	251	500	76	6	5	
164	251	501	76	6	5	
165	495	210	6	2	2	
166	496	176	6	3	2	

	1.						
		1.					
			1.				
				1.			
	0.	0.	0.				
1	1				-1	1	2
1	1		90.		-1	1	2
1	1	45.	45.		-1	1	2

079TI00001
Page 155

```
*********** ANSYS INPUT DATA LISTING (FILE18) **********

     6    12    18    24    30    36    42    48    54    60    66    72    78
     V     V     V     V     V     V     V     V     V     V     V     V     V
CARIZZO SOLAR RECEIVER-(DWG.NO.079000001)-SINGLE TUBE-THERMAL LOADING
W.PROPES
           1   1   1        9
         70.         70.
  1 20     1
  2  4     1
-1
       .75      .049
     .0085   5.74E-6   5.74E-6      .104      .104        0.
        1.       10.       10.        1.        1.
-1
/COM ELEMENT DEFINITION
     1     2                                                     1
     2     3                                                     1
     3     4                                                     1
     4     5                                                     1
     5     6                                                     1
     6     7                                                     1
     7     8                                                     1
     8     9                                                     1
     9    10                                                     1
    10    11                                                     1
    11    12                                                     1
    12    13                                                     1
    13    14                                                     1
    14    15                                                     1
    15    16                                                     1
    16    17                                                     1
    17    18                                                     1
    18    19                                                     1
    19    20                                                     1
    20    21                                                     1
    21    22                                                     1
    22    23                                                     1
    23    24                                                     1
    24    25                                                     1
    25    26                                                     1
    26    27                                                     1
    27    28                                                     1
    28    29                                                     1
    29    30                                                     1
    30    31                                                     1
    31    32                                                     1
    32    33                                                     1
    33    34                                                     1
    34    35                                                     1
    35    36                                                     1
    36    37                                                     1
    37    38                                                     1
    38    39                                                     1
     A     A     A     A     A     A     A     A     A     A     A     A     A
```

ANSYS SINGLE TUBE MODEL

INPUT DATA LISTING

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
     6    12    18    24    30    36    42    48    54    60    66    72    78
     V     V     V     V     V     V     V     V     V     V     V     V     V
    39    40                                                     1
    40    41                                                     1
    41    42                                                     1
    42    43                                                     1
    43    44                                                     1
    44    45                                                     1
    45    46                                                     1
    46    47                                                     1
    47    48                                                     1
    48    49                                                     1
    49    50                                                     1
    50    51                                                     1
    51    52                                                     1
    52    53                                                     1
    53    54                                                     1
    54    55                                                     1
    55    56                                                     1
    56    57                                                     1
    57    58                                                     1
    58    59                                                     1
    59    60                                                     1
    60    61                                                     1
    61    62                                                     1
    62    63                                                     1
     5    64                                               2     2
     6    65                                               2     2
    10    66                                               2     2
    11    67                                               2     2
    15    68                                               2     2
    16    69                                               2     2
    20    70                                               2     2
    21    71                                               2     2
    25    72                                               2     2
    26    73                                               2     2
    30    74                                               2     2
    31    75                                               2     2
    35    76                                               2     2
    36    77                                               2     2
    40    78                                               2     2
    41    79                                               2     2
    45    80                                               2     2
    46    81                                               2     2
    50    82                                               2     2
    51    83                                               2     2
    55    84                                               2     2
    56    85                                               2     2
    64   104                                               2     3    11  2
   104    65                                               2     3    11  2
-1
/COM TUBE GEOMETRY
     A     A     A     A     A     A     A     A     A     A     A     A     A
```

079TI00001
Page 157

********** ANSYS INPUT DATA LISTING (FILE18) **********

6 12 18 24 30 36 42 48 54 60 66 72 78
V V V V V V V V V V V V V

	6	24	36	48
101	1	2.14	12.	0.
102	2	0.	14.14	0.
103	3	0.	24.	0.
104	4	0.	36.	0.
105	5	0.	47.37	0.
106	6	0.	48.63	0.
107	7	0.	60.	0.
108	8	0.	72.	0.
109	9	0.	84.	0.
110	10	0.	95.37	0.
111	11	0.	96.63	0.
112	12	0.	108.	0.
113	13	0.	120.	0.
114	14	0.	132.	0.
115	15	0.	143.37	0.
116	16	0.	144.63	0.
117	17	0.	156.	0.
118	18	0.	168.	0.
119	19	0.	180.	0.
120	20	0.	191.37	0.
121	21	0.	192.63	0.
122	22	0.	204.	0.
123	23	0.	216.	0.
124	24	0.	228.	0.
125	25	0.	239.37	0.
126	26	0.	240.63	0.
127	27	0.	252.	0.
128	28	0.	264.	0.
129	29	0.	276.	0.
130	30	0.	287.37	0.
131	31	0.	288.63	0.
132	32	0.	300.	0.
133	33	0.	312.	0.
134	34	0.	324.	0.
135	35	0.	335.37	0.
136	36	0.	336.63	0.
137	37	0.	348.	0.
138	38	0.	360.	0.
139	39	0.	372.	0.
140	40	0.	383.37	0.
141	41	0.	384.63	0.
142	42	0.	396.	0.
143	43	0.	408.	0.
144	44	0.	420.	0.
145	45	0.	431.37	0.
146	46	0.	432.63	0.
147	47	0.	444.	0.
148	48	0.	456.	0.
149	49	0.	468.	0.
150	50	0.	479.37	0.

A A A A A A A A A A A A A

079TI00001
Page 158

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
     6     12    18    24    30    36    42    48    54    60    66    72    78
     V     V     V     V     V     V     V     V     V     V     V     V     V
    51                0.         480.63            0.
    52                0.         492.              0.
    53                0.         504.              0.
    54                0.         516.              0.
    55                0.         527.37            0.
    56                0.         528.63            0.
    57                0.         540.              0.
    58                0.         552.              0.
    59                0.         564.              0.
    60                0.         576.              0.
    61                0.         585.86            0.
    62                7.07       592.93            0.
    63                2.34       597.66            0.
    64                4.38        47.37            0.
    65                4.38        48.63            0.
    66                4.38        95.37            0.
    67                4.38        96.63            0.
    68                4.38       143.37            0.
    69                4.38       144.63            0.
    70                4.38       191.37            0.
    71                4.38       192.63            0.
    72                4.38       239.37            0.
    73                4.38       240.63            0.
    74                4.38       287.37            0.
    75                4.38       288.63            0.
    76                4.38       335.37            0.
    77                4.38       336.63            0.
    78                4.38       383.37            0.
    79                4.38       384.63            0.
    80                4.38       431.37            0.
    81                4.38       432.63            0.
    82                4.38       479.37            0.
    83                4.38       480.63            0.
    84                4.38       527.37            0.
    85                4.38       528.63            0.
   104                4.38       48.               0.
   106                4.38       96.               0.
   108                4.38       143.              0.
   110                4.38       192.              0.
   112                4.38       240.              0.
   114                4.38       288.              0.
   116                4.38       336.              0.
   118                4.38       384.              0.
   120                4.38       432.              0.
   122                4.38       480.              0.
   124                4.38       528.              0.
-1
VIEW
           0.0   0.0   1.0
PLOT               1     4
     A     A     A     A     A     A     A     A     A     A     A     A     A
```

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
     6     12    18    24    30    36    42    48    54    60    66    72    78
     V     V     V     V     V     V     V     V     V     V     V     V     V
-1
/COM MATERIAL PROPERTY DEFINITIONS
  EX          2.833669E7-2.882211E+3-3.697849E-07.709183E-04
ALPX        2
           12        100.        100.
   8.4732E-6   8.7389E-6   8.9839E-6   9.2093E-6   9.4160E-6   9.6051E-6
   9.7777E-6   9.9350E-6  10.0780E-6  10.0208E-6  10.0326E-6  10.4320E-6
NUXY         2.624811E-1 4.265787E-5
DENS        2
            2        100.       1100.
      744.E-6     719.E-6
-1
  1  1     1

/COM DISPLACEMENT DEFINITIONS
     1   UX         0.
     1   UY         0.
     1   UZ         0.
     1 ROTX         0.
     1 ROTY         0.
    63   UX
    63   UZ
    63 ROTX
    63 ROTY
    63 ROTZ
   104   UX         0.               124     2
   104   UZ         0.               124     2
   104 ROTX         0.               124     2
   104 ROTY         0.               124     2
-1


/COM ELEMENT TEMPERATURES
    610.    610.    610.                                               5
    617.    617.    629.
    620.    620.    635.
    626.    626.    642.
    632.    632.    650.
    635.    635.    655.
    639.    639.    660.
    647.    647.    673.
    657.    657.    684.
    667.    667.    699.
    673.    673.    706.
    679.    679.    715.
    691.    691.    730.
    705.    705.    750.
    719.    719.    767.
    728.    728.    777.
    735.    735.    787.
     A     A     A     A     A     A     A     A     A     A     A     A     A
```

079TID00001
Page 160

FORM 126 P 130 NEW 8 76

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
      6     12    18    24    30    36    42    48    54    60    66    72    78
      V     V     V     V     V     V     V     V     V     V     V     V     V
    751.  751.  808.
    769.  769.  830.
    786.  786.  850.
    796.  796.  860.
    807.  807.  872.
    825.  825.  891.
    843.  843.  914.
    861.  861.  930.
    871.  871.  940.
    881.  881.  950.
    899.  899.  966.
    916.  916.  984.
    932.  932.  997.
    940.  940. 1004.
    947.  947. 1010.
    961.  961. 1023.
    975.  975. 1033.
    987.  987. 1041.
    993.  993. 1045.
    999.  999. 1048.
   1008. 1008. 1053.
   1016. 1016. 1057.
   1024. 1024. 1060.
   1027. 1027. 1061.
   1030. 1030. 1063.
   1035. 1035. 1065.
   1040. 1040. 1066.
   1045. 1045. 1066.
   1046. 1046. 1066.
   1049. 1049. 1066.
   1050. 1050. 1066.
   1052. 1052. 1066.
   1053. 1053. 1065.
   1050. 1050. 1050.                                               8
    405.  405.  405.                                               2
    408.  408.  408.                                               2
    420.  420.  420.                                               2
    440.  440.  440.                                               2
    466.  466.  466.                                               2
    501.  501.  501.                                               2
    538.  538.  538.                                               2
    571.  571.  571.                                               2
    597.  597.  597.                                               2
    613.  613.  613.                                               2
    622.  622.  622.                                              25
END
FINISH
/POST22
RATIO,20
PLDISP
      A     A     A     A     A     A     A     A     A     A     A     A     A
```

079TI00001
Page 161

********** ANSYS INPUT DATA LISTING (FILE18) **********

```
        6     12    18    24    30    36    42    48    54    60    66    72    78
        V     V     V     V     V     V     V     V     V     V     V     V     V
 301  FINISH
```

079TI000001

Page 162

FORM 126 P 130 NEW 8 76

*********** ANSYS INPUT DATA LISTING (LE18) ***********

```
     6     12    18    24    30    36    42    48    54    60    66    72    78
     V     V     V     V     V     V     V     V     V     V     V     V     V
/PREP7
/TITLE SOLAR PANEL TUBE
KAN,0
ET,1,42,,,1
TREF,70.
KNL,1
TOFFST,460.
MPTEMP,1,70.,700.,800.,900.,1000.,1100.
MPDATA,ALPX,1,1,8.473E-6,9.778E-6,9.935E-6,10.08E-6,10.21E-6,10.33E-6
MPDATA,EX,1,1,28.01E6,24.77E6,24.06E6,23.31E6,22.53E6,21.72E6
NL,1,1,1.0,,,,,10.0
NL,1,7,0.0
NL,1,13,2
NL,1,19,800,1000,1200
NL,1,25,17000,15500,14500
NL,1,31,.089,.096,.103
MPLIST
LOCAL,11,1,100.,.0,.0
N,1,.375,180.,.0
N,6,.326,180.,.0
N,211,.375,-170.,.0
N,216,.326,-170.,.0
FILL,1,211,34,7,6
FILL,6,216,34,12,6
FILL,1,6,4,2,1,36,6
NLIST
NPLOT,1
VIEW,.0,.0,1.0
GRANGE,99.,101.,1.0,-1.0,.0,.0
E,1,2,8,7
EGEN,5,1,1
EGEN,35,6,1,5
E,211,212,2,1
E,212,213,3,2
E,213,214,4,3
E,214,215,5,4
E,215,216,6,5
ELIST
NPLOT
```

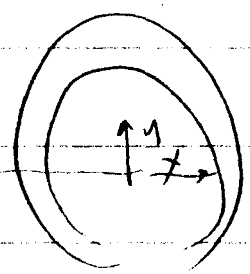
ANSYS TUBE CROSS_SECTION

MODEL INPUT DATA LISTING

079TI000001

```
ENUM,1
EPLOT
NRANGE
ELIST,1,180
NLIST,1,216
D,163,UY,.0
ITER,-10,16
LPRINT,1
KTEMP,-1
T,109,1022.5
T,110,997.4
```

A A A A A A A A A A A A A



*********** ANSYS INPUT DATA LISTING ....E18) ***********

```
     6     12    18    24    30    36    42    48    54    60    66    72    78
     V     V     V     V     V     V     V     V     V     V     V     V     V
T,111,971.5
T,112,944.7
T,113,916.9
T,114,888.1
T,115,1019.7
T,116,994.90
T,117,969.40
T,118,943.0
T,119,915.6
T,120,887.2
TGEN,6,-12,115,120
T,121,1011.3
T,122,987.60
T,123,963.1
T,124,937.9
T,125,911.7
T,126,884.6
TGEN,6,-24,121,126
T,127,997.5
T,128,975.50
T,129,952.9
T,130,929.5
T,131,905.4
T,132,880.3
TGEN,6,-36,127,132
T,133,978.6
T,134,959.1
T,135,939.0
T,136,918.2
T,137,896.7
T,138,874.5
TGEN,6,-48,133,138
T,139,955.3
T,140,938.70
T,141,921.7
T,142,904.2
T,143,886.1
T,144,867.4
TGEN,6,-60,139,144
```

```
 90   T,145,928.0
 91   T,146,915.1
 92   T,147,901.7
 93   T,148,888.0
 94   T,149,873.8
 95   T,150,859.1
 96   TGEN,6,-72,145,150
 97   T,151,879.9
 98   T,152,888.90
 99   T,153,879.7
100   T,154,870.2
          A    A    A    A    A    A    A    A    A    A    A    A    A
```

*********** ANSYS INPUT DATA LISTING (FILE18) ***********

```
             6     12    18    24    30    36    42    48    54    60    66    72    78
             V     V     V     V     V     V     V     V     V     V     V     V     V
T,155,860.3
T,156,850.1
TGEN,6,-84,151,156
T,157,866.6
T,158,862.0
T,159,857.1
T,160,852.0
T,161,846.6
T,162,841.0
TGEN,6,-96,157,162
T,163,838.4
T,164,838.20
T,165,837.5
T,166,836.4
T,167,835.0
T,168,833.0
TGEN,6,-108,163,168
T,169,832.2
T,170,832.2
T,171,832.0
T,172,831.7
T,173,831.4
T,174,830.9
TGEN,6,-120,169,174
T,175,830.5
T,176,830.50
T,177,830.5
T,178,830.5
T,179,830.5
T,180,830.5
TGEN,37,1,180
T,1,830.5
TGEN,48,1,1
LWRITE
TIME,7.35
ITER,-10,10
LPRINT,1
LWRITE
AFWRITE
```

```
FINISH
/INPUT,27
FINISH
```

Rockwell International
Energy Systems Group

SUPPORTING DOCUMENT

GO NO.	S/A NO.	PAGE 1 OF	TOTAL PAGES	REV LTR/CHG NO SEE SUMMARY OF CHG	NUMBER
09479	13400	73	73	nc	079TI000007

PROGRAM TITLE
Preliminary Design of the Carrizo Plains Solar Central Receiver Power Plant

DOCUMENT TITLE
Sodium Safety Plan

DOCUMENT TYPE
Technical Information

KEY NOUNS

ORIGINAL ISSUE DATE
April 18, 1983

REL. DATE
5-17-83 RK

PREPARED BY/DATE	DEPT	MAIL ADDR
C. E. McDade	360	EMSC
P. A. Scofield	360	EMSC

IR&D PROGRAM? YES ☐ NO ☒
IF YES, ENTER TPA NO.

APPROVALS		DATE
G. Lauer	[signature]	4/29/83
A. Z. Ullman	A. Z. Ullman	5/3/83
T. H. Springer	T. H. Springer	5/12/83

DISTRIBUTION

*	NAME	MAIL ADDR
*	A. Z. Ullman (4)	LA19
*	T. H. Springer(3)	LA18
*	G. J. Hallinan	LA24
*	R. E. Durand	LB23
*	C. E. McDade	EMSC
*	P. A. Scofield	EMSC

* COMPLETE DOCUMENT
NO ASTERISK, TITLE PAGE/SUMMARY OF CHANGE PAGE ONLY

ABSTRACT

A safety plan for sodium-containing portions of the Carrizo Plains solar power plant is presented. The plan specifies required personnel protective equipment for workers with varying levels of potential exposure to sodium. Hazard control and safety equipment requirements are specified. Emergency operating procedures are developed for sodium-related accidents, and spill counter measures are given.

FORM 734-C REV. 12-79

Table of Contents

Table of Contents (Continued)

1.0 INTRODUCTION

1.1 DESCRIPTION OF PROJECT

This document presents a safety plan for the heat transport system at the proposed Carrizo Plain solar power plant. The plant design will utilize a heliostat field and a 350 ft solar receiver tower. Liquid sodium will flow through the receiver tower as the heat transport medium, carrying heat to a series of steam generators, steam from which will drive a turbine to produce electricity. The sodium temperatures before and after passage through the receiver tower will be 610°F and 1050°F, respectively. The total system sodium capacity will be 470,000 gallons, and sodium will be stored in hot and cold storage tanks adjacent to the receiver tower. Each tank will be capable of accommodating the entire system sodium inventory.

This safety plan covers all major aspects of liquid sodium safety. The safety procedures apply to all facets of the heat transport system, including the solar receiver, sodium heat transport loop, sodium handling equipment, steam generators, thermal storage tanks, and auxiliary equipment. This document deals with only those topics directly or indirectly related to liquid sodium safety.

Several topics related to the liquid sodium safety plan are included in the appendices. Appendix A presents a brief history of the safety of liquid sodium heat transport systems. The report of an atmospheric dispersion modeling study designed to simulate sodium spills in a solar power plant is included as Appendix B. Appendix C consists of a brief discussion of the physical and chemical properties of liquid sodium, and an examination of the effects of sodium exposure upon people. Abundant references are available to the reader who wishes to learn more about sodium properties or biological effects (see, for example, Jackson, 1955). Appendix D contains several sections of the General Industry Safety Orders dealing with flammable substances.

1.2 SUMMARY OF RECOMMENDATIONS

Presented below is a summary of the recommendations which are made in this report to protect the plant employees, the public, and the plant equipment. Each of these recommendations is discussed in detail in this safety plan.

1. Although a number of governmental regulations address plant safety, few are directly applicable to liquid sodium. Thus, many regulatory decisions will be made on a case-by-case basis, so it is essential that the plant designers communicate with the regulatory agencies during the design phase.

2. Protective clothing shall be available to all plant personnel both for everyday use and for fire fighting and emergency protection.

3. Drip pans shall be placed under all system components which may be subject to leakage, and berms shall be constructed around large storage tanks. The sodium loop shall be designed so that sections can be isolated and drained.

4. All enclosed areas shall have adequate ventilation to disperse smoke from a sodium fire.

5. Leak detectors shall be placed near all system components which may be subject to leakage. Smoke detectors shall be placed on or near the ceiling in all enclosed areas.

6. Na-X fire extinguishers shall be placed at strategic locations throughout the sodium loop area.

7. Safety showers and eye washes shall be located in the vicinity of the sodium loop, yet far enough away that there is no possibility of the shower area being involved in a sodium spill.

8. All plant personnel shall be trained in fire fighting and first aid for sodium spills. Fire fighting and first aid equipment shall be located at the plant.

9. A plan for emergency evacuation of plant personnel shall be developed. Safe areas shall be provided for employee evacuation during emergencies.

10. All waste sodium shall be disposed of properly. Hazardous waste permits shall be obtained as necessary.

11. Sodium warning signs (Section 2.2) shall be posted at the access points to the sodium handling area.

2.0 FEDERAL, STATE & LOCAL GOVERNMENTAL SAFETY REQUIREMENTS

The Federal, state, and local safety requirements applicable to the design of the Carrizo Plain solar power plant are delineated in this section. Due to the nature of the facility (e.g, utilization of the sodium heat transport loop, equipment, and storage facilities) most of the existing regulations are not specific and comprehensive for sodium systems. Based on this preliminary evaluation, it appears that the state and county officials would require safety design information from the contractor to evaluate the plant safety needs on a case-by-case basis.

2.1 FEDERAL REQUIREMENTS

The primary Federal acts and regulations that would be applicable in the operation of the Carrizo Plain Solar Power Plant include:

* The Occupational Safety and Health Act of 1970 as amended, Public Law 91-596.
* Occupational Safety and Health Administration (OSHA) Safety and Health Standards (29 CFR 1910) - "General Industry Standards."

Section 5.(A)(1) of the Occupational Safety and Health Act specifies the duties of an employer:

DUTIES
[Employer]

Sec. 5. (a) Each employer--

1. shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees;
2. shall comply with occupational safety and health standards promulgated under this Act.

This means that even where there are no existing standards covering a given situation, the employer must furnish employment and a place of employment that are free from "recognized hazards." Failure of an employer to comply with the "recognized hazard" duty could result in a citation, or notice of violation and, if established, the imposition of a penalty.

The Federal OSHA, "General Industry, Occupational Safety and Health Standards" (29 CFR 1910) are, as the title denotes, applicable to general industry. For example, Subpart D, Working Surfaces, and Subpart E, Walking-Working Surfaces, would be generally applicable to the solar power plant as they would to any other industry. There are regulations applicable to hazardous substances that could also be applicable to the solar power facility. These regulations include Subpart H, Hazardous Materials, and Subpart L, Fire Protection.

The regulations specified in Subpart H, 29 CFR 1910.106 for flammable and combustible liquids could be generally extrapolated to sodium. It must be noted, however, that the definitions and regulations for combustible and flammable liquids take into account flashpoint and ignition sources. This is not sufficient for sodium, since it is a spontaneously combustible material in air and it does not require an ignition source.

Subpart H, Section 106, also specifies:

* Tank storage design and construction requirements,

* Piping, valves, and fitting requirements,

* Drainage dikes and walls for above ground tank design and construction requirements,

* Spill containment requirements, and

* Fire control measures (including alarm systems).

In Subpart L, Fire Protection, Section 1910.156, a class D fire is define as "fire in combustible metals such as magnesium, titanium, zirconium, sodium and potassium." This section identifies requirements for portable fire extinguishers, fixed fire suppression equipment and other fire protection systems (29 CFR 1910.167, Local Fire Alarm Signaling Systems).

Examples of codes and standards delineated in the Federal OSHA regulations include:

* ASME Boiler and Pressure Vessel Code, Section VIII.

* National Fire Protection Codes

* Title 49 Code of Federal Regulations, Transportation Regulations

These Federal OSHA regulations would be generally applicable to the Carrizo Plain Solar Power Plant, but would be superceded by the California Occupational Safety and Health Standards (see Section 2.2 for further details on state requirements). As a general rule-of-thumb, the state regulations cannot be less stringent than the Federal regulations and are often more stringent, especially in California.

2.2 STATE REQUIREMENTS

As mentioned at the beginning of this section, most of the existing regulations are not directly applicable, and the safety impacts would be assessed on a case-by-case basis. The state regulations generally applicable for the solar power plant include:

* California Administrative Code, Title 8 - General Industry Safety Orders and Electrical Safety Orders; and Title 24, Electrical Building Codes, as promulgated under the California Occupational Safety and Health Act (CALOSHA).

* California Environmental Quality Act.

* Uniform Building Code.

The General Industry Safety and Electrical Safety Orders would apply for overall plant safety. However, Title 8, Group 16, Article 109, "Hot, Flammable, Poisonous, Corrosive and Irritant Substances," has some applicability for sodium. Sodium is cited in Title 8, Section 5161 as a spontaneously flammable substance, defined as "a substance which, upon contact with air or moisture reacts so violently as to ignite or cause ignition."

Section 5176 of Article 109 specifies the regulations that pertain to spontaneously flammable substances. These are as follows:

A. Spontaneously flammable materials shall, as far as practicable, be stored and handled under a suitable liquid which will prevent contact of the material with air and with moisture if the substance reacts violently with water.

B. Where such substances are handled or used in the dry state, the amount at each work station shall not be more than one half-day's supply or product; provided, however, that where less than one half-day's supply or product may constitute a serious hazard, the permissible amount may be restricted to less than a half-day's supply.

C. Work stations where spontaneously flammable substances are used or handled in the dry state shall be separated by distance, barricades, or other means so that a fire in the material at one station will not ignite material at any other station.

D. All containers, either open, closed, or covered, which contain a spontaneously flammable substance shall be plainly marked, with an appropriate warning legend, or painted a distinctive color or otherwise distinguished, except that:

1. Where there are a number of containers, which usually contain spontaneously flammable substances warning signs may be posted in the room or area in which such containers are located instead of marking individual containers; however, portable containers in which spontaneously flammable substances are used, stored, or transported shall be marked in one of the manners described above. These containers should not be used for other purposes.

2. Original containers, marked as required by the General Industry Safety Orders, Article 112, labeling of injurious substances, shall be considered to comply with the requirements of this section. Containers (such as drums, cans, bottles, and carboys) in which spontaneously flammable substances are sold, shipped, or distributed, need not be marked, during time between filling and labeling.

The impacts of Section 5176 upon the Carrizo Plain liquid sodium system can be summarized as follows:

Part A - A liquid cover is not necessary since the sodium loop is a closed system.

Parts B and C - Applicable to laboratory and production facilities, not to closed loop systems such as Carrizo Plain.

Part D - Requires posting of warning signs around the heat transport system.

For additional regulations pertaining to flammable liquids, see Appendix D.

Other regulations within the General Industry Safety Orders that could be generally applicable to the Carrizo Plain power plant include the implementation of an Accident Program (Section 3203) and hazardous substance information requirements as specified in Section 5194, Material Safety Data Sheets.

The safety provisions stated in most of these sections are not oriented toward a sodium heat transport loop or the quantities utilized in the operation of the solar power plant. However, CALOSHA has stated that they would be interested in evaluating the safety design specifications for the power plant on a case-by-case basis (Eisen, 1983). This is due to the fact that the General Industry Safety Orders are not specific to sodium.

The California Environmental Quality Act will not impact the overall safety design requirements, but it may impact overall facility construction and operation. This act requires an analysis of any adverse environmental impacts resulting from the location and operation of the solar power plant. San Luis Obispo County will be the lead agency in determining whether an Environmental Impact Report (EIR) should be prepared (see Section 2.3 for further details). The California Uniform Building code would only be generally applicable for overall facility design.

2.3 COUNTY REQUIREMENTS

The lead governmental agency that would assess the public safety and environmental impacts of the facility would be the county. There are few county regulations that would be directly applicable to the Carrizo Plain solar power plant. The county agencies would need to evaluate the potential impacts of the plant on a case-by-case basis.

The primary written criterion that may be applicable to the facility is in the "Water Quality Control Plan" for the San Luis Obispo County Water Quality Control District (WQCD). The upper pH limit for wastewater discharge into a natural waterway can not exceed 8.5. There is also a sodium concentration limit of 69 ppm for water used in the irrigation of agricultural areas. It must be noted that these water quality requirements are not fixed and are also assessed on a case-by-case basis (Baldridge, 1983).

The Air Pollution Control District (APCD) in San Luis Obispo County has no specific or general criteria that would impact the facility (Allen, 1983). For comparison, the APCD in Ventura County does have a rule (Rule 62) for hazardous materials released in the atmosphere as shown below.

> Rule 62. Hazardous Materials (Adopted 5/23/72)
>
> No hazardous materials shall be discharged from any source so as to result in concentrations at or beyond the property line in excess of any State, Federal or local standards or emission limits established.
>
> In the absence of specific standards for a particular hazardous material, the airborne concentrations of such materials shall not exceed those levels and time intervals established by the State Division of Industrial Safety or the Occupational Safety and Health Administration.

There will be no release of sodium to the atmosphere under normal power plant operating conditions, so these air quality regulations should have minimal effect upon plant operations. Only during an emergency release or spill would an exceedance of recommended levels be expected (see Section 5.1 and Appendix B). Such an exceedance, however, would continue only for a brief period until the spilled sodium was contained. Plant operating personnel would be expected to report any releases to the San Luis Obispo County APCD.

As previously mentioned, San Luis Obsipo County will determine whether an Environmental Impact Report (EIR) needs to be prepared pursuant to the California Environmental Quality Act (Hamm, 1983). The EIR is prepared to assess the ecological, economical, social, and archaeological impacts resulting from a facility. Based on the EIR results, the plant may or may not be permitted to operate in a specific area or required to operate under specific restrictions.

In conclusion, the primary governmental safety requirements that may impact the design of the Carrizo Plain solar power plant are the CALOSHA case-by-case evaluation and the General Industry Safety Orders. The primary governmental environmental requirements that may impact the design and operation of the facility would be the San Luis Obispo County adverse impact determination as required by the California Environmental Quality Act. At this time, it appears that there are little or no governmental safety requirements at the Federal, state or county level for sodium, especially as it relates to a solar power plant.

Therefore, plant safety determination will have to be made on a case-by-case basis by both state and county regulatory agencies.

2.4 CODES, STANDARDS, AND GUIDES

In addition to the governmental safety requirements for the design of the solar power plant, other types of industrial or trade organization safety requirements may be applicable. Examples of these codes, standards, or guides are delineated below:

* National Fire Protection Association (NFPA), "National Fire Codes."
* Underwriters Laboratories (UL) approved equipment listings, and Factory Mutual (FM) approved equipment guide.
* ANSI Standard B31.1 - Power Piping.
* API Standard 620 Recommended Rules for Design and Construction of Large, Welded, Low-Pressure Storage Tanks.
* ANSI/ASME Boiler and Pressure Vessel Code, Section VIII, Division I.
* National Electrical Manufacturers Association Standards

Furthermore, insurance companies have their own safety standards, so it is important that the insurer be kept informed of the plant safety design so that required features can be incorporated.

3.0 PERSONNEL PROTECTION

Appropriate protective clothing should be available at any liquid sodium facility. Due to thick, caustic smoke and the possibility of sodium skin contact, it is inadvisable to perform any rescue or fire fighting duties without protective gear. For the purpose of defining adequate protective clothing, power plant personnel can be separated into three general categories - exposed operators, potentially exposed operators, and unexposed operators. Exposed operators would be those participating in fire fighting, rescue, or sodium disposal operations following a sodium leak or accident. Potentially exposed operators would be those working on the tower in the solar receiver area. In most cases, potentially exposed operators will not actually come in contact with liquid sodium. Nevertheless, they will be working in an area with many valves so the probability of a leak will be higher than normal, and they will be in an enclosed tower so rapid escape will not be possible. Unexposed operators would be those in no real danger of contact with liquid sodium, primarily those operators working at ground level in the control room, heliostat, or steam generator and turbine/pump areas. Unlike tower workers, unexposed operators will have rapid escape routes available to them in case of a soidum accident.

Exposed operators shall wear complete protective clothing at all times. The protective clothing provided will permit the operators to perform their duties but will afford adequate protection against injury. Protection for exposed operators should include:

Eye protection - Snug fitting, cup type safety goggles are required. Non-flammable, full-length face shields also shall be worn in addition to goggles (but not in place of goggles). A face shield alone is insufficient because liquid sodium may splash under it and caustic mists in the air can penetrate any non-sealed barriers.

Head protection - A phenolic resin hard hat is preferred. Hard hats made of reactive materials, aluminum, or asbestos shall not be used. Fire protection hoods covering the entire head and shoulders are available, and are recommended for fire fighting and rescue. These hoods normally include a safety hat.

Foot protection - Leather shoes with chrome leather leggings shall be worn. Care should be taken that leggings are tight and do not creep up the leg. Otherwise, splashed sodium may enter the top of the shoe and result in severe foot burns.

Body protection - All protective clothing shall have full-length sleeves and trousers. Especially recommended are flameproof coveralls with no cuffs, pockets, or other potential traps for splashed sodium. All clothing shall have snaps for rapid removal in case of accident.

As an option, fire fighting suits designed especially for liquid sodium may be substituted for flameproof coveralls. A number of protective suits are available, but one of the best was developed by the Hanford Engineering Development Laboratory (Ballif, 1979). The Hanford suit has separate pants and torso sections, as well as a head piece with a self-contained breathing device. The suit material consists of one-mil-thick annealed nickel foil to prevent the penetration of the liquid sodium. Fiber glass cloth was added for strength, and a layer of ceramic fiber insulation was added to protect the wearer from heat. The suit was designed for use only by trained fire fighters because it utilizes a self-contained breathing device and because its weight (60 pounds, including the breathing system) requires the wearer to be in good physical condition.

Gloves - PVC or chrome leather gloves are recommended; if these are unavailable, then flame retardant cotton or heavy moleskin are acceptable. Wool, leather, and asbestos gloves shall not be used. All gloves should be loose-fitting for easy removal if splashed. Gloves with elastic around the tops are unacceptable.

Respiratory protection - Exposed workers who are participating in sodium transfer operations and who are not directly exposed to sodium smoke need not wear full respiratory protection. However, each such worker should carry on his person a half-face mask with high efficiency filter for escape use in emergencies. This device should be used only as an escape mask and not as protection for fire fighting or work in sodium aerosols. For fire fighting, a self-contained breathing apparatus with full face piece is recommended; this apparatus can be designed into a complete protective suit as discussed above if desired. The self-contained breathing apparatus is superior to the half-face filter mask because it affords protection from any concentration of smoke, and it may be used in low levels of oxygen.

Potentially exposed operators shall wear goggles, face shield, hard hat, leather shoes (without leggings), and flameproof coveralls. Self-contained breathing apparatus need not be used, but a half-face filter mask should be carried for escape use in emergencies. Unexposed operators should not be required to wear special sodium protective clothing, although it is assumed that they will have hard hats, safety glasses, and leather shoes as one would expect at any industrial facility.

Full protective gear as described for exposed operators shall be available on-site for emergency use in rescue, fire fighting, or escape. Emergency protective clothing shall be stored within the immediate plant area but sufficiently removed from the sodium loop that a fire would not prevent access to the gear. One or more sets of protective clothing shall be stored in the control room, since this will be a protected area. As shown in the accompanying blueprint, protective clothing shall also be placed along principal foot traffic and escape routes, one set near the steam generators and one near the base of the tower. One set shall also be placed in the tower, preferably at the 417 foot level (near the midpoint). This set of clothing could be used by an operator who was in the tower when a leak occurred.

4.0 CONTROL EQUIPMENT

4.1 SPILL CONTAINMENT

There are two stages in controlling a spill once a leak is discovered - the first stage is to drain the leaking system component, and the second is to contain, extinguish, and clean up the sodium once it has leaked out. A properly designed plant will incorporate both of these safety features.

The concept of system drainage is quite simple and straightforward. Each component of the sodium loop (e.g., receiver tower, steam generator, etc.) should be designed so that it can be drained of liquid sodium within several minutes if a leak is discovered. An underground drainage sump should be provided to allow drainage by gravity flow. The drain lines must be maintained at a temperature above the melting point of sodium (208^{o}F) to ensure fluidity at all times.

Leakage in one of the thermal storage tanks would require transfer of the liquid sodium to the other tank. The Carrizo Plain plant is designed so that a tank-to-tank transfer could be completed in one hour. This design should be sufficient to mitigate all but the most catastrophic leaks. It should be noted, however, that simultaneous serious damage to both tanks would leave the system without a drainage reservoir and could result in a major sodium spill.

If the sodium loop develops a leak, it is expected that some sodium will leak out before the system can be drained. It is essential that containment vessels be designed to control the leaking sodium and protect nearby personnel and equipment. It is especially important to avoid sodium contact with electrical wiring, water (including moist soil), and concrete. Burning sodium on a concrete floor can cause the concrete to spall and scatter sodium over a wide area. Sodium can react violently with both the concrete chemicals themselves and with the residual moisture in the concrete.

Metal drip pans are recommended to protect concrete and electrical wiring from sodium spills. The pan should be designed to contain approximately 150% of the expected maximum volume of the leak, allowing for expansion of the sodium as it burns. The Carrizo Plain receiver tower has been designed with a large metal pan (actually a flooring) below the solar receiver and above the cable spreading room, separating the sodium loop from the electrical wiring area. The volume of this pan is approximately 7000 gallons. Since the entire tower can be drained of sodium in less than two minutes, this pan should be sufficient to contain any sodium that may leak out before drainage is complete. In fact, it might be wise to include shallow partitions in the floor (similar to speed bumps) to confine the surface area of small leaks and thus make fire fighting and cleanup easier. Leak-prone system components at ground level as well as in the tower shall also be provided with drip pans or metal-lined pits; this will include all valves, steam generators, and pumps. Since the various portions of the system can be drained within minutes, pans of approximately 100 gallon volume should be sufficient. These pans should be adequately drained to prevent accumulation of rainwater.

Containment of leaks from the thermal storage tanks involves slightly different problems. Each tank is designed with a surrounding berm which can contain approximately 12,000 gallons. Total system volume is 470,000 gallons of sodium, so the berm cannot contain all of the sodium in the tank. However, the berm could contain a 200 gallon per minute leak for one hour, which is the time required to drain one tank to the other. Since 200 gallons per minute is a very large leak, the designed berm volume should be sufficient.

Construction material for the berm is an important consideration. Concrete and untreated earth should not be used because excess moisture in the material could react with spilled sodium (Gaylord, 1983). Concrete lined with metal would be acceptable, but would also be quite expensive and might be considered "over-designed" for a plant in routine operation. Two alternatives seem acceptable. One would be a dirt berm lined with gunite or ferrocement. These materials contain very little water when cured, and they readily shed water. An adequate drainage system would be required so that no standing water would remain following a rainstorm. The second alternative would be a treated or modified earth berm. Porous earthen materials would be required to leach moisture down and away from the surface of the berm so that spilled sodium would not come in contact with water in moist soil. Extensive leaching of sodium would not be expected since sodium solidifies as it cools.

4.2 ISOLATION AND SHIELDING

For a low pressure sodium system such as the Carrizo Plain plant, equipment failure should not result in dispersion of burning sodium beyond the immediate area of the system and its drip pan. One would not expect to see high pressure jets of burning sodium endangering operating personnel, equipment, and buildings over a wide area. Thus, the thermal insulation should afford adequate shielding for most system components. If any parts of the sodium loop are not adequately insulated (valves, for example), then a simple metal shield can be provided to deflect any leaking sodium into the drip pan.

Equipment failure in the steam generator area could result in a violent reaction between high pressure water and sodium in the coolant loop. Burst diaphragms shall be designed into the system to eliminate the possibility of excessive pressure buildup in the sodium loop. If this is not done, then the steam generators shall be isolated from personnel and other equipment by blast walls to withstand a possible explosion.

4.3 VENTING AND VENTILATION

Since most of the sodium loop at the Carrizo Plant will be outdoors, an elaborate fan and ventilation system will not be required. The control room shall be adequately sealed and ventilated so that smoke will not collect in the room and endanger plant operating personnel during a sodium leak. The only enclosed area which will be directly subject to sodium leaks is the receiver area on the tower. An adequate ventilation system will be required on the tower to disperse sodium smoke and to protect workers in case of a leak.

Ventilation of an enclosed sodium operating area is required when a sodium fire occurs since burning sodium evolves large quantities of dense white smoke, reducing visibility and seriously hampering fire fighting and rescue operations. Mouth, throat, lung, and eye protection are afforded by protective equipment, but the density of the smoke where inadequate ventilation exists is such that little activity is possible due to lack of visibility. Exhaust fans should be located at the highest elevations in the area, with provision made for air supply at floor level. Louvers at various levels in the enclosed receiver tower may be necessary if floor ventilation alone proves to be inadequate. All ventilation equipment should be operated by power that will not be affected by a sodium leak.

Several portable fans should be stored in the control room for emergency use. These can be used to clear smoke from the control room, or they can be taken out to ventilate the area around the fire in order to make fire suppression easier. They should not be directed at the fire, however, because they will add to the flow of oxygen over the fire and increase its intensity.

4.4 AUTOMATIC ISOLATION

The sodium loop should be designed so that all or part of the electrical system and the sodium plumbing system can be easily isolated or shut down in case of emergency. There should be shutoff valves throughout the sodium loop to allow isolation and draining of specific sections of the loop if leaks are discovered. This design will promote worker safety and will also limit equipment loss in case of a leak.

System shutoff would normally be tied into the central power plant control room. Procedures should be developed to disable any or all valves and pumps in the loop, and to shut off electrical power as necessary. Separate shutoff and isolation procedures should be developed for the various sections of the loop, but there should also be a total system scram to allow the operator to quickly initiate shutdown of the entire power plant if rapid evacuation is necessary in an emergency. Written procedures and plans should be prepared for all nonroutine and emergency activities, and copies of the procedures should be prominently posted in the control room. All plant personnel should be trained in the emergency shutoff procedures, and emergency dry runs should be implemented.

5.0 SAFETY EQUIPMENT

5.1 LEAK DETECTORS

Automated leak detectors are recommended in liquid sodium systems for two principal reasons. First, certain sections of the plant may not be routinely staffed by operating personnel, so the smoke from a burning sodium leak may not be seen for some time. Second, some small but potentially dangerous leaks may not produce visible effects, whereas they may be detectable by sufficiently sensitive monitoring devices. This is especially true in well-insulated systems, where seepage leaks may be evident to the human eye only after many hours of operation.

Leak detectors for liquid sodium systems may be separated into two general classes - monitors within the sodium loop itself, and ambient air monitors (e.g., smoke or heat detectors) in the vicinity of the sodium loop. Monitors within the loop are especially important for detecting leaks in the steam generators, which may lead to the formation of hydrogen. An adequately sensitive detector for hydrogen in sodium makes use of a metal membrane such as nickel or palladium which is permeable to hydrogen but leak tight to sodium. A reference hydrogen concentration threshold in sodium must be established, however, since there will always be some hydrogen present in the sodium loop.

A number of ambient air sodium leak detectors are available. Some monitor smoke or vapor, some monitor heat, and others monitor the leaking liquid sodium itself. Several of the more common detection devices are listed in Table 5-1 (Ballif, 1979). Selection of a device is dependent upon the needs of a particular application, so the leak detection system must be designed on a case-by-case basis. Two or more types of leak detectors (e.g., heat and smoke) should be interspersed throughout the plant so that if one type of detector fails to detect a leak, the other type will.

Spacing and placement of leak detectors is also dependent upon the specific requirements of the power plant, although the NFPA fire code makes some suggestions in this area. In general, leak detectors should be placed in the vicinity of leak-prone

Table 5-1. TYPES OF SODIUM LEAK DETECTORS

Type of Emission Detected	Type Detector	Sensitivity	Comments
Liquid Sodium	Pair of electrodes (i.e., "spark plug")	160 g/hr	Widely used in USA and in Europe
	Pair of Wires Serving as Electrodes	Comparable to spark plug	Used by Dutch and French
Sodium Vapor	Absorption of Specific Frequencies of Light	75×10^{-6} g/m^3 under bench test conditions	No test data
(Emitted from non-Flowing Leaks)	Flame Photometry	1 ppb	Requires piping of samples to chemical analysis room
	Chemical Method (color indication phenolphthalein or thymol blue)	2.3×10^{-4} g/m^3	Final analysis performed in laboratory
	pH Method	1 ppb	Commercial pH meters available. Method suitable for on-line use
	Conductivity Method	1 ppb	Commercial meters available. Method suitable for on-line use.
Sodium Vapor-Sodium Oxide Mixture	Plugging Type Flowmeter	"As Responsive as any meter"	Sensitive to false alarms
	Filter Type Flowmeter	Probably better than plugging type	No test data. Sensitive to false alarms.
Smoke Detection	Various Methods (ionization, photo electric, laser beam)	Variable-Limit 1.5×10^{-3} g/l	Methods have been applied to sodium systems
Hydrogen (from Na reaction with H_2O)	Hydrogen Detector	Above 1.5 g/hr	Tested successfully
Heat	Infrared Detector	Not Avail.	Uses on-line light sensors

components (e.g., valves), and especially in enclosed areas where sodium smoke could be very hazardous to employees, such as in the receiver tower. A smoke trap should be placed above any smoke detector which is not mounted directly to the ceiling; an 18 inch diameter disk (similar to a pie pan) is recommended. Smoke traps help to ensure that buoyant plumes will not go undetected. During the planning and construction of the power plant, it is recommended that smoke generators be used to aid in the placement of smoke detectors. If the smoke generator is placed near the probable leak points, then the dispersion of the smoke can be observed and the detectors can be placed where necessary on the wall, ceiling, and/or floor. Such field testing can often make the difference between success and failure of a detection system.

For the Carrizo Plain plant, leak detectors shall be placed near each pump, steam generator, and valve, both at ground level and in the solar receiver tower. Smoke and heat detectors shall be placed on the ceiling of the enclosed tower area, as well as at each metal-grating floor level (these should also have smoke traps). All detectors shall be tied into an alarm system in the control room, and the detectors in the tower shall activate a warning light at the tower entrance to caution unprotected workers to stay out.

This discussion of detection devices has so far dealt only with leak detection and protection of employees within the power plant. A further consideration is atmospheric transport beyond the power plant boundaries and protection of the general public. A modeling study (Wang and Lauer, 1980; see Appendix B) has shown that, for a typical leak, sodium hydroxide will be deposited out to about 300 meters of the release point, with particulate matter beyond that distance being deposited as sodium carbonate, an innocuous substance. The plant boundary is less than 300 meters from the sodium loop on the south side, so there is a potential sodium hydroxide impact beyond the fence. The recommended NIOSH exposure limit for sodium hydroxide is 2 mg/m^3 of air for any 15-minute sampling period, and it is likely that this level would be exceeded during a significant sodium leak. However, there are no real-time monitoring methods for sodium hydroxide. It is monitored by collecting filter samples and analyzing them in a laboratory, so any sodium leaks would be contained long before the laboratory results were returned. Thus, there is no public safety advantage to be gained by monitoring for sodium hydroxide. Any sodium leaks which might endanger public safety should be adequately monitored by leak detectors within the plant boundaries. It shall be the responsibility of plant operating personnel to notify local law enforcement officials if evacuation of areas outside the plant boundaries appears to be necessary. A pre-planning session should be held with local officials to develop an evacuation plan.

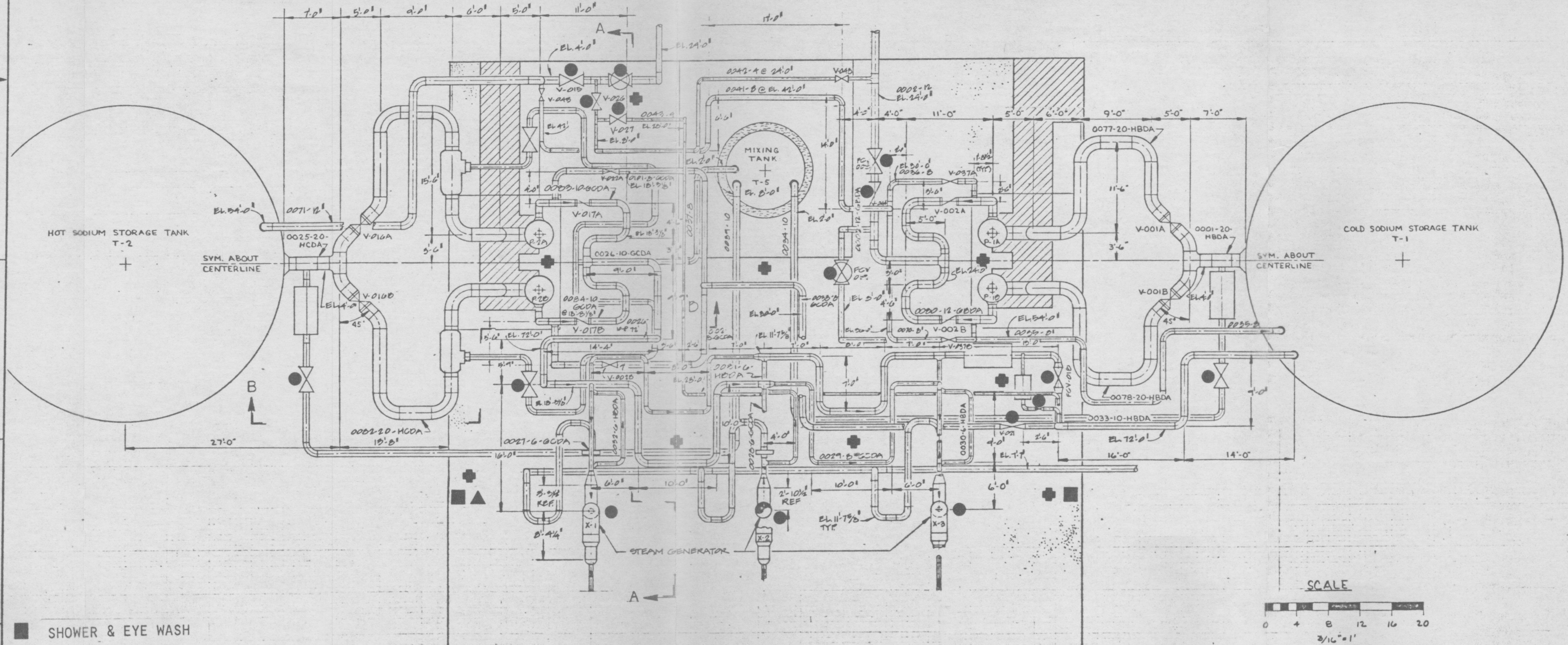
5.2 FIRE EXTINGUISHERS

A sodium fire is generally extinguished by the removal of oxygen and cooling of the sodium below the melting point. Extinguishing agents normally used in conventional firefighting must not be applied to sodium fires because of the violent reaction of sodium with such common extinguishing materials as water, halon 1211, and sodium bicarbonate. Placement of these extinguishing agents in the vicinity of the sodium loop should be avoided if possible.

The required extinguishing agent for sodium fires is Na-X powder. Na-X is composed of sodium carbonate, stearates, attaclay for flow characteristics, and nylon. Ansul developed this agent of low chloride (less than 0.03%) to control the rapid rate of stress corrosion on austentistic stainless steel at elevated temperatures. Na-X will extinguish sodium fires at temperatures up to 1400°F. It is available in 30 lb, 150 lb, and 350 lb extinguishers, in 2000 or 3000 lb skid-mounted trailers, or in bulk to be applied by scoop or shovel. Yellow has been adopted as the standard color for sodium fire extinguishers, and all containers for Na-X should be painted this color for easy identification. Any buckets containing Na-X should be labeled and numbered just like any other fire extinguisher. Dry sodium carbonate shall not be used for fire fighting, although it may be used to separate layers of non-burning sodium in cleanup operations.

The amount of Na-X required to extinguish a fire depends upon the surface area of the burning sodium. Concentrations of burning sodium of 1/2 inch in depth or less will take 6 lbs of extinguishing agent per square foot, and depths greater than 1/2 inch will required 10 lbs per square foot for extinguishment (Rocketdyne, 1976). The Na-X powder should be applied first in a thin layer since it tends to fuse and form a crust over the burning sodium. Additional layers should then be added to further blanket the fire.

As shown in Figures 1 and 2, Na-X fire extinguishers shall be located near the sodium pumps and steam generators, on elevated walkways in the vicinity of all valves, near the sodium storage tanks, and at all levels in the enclosed portion of the solar receiver tower. It is recommended that the Na-X available for initial application to a sodium fire be supplied in 30 lb extinguishers since they are light and easy to handle in an emergency. Additional Na-X may be stored in covered drums or buckets (scoops or shovels should be provided) or in 150 lb or larger extinguishers stored at the facility. Note that 30 lb extinguishers from adjacent plant areas can be consolidated to extinguish a sodium fire.



■ SHOWER & EYE WASH

▲ PROTECTIVE CLOTHING

● DRIP PANS

✚ FIRE EXTINGUISHER

PACIFIC GAS AND ELECTRIC COMPANY
SOLAR CENTRAL RECEIVER
POWER PLANT
CARRIZO PLAINS – UNIT 1

DR BY	L TUEGEL 6-1983
CHK BY	

Rockwell International Corporation
Energy Systems Group

CARRIZO PLAINS POWER PLANT-
PIPING LAYOUT
PLAN VIEW

SIZE E

FIGURE 1: STEAM GENERATOR AREA SAFETY EQUIPMENT

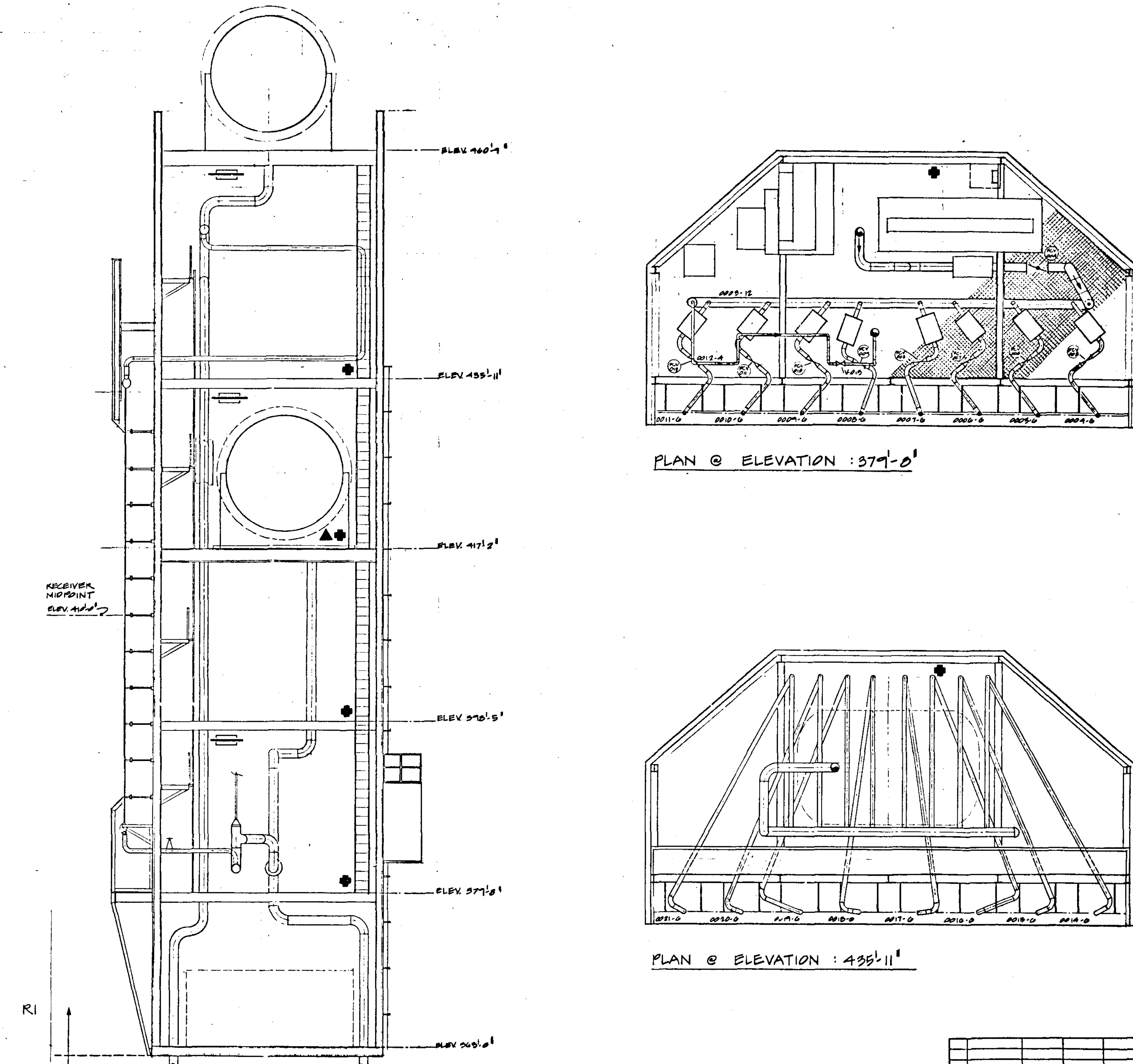
SCALE 3/16" = 1'

DASH NO.	NEXT USING DWG	MODEL	SERIAL NO.	THRU
APPLICATION		EFFECTIVITY		

NOTES: UNLESS OTHERWISE SPECIFIED

▲ FIRE EXTINQUISHER
✚ PROTECTIVE CLOTHING
SMOKE/HEAT DETECTOR

NO. 079TI000007
PAGE. 26



PACIFIC GAS AND ELECTRIC COMPANY
SOLAR CENTRAL RECEIVER
POWER PLANT
CARRIZO PLAINS – UNIT 1

Rockwell International Corporation
Energy Systems Group

DR BY N L CIRLAS

CARRIZO PLAINS POWER PLANT
TOWER-
LAYOUT DRAWING

FIGURE 2: SOLAR RECEIVER AREA SAFETY EQUIPMENT

DASH NO.	NEXT USING DWG	MODEL	SERIAL NO.	THRU
APPLICATION		EFFECTIVITY		

The total amount of Na-X required will be dependent upon the surface area of the burning sodium, and may be minimized by including partitions in the drip pans and berms. The floor area in the receiver tower, for example, is approximately 900 square feet, which would require 5400 lbs of Na-X at 6 lbs per square foot. If the floor were partitioned into 10 sections, however, this number could be decreased to 540 lbs, which should be sufficient to extinguish the amount of sodium that would be lost due to a leak before the tower loop could be drained (approximately two minutes).

5.3 SAFETY SHOWERS AND EYE WASHES

A person who has been splashed with molten sodium should remove all outer clothing and flood the affected area with water as quickly as possible. Safety showers should be located in the vicinity of the sodium loop, yet far enough away that there is no possibility of the shower area being involved in a sodium spill. Two safety showers shall be installed at the Carrizo Plain plant along principal foot traffic and escape routes, one near the steam generators and one near the base of the tower; both are marked on Figure 1. The showers shall be shielded on the sodium loop side to avoid sodium/water contact, and shall be drained below plant level so that water will not flow into the drip pans or berms. Safety showers shall be of the quick opening type which provide a large volume of water since it is essential that any sodium remaining on the body be removed as quickly as possible because of the reaction which occurs when water contacts sodium.

A standard eye fountain shall be provided in the vicinity of each safety shower for washing eyes with clean, low pressure water. High pressure water is not recommended because excessive washing with a high pressure stream can cause permanent damage to the eyes.

6.0 EMERGENCY OPERATING PROCEDURES

6.1 FIRE FIGHTING

Burning sodium gives off large quantities of opaque, white smoke making visibility very poor. No flame is visibile - only a glowing mass of sodium. Sodium fires are not generally difficult to control and extinguish, provided that smoke does not mask the location of the fire, and that proper techniques are used. Complete protective clothing and breathing apparatus shall be worn by all fire fighters. It is important that fire fighters practice controlling sodium fires, since the materials and techniques involved are unusual. All plant personnel shall be trained in fighting sodium fires.

Complete coverage of the burning area with Na-X is essential if the fire is to be extinguished. When heated, Na-X fuses to form a crust which excludes air from the burning sodium. Until this crust is formed, the fire can be controlled but not extinguished. Formation of this crust is best accomplished by careful application of the material in several shallow layers rather than one deep layer to prevent disturbing the burning material. Intermittent dusting of the surface increases the rapidity of crust formation and fire extinction since there is less tendency for the powder to sink in the sodium. Sodium fires on vertical or irregular surfaces pose a problem because of the difficulty of applying extinguishing powder and making it stick.

Na-X should be applied carefully to prevent splashing of the burning metal. Since no volatile combustibles are evolved from sodium fires, there will be no flame but merely a glowing mass of burning sodium. If the material is contained in a berm or metal drip pan, it will burn quietly and may be approached with little danger to fire fighting personnel. A sodium fire in itself is not particularly hazardous; the secondary reactions with other materials increase the hazard. In case of a sodium fire on a concrete floor, the concrete will become overheated, spall, and throw burning sodium over a wide area, spreading the danger and damage far beyond the normal scope of the fire. Fire fighting and/or rescue work under such conditions can be quite hazardous, whereas provision of a metal pan to confine possible sodium spills would reduce the hazard and permit effective fire fighting.

The following rules should be followed to ensure prompt action, prevent spread of the fire, and effect its prompt extinction:

1. Make certain that proper and adequate respiratory protection and fire fighting materials are available for instant use, and that plant personnel have been trained in fire fighting techniques.

2. Remove as much of the potential fire hazard as possible by draining the remaining sodium from the involved components.

3. Apply a blanket of Na-X to exclude oxygen and extinguish the fire; use caution to avoid splashing.

4. Clean up and dispose of all remaining sodium immediately. It will absorb water from the air and make cleanup hazardous if allowed to stand. Dry sodium carbonate may be used to separate layers of waste sodium.

6.2 FIRST AID

Sodium will destroy tissue as a result of thermal and/or chemical reaction with the moisture in tissue. Both reactions occur simultaneously as a result of (1) heat from hot or burning sodium, and (2) the formation of sodium hydroxide with body fluids.

Personnel splashed with molten sodium should remove all outer clothing and wash the affected area in a safety shower. Immediate flushing is recommended to wash off gross sodium contamination, extinguish any fire, and cool tissues, and to quickly react the sodium that may be clinging to the skin so as to reduce the sodium hydroxide reaction with body fluids. The recommended first aid is cold water or iced sterile compresses over the affected area. The services of an emergency hospital and physician should be obtained.

Even if eye protection is worn, minute particles of sodium and sodium hydroxide may enter the eye during a sodium release. Water flushing is recommended and the services of an opthalmologist should be obtained immediately. Treatment of sodium eye injuries with boric acid and/or mineral oil or other types of eye medication has been discouraged. These materials are difficult to remove from the eye and interfere with evaluation of the extent of the injury.

Persons wearing contact lenses shall not be allowed to work with sodium systems regardless of the type of eye protection used. Loss of a contact lens in an emergency situation, rotation of the lens behind the eyeball, and/or the reaction of sodium with plastics used in contact lenses may result in more serious injury. A minute particle of sodium worked under a contact lens will produce a much more aggravated injury than the reaction with tears and water flushing. Ordinary eyeglasses with plastic lenses shall also be forbidden around sodium systems. Only approved safety glasses shall be worn.

The effects on the mouth, throat, and lungs will be mainly those of the reaction of the oxides into hydroxides and the resultant caustic burn to sensitive mucous tissues. Immediate use of the safety shower, eye wash station, drinking fountain or other sources of water is recommended. Complaints of soreness in the mouth, throat, and lungs should be noted and the services of a physician, preferably an otolaryngologist, should be obtained immediately.

6.3 EMERGENCY EVACUATION

The power plant facility should be provided with an area or areas from which personnel can remotely control, monitor, and observe operations to maintain the plant in a safe operating status at all times. This area should be sufficiently isolated or provided with adequate protection to permit occupancy and access under accident conditions. For example, if leaks occur, the operators must be able to control pumps, isolation valves, drain systems, and ventilation systems without danger of injury or exposure to hazardous materials. Consideration should be given to protection against missile and blast hazards, heat hazards, and contamination and inhalation hazards which may occur in the facility as a result of sodium fires. It is expected that the power plant control room will satisfy these protection criteria.

Escape routes and exits should be preplanned and provided in the design of the power plant. There should be secondary exits available in case the primary exit routes are blocked. The plant safety system shall include an audible evacuation alarm which will be activated by the smoke or heat alarm system, but which can also be activated manually if necessary. At the sound of the alarm, plant employees shall proceed to one of several designated evacuation areas, avoiding those that are downwind of the sodium fire. Personnel protective equipment shall be available at convenient locations throughout the plant, as shown on the accompanying blueprint. In particular, half-face filter masks should be available so that all employees can escape from the sodium smoke cloud without respiratory damage. The small size and low cost of this type of respirator make it desirable to be carried on the person of every worker in the facility.

Protective gear for fire fighting should be available at a central location such as the control room. Only those individuals trained in fire fighting techniques and wearing complete fire fighting gear shall be allowed in the vicinity of a sodium fire; all others should be evacuated to a safe location. It is recommended that evacuation drills be conducted on a periodic basis.

Due to the low frequency of occurrence of sodium fires, the low population density in the Carrizo Plain area, and the expected limited range of sodium hydroxide impact (less than 1 kilometer), it is not anticipated that evacuation of nearby communities will be necessary. The worst case public impact that would reasonably be expected would be a sodium hydroxide cloud drifting across the state highway adjacent to the power plant. Local fire fighting and law enforcement officials shall be contacted to develop a contingency plan for stopping traffic on the highway if smoke from a sodium fire becomes a hazard. The details of this plan shall be worked out in a pre-planning session with local officials before plant operation begins.

7.0 SPILL COUNTERMEASURES

7.1 DISPOSAL OF WASTE SODIUM

As soon as possible after a sodium spill occurs, the remaining sodium or sodium residue should be shoveled into a dry metal container with a lid to exclude oxygen. To assure safe disposal, the sodium or residue should then be converted to a non-reactive form prior to final disposal. This is necessary to avoid the possibility of subsequent chemical reactions which could injure waste handling personnel or the public (e.g., burns, fires, or hydrogen explosion). Conversion to a less reactive form may be performed by burning or reacting the sodium or residue with water, steam, or other chemical compounds under controlled conditions.

Small amounts of sodium (gram batches) can be conveniently disposed of by burning in a heavy metal disk under a hood or in a well-ventilated outdoor area, using a gas flame. The residues may be disposed of by flushing with water to normal waste systems. Small amounts may also be disposed of by reacting with alcohol in a pan with proper ventilation. The mixture may then be disposed of as normal industrial waste.

Larger amounts of sodium (e.g., 1 pound batches) may be burned in large shallow pans if controlled, isolated, or remote areas are available. The sodium should be spread out and then sprayed with a fog nozzle. Sufficient ventilation must be available to prevent potential hazards from hydrogen buildup and to protect operating personnel.

Disposal of bulk amounts of waste sodium will probably not be feasible at the Carrizo Plain site. In the event of a major spill, the waste material should be placed in covered containers and should be transported to an approved waste disposal facility as soon as possible. Proper transportation and disposal of large amounts of liquid sodium can be performed by a private contractor or perhaps by the Rockwell liquid metals group at the Santa Susana Field Laboratory.

If bulk waste disposal is required, the waste sodium must be safely stored while awaiting removal from the facility. The covered, sealed metal containers should be stored in a dry, fireproof building. The containers should be stored slightly above floor level (e.g., on pallets) to prevent contact with metal which might leak from another container. The storage area must be kept free from highly combustible materials or from materials which may react with sodium. The area should have sufficient air circulation to prevent accumulation of hydrogen.

7.2 CLEANING CONTAMINATED EQUIPMENT

If equipment is contaminated with sodium and needs to be cleaned, it should be moved to a decontamination area. If the equipment contains more than just surface contamination (e.g., solid sodium), the excess should be removed by chipping or scraping off the material. If the contaminant is not accessible, hot oil baths or controlled heating may be used to melt out the material. Decontamination of the equipment may then be accomplished by burning, or by treating with dry steam or with alcohol. A steam hood or steam cabinet is useful for this operation. Water sprays or immersion may be used to remove surface films. Once the item is free of significant sodium it can be placed back into service, shipped out for repair, or disposed of by normal methods.

7.3 HAZARDOUS WASTE PERMITS

Sodium is a hazardous substance and thus should not be disposed of without the appropriate permits. Before disposal operations begin, the power plant operators should contact state and local authorities to acquire disposal permits which will account for the waste sodium. It is important to note that even if disposal is performed by a commercial contractor, the plant itself is still legally responsible for the waste sodium. Therefore, it is critical that a reputable contractor be chosen and that all shipping and disposal documents are complete. A copy of the shipping manifest should be retained by the power plant operator.

8.0 REFERENCES

Allen, P., San Luis Obsipo County Air Pollution Control District, personal communication, 1983.

Baldridge, R., San Luis Obsipo County Water Pollution Control District, personal communication, 1983.

Ballif, J.L., "Liquid Metals Fire Control Engineering Handbook," Hanford Engineering Development Laboratory Report # HEDL-TME-79-17, February 1979.

Eisen, J., CALOSHA, personal communication, 1983.

Gaylord, G.G., Rockwell International, personal communication, 1983.

Hamm, J., San Luis Obispo County Planning Department, personal communication, 1983.

Jackson, C.B., "Liquid Metals Handbook: Sodium (NaK) Supplement, Third Edition," U.S. Atomic Energy Commission, 1955.

Rocketdyne Division, Rockwell International, "Protective Services Basic Training Course: Fire Extinguishment," February 1976.

Wang, I.T., and Lauer, G., "A Mathematical Model for the Fallout of Particulate Matter and Its Application to the Combustion of Sodium Aerosols," Rockwell International Environmental Monitoring & Services Center Report, June 1980.

Appendix A

LIQUID SODIUM SAFETY HISTORY

Liquid sodium heat transfer systems have been used in component testing and routine operation for approximately 20 years. During this time, significant leaks (i.e., more than seepage of trace amounts) have been extremely rare, and most of the recorded leaks have been only a few gallons or less. Leaks are so rare that there appear to be no statistical evaluations of leak rates (leaks per hundred hours of operation, for example). Instead, leaks are reported as individual events since there are so few of them.

Table 1 presents a summary of all known Sodium Spill Unusual Occurrence Reports (UORs) in the United States during a five year period from 1977 to 1982 (Peterson, 1983). Only 21 spills occurred during the entire period, and the largest reported magnitude was approximately five gallons; many were less than one gallon. Furthermore, many of the reported leaks were in test facilities, which would be expected to have higher leakage probabilities than a fully tested, routinely operating plant such as the Carrizo Plain solar facility.

Similar rare leak occurrences have been reported in French sodium systems (DOE, 1982). During the past 15 years there have been approximately 70 reported sodium spills at five separate installations in France. The leaks observed were all considered minor leaks since the amounts of sodium spilled did not exceed several kilograms, with average leakage rates of only several liters per day. The development of the leakage rate was always slow.

The Rockwell International Energy Technology Engineering Center (ETEC) has been testing sodium components approximately full time for over 20 years. During that time, they have had six reportable spills, the largest of which was approximately 20 gallons (DeBear, 1983). Three of these six spills were due to heater failure, which will not be a factor at Carrizo Plain since the heating will come from the solar receiver.

REFERENCES - APPENDIX A

DeBear, W.S., Rockwell International, personal communication, 1983.

DOE Report, "Service for Sodium-Cooled Reactor Technology: Fast Neutron Line," #DOE/CEA/BMFT--87, 1982.

Peterson, E.V., "SCTI Fire Suppression System Study for Economizer Building," Rockwell International ETEC Report #355-XR-0009, 1983.

Table 1. Summary of Sodium Spill Unusual Occurrence Reports

US Experience

Item	Component	Description of Incident	Quantity of Sodium Leaked	Detection	Date	Documentation
1	Source Term Control Loop #4 (STCL-4) (Hanford Engineering Development Laboratory)	The loop was being brought up to temperature after a routine shutdown when abnormalities were noticed in the cover gas pressure, surge tank level, and temperature. Visual inspection located the leak. Subsequent investigation determined that the leak was due to poor sealing at a Greyloc flange. The seal was a reused one that had previously been used several times at temperatures above its upper design limit and had undergone permanent plastic deformation.	Less than 1/2 lb	Visual	01/24/77 1430 hr	UOR 3-77 (HEDL)
2	LMEC 6-inch Drag Valve (in SCTL)	Sodium leaked between the seal ring and the valve body seal face because the operating pressure (200 psi) was insufficient to effect a tight seal (valve was designed for steam service at 1500 psi).	Given as small	Fire alarm in high bay	10/02/77 0258 hr	UOR SCTL-77-3 (LMEC)
3	Mechanical Property System #3 (MPS-3) (Westinghouse)	A trace heater failed and shorted to a tube wall, causing the sodium leakage. The tube was Type 316 SS with 0.500-in. OD x 0.049-in. wall.	Given as small	Visual	11/21/77 0330 hr	UOR 77-07 (WARD)
4	Sodium Sample Station (SCTL)	A vent valve (V-10G) on the sodium sample station was left open. Closure of the valve stopped the leak.	Approx. 1 lb	Visual	08/11/78 1932 hr	UOR ETEC-78-09 SCTL-78-01
5	Vapor Trap VT-3 Vent System (SCTI)	A defective level indicator allowed T-3 to be overfilled with sodium and the sodium leaked across the vent valve ORV-710B2.	Approx. 5 gal	Visual	08/25/78 2303 hr	UOR ETEC 78-10
6	AI Advanced Pump (SCTL)	A wisp of smoke was noticed by an operator. Investigation revealed a small sodium leak at the north pump flange. Evaluation of the leak determined that it was due to leakage of the cover gas which allowed the sodium to rise to the level of the flange.	Approx. 2 pints	Visual	09/02/78 0835 hr	UOR ETEC 78-11 SCTL 78-02

Table 1. Summary of Sodium Spill Unusual Occurrence Reports

US Experience

Item	Component	Description of Incident	Quantity of Sodium Leaked	Detection	Date	Documentation
7	Return Mixing Tee - SSGM Double Wall S/G Test (Westinghouse Advanced Reactors Div.)	The sodium leaked through a crack adjacent to the pipe-to-tee weld in the vertical discharge line from the tee. The crack was circumferential in nature and had progressed approximately 90^{o} around the circumference of the pipe.	Not given	Visual	02/23/77 1600 hr	UOR 77-02 (WARD)
8	Rupture Disc Assembly - Auxiliary Loops A&B (Westinghouse Advanced Re-Actors Div.)	A thermocouple downstream of the rupture disc assembly was being removed. The system was non-operational and drained. During the thermocouple/Swagelok assembly removal, sodium was released. The presence of sodium was unexpected. The sodium was released by the 10 psig-to-atmosphere pressure differential.	Approx. 1 to 5 lb	Inadvertent release by test personnel	10/24/78 1400 hr	UOR WARD-78-06 GPL2-78-2
9	ISSS-ACA Test Item	An argon vent line was plugged (later it was hypothesized that the plug was sodium). The line was opened to inspect the vent valve. When this was done, sodium was sprayed out of the line until ambient pressure was attained.	1 lb	Inadventent release by personnel	01/03/79 1403 hr	UOR ETEC-79-01 T032-79-01
10	Tubing at MPS-3, Small Sodium Loop (Westinghouse Advanced Reactors Div.)	During preheat of the system (prior to sodium fill), a heater was left on longer than procedure dictated. The tubing overheated and residual sodium leaked out and burned.	Small (residual sodium)	Not reported; implied visual	04/05/79 0945 hr	UOR WARD-79-01 MPS/3-79-01
11	L-5 Leak Detector (SCTL)	L-5 was flooded (no reason given) and sodium leaked from the upper flange.	Not given	Visual	03/14/79 0412 hr	UOR ETEC-79-05 SCTL-79-03

Table 1. Summary of Sodium Spill Unusual Occurrence Reports

US Experience

Item	Component	Description of Incident	Quantity of Sodium Leaked	Detection	Date	Documentation
12	Rig 1 - Sodium Sample Station #1	A sample station extension tube (0.5-in. OD SS tubing) ruptured, causing the leak. Investigation revealed that the tube was crimped where ruptured, thus weakening the tube.	1 pint	Bldg 032 control room audio fire alarm	12/13/79 1545 hr	UOR ETEC-79-28 032-79-05
13	Cold Trap at MPS-3 Sodium Loop (Westinghouse Advanced Reactors Div.)	Attachment of a flowmeter lead to 1/2-in. tubing melted through the tubing wall at the weld and the weld cover gas caused a "blow-out" at this location.	Less than 30 grams	Visual and fire alarm	05/05/80 1430 hr	UOR WARD-[illegible]-03
14	GPL-1 and GPL-1A Loops in Thermal Stripping Test Facility (TSTF) (Westinghouse Advanced Reactors Div.)	The nozzle design caused sodium splashing which plugged the cover gas line; this plugging reduced the effectiveness of the Stein seal (by reducing the pressure differential). When sodium finally contacted the Stein seal, leakage occurred.	6 lb	Smoke Detectors	04/12/80 1350 hr	UOR WARD-80-02 TSTF-80-02
15	Dump Valve in Sodium Pre-Exposure Loop (Westinghouse Advanced Reactors Div.)	The bellows on the valve failed due to fatigue cracking.	1-2 lb	Smoke Alarm	07/20/80 1930 hr	UOR WARD-80-04 PEL-80-01
16	GPL-2 Electromagnetic Pump (Westinghouse Advanced Reactors Div.)	Suspected area of leak is one of the header tubes between the bottom of the pump outlet header and the top of the stator laminations. (Initial report only.)	90 grams	Smoke Alarm	01/24/81 1945 hr	UOR WARD-81-01 GPL/2-81-01

Table 1. Summary of Sodium Spill Unusual Occurrence Reports

US Experience

Item	Component	Description of Incident	Quantity of Sodium Leaked	Detection	Date	Documentation
17	SASS-ACA Test Article Lower Housing	Sodium residue was discovered during demolition. It is hypothesized that somehow sodium hydroxide formed during testing and initiated transgranular stress corrosion cracking, causing the leak path.	Small - pipe area covered was 1-2 $in.^2$	Visual	12/09/80 0930 hr	UOR ETEC-80-21 T032-80-05
18	Main Flow Loop (MFL) Venturi Flowmeter (SPTF)	The 1/2-in. stainless steel line to the pressure sensor had undergone intergranular attack, initiating the sodium leak. The IGA was attributed to the use of mineral fiber insulation. Similar occurrences had also been attributed to the use of mineral fiber insulation, so use of that type of insulation was discontinued.	1-2 gallons	Doesn't say; implies visual	05/19/81 0045 hr	UOR ETEC-81-05 SPTF-81-01
19	H-1 Sodium Heater (SCTI)	There was extensive intergranular attack (IGA) of 304H SS tubing in both H-1 and the H-1 preheater. The corrosion initiated on the exteriors of the tubes. A definite source for the IGA was not identified. However, the tubes had been in service for over 25 years and the presence of surface contaminants was not surprising.	Not adequately defined; i.e.: H-1 - a small mound of sodium reaction products. H-1 preheater - large accumulations of sodium reaction products.	Smoke Detector SME-H-1 & visual	09/10/80 2047 hr	UOR ETEC-80-13 SCTI-80-02
20	GPL-1 Electromagnetic Pump (Westinghouse Advanced Reactors Div.)	A single tube on the suction side of the pump failed. Identical failures had occurred twice before at GPL-2. Severe thin-walling of the tube had been identified as the cause of the leak in the previous two indicents. It is suspected that the design imposed higher than anticipated stresses at the leak location. Design modifications were initiated to alleviate the problem.	Minimum sodium leakage	Visual	03/17/82 1115 hr	UOR WARD-82-01 GPL1-82-01

Table 1. Summary of Sodium Spill Unusual Occurrence Reports

US Experience

Item	Component	Description of Incident	Quantity of Sodium Leaked	Detection	Date	Documentation
21	2-in. Header to Purification System (P/S) Pumps (SPTF)	The leak occurred at a tee in the 2-in. suction header to the P/S EM pumps. It was determined that the leaks were due to intergranular attack (IGA) of the pipe, originating on the outside surface. The initial attack was attributed to the use of mineral fiber insulation, which has caused similar problems in the past (see Item 18).	A "small sodium leak" with a "substantial buildup of sodium reaction products."	Ground Fault Interrupter (GFI) trip	07/25/81 0124 hr	UOR ETEC-81-08 SPTF-81-03

Appendix B

MODELING STUDY

A MATHEMATICAL MODEL FOR THE FALLOUT OF PARTICULATE MATTER AND ITS APPLICATION TO THE COMBUSTION OF SODIUM AEROSOLS

Prepared by:

I-Tung Wang, Ph.D.
George Lauer, Ph.D.

June 1980

Rockwell International

Environmental Monitoring & Services Center
Environmental & Energy Systems Division
2421 West Hillcrest Drive
Newbury Park, CA 91320
(805) 498-6771

TABLE OF CONTENTS

1.0 INTRODUCTION

This document has been prepared in response to questions concerning the potential environmental impact(s) of accidental releases of hot liquid sodium which might result from a liquid sodium cooled solar tower facility. The report addresses those impacts which could result from a set of hypothetical "credible" accidents and are based on the field work of Johnson, et.al. (1978). It is concluded that although sodium oxide will deposit in the near field (out to 300 meters of the release point), the particulate matter carried off site (beyond one kilometer) will be in the form of sodium carbonate which is innocuous in terms of environmental impact on the local ecology.

A generally useful air quality model has been developed to simulate the physical phenomena of buoyant rise, transport, dispersion, and fallout of combustion aerosol particles. It differs from the conventional steady-state plume dispersion-deposition models in several aspects:

1. use of detailed dynamic equations to describe the entrainment and buoyant rise of the contaminated air parcel or the smoke puff;

2. a travel-time-dependent Gaussian puff formulation for calculating the transport and dispersion of the puff; and

3. use of generalized terminal velocity calculations by Beard (1976) to calculate the rates of fallout of polydisperse aerosol particles.

Model predictions are compared with field data (Johnson et al., 1978) of sodium oxide deposition resulting from low-level spray releases of heated sodium particles. The predictions are based on measured sodium oxide aerosol particle size distributions. The model is also used to predict the ground-level air quality impacts and depositions under five different release conditions. In each case, a predetermined set of worst-case meteorological parameters is used as model input.

2.0 FORMULATION

2.1 Equations for the Buoyant Rise of the Puff

The mechanical and thermal properties of the rising puff are described by the following set of equations, in which Q_x and R_x denote the entrainment coefficient and effective radius of the puff with the subscripts m and t signifying the momentum and temperature puffs respectively. E_m is the ratio of the effective momentum flux to the momentum flux within the temperature puff, i.e., $E_m = (R_m/R_t)^2$. The concept of describing the plume element in terms of the momentum, temperature, and moisture components has been discussed by Hanna (1976).

2.1.1 Equation of Vertical Motion

$$\frac{1}{2}\frac{\partial(w^2)}{\partial z} = \frac{g}{E_m}\left(\frac{T_p - T_e}{T_p}\right) - Q_m\frac{w^2}{R_m} \qquad (1)$$

Equation (1) is based on momentum conservation and determines the change of the vertical velocity of the puff, w, with height. The first term on the right-hand side of Equation (1) is the force per unit mass of the puff due to buoyancy, expressed in terms of the temperature of the puff, T_p, and that of the ambient air, T_e. The second term expresses the drag force per unit mass due to the entrainment of ambient air.

2.1.2 Equations of Horizontal Motion

$$\frac{\partial V_c}{\partial z} = -\alpha_m \frac{V_c}{R_m} \ , \qquad (2a)$$

$$V = V_c + U \ . \qquad (2b)$$

Equation (2a) is also derived from conservation of momentum. The buoyancy force is not present, however, leaving only the drag term on the right. V_c is the horizontal component of the puff velocity with respect to still air. It is added to the ambient wind velocity, U, to obtain the horizontal puff velocity, V, with respect to the ground, in Equation (2b).

2.1.3 Equation of Temperature

$$\frac{\partial T_p}{\partial z} = -\frac{g}{c_p} - \alpha_t \frac{(T_p - T_e)}{R_t} \ . \qquad (3)$$

This equation describes the change of puff temperature with height. The first term on the right-hand side of Equation (3) expresses the temperature change due to adiabatic expansion, and the second term is the temperature change due to the entrainment of ambient air. c_p is the heat capacity of the puff at constant pressure.

2.1.4 Entrainment Equations

$$\frac{\partial R_t}{\partial z} = 0.3 - \frac{R_t}{2U}\frac{\partial U}{\partial z} \ , \qquad (4a)$$

$$\frac{\partial R_m}{\partial z} = 1.5\frac{\partial R_t}{\partial z} \ . \qquad (4b)$$

In Equations (1) to (3), the entrainment coefficients are given by

$$\alpha_t = 0.8, \quad (5a)$$

$$\alpha_m = 1.2. \quad (5b)$$

The above dynamic equations are appropriate for bouyant puffs that do not have significant water contents. For wet puffs, the above equations can be generalized to include latent heat and cloud physics effects (see, e.g., Hanna, 1976). These puff dynamic equations are used mainly to describe the buoyant rise of the puff and its interaction with the vertical variations of ambient temperature such as inversions, if any. Vertical temperature and wind speed profiles, as well as the initial physical conditions of the puff, its temperature, size, and velocities, are required as model input.

2.2 Dispersion and Deposition

The spread of the puff is governed by the turbulent dispersive action of the atmospheric boundary layer. The turbulent motion of the air spreads the puff both vertically and horizontally to a degree determined in part by the wind profile and in part by the thermal stratification of the boundary layer. A covenient method of describing this dispersion is in terms of the Gaussian puff dispersion equations with the horizontal and vertical standard deviations determined by field data for low level releases of short durations. The best known data are those compiled by Pasquill and Gifford for three-minute sampling time (see Pasquill, 1978).

Gravitational settling of particulate matters can be modelled by incorporating the downward drift of the particles in the vertical component of the puff dispersion. Thus the puff can be visualized as an aggregate of puffs each consisting of particles of a specified size range with an average terminal velocity v_s and effective elevation $H - v_s*x/U$, H being the effective elevation of the puff had there been no downward gravitational drift. The net rate of particulate deposition (mass per unit area) is then obtained by summing over the entire particle size spectrum,

$$D(x,y) = \frac{2Q}{(2\pi)^{3/2}\sigma_H^2\sigma_z} exp\left[\frac{(x-Ut)^2}{2\sigma_H^2}\right] exp\left[\frac{y^2}{2\sigma_H^2}\right] \sum_i v_s(d_i)\, exp\left[\frac{(H - x\,v_s(d_i)/\bar{U})^2}{2\sigma_z^2}\right] \cdot p(d_i), \quad (6)$$

where $p(d_i)$ is the normalized size spectrum weighting factor for size d_i. U is the wind speed at the effective puff height, and U is the mean wind speed between the effective puff height and the ground. The functional dependence of the terminal velocity, v_s, on the aerosol particle size, d_i, and ambient conditions, as determined by Beard (1976) is used in the present model.

It should be noted that the above formulation is applicable to a puff that has completed its initial phase of buoyant rise and has attained thermal equilibrium with the ambient air. In the case of a rising puff, the simple assumption is made that only aerosol particles with terminal velocities greater than the effective vertical velocity of the puff will fall out.

2.3 CHEMICAL TRANSFORMATIONS

When sodium burns in the atmosphere a number of reactions are possible. The primary reactions are:

$$4Na + O_2 \longrightarrow 2\,Na_2O \quad (7)$$

$$2Na + O_2 \longrightarrow Na_2O_2 \quad (8)$$

Reaction (7) is predominant when there is insufficient oxygen for reaction (8). However Na_2O, itself reacts with oxygen according to:

$$2Na_2 + O_2 \longrightarrow 2Na_2O_2 \quad (9)$$

Sodium peroxide is stable only at temperatures below 650°C. The temperature of the plume, as is shown below, is below this critical temperature within a few meters of the sodium fire.

Sodium oxide as well as sodium peroxide will both react with water to form the hydroxide:

$$Na_2O + H_2O \longrightarrow 2NaOH \quad (10)$$

$$2Na_2O_2 + 2H_2O \longrightarrow 4NaOH + O_2 \quad (11)$$

Sodium hydroxide will react with carbon dioxide to form the carbonate; in addition, sodium peroxide will react directly with CO_2 to form the carbonate:

$$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O \qquad (12)$$

$$2Na_2O_2 + CO_2 \longrightarrow 2Na_2CO_3 + O_2 \qquad (13)$$

It can be seen that in the presence of sufficient carbon dioxide, the reaction will go to the carbonate in all cases. The primary question then is whether there is sufficient CO_2 in the plume for the reaction to go to completion. This question is treated in the next chapter.

3.0 APPLICATION

In the model applications discussed below, the particle size spectrum has been determined on the basis of experimental data obtained near the ground at distances of 100m and 200m from the source, at which points the large particles have already fallen out of the puff; and Equation (6) is used to compute the deposition of combustion aerosols beyond the 100m range. The emission strength, Q in Equation (6), was obtained by multiplying the total sodium aerosol mass generated in each case by a factor $f = f_d * f_r$ where f_d denotes the fraction (in mass) of aerosols that fallout and f_r is the fraction of fallout (in mass) that reach beyond the 100m range. For spray releases, the fallout mass fraction was observed by Johnson et al. to be $f_d = 0.17$. The second factor, f_r, was derived from the actual observed sodium oxide deposition data by Johnson et al., shown in Figure 1, by integrating the empirically determined distribution functions as indicated in the figure. The result was $f_r = 0.108$. The experimental data of Johnson et al. also indicated that at 100 m downwind of low-level spray releases, about ninety percent of the sodium released was converted to Na_2O and the rest to Na_2CO_3 and NaOH, depending on the ambient humidity. This particular chemical composition, however, is not expected to be applicable to all downwind distances. As will be discussed in Section 3.3, the chemical composition of the aerosol particle is dependent on its surface area or size. For the smaller aerosol particles that fall out at greater downwind distances , it is expected that the stable form of sodium carbonate, Na_2CO_3, will dominate.

3.1 Comparison with Field Data

A brief comparison has been carried out to test the accuracy of the model using the spray release data of Johnson et al. The initial radius, R, of the smoke puff is set to be 1 m for the spray releases, on the basis of actual field observations (Johnson, 1980). The initial temperature is then estimated using the heat release rate, Q_h, for oxidation of sodium particles in the air. Assuming a steady wind speed, U_r, at the release height, the initial average temperature of the puff and that of the ambient air differ by an amount ΔT that is given by the following relationship:

$$\pi C_p \rho \cdot U_r \cdot t \cdot R^2 \cdot \Delta T = M \cdot Q_h \, . \tag{14}$$

In the above, t is the total release time, and M the total mass of sodium released. Q_h is taken to be 14.2 MJ per kg of sodium.

In the simulation, a constant temperature lapse rate of +0.025 K/m was used for Test 1. For Test 2, the lapse rate was taken to be -0.033 K/m up to the 30m level, and -0.01 K/m above 30m. These vertical temperature lapse rates were used to approximate the actual measured vertical temperature profiles.

The Pasquill-Gifford horizontal and vertical plume spreads, σ_y and σ_z, were used, whereby a release time conversion factor of $(t/180)^{0.2}$ was incorporated in the horizontal spread following Pasquill's suggestion that the standard Pasquill-Gifford σ_y corresponds to a three-minute release time. The classical Pasquill-Gifford vertical plume spread for stability A has been known to have an artificial upward trend beyond 800m downwind distance that is too high (see, for example, Pasquill, 1978). It is replaced, in the present study, by the more recent simple functional form recommended by Pasquill (1974). Based on the observed wind speeds and cloud conditions, the Pasquill stability categories for Test 1 and Test 2 were determined to be C and B respectively. Table 1 compares the modelled area deposition densities with the observed values.

Table 1. Observed and modelled average fallout area densities of sodium aerosols(g/m2)

Radial distance (m)	Test 1		Test 2	
	Observation	Model	Observation	Model
100	$1.9*10^{-2}$	$2.0-3.4*10^{-2}$	$1.6*10^{-2}$	$1.5-2.5*10^{-2}$
200	$9.1*10^{-3}$	$4.7-7.7*10^{-3}$	$3.6*10^{-3}$	$5.2-8.6*10^{-3}$
400	$1.5*10^{-3}$	$0.8-1.1*10^{-3}$	$5.0*10^{-4}$	$0.9-1.3*10^{-3}$
800	$5.9*10^{-4}$	$4.9-5.5*10^{-4}$	$4.7*10^{-4}$	$4.6-5.1*10^{-4}$

In making the comparison, the receptor locations were specified in such a way as to resemble closely the actual collector positions used in the field study. The average fallout in the table was taken to be the area deposition density averaged over a ninety degree quadrant about the plume center line; and, a constant measured background value of $4*10^{-4}$ g/m^2 has been added to each of the modelled area densities. Recognizing the complex sodium aerosol chemistry and surface effects, the modelled values are expressed in terms of ranges where the lower limits represent total conversions into Na_2O, and the upper limits total conversions into Na_2CO_3. As will be discussed in Section 3.3, the lower limits probably apply to large aerosol particles that fall out close to the source and the upper limits may be applicable to a few hundred meters from the source and beyond, where the deposition is expected to be mostly in the stable form of sodium carbonate.

3.2 Five Credible Spill Scenarios

Five scenarios of sodium combustion product release are considered. The first two involve ground level releases that last for three hours. The other three are elevated releases (at heights of 166-184m) of shorter durations. Computer simulations under different assumptions of stability and temperature lapse rate have indicated that for ground level releases, stable atmospheric conditions tend to lead to the highest ground-level impacts. Also, it is clear that, for each assumed stability category, the higher the surface wind speed the lower the effective plume rise. Therefore, the worst-case meteorological conditions for ground releases were assumed to have Pasquill F stability and a surface wind speed (at the 10m level) of 3 m/sec. For elevated releases, similar test runs indicated that the most adverse meteorological conditions would correspond to Pasquill stability A and surface wind speed of 3 m/sec. The complete set of assumed meteorological conditions is presented in Table 2.

Table 2. Worst-case meteorological conditions

	Ground release	Elevated release
Pasquill stability	F	A
Surface wind speed	3 m/sec	3 m/sec
Surface temperature	300 K	300 K
Temperature lapse rate	+0.03 K/m	-0.02 K/m

The total mass of sodium released, the release time, and the assumed initial puff temperature, radius and elevation for each of the five scenarios are given in Table 3.

Table 3. Assumed source and initial puff conditions

Scenario	Total mass of Na(kg)	Release time(sec)	Initial puff conditions temp.(K)	radius(m)	elevation(m)
1. Tank fire	$0.227*10^5$	$0.108*10^5$	334.0	15.2	0
2. Small fire	$0.222*10^2$	$0.108*10^5$	348.5	0.4	0
3. Spray rel.	$0.500*10^3$	$0.100*10^4$	765.0	1.0	166
4. Spray rel.	$0.300*10^5$	$0.566*10^3$	513.0	15.2	174
5. Spray rel.	$0.200*10^5$	$0.900*10^2$	1192.0	15.2	174

In Table 3, the total sodium mass for ground releases (scenarios 1 and 2) has been adjusted for thirty percent aerosol formation.

The maximum calculated ground-level sodium aerosol concentrations as well as the maximum calculated deposition densities for the five hypothetical scenarios are given in Table 4. It is seen that scenario 1 is predicted to have the highest ground-level impact, with a maximum area deposition of sodium aerosol of 3.7-6.3 g/m^2. The more detailed predicted ground deposition density distributions are presented in Figures 2 to 6 for the five scenarios. For reasons discussed in Sections 3.1 and 3.3, the deposition densities plotted for scenarios 1,3,4, and 5 correspond to the upper limits, and those for scenario 2 the lower limits. Although the predicted deposition density of Na_2O was fairly high in scenario 2 at the 100m point, it can be seen from Figure 3 that it drops off very rapidly within a few hundred meters.

Table 4. Maximum ground-level sodium aerosol concentrations and deposition densities

Scenario	Downwind distance (m)	Maximum concentration (g/m^3)	Maximum deposition (g/m^2)
1. Tank fire	$4.0*10^2$	$0.31-0.54*10^{-1}$	$0.37-0.63*10^{+1}$
2. Small fire	$1.0*10^2$	$0.22-0.38*10^{-1}$	$0.16-0.27*10^{+1}$
3. Spray rel.	$5.5*10^2$	$0.26-0.44*10^{-4}$	$0.68-1.2*10^{-2}$
4. Spray rel.	$4.5*10^3$	$0.28-0.48*10^{-4}$	$0.27-0.45*10^{-1}$
5. Spray rel.	$4.5*10^3$	$0.27-0.46*10^{-4}$	$0.27-0.47*10^{-1}$

3.3 Chemical Composition of the Sodium Aerosols

It is expected that the fine sodium particles are rapidly oxidized at high temperatures near the release point. To understand the chemical transitions of the plume element as it is transported downwind, it is useful to neglect for the time being the effects of particle agglomeration and formation of protective layers of chemicals on the aerosol surface. Under such simplified, hypothetical conditions, the entrained water vapor will react with the oxides rapidly into sodium hydroxide. The entrained carbon dioxide will then interact quickly with part of the sodium hydroxide and form sodium carbonate which is relatively stable and hygroscopic.

The source and meteorological conditions in Scenario 1 were used to study the plume chemical composition by assuming an ambient water vapor mixing ratio of

2.5 g/kg, corresponding to a low relative humidity of 15-20% depending on the ambient air pressure, and the standard CO_2 concentration of 357 ppm. The surface wind speed was assumed to be 3 m/sec. Figure 7 shows the expected sodium aerosol chemical composition under the hypothetical conditions that all sodium oxide molecules were exposed to react with entrained water vapor and carbon dioxide molecules. It is seen that at a few hundred meters downwind, virtually all sodium aerosol particles had settled into the stable form of sodium carbonate.

With rapid particle agglomeration and formation of protective layers on the aerosol particle surfaces, the conversion into carbonate is probably not as thorough as depicted in Figure 7. The larger particles that carry less effective surface per unit mass are expected to have less carbonate content. This is reflected in the observed chemical composition at 100 m. It would be of significant interest to have chemical analyses performed on species collected much further downwind, as the small particles with greater effective surface per unit mass are expected to have much greater carbonate content than that measured at 100 m from the source, as predicted by the entrainment model.

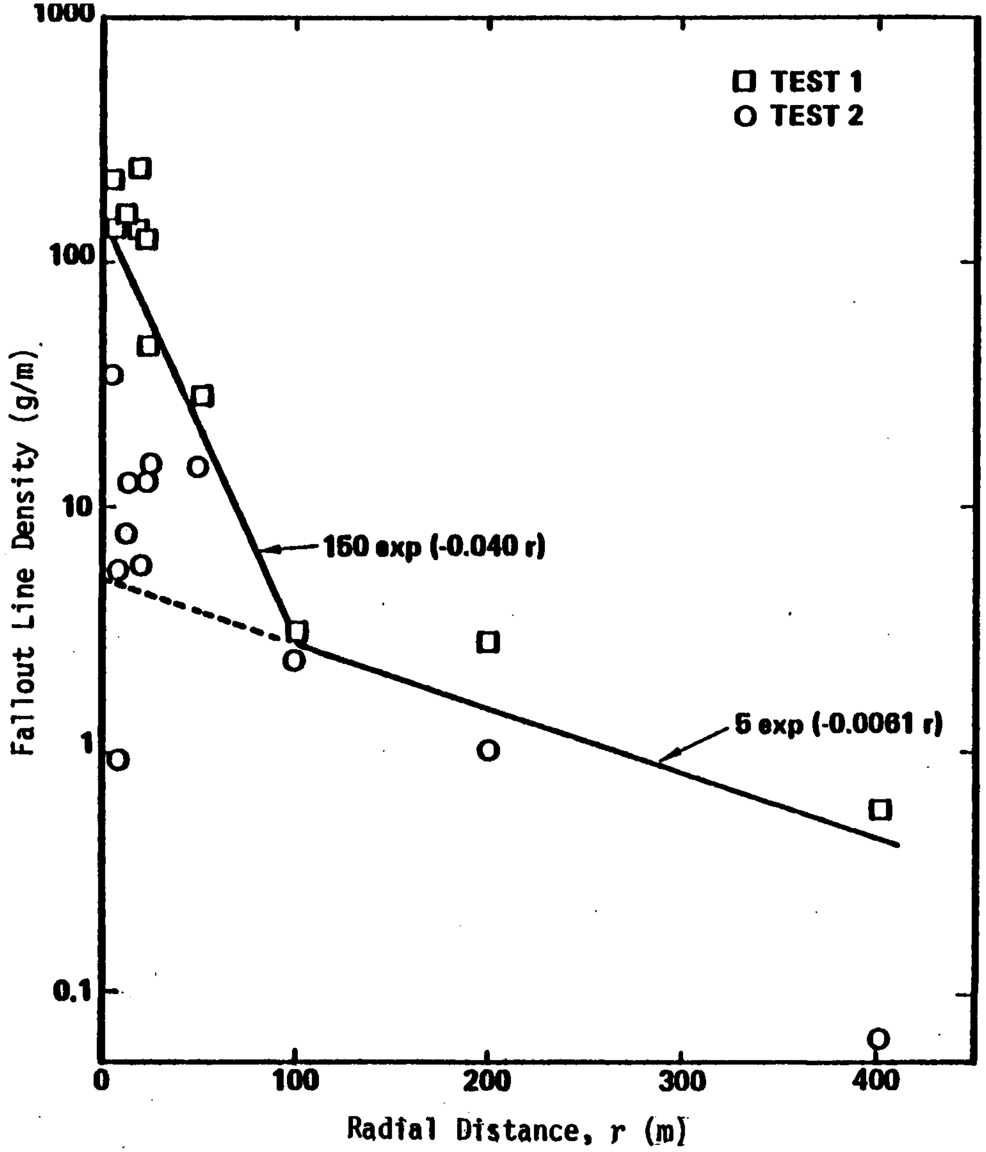


Figure 1. Fallout Line Density vs Radial Distance

Figure 2. Area Density of Sodium Aerosol Deposition (gm/m^2)

(Case 1)

Crosswind Distance (km) \ Downwind Distance (km)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.08
0.15	0.00	0.00	0.00	0.00	0.03	0.07	0.11	0.16	0.19	0.28
0.10	0.00	0.00	0.02	0.20	0.50	0.63	0.65	0.63	0.61	0.70
0.05	0.00	0.02	0.73	2.61	3.20	2.56	1.91	1.49	1.23	1.22
0.00	0.00	0.17	2.73	6.33	6.05	4.17	2.75	1.99	1.55	1.47
0.05	0.00	0.02	0.73	2.61	3.20	2.56	1.91	1.49	1.23	1.22
0.10	0.00	0.00	0.02	0.20	0.50	0.63	0.65	0.63	0.61	0.70
0.15	0.00	0.00	0.00	0.00	0.03	0.07	0.11	0.16	0.19	0.28
0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.08
0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02

Downwind Distance (km)

Figure 3. Area Density of Sodium Aerosol Deposition (gm/m^2)

(Case 2)

Crosswind Distance (m)	100	120	140	160	180	200	220	240
25	0.05	0.03	0.01	0.01	0.00	0.00	0.00	0.00
20	0.17	0.07	0.02	0.01	0.01	0.00	0.00	0.00
15	0.45	0.15	0.04	0.02	0.01	0.00	0.00	0.00
10	0.90	0.26	0.06	0.02	0.01	0.01	0.00	0.00
5	1.39	0.36	0.08	0.03	0.01	0.01	0.00	0.00
0	1.60	0.40	0.09	0.03	0.01	0.01	0.00	0.00
5	1.39	0.36	0.08	0.03	0.01	0.01	0.00	0.00
10	0.90	0.26	0.06	0.02	0.01	0.01	0.00	0.00
15	0.45	0.15	0.04	0.02	0.01	0.00	0.00	0.00
20	0.17	0.07	0.021	0.01	0.01	0.00	0.00	0.00
25	0.05	0.03	0.01	0.01	0.00	0.00	0.00	0.00

Downwind Distance (m)

Figure 4. Area Density of Sodium Aerosol Deposition (gm/m^2)

(Case 3)

Crosswind Distance (km)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0.25	.002	.004	.005	.007	.008	.008	.008	.007	.007	.006
0.20	.002	.005	.006	.008	.009	.009	.009	.008	.008	.007
0.15	.003	.005	.007	.009	.010	.010	.010	.009	.008	.007
0.10	.004	.006	.008	.010	.010	.011	.010	.010	.009	.008
0.05	.004	.006	.009	.010	.011	.011	.011	.010	.009	.008
0.00	.004	.007	.009	.011	.011	.012	.011	.010	.009	.008
0.05	.004	.006	.009	.010	.011	.011	.011	.010	.009	.008
0.10	.004	.006	.008	.010	.010	.011	.010	.010	.009	.008
0.15	.003	.005	.007	.009	.010	.010	.010	.009	.008	.007
0.20	.001	.005	.006	.008	.009	.009	.009	.008	.008	.007
0.25	.002	.004	.005	.007	.008	.008	.008	.007	.007	.006

Downwind Distance (km)

Figure 5. Area Density of Sodium Aerosol Deposition (gm/m^2)

(Case 4)

Crosswind Distance (km)	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
.5	.014	.024	.033	.039	.040	.039	.035	.030	.025	.020
.4	.015	.026	.035	.041	.042	.042	.036	.031	.026	.021
.3	.016	.027	.036	.042	.043	.041	.037	.032	.026	.021
.2	.017	.028	.037	.043	.044	.042	.038	.033	.027	.021
.1	.017	.028	.038	.043	.045	.043	.038	.033	.027	.022
.0	.017	.028	.038	.044	.045	.043	.038	.033	.027	.022
.1	.017	.028	.038	.043	.045	.043	.038	.033	.027	.022
.2	.017	.028	.037	.043	.044	.042	.038	.033	.027	.021
.3	.016	.027	.036	.042	.043	.041	.037	.032	.026	.021
.4	.015	.026	.035	.041	.042	.042	.036	.031	.026	.021
.5	.014	.024	.033	.039	.040	.039	.035	.030	.025	.020

Downwind Distance (km)

Figure 6. Area Density of Sodium Aerosol Deposition (gm/m^2)

(Case 5)

Crosswind Distance (km) \ Downwind Distance (km)	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
.5	.007	.016	.026	.034	.037	.036	.033	.029	.024	.019
.4	.008	.019	.030	.037	.040	.039	.036	.031	.026	.020
.3	.009	.021	.032	.040	.043	.042	.038	.032	.027	.021
.2	.010	.022	.034	.043	.045	.043	.039	.033	.028	.022
.1	.011	.023	.036	.044	.046	.044	.040	.034	.028	.022
.0	.011	.024	.036	.044	.047	.045	.040	.034	.028	.022
.1	.011	.023	.036	.044	.046	.044	.040	.034	.028	.022
.2	.010	.022	.034	.043	.045	.043	.039	.033	.028	.022
.3	.009	.021	.032	.040	.043	.042	.038	.032	.027	.021
.4	.008	.019	.030	.037	.040	.039	.036	.031	.026	.020
.5	.007	.016	.026	.034	.037	.036	.033	.029	.024	.019

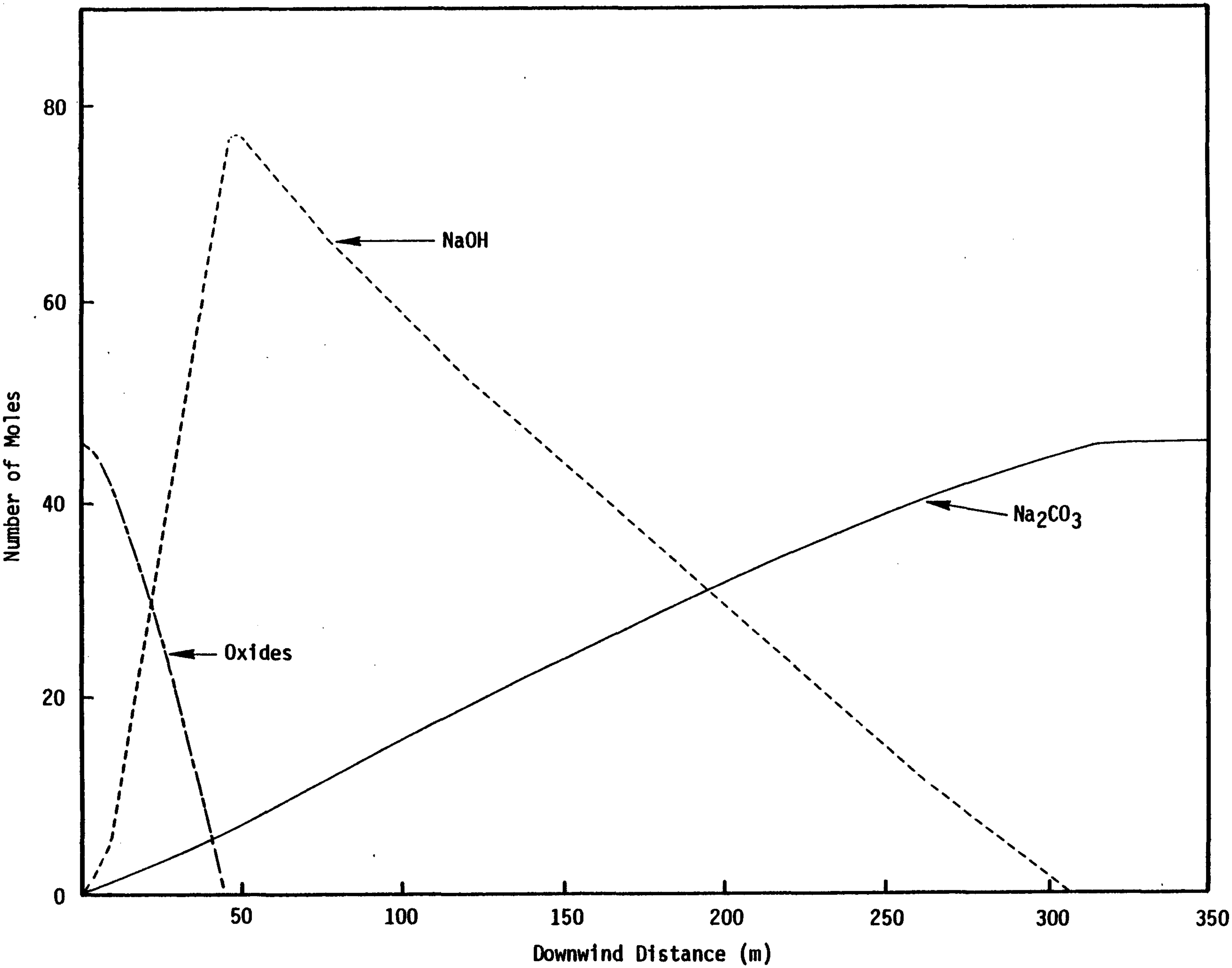


Figure 7. Modelled Aerosol Chemical Composition

4.0 ACKNOWLEDGMENTS

Helpful discussions by Allen Allman and Richard Johnson are gratefully acknowledged.

5.0 REFERENCES

Beard, K.V., 1976: Terminal velocity and shape of cloud and precipitation drops aloft, J. Atmos. Sci., 33, 851-864.

Hanna, S.R., 1976: Predicted and observed cooling tower plume rise and visible plume length at the John E. Amos power plant, Atmos. Environ., 10, 1043-1052.

Johnson, R.P., C. Guderjahn, H.A. Morewitz, C.T. Nelson, and J. Otter, 1978: Atmospheric fallout of sodium combustion aerosols, Rockwell International Energy Systems Group report on work performed under DOE Contract EY-76-C-03-0824.

Johnson, R.P.,1980: Private communication.

Pasquill, F., 1974: Atmospheric diffusion. John Wiley and Son, New York.

Pasquill, F., 1976: Atmospheric dispersion parameters in Gaussian plume modeling. Part 2. Possible requirements for change in the Turner Workbook values. EPA-600/4-76-030b.

Appendix C

PROPERTIES AND HAZARDS OF LIQUID SODIUM

This appendix presents a brief discussion of the properties and hazards of liquid sodium. This discussion is oriented toward the fundamental properties and behavior of liquid sodium, showing how sodium can react in the event of a spill. It is important to realize, however, that the Carrizo Plain plant is designed for zero release during normal operation, so the reactions and hazards described here will be rare occurrences in the operating power plant. Appendix A gives an outline of the safety history of sodium loops, illustrating the rarity of significant spills.

C.1 PROPERTIES OF LIQUID SODIUM

Sodium is a slightly spongy solid at room temperature. However, the melting point of sodium at 1 atmosphere pressure is 208°F, so the sodium in the Carrizo Plain system will all be liquid. Liquid sodium has very high thermal conductivity, so it is well-suited for use in a heat transfer loop.

Sodium reacts vigorously with water, oxygen, and several other common substances. The initial reactions (e.g., sodium + H_2O) and secondary reactions (e.g., liberated H_2 burning in air) may be violent.

When liquid sodium and water are brought into contact with each other, a vigorous exothermic chemical reaction takes place. Sodium hydroxide and sodium oxides are formed and heat and hydrogen are liberated. If the sodium-water reaction occurs in air, ignition of the liberated hydrogen and oxygen from the air can occur. Steam and additional heat will be produced, and if sufficient water and sodium are present the reaction may be explosive. If the sodium-water reaction occurs within the sodium loop, the most severe immediate problem will be generation of heat and free hydrogen. The reaction rate is very rapid and can result in a rapid rise in system pressure. If sufficient water and sodium are involved to cause pressures exceeding system limitations, then leaks can occur through rupture disks. However, the Carrizo Plain plant is designed to withstand a certain amount of water in the sodium system.

A common reaction encountered in using liquid sodium is its interaction with air. Liquid sodium will ignite spontaneously in air and combustion will be sustained if initial conditions of temperature and environment continue to prevail. The initial reaction of sodium with oxygen will form sodium oxides. However, these oxides react quickly with the moisture in the air to form sodium hydroxide; as mentioned previously, sodium hydroxide is also formed in the air by the direct reaction of sodium and water. Dense clouds of sodium hydroxide and sodium oxides resulting from sodium leaks can pose a significant hazard to personnel working within the plant area. However, sodium hydroxide will eventually react with carbon dioxide in the air to form the carbonate, which is essentially harmless compared to the very caustic nature of sodium hydroxide. A modeling study (Wang and Lauer, 1980) has shown that, for a typical sodium leak, reaction to the carbonate is complete at the time of aerosol deposition beyond approximately 1 kilometer or less from the release point, so there are no long-range effects.

C.2 LIQUID SODIUM HAZARDS

Plant personnel may be exposed to sodium as a result of accidents or fire fighting activities. The most likely organs affected would be the skin, eyes, and mouth or mucous membranes. Reaction of sodium with the skin and eyes is of prime concern in any sodium accident. Sodium will destroy tissues as a result of thermal contact and/or chemical reaction with the moisture in tissue. Both reactions occur simultaneously as a result of (1) heat from hot or burning sodium, and (2) the formation of sodium hydroxide with body fluids. Treatment of a sodium burn is not the same as treatment of a typical thermal burn since the hydroxide penetrates the tissues and must be neutralized or removed before effective healing begins. Sodium burns are self-cauterizing and are rarely accompanied by bleeding.

Sodium contact with the eyes is very serious and can result in blindness if not treated promptly. Even if eye protection is worn, minute particles of sodium or its oxides and hydroxide may enter the eye during release. Water flushing is recommended and the services of an opthalmologist should be obtained immediately. Further eye damage ceases once the eye has been thoroughly flushed.

The possibility of a reaction between sodium and the mouth, throat, and lungs is generally limited to contact of oxide smoke from a fire or caustic mist from a sodium-water reaction. Chronic exposure is very unlikely since contact of sodium oxide smoke or hydroxide mist with the mouth, throat, and lungs is very irritating and generally cannot be tolerated due the stinging and coughing caused by the smoke. There is no recognized local or systemic form of acute or chronic toxicity resulting from sodium or sodium oxide smoke. The fumes do not act as a poison, but rather as an irritant. Any injury to the mouth, throat, or lungs resulting from contact with sodium or sodium oxide would be due to thermal or alkali burns and not to any toxicity of the fumes, metal, or smoke.

Plant operating personnel should be made aware of the potential reactions and physiological effects of sodium accidents so that they can take prompt and proper action to prevent or minimize injury. Appropriate first aid and medical assistance should be provided to further minimize damage and treat injuries. First aid procedures are discussed in greater detail in Section 6.0 of this document.

Appendix D

GENERAL INDUSTRY SAFETY ORDERS

Article 135. General

5416. Flammable Vapors.

(a) Ventilation shall be sufficient so that under normal operating conditions concentrations of flammable vapors or gases in buildings, rooms or similarly enclosed places shall not exceed 20 percent of the lower explosive limit for such vapors except that in pits, sumps, or other locations which are not normally entered, except in cases of emergency, such ventilation will not be required. In such locations, the provisions of paragraph (c) shall be complied with.

(b) No source of ignition shall be permitted in or near a pit or sump in a location near which flammable liquids are regularly and frequently, or have recently been, used, handled or stored in other than closed containers unless tests have been made which indicate that the concentration of flammable vapor is less than 20 percent of the lower explosive limit.

(c) No source of ignition shall be permitted in any location, indoors or outdoors, where the concentration of the flammable gases or vapors exceeds or may reasonably be expected to exceed 20 percent of the lower explosive limit in the working atmosphere. Tests shall be made to ascertain that this limit is not exceeded before a source of ignition is introduced into such location, and such tests shall be repeated frequently (or a continuous indicator used) as long as conditions giving rise to such concentrations of flammable vapors or gases continue and a source of ignition is present.

(d) Smoking shall be forbidden in any location where flammable vapors in concentrations greater than 20 percent of the lower explosive limit may reasonably be expected.

5417. Flammable Liquids—General.

(a) All containers, either open or closed, which contain a flammable liquid shall be plainly marked with an appropriate warning legend or painted a distinctive color or otherwise distinguished from containers which contain nonflammable substances, except that:

(1) Where there are a number of fixed or permanent containers which usually contain flammable liquids, warning signs may be posted in the room or area in which such containers are located instead of marking individual containers; however, portable containers in which flammable liquids are used, stored, or transported, shall be marked in one of the manners described above unless such containers are used under controlled conditions that reduce the possibility of confusion to a minimum. Nonflammable liquids should not be placed in such containers.

(2) Original containers marked as required by the General Industry Safety Orders, Article 112, Labeling of Injurious Substances, shall be considered to comply with the requirements of this section. Containers such as drums, bottles, or carboys, in which flammable liquids are placed for sale, distribution, or shipment need not be marked during the time between filling and labeling.

(b) Flammable liquids shall not be used to wash floors, walls, ceilings, structural members, furniture, equipment, machines or machine parts, unless ventilation is provided and maintained in accordance with Section 5143.

(c) Spraying of flammable liquids for cleaning purposes shall be forbidden except when performed as follows:

(1) In a booth equipped with adequate ventilation. See Section 5153.

(2) Outdoors, or in open sheds, with no source of ignition within 25 feet of the spraying operation.

(d) Class IA flammable liquids shall not be used for washing except that two quarts or less may be so used in an enclosed booth provided adequate ventilation is maintained and all sources of ignition are excluded from locations where concentrations of vapors of such liquids may reasonably be expected to exceed 20 percent of lower explosive limit.

(e) Flammable liquids shall be kept in covered containers when not actually in use, being processed or compounded, or shall be stored in permanent storage tanks. Such liquids shall not be transported from storage areas to areas of use in open containers. Containers used to transport flammable liquids or as dispensing devices shall be covered containers or original closed containers. Closures of such containers shall be kept in place at all times except when liquid is being drawn from the container. See Articles 141 and 145.

(f) Tubular gauges on stationary tanks, vats, or containers which contain flammable liquids shall be shielded to prevent liquid spray from endangering employees should the gauge break. All such gauges shall be guarded when exposed to the hazards of being broken by accidental impact and in all cases when located less than 7 feet above or 3 feet laterally from working levels or passageways. All such gauges shall be provided with valves which can be readily closed in case of breakage. Where practicable, ball-check or other self-closing valves shall be used.

NOTE: Authority cited: Section 142.3, Labor Code. Reference: Section 142.3, Labor Code.

HISTORY:

1. New subsection (f) filed 3-2-76; effective thirtieth day thereafter (Register 76, No. 10).
2. Amendment of subsections (d) and (e) filed 11-18-76; effective thirtieth day thereafter (Register 76, No. 47).
3. Amendment of subsections (b) and (d) filed 7-13-78; effective thirtieth day thereafter (Register 78, No. 28).
4. Amendment of subsection (b) filed 9-6-79 as procedural and organizational; effective upon filing (Register 79, No. 36).

5418. Carboys Containing Flammable Liquids.

(a) Carboys containing flammable liquids shall not be stored near steam coils or other source of heat.

(b) Carboys containing flammable liquids shall not be emptied by air pressure except as produced by hand pumps or bulbs.

5419. Drums Containing Flammable Liquids.

(a) Drums containing flammable liquids shall not be stored where they are exposed to heat sufficient to rupture the containers.

(b) Drums containing flammable liquids shall not be emptied by air pressure except as produced by hand pumps or bulbs. Faucets or cocks shall be used where practicable.

(c) No naked flame, torch, or similar source of ignition shall be allowed in contact with drums which contain or have last contained flammable or combustible liquids except for purposes of repair as provided in (d).

(d) Repair of drums which contain or have last contained a flammable liquid:

Before repair work involving the use of open flames or other source of ignition, drums shall be purged of flammable vapors and insofar as is practicable, cleansed of residues which may give rise to such vapors. Ventilation, water, inert gas, or other suitable and effective means shall be used to prevent formation of explosive mixtures as necessary. Where such work is regularly or frequently undertaken, means shall be provided for testing the air in drums for explosibility.

(e) When drums containing or having last contained a flammable liquid are opened, any pressure which may have developed in the drum shall be relieved through a loosened plug before plugs are removed. During such operation, no source of ignition shall be permitted within 25 feet of the drum.

5420. Tanks, Vats and Containers Containing Flammable Liquids. (a) When repairs, alterations, or cleaning operations are performed on tanks, vats, or confined spaces, which contain or have last contained a flammable liquid or a substance giving rise to flammable vapors the following procedure shall be followed:

(1) All employees engaged in the operation shall be advised of hazards they may encounter.

(2) Lines which may convey hazardous materials to the vessels shall be disconnected, or other positive means shall be used to prevent discharge of such material into the vessel.

(3) If work involving the use of flame, arc, spark, or other source of ignition is to be done, the vessel shall be emptied, flushed or otherwise purged of flammable vapors. A test for flammability of the vapors in the vessel shall be made, using an appropriate device for this purpose, and no source of ignition shall be permitted in or in contact with the vessel if the percentage of combustible vapor is greater than 20 percent of the lower explosive limit. As long as any source of ignition is used in or in contact with the vessel, frequent tests shall be made to determine the concentration of combustible vapors. If this concentration exceeds 20 percent of the lower explosive limit of the vapor present, sources of ignition shall be extinguished or removed until such concentration is reduced below 20 percent of the lower explosive limit.

(4) Fire extinguishing equipment adequate to cope with the hazards which may be encountered shall be provided and maintained close at hand.

Note: See Section 5182 for further instruction when working in confined spaces.

NOTE: Authority cited: Section 142.3, Labor Code.

History: 1. New section filed 7-13-78; effective thirtieth day thereafter (Register 78, No. 28).

Article 136. Dip Tanks

5426. Construction of Dip Tanks. Note: Closed system quench tanks of integral quench furnaces are not included in this Article.

(a) Dip tanks, including drain boards if provided, shall be constructed of substantial noncombustible material, and their supports shall be of heavy metal, reinforced concrete or masonry.

Note: Where dip tanks extend through a floor to the story below or where the weakening of the tank supports by fire may result in the tank collapse, supports should be of material having not less than one-hour fire resistance.

(b) Dip tanks of over 150 gallons in capacity or 10 square feet in liquid surface area shall be equipped with a properly trapped overflow pipe leading to a safe location outside buildings. Smaller dip tanks should also be so equipped, where practical. The discharge of the overflow pipe should be so located and arranged that if the entire combustible contents of dip tank is overflowed through overflow pipe by the application of water during fire fighting, property will not be endangered. The size of the overflow pipe should be sufficient to conduct the maximum rate of flow of water expected to be applied to the liquid surface of the dip tank from automatic sprinklers or from other sources in the event of fire.

(c) Overflow pipes shall be of sufficient capacity to overflow the maximum delivery of dip tank liquid fill pipes but shall not be less than 3 inches in diameter and shall be increased in size depending upon the area of the liquid surface and the length and pitch of pipe.

(d) If the liquid surface area of dip tank (and drain board, unless drain board is arranged to positively prevent drainage into dip tank) is 75–150 square feet, diameter of overflow pipe should be not less than 4 inches; if 150–225 square feet, not less than 5 inches; if 225–325 square feet, not less than 6 inches.

(e) On large dip tanks, multiple overflow connections are preferable to a single large pipe, provided the aggregate cross sectional area is equivalent.

(f) Overflow pipes should be connected to dip tanks through a flared outlet where the accumulation of caked or dried material may clog the overflow opening.

(g) Piping connections on drains and overflow lines shall be designed so as to permit ready access for inspection and cleaning of interior.

Rockwell International
Energy Systems Group

SUPPORTING DOCUMENT

GO NO.	S/A NO.	PAGE 1 OF	TOTAL PAGES	REV LTR/CHG NO SEE SUMMARY OF CHG	NUMBER
09479	11000	8	8	Rev. A	079TI000004

PROGRAM TITLE

Solar Central Receiver Power Plant (SCRPP)

DOCUMENT TITLE

Materials of Construction, Carrisa Plains SCRPP

DOCUMENT TYPE	KEY NOUNS
Technical Information	Corrosion, Carburization

ORIGINAL ISSUE DATE	REL. DATE
	4-20-83 RK

PREPARED BY/DATE	DEPT	MAIL ADDR
W. H. Friske 3/16/83	737-730	LB30

IR&D PROGRAM? YES ☐ NO ☐
IF YES, ENTER TPA NO.

APPROVALS	DATE
D. Kramer [signature]	3/16/83

DISTRIBUTION

*	NAME	MAIL ADDR
*	L. Glasgow	LA19
*	T. Ricci	LB26
*	A. Ullman	LA19
*	T. Johnson	LA19
*	D. Nelson	LA19
*	B. Katz	LA19
*	H. Minami	LB30
*	F. Cubillos	LB26
*	D. Kramer	NA02
*	F. Koepenick	NA02
*	A. Carnazzola	LB30

* COMPLETE DOCUMENT
NO ASTERISK, TITLE PAGE/SUMMARY OF CHANGE PAGE ONLY

ABSTRACT

This document addresses two materials - related concerns in the design of the Carrisa Plains (SCRPP), stress corrosion cracking and carburization of austenitic stainless steels. It is concluded that these concerns are not design-limiting. The rationale for this conclusion is presented.

REV	SUMMARY OF CHANGE	APPROVALS AND DATE
A	Editorial changes. Added: 9. Sodium Corrosion	4-19-83 D.F. Atkins for D. Kramer 4.19.83 4-20-83

Internal Letter

Rockwell International

Date: February 2, 1983

No:

TO: (Name, Organization, Internal Address)
L. E. Glasgow
715, 071-LA19

FROM: (Name, Organization, Internal Address, Phone)
W. H. Friske
737, 071-LB30

3261

Subject: Materials of Construction, Carrisa Plains SCRPP

SUMMARY

The purpose of this letter is to address two materials-related concerns in the design of the Carrisa Plains SCRPP, namely: (1) stress-corrosion-cracking and intergranular corrosion of austenitic stainless steel components in the presence of halogen- or caustic-bearing environments and (2) carburization of austenitic stainless steel receiver panel tubes due to carbon transport from the ferritic steel steam generator tubes. I have evaluated these concerns and concluded that, with proper design, materials selection, fabrication, inspection, and maintenance controls, these concerns are not design limiting. The rationale for this conclusion is presented in the following paragraphs.

I. CORROSION

Type 304 stainless steel has been selected for the hot leg piping and storage tanks and Type 316 for the receiver panel tubing and headers. The reliability of these steels has been demonstrated by usage in essentially all sodium heat transport systems in this country and abroad. In a few systems, the stabilized grades of stainless steels (Types 321 or 347) have been used. ESG-designed sodium systems have historically used Type 304, with Type 316 being selected for those components where higher elevated temperature strength was required. ESG sodium systems have included the SRE and Hallam power plants, component test facilities such as the SCTI, SCTL, and SPTF, plus numerous laboratory test loops.

While it is well documented that austenitic stainless steels are susceptible to stress corrosion cracking and intergranular corrosion, component failures due to these corrosion modes have been infrequent in sodium systems. The austenitic stainless steels are highly resistant to corrosion by the sodium. When corrosion failures have occurred, failure analyses have consistently attributed the cause to contamination, primarily chloride or caustic-bearing solutions, from off-design and unforeseen environmental conditions.* Typically, when sodium leaks have been detected, the failure can be traced to such sources as (1) chlorides leached from thermal insulation by exposure to water and then concentrated by alternate wet-dry conditions;

---

*LMEC Memo 71-5, "Sodium Piping and Component Failures of the Large Component Test Loop"

(2) residual halogen-bearing weld fluxes, entrapped in crevices; (3) residual halogenated lubricants or oils used in fabrication or assembly; (4) residual sodium which forms caustic (hydroxide ions) in the presence of moisture; or (5) residuals from chlorinated cleaning solutions. Stainless steel components that are exposed to such contamination are subject to stress-corrosion-cracking if tensile stresses are present (stress-corrosion-cracking does not occur with compressive stresses). Also, the stainless steels are susceptible to intergranular corrosion, in the absence of any stresses, in the sensitized condition (i.e., prior exposure to the temperature range of about 850 to 1500°F). When sensitized, the grain boundaries are depleted of the alloying element chromium; hence, the inherent corrosion resistance is diminished.

Preventative action and controls imposed on the Carrisa Plains SCRPP to minimize the risk of corrosion-related failures in stainless steel components are as follows:

1. Design

The heat transport system will be designed to eliminate crevices and nondrainable areas in the piping and tanks. This will eliminate sites for any corrosive contaminants to collect and concentrate, thus minimizing the risk of stress-corrosion-cracking and intergranular corrosion. Also, there will be no stagnant or residual sodium if the system is drained, thus eliminating the potential for caustic-stress-corrosion-cracking.

2. Materials

All materials for the heat transport system will be procured to code specifications. The stainless steel components will be in the solution annealed condition for maximum corrosion resistance. Grain flow control will assure that any inclusions in the microstructure will be parallel to the pressure boundary. This will prevent penetration of the pressure boundary by sodium corrosion of the inclusion material.

3. Welding

All sodium containment welding will be in accordance with the requirements of the applicable code. All containment welds will be full penetration. This eliminates crevices at the weld joints, which in turn, eliminates potential sites where corrosive contaminants can collect and concentrate.

All welds will be made without a flux. This eliminates one source of halogen contaminants that can cause stress corrosion cracking in the weldment or intergranular corrosion in the sensitized area of the weldment.

Weld procedures, weldors, nondestructive examination procedures, and inspectors will be Code qualified. This imposes a high level of welding expertise and quality assurance in fabrication. Backup plates will not be used in welding. This eliminates potential crevices in welded joints and the potential of corrosion cracking.

4. Cleanness

All materials, components, and subsystems will be cleaned in conformance to cleaning and cleanliness requirements which impose controls on cleaning solutions, water quality, lubricants, corrosion inhibitors, degreasing procedures, cleaning procedures, handling procedures, and assembly testing.

5. Sodium System Heating

Except for the solar panel tubes, the entire sodium containment system will be trace heated to provide the capability of maintaining the sodium in the liquid condition at all times. This trace heating also eliminates alternate wet-dry conditions which can concentrate any corrosive contaminants on the surfaces of the stainless steel.

6. Insulation

Thermal insulation on the heat transport system shall meet the test requirements for thermal insulating materials for use on stainless steels. Insulation materials conforming to this specification will have passed the test for susceptibility to chloride stress-corrosion-cracking.

The insulation on all piping and tanks will be weatherproofed. This will prevent moisture, rain, etc., from contacting the insulation and subsequently leaching out any trace chloride or other corrosive contaminants which could be deposited on the stainless steel. Even in the event of rupture of the weatherproofing, any water leaching would not promote corrosion because the trace heating prevents alternate wet-dry chloride concentration from occurring.

7. Sodium Removal

As mentioned, the design and fabrication will preclude nondrainable areas and crevices in the sodium containment where possible. This means that sodium can be drained from the sodium lines without entrapment of residual sodium. It is this residual sodium, if it is eventually exposed to moisture to form sodium hydroxide, that can promote caustic stress-corrosion-cracking.

8. Receiver Panels

The Type 316 stainless steel tubes of the receiver panel will be exposed to the weather and subjected to daily thermal cycles between ambient and the 600-1050°F temperature range with concomitant draining of the sodium from the panel. In the lower half of the panel, where the temperature does not exceed about 850°F, the tube material will retain its inherent resistance to corrosion since it remains in the solution-annealed condition. In the upper section of the panel, the material will become sensitized during exposure to temperatures above 850°F. When sensitized, stainless steels are susceptible to intergranular stress-corrosion-cracking, in the presence of tensile stresses and to intergranular corrosion, even in the absence of stresses.

In the case of these receiver tubes, the only credible source of contamination is from airborne sodium chlorides which could conceivably be concentrated by the alternate condensation of moisture after cooldown and the evaporation of the condensed moisture upon heatup. Even with the unlikely assumption that the tubes do become chloride contaminated, stress corrosion cracking is not probable since (1) the stresses during initial stages of heatup will be too low (i.e., below the threshold level for stress-corrosion-cracking to occur) and (2) as the temperature increases, the moisture will evaporate and the contamination will not be in the prerequisite ion form. Similarly, intergranular corrosion is expected to be limited to surface effects which would not effect life or performance significantly. This is supported by the absence of intergranular corrosion on the ESG test panel which was exposed to the environment in the recent test at White Sands.

The headers of the receiver panel, including the tube-to-header welds, will be trace heated, insulated, and weatherproofed; therefore, they will not be susceptible to this corrosion.

It is recognized that the welded junctions between the tubes and the supporting tangs could serve as crevices. The final design of this attachment will provide some means for drainage of water or moisture from this area to prevent accumulation of contaminants that could cause stress corrosion cracking.

9. Sodium Corrosion

At the hot leg design temperature of 1050°F, the maximum sodium corrosion rate for stainless steel is about 0.032 mils per year per ppm of oxygen. Accordingly, the expected sodium corrosion at various sodium plugging temperatures is as follows (data source: TID 26666).

Plugging Temperature (°F)	Oxygen (ppm)	Corrosion	
		(mpy)	mils in 30 years*
350	6	0.186	1.86
400	12	0.372	3.72
450	24	0.744	7.44

*Assume 0.33 plant factor

Assuming that the plugging temperature does not exceed 450°F, the maximum reduction of wall thickness will be 7.5 mils during the 30-year plant life. In the case of the receiver panel tubes, this is less than 15 percent of the original wall thickness of 49 mils.

Sodium corrosion of 2-1/4 Cr - 1 Mo is of the same magnitude. In the case of steam generator tubes (109 mil wall), the maximum wall thickness reduction due to corrosion in 1050°F sodium will be less than 7 percent during the plant life. Sodium corrosion in the cold leg, design temperature of 610°F, is negligible for stainless steel, 2-1/4 Cr - 1 Mo, or carbon steel.

II. CARBURIZATION

The material of construction for the steam generator is 2-1/4 Cr - 1 Mo steel. Liquid sodium acts as a carbon transport medium, transferring carbon from the 2-1/4 Cr - 1 Mo ferritic steel (the source of the carbon) to the higher temperature Type 316 stainless steel of the receiver panel (the sink for carbon). The concern is whether the carbon diffusing into the tubes (carburization) will produce a brittle surface that might crack under stress and lead to failure of the tube.

In an analysis of decarburization-carburization kinetics for the Modular Steam Generator (MSG),* it was concluded that the maximum carbon level on the stainless steel tubes of the intermediate heat exchanger would be 0.64% in about 150,000 hours of service, assuming all carburization occurred in a uniform temperature gradient of 800°F to 1050°F. After this time, the carbon level would decrease as it diffused into the bulk thickness of the tubes. It was concluded that (1) the carbon increase due to carburization would not limit the performance of the material by embrittlement and (2) there would be a small increase in strength that would actually improve the design margin of the Code-allowable stresses. The carburization-decarburization kinetics have also been extensively evaluated in the CRBRP programs with the same general conclusions. However, the service temperatures were lower than for the MSG.

In the Carrisa Plains SCRPP, the temperature of the 316 stainless steel tubes will be higher (1050°F), thus the diffusion rate of the carbon into the material will also be higher than for other systems. However, the tubes are not at temperature continuously. The receiver tubes are also subjected to thermal stresses due to temperature gradients and to thermal shock when drained of sodium.

An analysis of the carburization kinetics specific to SCRPP conditions was beyond the scope of this paper. However, it is believed that the potential for embrittlement of the receiver panel tubes due to carburization is not significantly different than for the MSG and is therefore not design limiting.

---

*TI-095-33-072, "Carbon Transfer - Croloy Steam Generator to Type 304 Stainless Steel IHX," W. J. Anderson, July 11, 1968

W. H. Friske
Materials and Producibility

0086G/kld

cc: A. Ullman, T. Johnson, B. Katz, D. Kramer , F. Koepenick,
H. Minami, W. Castle, W. Lee, A. Pard

Rockwell International
Energy Systems Group

SUPPORTING DOCUMENT

GO NO.	S/A NO.	PAGE 1 OF	TOTAL PAGES	REV LTR/CHG NO SEE SUMMARY OF CHG	NUMBER
09479	13400	255	255	NC	079TI000008

PROGRAM TITLE

Preliminary Design of Heat Transport Loop - Carrisa Plains - Unit 1

DOCUMENT TITLE

Preliminary Piping Stress Report
Carrisa Plains - Unit 1 Solar Power Plant

DOCUMENT TYPE

Technical Information

KEY NOUNS

Sodium Piping, Stress
Steam Piping, Solar Power

ORIGINAL ISSUE DATE

REL. DATE 4-29-83 RK

APPROVALS K. R. Jaquay — DATE 4-29-83

PREPARED BY/DATE	DEPT	MAIL ADDR
K. C. Gursahani	731	LB30

IR&D PROGRAM? YES ☐ NO ☒
IF YES, ENTER TPA NO.

DISTRIBUTION

*	NAME	MAIL ADDR
	T. L. Anderson	LB26
*	W. Castle	LB30
	F. Cubillos	LB26
	L. E. Glasgow	LA19
*	K. R. Jaquay	LB30
	B. Katz	LA19
*	J. Moldenhauer	LB30
	D. K. Nelson	LA19
*	T. Springer	LA24
	A. Z. Ullman	LA29
*	W. Veljovich	LB30

5332F/jjs

* COMPLETE DOCUMENT
NO ASTERISK, TITLE PAGE/SUMMARY OF CHANGE PAGE ONLY

ABSTRACT

The piping used in the heat transport system of Carrisa Plains Solar Power Plant is analyzed in accordance with the rules of Power Piping Code ANSI B31.1, 1980 Edition.

This report documents the preliminary analyses and calculations performed that show that the piping has enough thermal flexibility and the stress levels are below the Code allowable values.

RESERVED FOR PROPRIETARY/LEGAL NOTICES

FORM 734-C REV. 12-79

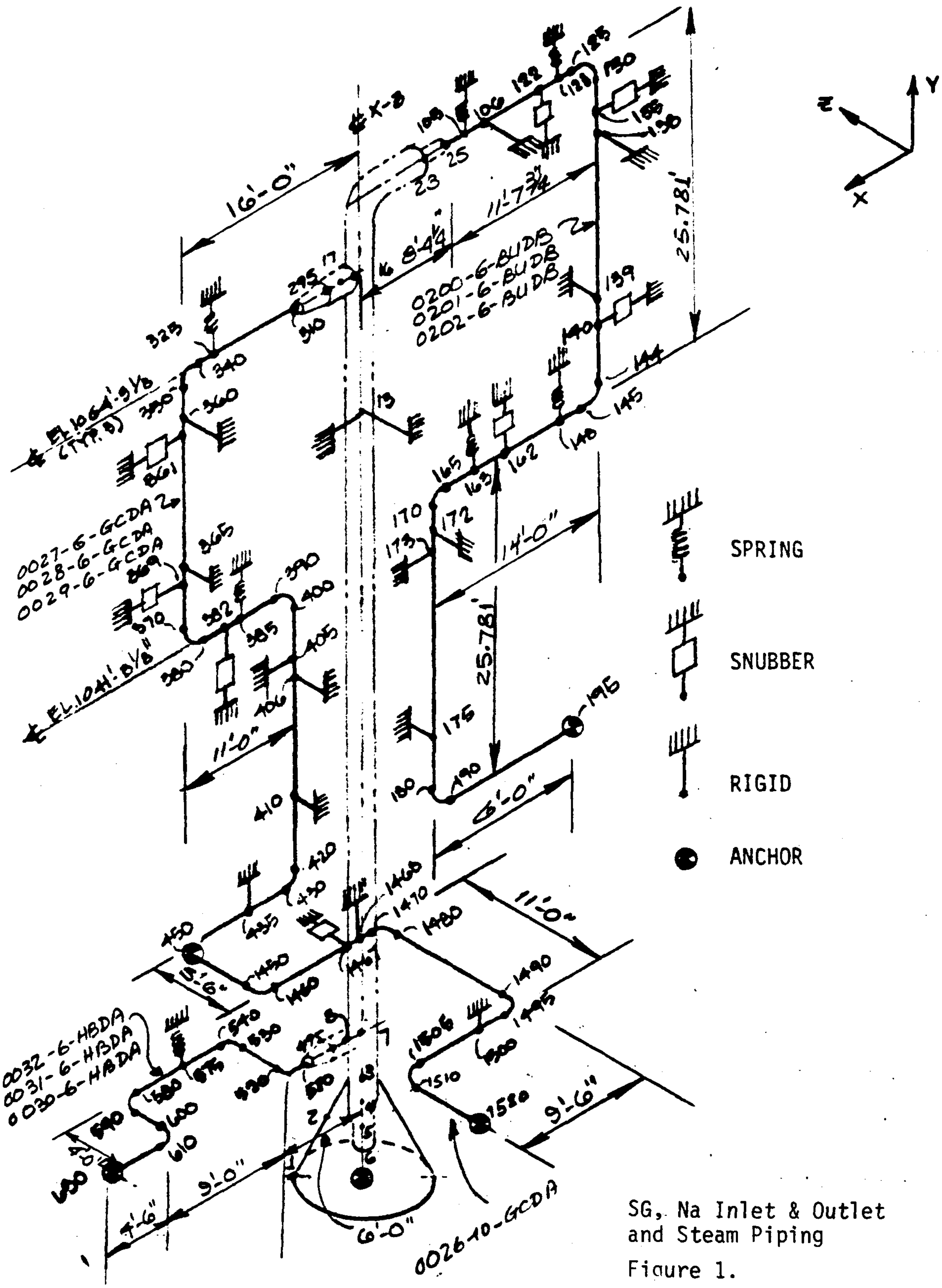
CONTENTS

1.0 INTRODUCTION

This report contains the preliminary stress analyses results of the sodium and the main steam piping for Carrisa Plains Solar Unit 1. With the exception of sodium inlet and outlet lines to the steam generator, all the sodium lines within the scope of this report were analyzed for thermal flexibility only. For these lines, the rest of the loading conditions will be analyzed in the next phase of the project. The main steam line, sodium inlet and outlet lines to the steam generator were analyzed for deadweight, thermal, seismic, and wind loading conditions. All the lines were analyzed to meet the stress requirements of ANSI B31.1, 1980 Edition.

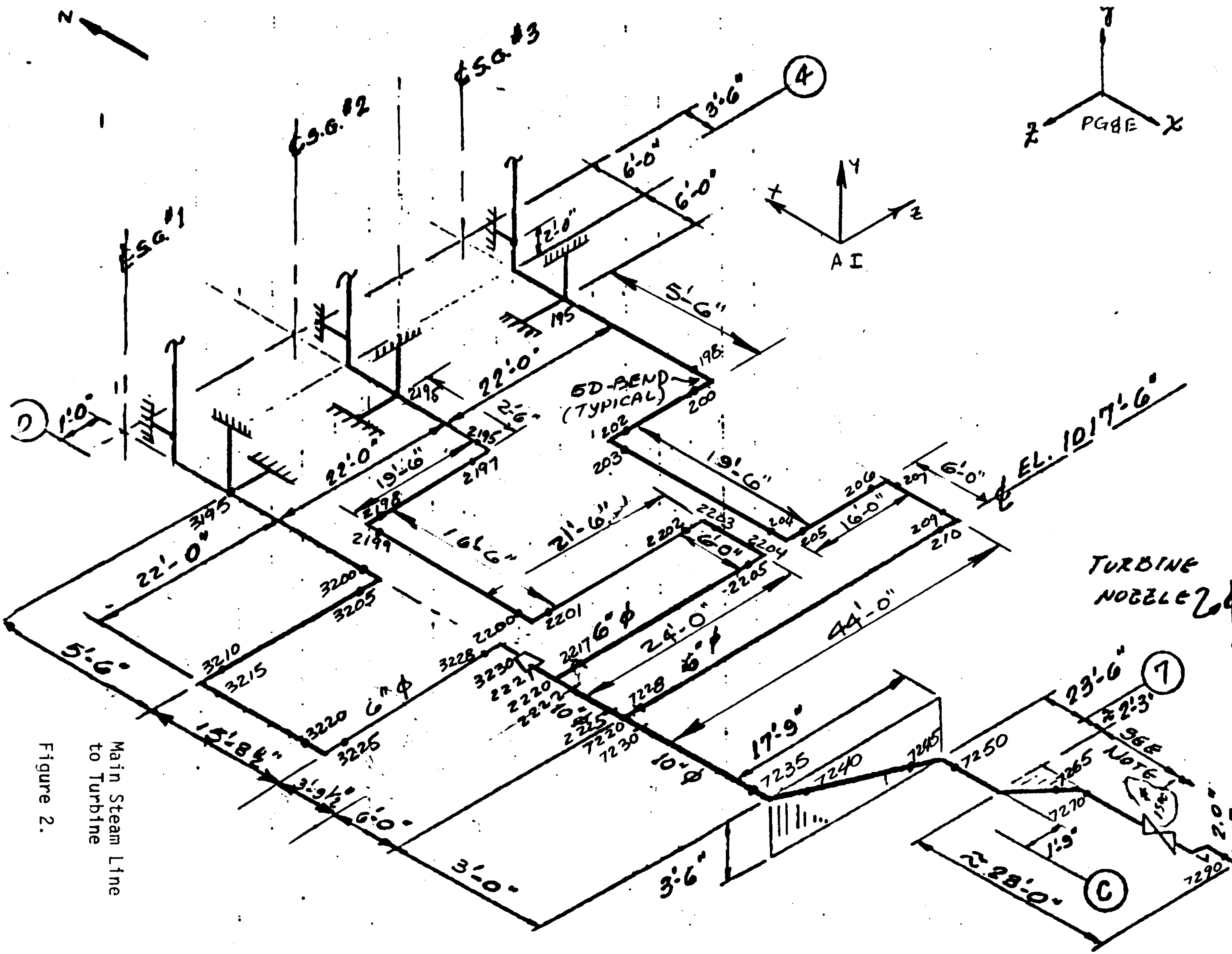
2.0 SUMMARY

Piping shown in Figures 1 through 8 were analyzed. The maximum stresses from the analyses are summarized in Tables 1 through 5. Detailed input and computer results are included in Appendices 6.1 through 6.6. Analysis of lower manifold piping shown in Figure 6 are included with the analysis of the upper manifold piping shown in Figure 5.



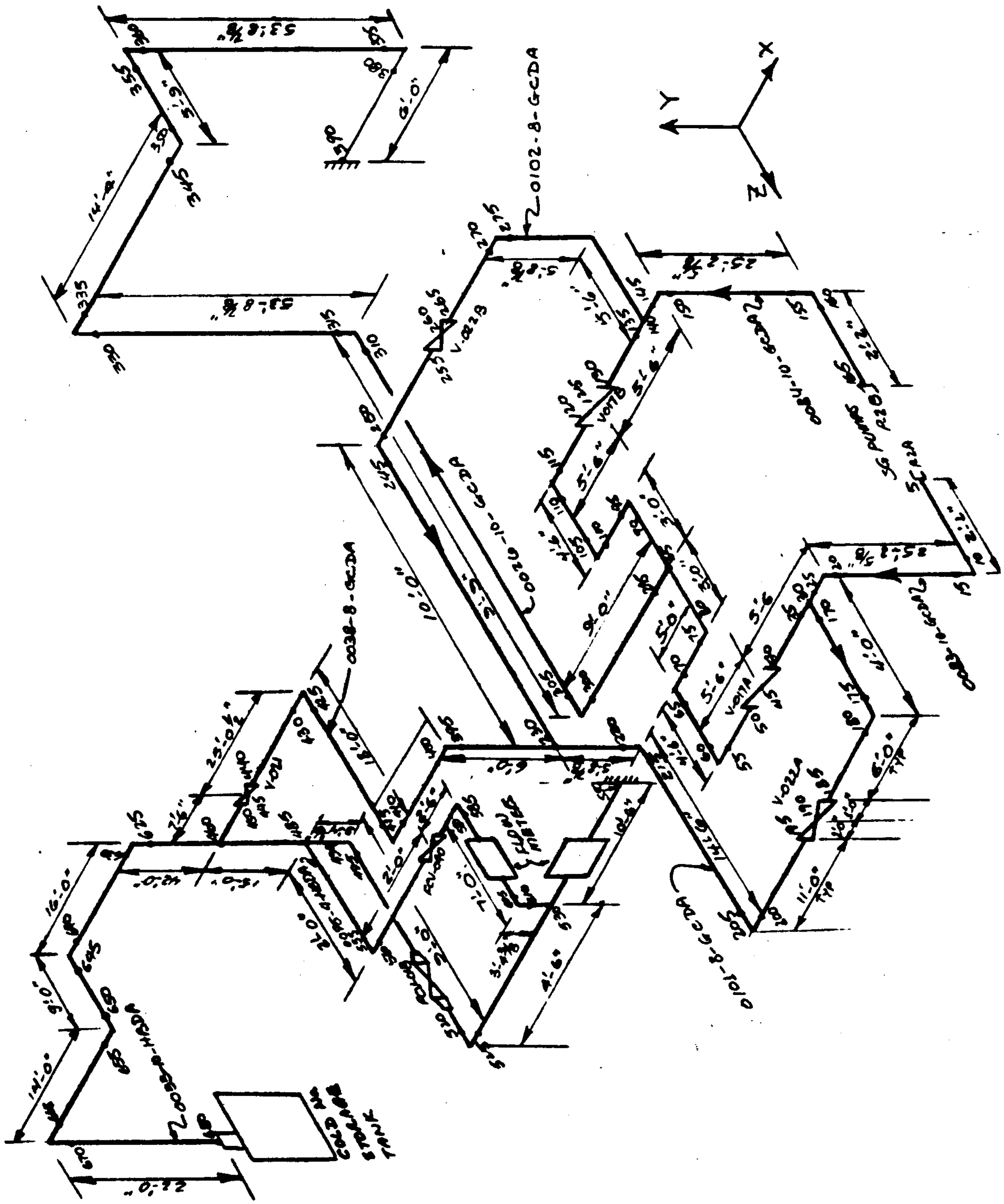
SG, Na Inlet & Outlet
and Steam Piping

Figure 1.

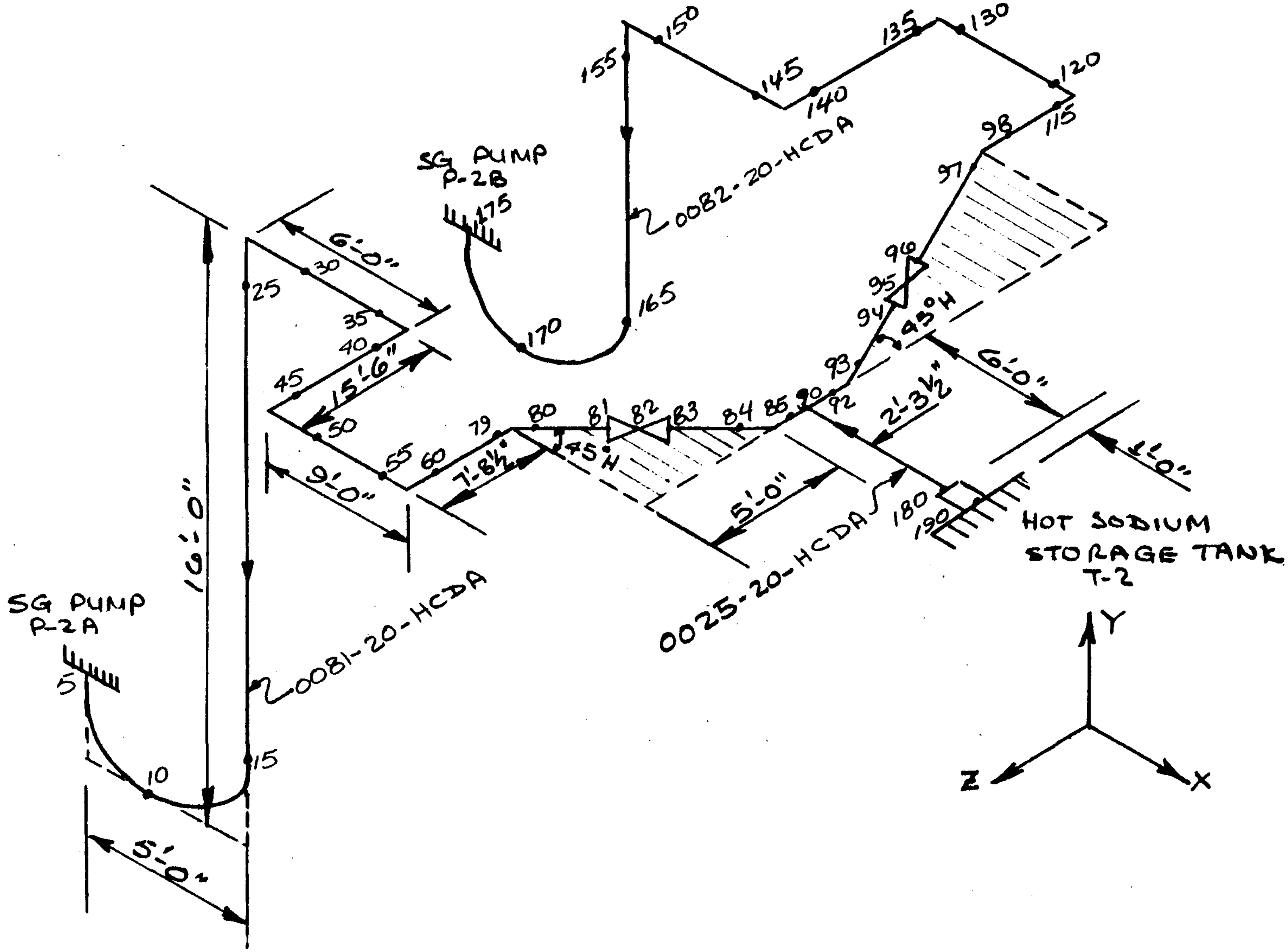


Main Steam Line to Turbine

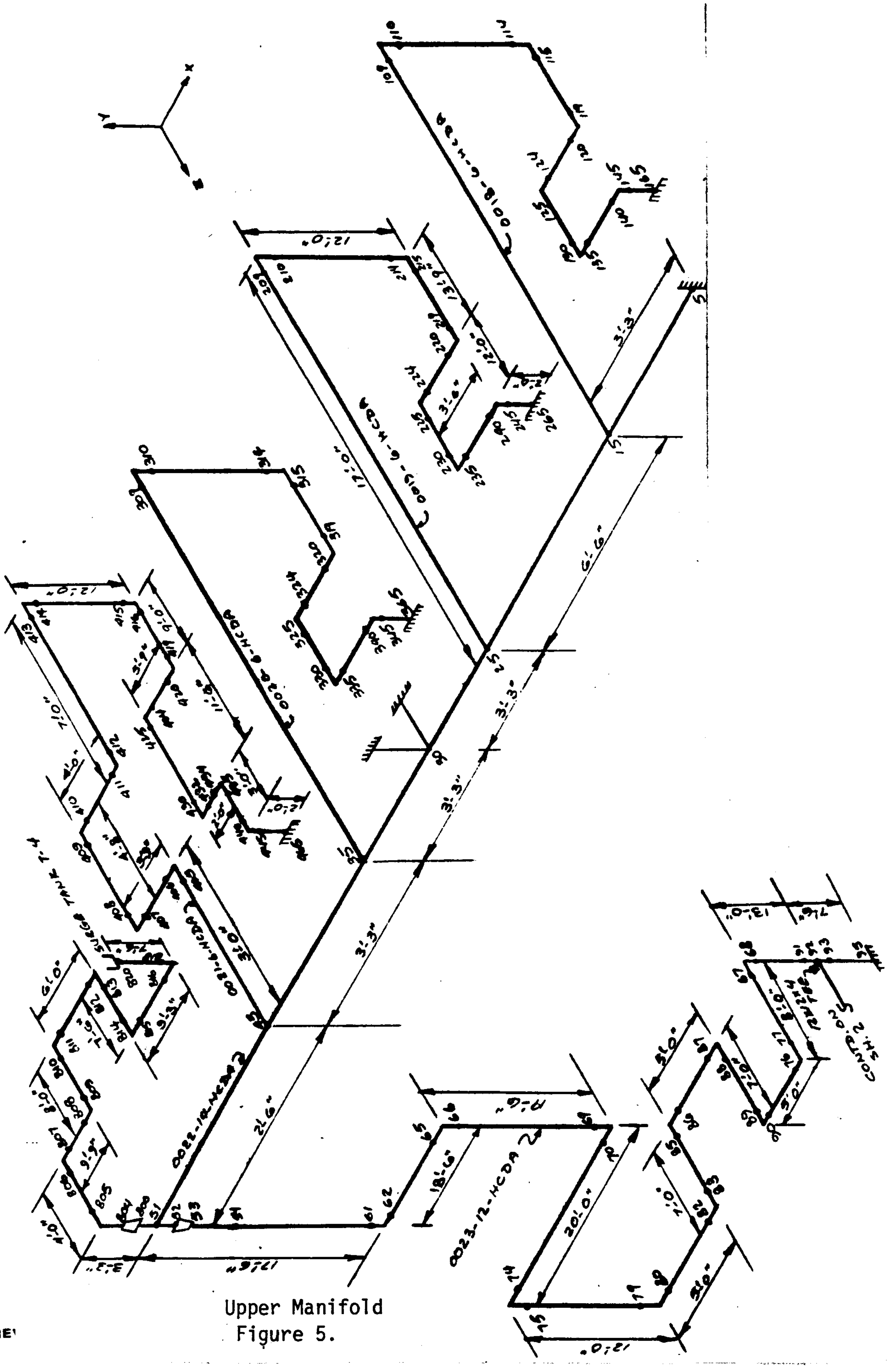
Figure 2.



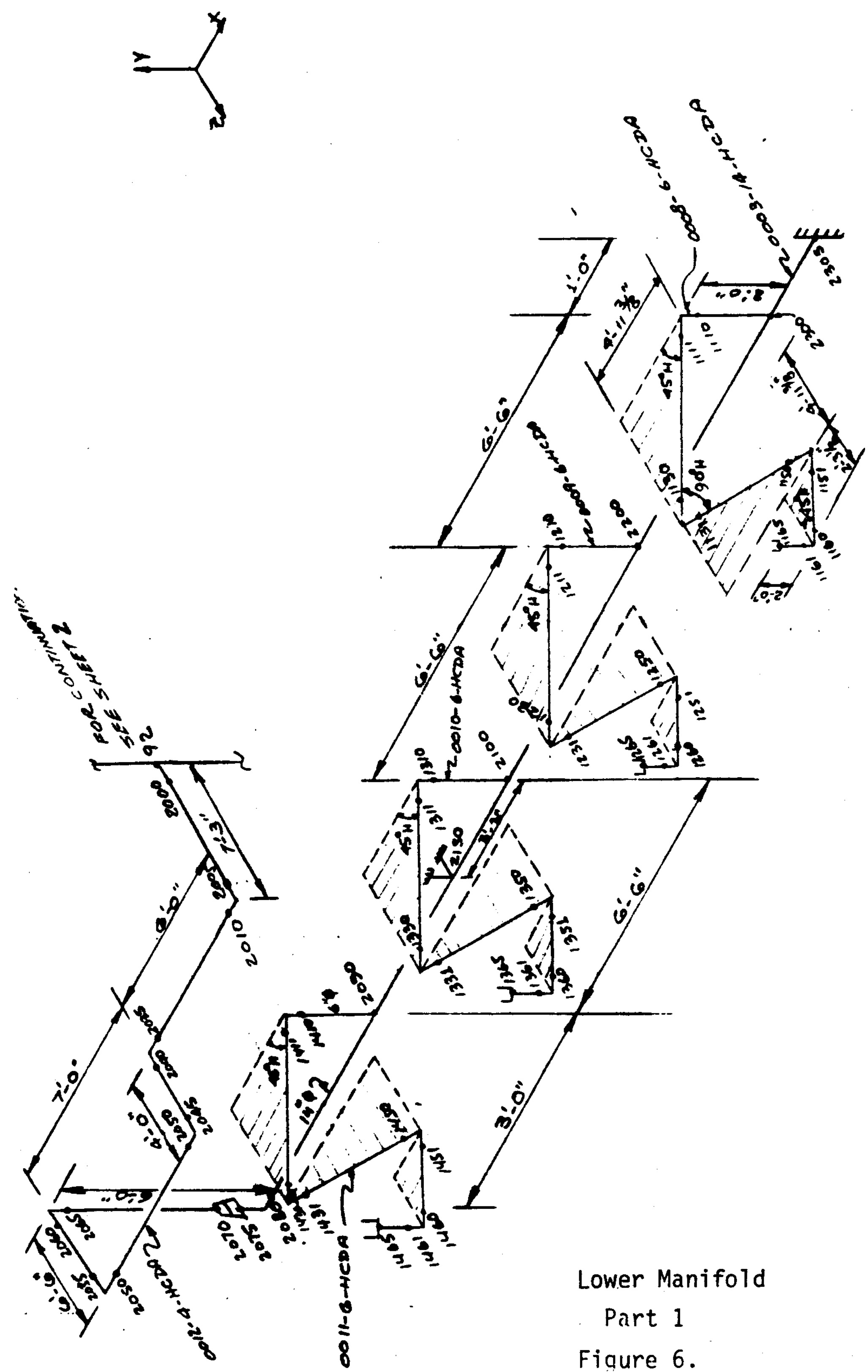
S.G. Pump Discharge
Figure 3.



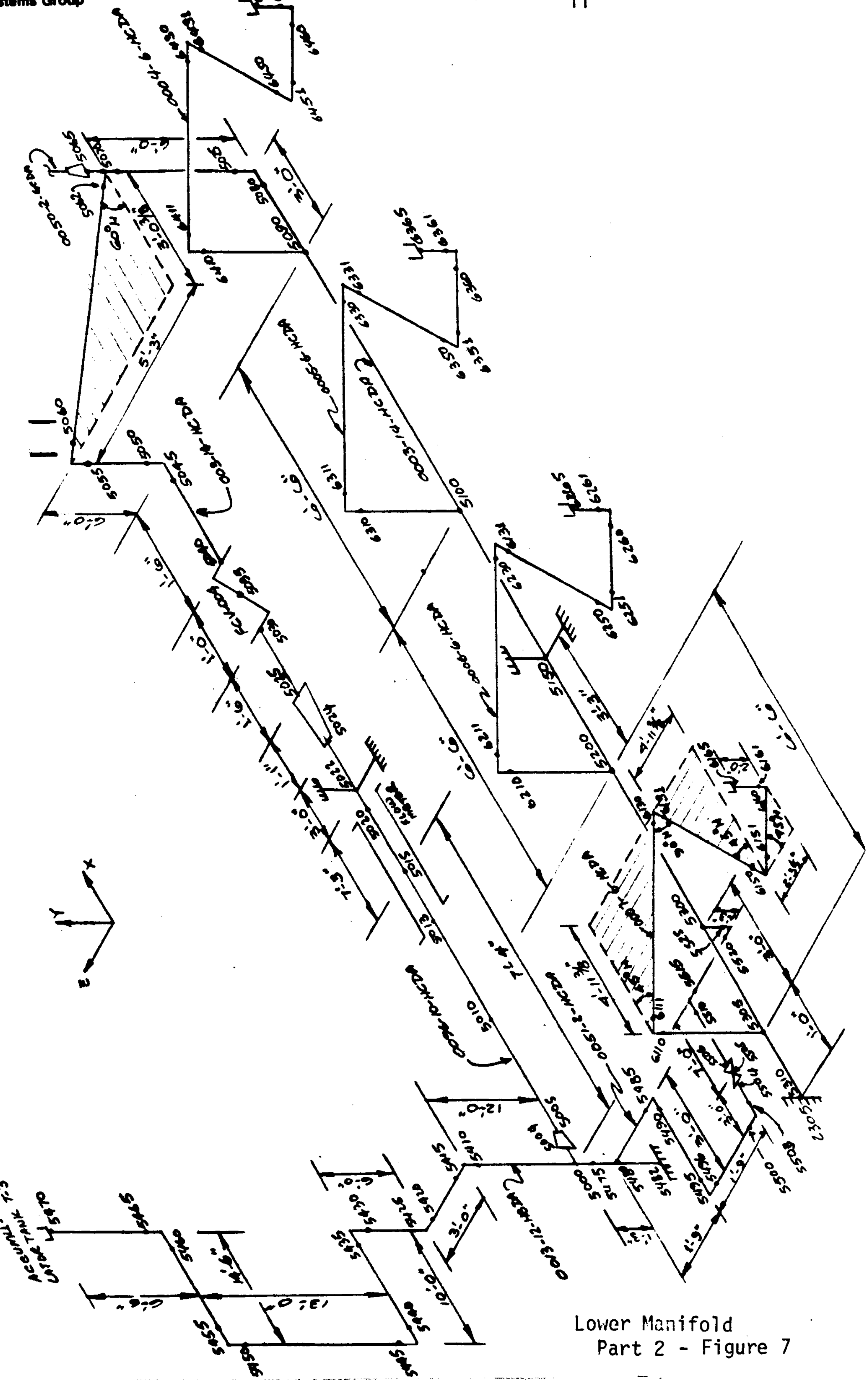
S.G. Pump Suction
Figure 4.



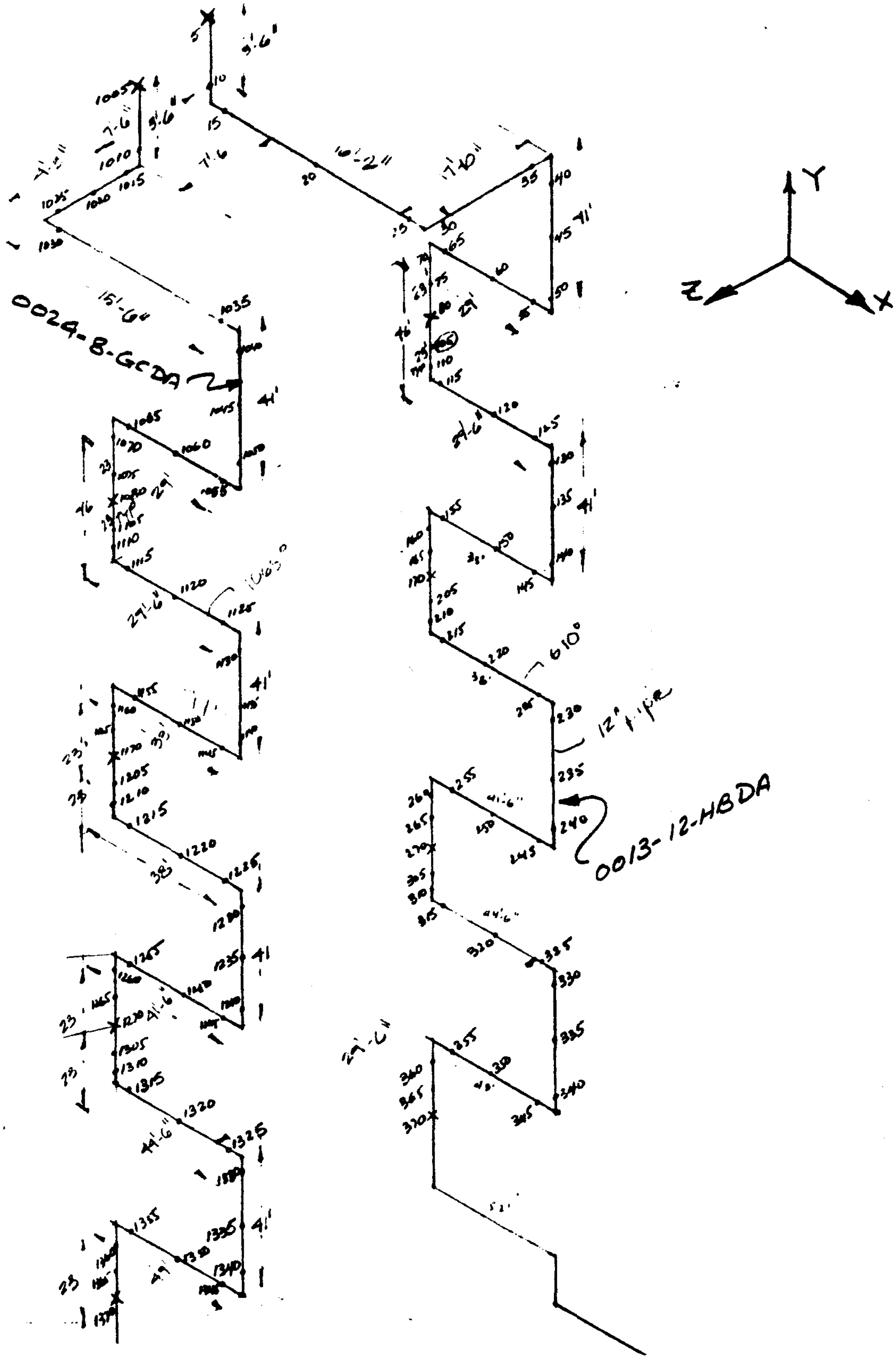
Upper Manifold
Figure 5.



Lower Manifold
Part 1
Figure 6.



Lower Manifold
Part 2 - Figure 7



Sodium Piping in Tower
Figure 8.

TABLE 1
SODIUM OUTLET PIPING
(FIGURE 1)

	Stress Due To Sustained Loads Dead wt + P + 30 mph Wind Eq. 11	Stress Due To Occasional Loads Eq. 12		Thermal Expansion Stress Eq. 13	Sustained Plus Thermal Expansion Stress Eq. 14
		Dead wt + P + OBE + 30 mph Wind	Dead wt + P + 90 mph Wind		
Component	6 in. Elbow	6 in. Elbow	6 in. Pipe Anchor	6 in. Elbow	6 in. Elbow
Node Point	510	510	630	510	510
Stress Intensification Factor	2.267	2.267	1.0	2.267	2.267
Calculated Stress	1,802 psi	2,955 psi	3,984 psi	21,029 psi	22,831 psi
Allowable Stress	15,000 psi	18,000 psi	18,000 psi	20,250 psi	35,250 psi
Damage Fraction = $\frac{\text{Calculated}}{\text{Allowable}}$	0.12	0.16	0.22	1.04*	0.65

5332F/kld

* Not needed to be less than unity if Eq 14. damage fraction less than unity

TABLE 2

SODIUM INLET PIPING

(FIGURE 1)

	Stress Due To Sustained Loads Dead wt + P + 30 mph Wind Eq. 11	Stress Due To Occasional Loads Eq. 12		Thermal Expansion Stress Eq. 13	Sustained Plus Thermal Expansion Stress Eq. 14
		Dead wt + P + OBE + 30 mph Wind	Dead wt + P + 90 mph Wind		
Component	6 in. Straight Pipe	6 in. Straight Pipe	6 in. Straight Pipe	12 in. x 6 in. Reducer	12 in. x 6 in. Reducer
Node Point	335	335	335	295	295
Stress Intensification Factor	1.0	1.0	1.0	2.0	2.0
Calculated Stress	7,047 psi	8,176 psi	9,514 psi	11,010 psi	14,171 psi
Allowable Stress	12,400 psi	14,880 psi	18,480 psi	23,800 psi	36,200 psi
Damage Fraction = $\frac{\text{Calculated}}{\text{Allowable}}$	0.57	0.55	0.51	0.46	0.39

5332F/kld

TABLE 3

STEAM LINE

(FIGURE 1)

	Stress Due To Sustained Loads Dead wt + P + 30 mph Wind Eq. 11	Stress Due To Occasional Loads Eq. 12		Thermal Expansion Stress Eq. 13	Sustained Plus Thermal Expansion Stress Eq. 14
		Dead wt + P + OBE + 30 mph Wind	Dead wt + P + 90 mph Wind		
Component	Butt Weld 6 in. Pipe	Butt Weld 6 in. Pipe	Straight Pipe Pipe 6 in.	Butt Weld 6 in. Pipe	Butt Weld 6 in. Pipe
Node Point	23	23	173	23	23
Stress Intensification Factor	1.0	1.0	1.0	1.0	1.0
Calculated Stress	5,108 psi	5,775 psi	6,994 psi	9,468 psi	14,577 psi
Allowable Stress	7,500 psi	9,000 psi	17,280 psi	18,560 psi	26,060 psi
Damage Fraction = $\frac{\text{Calculated}}{\text{Allowable}}$	0.68	0.64	0.40	0.51	0.56

5332F/kld

TABLE 4

Na INLET PIPING HEADER

(FIGURE 1)

	Stress Due To Sustained Loads Dead wt + P + 30 mph Wind Eq. 11	Stress Due To Occasional Loads Eq. 12: Dead wt + P + OBE + 30 mph Wind	Stress Due To Occasional Loads Eq. 12: Dead wt + P + 90 mph Wind	Thermal Expansion Stress Eq. 13	Sustained Plus Thermal Expansion Stress Eq. 14
Component	6 in. Pipe Anchor	6 in. Pipe Anchor	6 in. Pipe Anchor	6 in. Elbow	6 in. Elbow
Node Point	450	450	450	1450 & 1510	1490
Stress Intensification Factor	1.0	1.0	1.0	2.606	2.606
Calculated Stress	2,367 psi	4,299 psi	5,736 psi	20,994 psi	22,042 psi
Allowable Stress	12,400 psi	14,880 psi	18,480 psi	23,800 psi	36,200 psi
Damage Fraction = $\frac{\text{Calculated}}{\text{Allowable}}$	0.19	0.29	0.31	0.88	0.61

5332F/kld

TABLE 5

MAXIMUM THERMAL STRESSES

Line Description	Component	Node Point	Stress Intensification Factor	Thermal Expansion Stress Eq. 13: Calculated	Thermal Expansion Stress Eq. 13: Allowable	Damage: Calculated/Allowable
Steam Gen. Pump Suction Loop	20 in. Elbow	50 and 130 Figure 4	3.768	22,303 psi	23,800 psi	0.94
Steam Gen. Pump Discharge Loop	4 in. Elbow	585 Figure 3	1.953	10,536 psi	22,500 psi	0.47
Sodium Outlet From Receiver (Upper Manifold)	6 in. Elblow	315 Figure 5	2.267	23,966 psi	25,575 psi	0.94
Sodium Inlet to Receiver (Lower Manifold)	6 in. Elbow	6130 Figure 7	2.267	24,026 psi	26,215 psi	0.92
Sodium Piping in Tower	8 in. Elbow	1050 Figure 8	2.440	18,249	25,575 psi	0.71
Main Steam Line	6 in. Pipe	3195 Figure 2	1.0	17,861 psi	18,560 psi	0.96

5332F/kld

Note: Page left intentionally blank.

3.0 DISCUSSIONS

The main steam line and the sodium inlet and outlet lines to the steam generator are shown in Figures 1 and 2. The lines shown in Figure 1 were analyzed for deadweight, thermal, seismic, and wind loading conditions. The routings shown are typical for three steam generators. Although Figure 1 shows steam lines anchored at node point 195 and was modeled as such in the analysis, it was subsequently replaced by a guide at node 195 and a support in the third direction at node 178. Figure 2 shows the routing between these virtual anchors for three steam generators and the steam turbine.

In order to validate the runs made according to Figure 1, the following procedure was used:

A thermal run was made for the steam generator model only (with no connected piping) in order to determine the thermal growth of the steam nozzle (node point 23). Next three steam lines shown on Figure 2 were extended to SG nozzles and anchored. Thermal movements obtained from Run 1 were imposed on each nozzle. Runs were made for different thermal modes to determine the degree of thermal coupling of three steam generators. The forces and the moments at the SG nozzles showed little change when one of the other steam generators was shut down. This led to the conclusion that the three steam generators were not thermally interconnected and that analyses done as per Figure 1 was valid.

Thermal flexibility of the steam piping shown in Figure 2 was checked by analysis with the node points 195, 2195, and 3195 anchored.

Calculations for wind loading are included in Appendix 6.1. For all piping shown in Figures 1 through 8, stress identification factor of 1.0 was used at the girth butt weld if the pipe weld thickness exceeded 3/16 in. This meets the Code requirement since Reference 2 restricts the δ/t value specified in Code to ≤ 0.1.

4.0 CONCLUSION

On the basis of the analyses performed, it is concluded that all the sodium and steam piping shown in Figures 1 through 8 have adequate thermal flexibility and the stresses are below allowable limits as per the requirements of the Code.

5.0 REFERENCES

1.0 Power Piping ANSI B31.1 - 1980 Edition

2.0 Design Specification - Solar Central Receiver Power Plant Carrisa Plains, Unit 1

3.0 Carrisa Plains - Unit 1, Main Heat Transport Systems P&ID 079R000029

4.0 American National Standard Code For Minimum Design Loads in Buildings and other structures, ANSI A58.1-1972 Edition, American National Standard Institute, Inc., 1430 Broadway New York, N.Y. 10018

APPENDIX 6.1
INPUT AND OUTPUT DATA FOR NA INLET AND OUTLET LINES TO SG AND MAIN STEAM PIPING

PREPARED BY: KCG	Rockwell International Energy Systems Group	23 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
DATE: 4-4-83		MODEL NO.

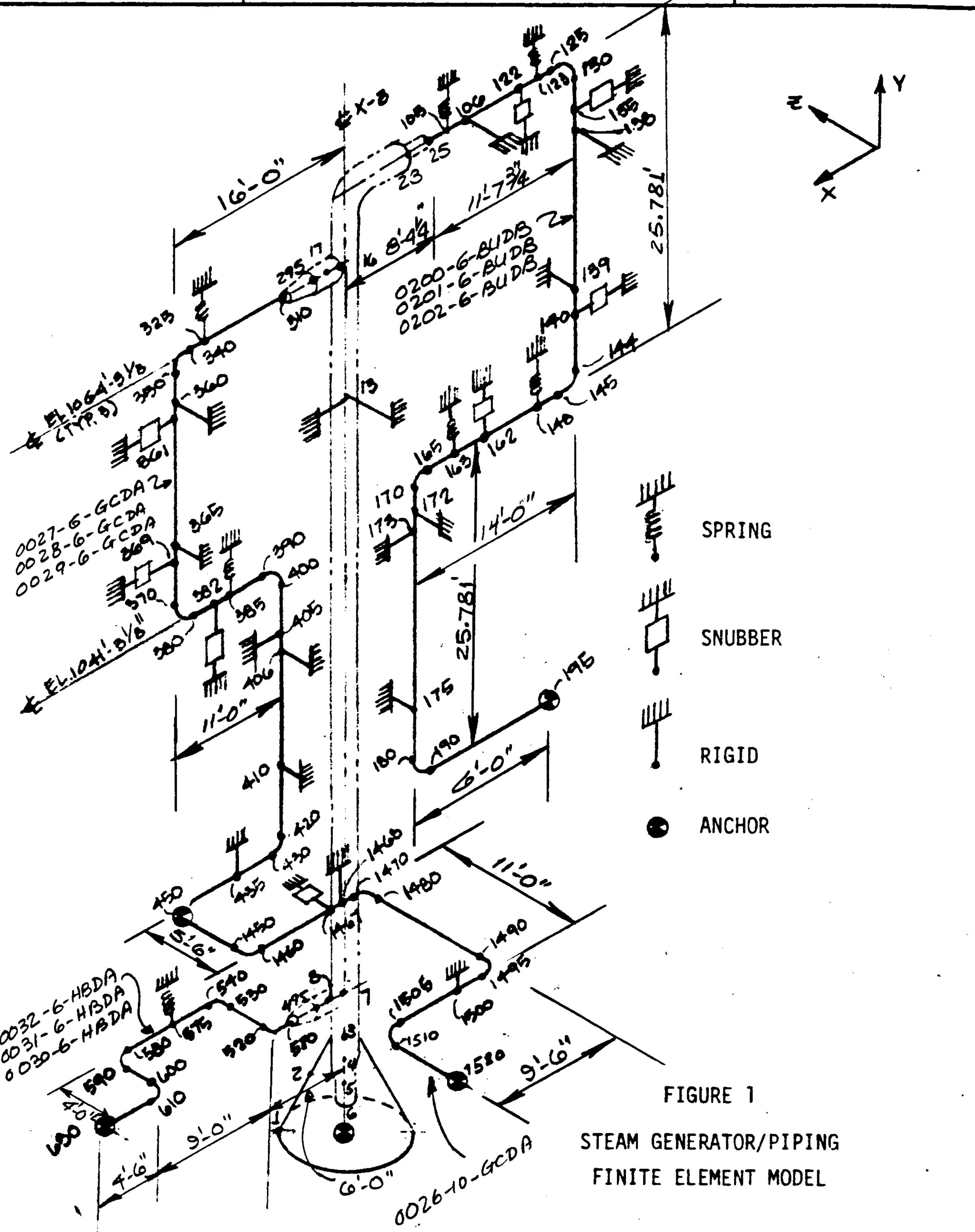


FIGURE 1

STEAM GENERATOR/PIPING

FINITE ELEMENT MODEL

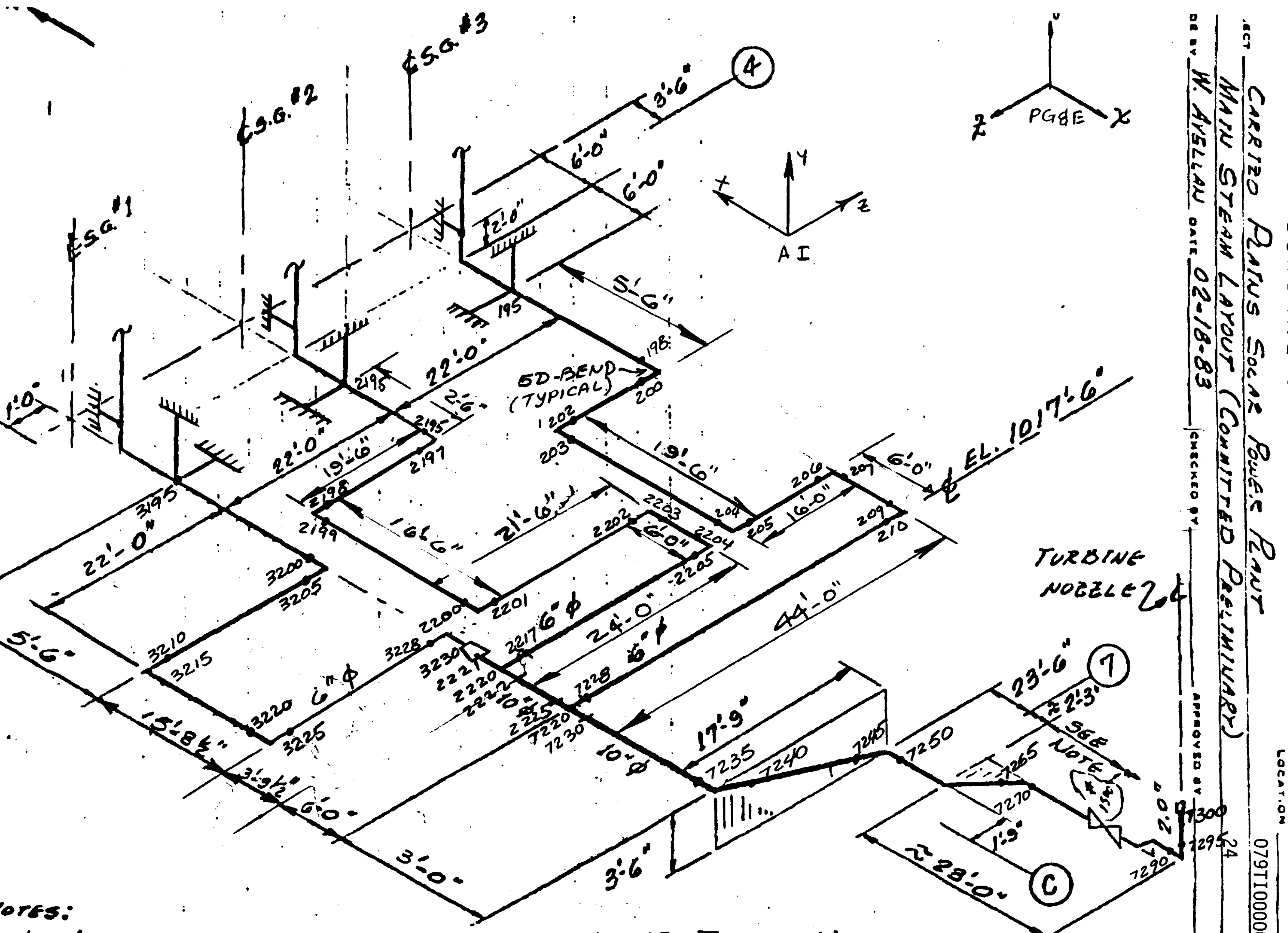


FIGURE 2

NOTES:

1. SEE DWG. 511706, REV. 04, FOR PIPE ROUTING TO TURBINE NOZZLE

PREPARED BY: KCh	Rockwell International Energy Systems Group	25 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
DATE: 2-8-83		MODEL NO.

TABLE B-1
INPUT DATA

SYSTEM	STEAM LINE	REFERENCE		
		NO.	REV.	PAGE
Line Number	0200-6-BUDB 0201-6-BUDB 0202-6-BUDB			
Design Temperature	1015°F			
Design Pressure	1575 psig			
Normal Operating Temperature	1003 °F			
Normal operating Pressure	1500 psig			
Pipe O.D./schedule	6.625 / XXS			
Pipe Thickness	0.864"			
Pipe Material	2¼ Cr - 1 Mo			
Insulation Type				
Weight of Pipe LBS/Ft	53.16			
weight of contents Lbs/ft	8.17			
Weight of Insulation Lbs/ft	24.2			
Total Weight Lbs/ft	85.5			
E_c	29.9			
Seismic Category	II			

TABLE B-1

INPUT DATA

SYSTEM		REFERENCE		
		NO.	REV.	PAGE
Line Number	Na Outlet Header			
Design Temperature	610°F			
Design Pressure	65 psi			
Normal Operating Temperature	610°F			
Normal operating Pressure	65 psi			
Pipe O.D./schedule	12.75/sch.40S			
Pipe Thickness	0.375"			
Pipe Material	C.S. 106			
Insulation Type	Cal. Silicate 6" thick			
Weight of Pipe Lbs/Ft	49.56			
weight of contents Lbs/ft	49 X .91 = 44.6			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(24.75^2-12.75^2)\times\frac{14}{144}$ = 34.4			
Total Weight Lbs/ft	128.5			
E_e	27.9			
Seismic Category	I			

PREPARED BY: KCG	Rockwell International Energy Systems Group	27 PAGE NO OF
CHECKED BY:		079TI000008 REPORT NO
DATE: 2-8-83		MODEL NO

TABLE B-1
INPUT DATA

SYSTEM	Na Outlet from Steam Generator	REFERENCE NO.	REFERENCE REV.	REFERENCE PAGE
Line Number	0030, 0031 & 0032 - 6 - HBDA			
Design Temperature	610°F			
Design Pressure	65 psi			
Normal Operating Temperature	610°F			
Normal Operating Pressure	65 psi			
Pipe O.D./schedule	6.625 / sch 40			
Pipe Thickness	.28"			
Pipe Material	CS L06			
Insulation Type	Cal Silicate 6" thick			
Weight of Pipe Lbs/Ft	18.97			
Weight of Contents Lbs/ft	11.26			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(18.625^2 - 6.625^2) \times \frac{14}{144}$ = 23.14			
Total Weight Lbs/ft	53.4 #/ft			
E_c	28.3×10^6			
Seismic Category	III			

PREPARED BY: KCS	Rockwell International Energy Systems Group	PAGE NO. 28 OF
CHECKED BY:		REPORT NO. 079TI000008
DATE: 2-3-83		MODEL NO.

TABLE B-1
INPUT DATA

SYSTEM	Na Inlet Header to S. G	REFERENCE		
		NO.	REV.	PAGE
Line Number	0026-10-GEDA			
Design Temperature	1065°F			
Design Pressure	65 psi			
Normal operating Temperature	1050°F			
Normal operating Pressure	65 psi			
Pipe O.D.x/schedule	10.75"/sch. 40			
Pipe Thickness x	0.365"			
Pipe Material	SS 316			
Insulation Type	12" thick Cal. Silicate			
Weight of Pipe LBS/Ft	40.48			
weight of contents Lbs/ft	.9 (34.1) = 30.69			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(34.75^2-10.75^2)\times\frac{14}{144}=83.38$			
Total Weight x Lbs/ft	154.6 lbs/ft			
E_e x	28.3			
Seismic Category	II			

PREPARED BY: KCG	Rockwell International Energy Systems Group	PAGE NO 29 OF
CHECKED BY:		REPORT NO 079TI000008
DATE: 2-8-83		MODEL NO

TABLE B-1

INPUT DATA

SYSTEM	Na Inlet to Steam Generator	REFERENCE NO.	REFERENCE REV.	REFERENCE PAGE
Line Number	0027, 0028 & 0029 - 6 - GCDA			
Design Temperature	1055°F			
Design Pressure	65 psi			
Normal operating Temperature	1050°F			
Normal operating Pressure	65 psi			
Pipe O.D./schedule	6.625 / sch. 40			
Pipe Thickness	.28"			
Pipe Material	SS 316			
Insulation Type	Calcium Silicate 12" thick			
Weight of Pipe Lbs/Ft	18.97			
Weight of Contents Lbs/ft	.9×12.51 = 11.26			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}\frac{(30.625^2 - 6.625^2)\times 14}{144} = 68.3$			
Total Weight Lbs/ft	98.5 lbs/ft			
E_c	28.3×10^6			
Seismic Category	III			

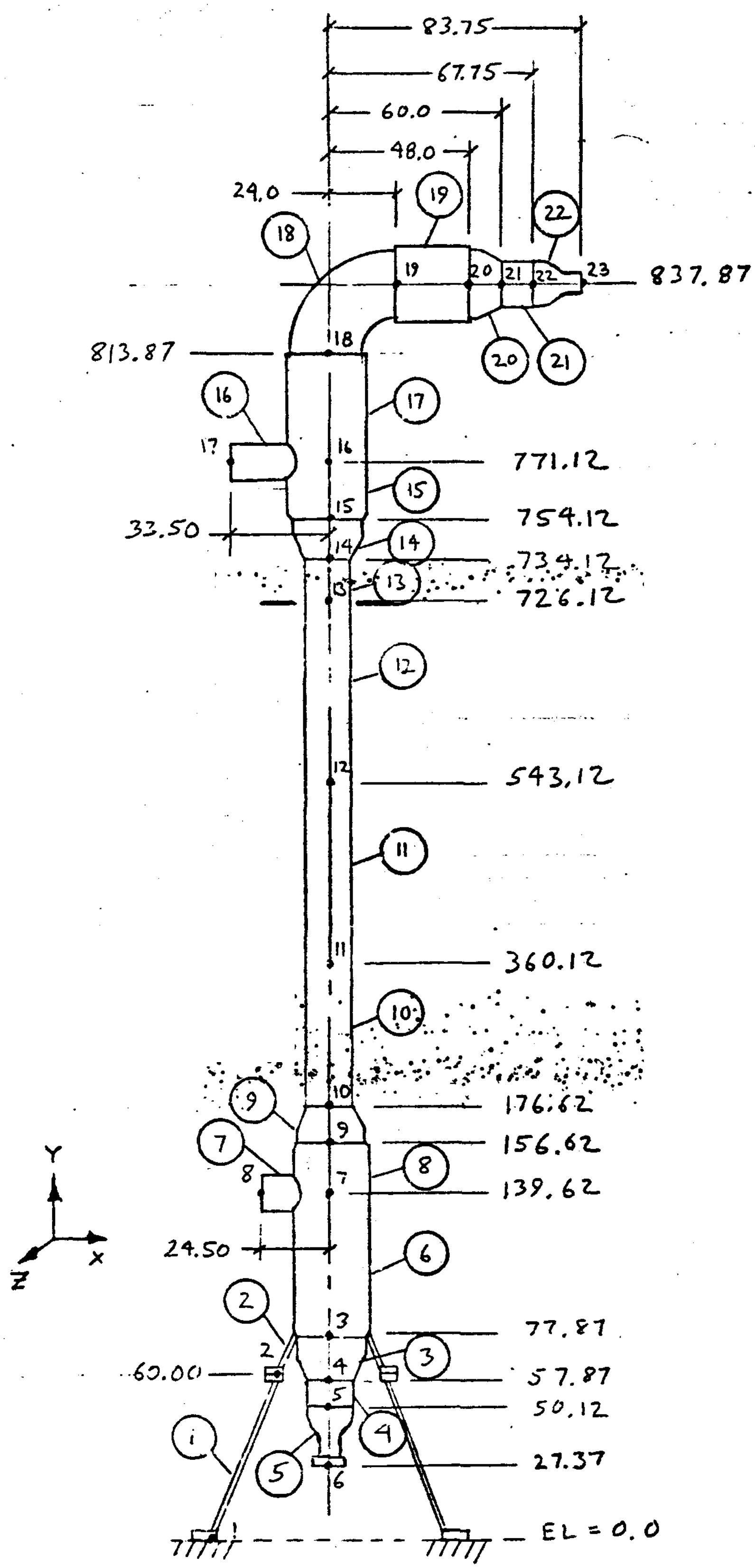
TABLE B-1

INPUT DATA

SYSTEM	Na Inlet to Steam Generator	REFERENCE		
		NO.	REV.	PAGE
Line Number	Near Nozzle			
Design Temperature	1055°F			
Design Pressure	65 psi			
Normal Operating Temperature	1050°F			
Normal operating Pressure	65 psi			
Pipe O.D./Schedule	12.75 / Sch 80			
Pipe Thickness	.687"			
Pipe Material	SS 316			
Insulation Type	Cal. Sil. 12" thick			
Weight of Pipe Lbs/Ft	88.51			
Weight of Contents Lbs/ft	19.44			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}\left(\frac{36.75^2 - 12.75^2}{144}\right) \times 14 = 90.7$			
Total Weight Lbs/ft	218.8			
E_c	28.3×10^6			
Seismic Category	II			

Jim Moldenhauer PREPARED BY:	Rockwell International Energy Systems Group	31 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
2-2-83 DATE:		MODEL NO.

Steam Generator Model



PREPARED BY: Jim Moldenhauer	Rockwell International Energy Systems Group	PAGE NO. 32 OF
CHECKED BY:		REPORT NO. 079TI000008
DATE: 3-8-83	APPENDIX I	MODEL NO.

TABLE 1.

MSG DATA FOR USE IN PIPING MODEL. SEE FIGURE 1.

ELEMENT	NODES	OD (IN)	t (IN)	ω_{METAL} (LB/IN)	ω_{INS} (LB/IN)
1 SUP. CONE	1 2	54.22	0.721	56.39	11.28 EST-12" THK L=36"
2 SUP. CONE	2 3	30.94	0.721	45.26	13.50 (EST-12" THK)
3 REDUCER	3 4	21.5	1.0	42.93	10.23
4 TUBESHEET	4 5	19.0	1.0	62.18	9.47
5 STEAMHEAD	5 6	12.81	1.0	31.17	7.71
6 OUT. HDR.	3 7	26.0	1.97	71.16	11.61
7 Na OUT. NOZ.	7 8	12.75	0.562	4.458 (47%)	0.0
8 OUT. HDR	7 9	26.0	1.97	71.16	11.61
9 REDUCER	9 10	21.0	0.86	35.47	10.08
10 SHELL	10 11	18.0	0.75	26.99	9.16
11 SHELL	11 12	18.0	0.75	26.99	9.16
12 SHELL	12 13	18.0	0.75	26.99	9.16
13 SUP. RING	13 14	18.0	0.75	26.99	9.16
14 REDUCER	14 15	21.0	0.86	35.47	10.08

TABLE 1. (CONT'D)

ELEMENT	NODES	OD (IN)	t (IN)	ω_{METAL} (LB/IN)	$\omega_{INS.}$ (LB/IN)
15 IN. HDR	15 16	26.0	1.97	71.89	11.61
16 Na IN. NOZ.	16 17	12.75	0.562	5.786 (61%)	1.89 (25%)
17 IN. HDR	16 18	26.0	1.97	71.89	11.61
18 ELBOW R = 24.0 IN.	18 19	24.0	1.0	32.70	11.00
19 CROSS	19 20	26.0	1.97	65.68	11.61
20 REDUCER	20 21	21.5	1.0	39.47	10.23
21 TUBESHEET	21 22	19.0	1.0	62.18	9.47
22 STEAMHEAD	22 23	12.81	1.0	23.81	7.71

Notes:

1) ρ_{STL} = 0.283 LB/IN^3
2) ρ_{NA} = 0.032 LB/IN^3
3) ρ_{INS} = 14.0 LB/FT^3 t_{INS} = 12.0 INCHES

ELEMENT	NODES	$TE1_D$ (°F)	TE2 (°F)	TE3 (°F)	$TE1_\phi$ (°F)	
1 SUPPORT CONE	1, 2	225	201	226	210	
2 SUPPORT CONE	2, 3	435	381	492	420	
3 REDUCER	3, 4	470	420	600	455	
4 L. TUBESHEET	4, 5	450	400	600	435	
5 L. STEAMHEAD	5, 6	450	400	600	435	
6 OUT. HEADER	3, 7	587	550	600	572	
7 Na OUT. NOZ.	7, 8	620	570	600	605	
8 OUT. HEADER	7, 9	625	575	600	610	
9 REDUCER	9, 10	640	585	600	625	
10 SHELL	10, 11	705	650	600	690	
11 SHELL	11, 12	865	770	600	850	
12 SHELL	12, 13	1010	890	600	995	
13 SHELL	13, 14	1050	940	600	1035	
14 REDUCER	14, 15	1055	942	600	1040	

$TE1_D$ = DESIGN TEMPERATURE
TE3 = EXTENDED SHUTDOWN
$TE1_\phi$ = OPERATING TEMPERATURE
TE2 = HOT LOCKUP

PREPARED BY:	Rockwell International Energy Systems Group	PAGE NO. 35 OF
CHECKED BY:		REPORT NO. 079TI000008
DATE: 2-9-83		MODEL NO.

ELEMENT	NODES	TE1 (°F) D	TE2 (°F)	TE3 (°F)	TE1 (°F) ϕ	
15 IN. HEADER	15 16	1057	948	600	1042	
16 Na IN. NOZ.	16 17	1065	950	600	1050	
17 IN. HEADER	16 18	1055	950	600	1040	
18 ELBOW	18 19	1025	910	600	1010	
19 CROSS	19 20	1020	905	600	1005	
20 REDUCER	20 21	1020	902	600	1005	
21 U. TUBESHEET	21 22	1015	900	600	1000	
22 U. STEAMHEAD	22 23	1015	900	600	1000	

PREPARED BY: Jim Moldenhauer	**Rockwell International** Energy Systems Group	PAGE NO. 36 OF
CHECKED BY:		REPORT NO. 079TI000008
DATE: 1-21-83		MODEL NO.

MSG - SOLAR PIPING LOADS

TE1 (DESIGN)	FEEDWATER INLET & PIPING	460°F	436°F
	NA OUTLET & PIPING	605°F	610°F
	NA INLET & PIPING	1050°F	1065°F
	STEAM OUTLET & PIPING	1000°F	1015°F
TE2 (HOT LOCKUP)	FEEDWATER INLET-NOZZLE	460°F	
	-PIPING	400°F	
	NA OUTLET - AT NOZZLE	570°F	
	- PIPING	300°F	
	NA INLET - AT NOZZLE	950°F	
	- PIPING	950°F	
	STEAM OUTLET - AT NOZZLE	900°F	
	- PIPING	850°F	
TE3 (LONG TERM SHUTDOWN)	FEEDWATER INLET - NOZZLE	600°F	
	-PIPING	70°F	MSG @ 600°F
	NA OUTLET - AT NOZZLE	600°F	
	- PIPING	300°F	
	NA INLET - AT NOZZLE	600°F	
	- PIPING	600°F	
	STEAM OUTLET - AT NOZZLE	600°F	
	- PIPING	70°F	

COMBINATIONS

(29) DW + $WIND_{90}$

(18) DW + $WIND_{30}$ + OBE

(19) DW + TE1 + $WIND_{30}$ + OBE

(29) DW + TE2 + $WIND_{30}$ + OBE

(21) DW + TE2 + $WIND_{90}$

(24) DW + WIND 30

(30) DW + TE3 + $WIND_{30}$ + OBE

(22) DW + TE3 + $WIND_{90}$

N 152-R-2 REV. 8-78

Piping Analysis Load case details.

Load Case No.	Title	Description
1	X-Direction 30 MPH wind (Steam generator wind loads $P_w = 4.16$ PSF)	Wind loads for: Steam piping = 6.7 lbs / ft Na Inlet piping: 11.0 lbs / ft Na Outlet piping: 6.7 lbs / ft All snubbers inactive.
2	Z-Direction 30 MPH wind	wind loads same as for x-direction.
3.	Maximum of X and Z Absolute 30 mph wind	Maximum values are selected (regardless of sign) from case 1 and 2 for each force and moment component.
4	Maximum of x and z Absolute 90 MPH wind	Same as case 3 except wind loads on piping are 9 times the values given above for 30 mph wind.
5	Deadweight	Total weights used for: 6" Steam piping: 85.5 lbs / ft 6" Na Inlet Piping: 98.5 lbs / ft 6" Na Outlet Piping: 53.4 lbs / ft
6	TE 1 (Thermal at the design temperature)	Design Tempr. used: Steam piping: 1015°F Na Inlet piping: 1065°F Na Outlet Piping: 610°F

PREPARED BY: KCS	Rockwell International Energy Systems Group	38 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
DATE: 3-10-83		MODEL NO.

Load Case No.	Title	Description
7	TE2 (Thermal Overnight Shutdown)	Operating tempr. used: Steam piping: 850°F Na Inlet piping: 950°F Na Outlet Piping: 300°F
8	TE3 (SG and Na Inlet at 600, Na outlet at 300 and steam piping at 70)	Operating tempr. used: Steam piping: 70°F Na Inlet Piping: 600°F Na Outlet Piping: 300°F
9	OBE X-Direction at ·4g.	all snubbers active.
10	OBE Y-Direction at ·2667g	
11	OBE Z-Direction at ·4g.	
12	DWT (Sign) + TE1 (Sign) Direct combination	Algebraic summation of load cases 5 and 6
13	DWT (Sign) + TE2 (Sign) Direct combination	Algebraic summation of load cases 5 and 7
14	DWT (Sign) + TE3 (Sign) Direct Combination	Algebraic summation of load cases 5 and 8
15	Maximum of X-OBE (abs) and Z-OBE (abs).	Maximum absolute value for each force and moment component from load cases 9 and 11.

PREPARED BY: KCQ	Rockwell International Energy Systems Group	39 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
DATE: 3/10/83		MODEL NO.

Load case no.	Title	Description
16	Y (abs) + Maximum of X (abs) and Z (abs) Call this "Total OBE"	Absolute summation of load cases 10 and 15.
17	Total OBE + wind load (30 mph)	Absolute summation of load cases 3 and 16
18	DWT + Total OBE + wind load (30 mph)	Absolute summation of load cases 5 and 17.
19	(DWT + TE1) ABS + Total OBE + wind load (30 mph)	Absolute summation of load cases 12 and 17
20	DWT + 90 MPH wind	Absolute summation of load cases 5 and 4
21	(DWT + TE2) ABS + 90 MPH WIND	Absolute summation of load cases 13 and 4
22	(DWT + TE3) ABS + 90 MPH WIND	Absolute summation of load cases 4 and 14.
23	(DWT + TE1) Abs + 30 mph wind	Absolute summation of load cases 3 and 12
24	DWT + 30 mph wind	Absolute summation of load cases 3 and 5.
25	DWT + 30 mph wind + TE2	Absolute summation of loadcases 3 and 13
26	DWT + 30 mph wind + TE2 + OBE	Absolute summation of loadcases 16 and 25

Load case no.	Title	Description
27	DWT + TE3 + 30 mph wind	Absolute summation of load cases 3 and 14
28	DWT + TE3 + Total OBE + 30 mph wind	Absolute summation of load cases 16 and 27.

Calculation of minimum wall thickness for the Steam line

$$t_m = \frac{PDo}{2(SE^* + Py)} + A$$

P = 1590 psi

S = 7200 psi @ 1015°F.

y = .4

A = .0625" (as per PG&E)

$$t_m = \frac{1590\,Do}{2(7200 + .4 \times 1590)} + .0625$$

$$= .101\,Do + .0625"$$

$$t_{nominal} = \frac{t_m}{.875} = .116\,Do + .071"$$

6" pipe $t_{nominal}$ = .840"

10" Pipe $t_{nominal}$ = 1.318"

12" Pipe $t_{nominal}$ = 1.463".

<u>Steam piping:</u> 6" pipe with 6" thick insulation $C_F = 1.2$

$$OD = 6.625 + 2(6) = 18.625"$$

From sheet 43

At 30 mph: wind load $= 1.2 \times \frac{18.625}{12} \times 1 \times 3.6 = 6.7$ lbs/ft

At 90 mph: wind load $= 1.2 \times \frac{18.625}{12} \times 1 \times 32.1 = 59.8$ lbs/ft.

<u>Na Inlet Piping:</u> 6" pipe with 12" thick insulation

$$OD = 6.625 + 2(12) = 30.625"$$

At 30 mph: wind load $= \frac{30.625}{12} \times 1 \times 3.6 \times 1.2 = 11.0$ lbs/ft

At 90 mph: wind load $= 1.2 \times \frac{30.625}{12} \times 1 \times 32.1 = 98.3$ lbs/ft

Pipe	Dead wt	Wind load		Ratio $\frac{\text{wind load}}{\text{dead wt}}$
6" steam	85.5 lbs/ft	6.7	30 mph	.078
		59.8	90 mph	.699
6" Na Inlet	98.5 lbs/ft	11.0	30 mph	.112
		98.3	90 mph	.998
6" Na Outlet	53.4 lbs/ft	6.7	30 mph	.125
		59.8	90 mph	1.12

WIND LOADING CALCULATIONS

$$\sigma\sqrt{P} = 1.7\left[T(2h/3)\right]\left[0.785\,PF/\beta + S/(1+.002C)\right]^{1/2}$$

$\beta = .01$ Reference 4.

Height	V_{30} wind speed	$q_{30} = .00256\,V_{30}^2$	K_z	$T(\frac{2h}{3})$	$1.12(\sqrt{K_{30}})\frac{V_{30}}{f}$, $f = 7$ hz	P	$\frac{.88\,fh}{V_{30}\sqrt{K_h}}$	$\frac{h}{c}$	F	S	$\sigma\sqrt{P}$	G_F	q_F psf.
70'	90 MPH	20.736	1.3 @ 70'	.16	$1.12 \times \sqrt{1} \times \frac{90}{7}$ = 14.4	.025	$\frac{.88 \times 7 \times 70}{90 \times \sqrt{1.3}}$ = 4.2	$\frac{70}{18.625}$ = 3.76	3.2×10^{-4}	1.07	.28	1.19	32.1
								$\frac{70}{30.625}$ = 2.3	10^{-4}				32.1.
460'	90 mph	20.736	2.3 @ 460'	.13	$1.12 \times \sqrt{1} \times \frac{90}{7}$ = 14.4	.025	$\frac{.88 \times 7 \times 460}{90 \times \sqrt{2.3}}$ = 20.76	3.76	10^{-4}	.77	.19	1.02	48.[illegible]
460'	30 MPH	2.304	2.3 @ 460'	.13	$1.12 \times \sqrt{1} \times \frac{30}{7}$ = 4.8	.018	$\frac{.88 \times 7 \times 460}{30 \times \sqrt{2.3}}$ = 62.3	3.76	10^{-4}	.77	.19	1.02	5.4
70'	30 MPH	2.304	1.3 @ 70'	.16	4.8	.018	$\frac{.88 \times 7 \times 70}{30 \times \sqrt{1.3}}$ = 12.6	3.76	10^{-4}	1.07	.28	1.19	3.6

REVISED MSG WIND FORCE (ANS58.1-1972)

$$F_w = \frac{P_w A}{144}$$

$A = 42040 \text{ IN}^2$

P_w (PSF) @ h=70 FT; f=4.0 Hz
c=3.8 FT

FOR NORMAL OPERATION

$$F_w = \frac{(4.16)(42040)}{144}$$

$$= 1214.5 \text{ LB}$$

$$\frac{F_w}{D_w} = \frac{1214.5}{46493.9} = .0261$$ [EQUIVALENT G-LEVEL]

FOR SURVIVAL CONDITION

$$F_w = \frac{(37.8)(42040)}{144}$$

$$= 11036 \text{ LB}$$

$$\frac{F_w}{D_w} = \frac{11036}{46493.9} = .237$$ [EQUIVALENT G-LEVEL]

If use g = ·125

multiply wt. of Na Inlet line by $\frac{\cdot 112}{\cdot 125} = \cdot 896$

" " " Steam line by $\frac{\cdot 078}{\cdot 125} = \cdot 624$

" " " Steam Generator by $\frac{\cdot 0261}{\cdot 125} = \cdot 2088$

" " " Na Inlet header by $\frac{\cdot 081}{\cdot 125} = \cdot 65$

Since only one value of acceleration can be input in a NUPIPE run, it was decided to use ·125 g for wind loading cases. Therefore weights of other piping were adjusted as per above factors.

STEAM PIPING

Material : 2¼Cr-1Mo A 335 P 22

Design Temp. : 1015° F.

$S_c = 15.0$ ksi

$S_{h\,@1015°F} = 7.2$ ksi

$S_A = .9(1.25 \times 15 + .25 \times 7.2) = 18.495$ ksi

$S_h + S_A = 26.06$ ksi

FOR 90MPH WIND $S_{h\,@850°F} = 14.4$ ksi

Sodium Inlet Piping

Material : SS 316 A 312 TP 316.

Design Temp. : 1065° F

However allowables calculated at 1100° F.

$S_c = 18.7$ ksi

$S_{h\,@1100°F} = 12.4$ ksi

$S_A = .9(1.25 \times 18.7 + .25 \times 12.4)$
$= 23.8$ ksi

$S_A + S_h = 36.2$ ksi

FOR 90 MPH WIND, $S_{h\,@950°F} = 15.4$ ksi

PREPARED BY: KCG	Rockwell International Energy Systems Group	PAGE NO. 47 OF
CHECKED BY:		REPORT NO. 079TI000008
DATE: 2-8-83		MODEL NO.

Na Outlet Piping

Material : Carbon Steel A106 Grade 'B'

Design temperature : 610° F.

$S_c = 15$ ksi

$S_h = 15$ ksi

$S_A = .9\,(1.25 \times 15 + .25 \times 15)$

$= 20.25$ ksi

$S_h + S_A = 35.25$ ksi

N 152-R-2 REV. 8-78

```
*************************************************************************************************************
*  JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL  *
*************************************************************************************************************

//$WW232X1 JOB 'GURSAHANI LB30731160*0716935              4444449    ', *00000100
// TIME=(02,00),REGION=1500K,NOTIFY=$WW232,MSGCLASS=A,MSGLEVEL=1        00000200
//*MAIN ORG=RM005                                                       00000300
//*  THIS IS DATASET $WW232.PRINT.EDIT.CNTL                             00000400
//* THESE THREE ARE FOR XEROX OUTPUT                                    00000500
//*FORMAT PR,DDNAME=SYSMSG,DEST=RM006PR3,FCB=JB10,COPIES=1              00000600
//*FORMAT PR,DDNAME=SYSPRINT,DEST=RM006PR3,FCB=JB10,COPIES=1            00000700
//*FORMAT PR,DDNAME=SYSUT2,DEST=RM006PR3,FCB=JB10,COPIES=1              00000800
//* THESE THREE ARE FOR NORMAL OUTPUT                                   00000900
//* //*FORMAT PR,DDNAME=SYSMSG,DEST=RM005,COPIES=1                      00001000
//* //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM005,COPIES=1                    00001100
//* //*FORMAT PR,DDNAME=SYSUT2,DEST=RM005,COPIES=1                      00001200
//* THESE THREE ARE FOR MICROFICHE OUTPUT                               00001300
//* //*FORMAT PR,DDNAME=SYSMSG,DEST=RM001PR5,FORMS=FICHE,COPIES=1       00001400
//* //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM001PR5,FORMS=FICHE,COPIES=1     00001500
//* //*FORMAT PR,DDNAME=SYSUT2,DEST=RM001PR5,FORMS=FICHE,COPIES=1       00001600
// EXEC PGM=IEBGENER                                                    00001700
//SYSPRINT DD SYSOUT=A                                                  00001800
//SYSIN DD DUMMY                                                        00001900
//SYSUT1 DD DSN=$WW232.N1.DATA,DISP=SHR                                 00002000
//       DD DSN=$WW232.N2.DATA,DISP=SHR                                 00002100
//       DD DSN=$WW232.N3.DATA,DISP=SHR                                 00002200
//       DD DSN=$WW232.N4.DATA,DISP=SHR                                 00002210
//       DD DSN=$WW232.N5.DATA,DISP=SHR                                 00002220
//SYSUT2 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330)             00002300
    1     //$WW232X1 JOB 'GURSAHANI LB30731160*0716935              4444449    ', *00000100
          // TIME=(02,00),REGION=1500K,NOTIFY=$WW232,MSGCLASS=A,MSGLEVEL=1        00000200
          ***  THIS IS DATASET $WW232.PRINT.EDIT.CNTL                             00000400
          *** THESE THREE ARE FOR XEROX OUTPUT                                    00000500
          *** THESE THREE ARE FOR NORMAL OUTPUT                                   00000900
          *** //*FORMAT PR,DDNAME=SYSMSG,DEST=RM005,COPIES=1                      00001000
          *** //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM005,COPIES=1                    00001100
          *** //*FORMAT PR,DDNAME=SYSUT2,DEST=RM005,COPIES=1                      00001200
          *** THESE THREE ARE FOR MICROFICHE OUTPUT                               00001300
          *** //*FORMAT PR,DDNAME=SYSMSG,DEST=RM001PR5,FORMS=FICHE,COPIES=1       00001400
          *** //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM001PR5,FORMS=FICHE,COPIES=1     00001500
          *** //*FORMAT PR,DDNAME=SYSUT2,DEST=RM001PR5,FORMS=FICHE,COPIES=1       00001600
    2     // EXEC PGM=IEBGENER                                                    00001700
    3     //SYSPRINT DD SYSOUT=A                                                  00001800
    4     //SYSIN DD DUMMY                                                        00001900
    5     //SYSUT1 DD DSN=$WW232.N1.DATA,DISP=SHR                                 00002000
    6     //       DD DSN=$WW232.N2.DATA,DISP=SHR                                 00002100
    7     //       DD DSN=$WW232.N3.DATA,DISP=SHR                                 00002200
    8     //       DD DSN=$WW232.N4.DATA,DISP=SHR                                 00002210
    9     //       DD DSN=$WW232.N5.DATA,DISP=SHR                                 00002220
   10     //SYSUT2 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330)             00002300
```

```
IAT6140 JOB ORIGIN FROM GROUP=RM206    , DSP=IJP, DEVICE=INTRDR   , 000
13:43:09 IAT4401  LOCATE FOR STEP=A          DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
13:48:09 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
13:48:09 IAT4401  LOCATE FOR STEP=G          DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
13:48:09 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
13:48:09 IAT4401  LOCATE FOR STEP=G          DD=FT12F001 DSN=$WW232.SOLAR.WINDD
13:48:09 IAT4402 UNIT=3350     ,VOL(S)=AVTSOA
13:48:09 IAT4401  LOCATE FOR STEP=G          DD=FT15F001 DSN=$WW232.CARRIZO.MSG.DATA
13:48:09 IAT4402 UNIT=3350     ,VOL(S)=AVTSOA
13:48:09 IAT4401  LOCATE FOR STEP=ELTEMP     DD=STEPLIB  DSN=$WW049.ELTEMP.LOAD
13:48:09 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
13:48:10 USES     CVTSOK  01 048884 D $WW049.NUPIPE.LOAD
13:48:10 USES     AVTSOA  01 048884 D $WW232.SOLAR.WINDD
13:48:10 IAT5200 JOB 2981 ($WW232E1) IN SETUP ON MAIN=C        P=07 LOCAL
13:48:10 IAT5210 J=2981 STEPLIB  USING D CVTSOK ON 528   $WW049.NUPIPE.LOAD
13:48:10 IAT5210 J=2981 FT12F001 USING D AVTSOA ON 520   $WW232.SOLAR.WINDD
13:50:40 IAT2000 JOB 2981 $WW232E1 SELECTED L        GRP=BIG
13:50:41 L R= $WW232E1 NEF995I $WW232E1 STARTED, 2/10/83,13.50.41 ASID=00024
13:50:42 L R= $WW232E1 IEF403I $WW232E1 - STARTED - TIME=13.50.41
13:52:19 L R= $WW232E1 +IH0002I STOP      1
13:52:20 L R= $WW232E1 IEF404I $WW232E1 - ENDED - TIME=13.52.20
13:52:20 L R= $WW232E1 NEF996I $WW232E1 ENDED,  2/10/83,B.U.=     1.4318 *0716935   ,3033-L3,JOB CC= 001
13:52:22 IAT5400 JOB 2981 ($WW232E1) IN BREAKDOWN
/$WW232E1 JOB 'GURSAHANI LB30130340*0716935          005  5001007037', *
/ REGION=4500K,TIME=2,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
/*MAIN ORG=RM206                                                    00000300
/* THESE THREE ARE FOR XEROX OUTPUT                                 00000500
/*FORMAT PR,DDNAME=SYSMSG,DEST=RM271PR3,FCB=JB10,COPIES=1           00000600
/*FORMAT PR,DDNAME=FT66F001,DEST=RM271PR3,FCB=JB10,COPIES=1         00000700
/*FORMAT PR,DDNAME=FT06F001,DEST=RM271PR3,FCB=JB10,COPIES=1         00000800
/* THESE THREE ARE FOR MICROFICHE OUTPUT                            00001300
/*FORMAT PR,DDNAME=SYSMSG,DEST=RM001PR5,FORMS=FICHE,COPIES=1        00001400
/*FORMAT PR,DDNAME=SYSPRINT,DEST=RM001PR5,FORMS=FICHE,COPIES=1      00001500
/*FORMAT PR,DDNAME=SYSUT2,DEST=RM001PR5,FORMS=FICHE,COPIES=1        00001600
/ EXEC ROCKPIPE,PROG=SMALL
/G.FT12F001 DD VOL=REF=$WW232.REFER,DISP=(,CATLG),
/ SPACE=(TRK,(20,20),RLSE),DCB=(RECFM=VBS,BLKSIZE=19069),
/ DSN=$WW232.SOLAR.WINDD
/G.SYSIN DD DSN=$WW232.CARRIZO.MSG.DATA,DISP=SHR
   1       //$WW232E1 JOB 'GURSAHANI LB30130340*0716935          005  5001007037', *
           // REGION=4500K,TIME=2,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
           *** THESE THREE ARE FOR XEROX OUTPUT                                 00000500
           *** THESE THREE ARE FOR MICROFICHE OUTPUT                            00001300
   2       // EXEC ROCKPIPE,PROG=SMALL
   3       XXROCKPIPE PROC DSN='$WW049.NUPIPE.LOAD',PROG=SMALL,C=10,
           XX PROGA=SEVEN,B=19069,PROGE=OPT2,DSNE='$WW049.ELTEMP.LOAD'
           *** AL HROMJAK ROCKWELL INTERNATIONAL, ESG. COMNET 393-3318
           *** FT50F001 FOR 7-SPECTRA NODE ACCELERATIONS.
           *** IN BOTH STEPS, FT66 CONTAINS DIAGNOSTIC OUTPUT.
           *** FT66F001 IN G STEP CONTAINS TIME SPENT IN MAJOR PROGRAM PHASES.
           *** FT16F001 DUMMIED WHEN P STEP DELETED.
           *** FT17F001, FT18F001, FT19F001, FT20F001 ADDED FOR SNUBBER ITERATIONS
   4       XXA EXEC PGM=&PROGA
           *** THIS STEP READS THE 7 SPECTRA AND TRANSLATES THEM TO A NEW POINT
           ***  NEW SPECTRA WRITTEN  ON FT01F001
   5       XXSTEPLIB DD DSN=&DSN,DISP=SHR
   6       XXFT01F001 DD UNIT=SYSDA,DSN=&&SPEC,SPACE=(TRK,(10),RLSE),DISP=(,PASS),
           XX DCB=(RECFM=F,LRECL=80,BLKSIZE=80)
   7       XXFT05F001 DD DDNAME=SYSIN
   8       XXFT06F001 DD SYSOUT=*
   9       XXFT66F001 DD DUMMY,DCB=(RECFM=VBA,BLKSIZE=2020)
```
FORM 126-P-130 NEW 7-82

079TI000008
49

P R O G R A M   I N P U T   D A T A

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET

CONTROL			2.0	1.0				
FLEXAN	1	1	4.0			1.0	1.0	
X-DIRECTION 30 MPH WIND								
FLEXAN	2	1	4.0			3.0	1.0	
Z-DIRECTION 30 MPH WIND								
MODFLEX	3	1 2	1.0	1.0	3.0		1.0	
MAXIMUM OF X AND Z ABSOLUTE 30 MPH WIND								
MODFLEX	4	3 1	9.0	0.0	1.0		1.0	
MAXIMUM OF X AND Z ABSOLUTE 90 MPH WIND								
ACCEL			.125		.125			
XSECTN		1	54.22	0.721	169.6	29.9		
XSECTN		2	30.94	0.721	147.2	29.9		
XSECTN		3	21.5	1.0	121.1	29.9	0.0	
XSECTN		4	19.0	1.0	179.5	29.9	0.0	
XSECTN		5	12.81	1.0	77.3	29.9	0.0	
XSECTN		6	26.0	1.97	207.4	29.9	0.0	
XSECTN		7	12.75	.562	10.8	29.9	0.0	
XSECTN		8	26.0	1.97	207.4	29.9	0.0	
XSECTN		9	21.0	0.86	114.1	29.9	0.0	
XSECTN		10	18.0	0.75	90.6	29.9	0.0	
XSECTN		11	18.0	0.75	90.6	29.9	0.0	
XSECTN		12	18.0	0.75	90.6	29.9	0.0	
XSECTN		13	18.0	0.75	90.6	29.9	0.0	
XSECTN		14	21.0	0.86	114.1	29.9	0.0	
XSECTN		15	26.0	1.97	209.2	29.9	0.0	
XSECTN		16	12.75	.562	19.2	29.9	0.0	
XSECTN		17	26.0	1.97	209.2	29.9	0.0	
XSECTN		18	24.0	1.0	109.5	29.9	0.0	
XSECTN		19	26.0	1.97	193.7	29.9	0.0	
XSECTN		20	21.5	1.0	124.5	29.9	0.0	
XSECTN		21	19.0	1.0	179.5	29.9	0.0	
XSECTN		22	12.81	1.0	78.7	29.9	0.0	
XSECTN800		23	12.75	0.562	10.4	299.	0.0	
XSECT1700		24	12.75	0.562	18.0	299.	0.0	
XSECTN		25	6.625	0.864	53.4	29.9	1590.	
XSECTN NA		26	6.625	0.864		29.9	1590.	
XSECTN NA		27	12.75	0.406	175.	28.3	65.	
XSECTN		28	6.625	0.280	88.3	28.3	65.	
XSECTN NA		29	12.75	0.406	130.	27.9	65.	
XSECTN		30	6.625	0.280	53.4	27.9	65.	
XSECTN		31	12.75	0.687	218.8	28.3	65.	
XSECTN NA		32	6.625	0.280		27.9	65.	
XSECTN		33	12.75	0.687	218.8	27.9	65.	
XSECTN		34	10.75	0.365	100.2	28.3	65.	
OPVAL225	1	1	29.4	.01198				
OPVAL435	1	2	28.4	.03022				
OPVAL470	1	3	28.2	.03344				
OPVAL450	1	4	28.3	.03160				
OPVAL450	1	5	28.3	.03160				
OPVAL620	1	6	27.2	.04086				
OPVAL620	1	7	27.2	.04086				
OPVAL625	1	8	27.2	.04858				
OPVAL640	1	9	27.1	.05012				
OPVAL705	1	10	26.6	.05684				
OPVAL865	1	11	24.9	.07422				
OPVAL	1	12	22.7	.09005				
OPVAL	1	13	21.7	.09465				
OPVAL	1	14	21.6	.09523				

OPVAL1057	1	15	21.5	.09546	
OPVAL1065	1	16	21.3	.09638	
OPVAL1055	1	17	21.6	.09523	
OPVAL1025	1	18	22.4	.09178	
OPVAL1020	1	19	22.5	.09120	
OPVAL1020	1	20	22.5	.09120	
OPVAL1015	1	21	22.6	.09063	
OPVAL1015	1	22	22.6	.09063	
OPVAL800	1	23	273.0	.04703	
OPVAL1065	1	24	213.0	.09638	
OPVAL1015	1	25	22.60	.09063	1590.
OPVAL NA	1	26	22.74	.09005	1590.
OPVAL NA	1	27	22.4	.12364	65.
OPVAL1065	1	28	22.4	.12364	65.
OPVAL NA	1	29	25.61	.04703	65.
OPVAL 610	1	30	25.61	.04703	65.
OPVAL201	2	1	29.5	.00998	
OPVAL381	2	2	29.1	.02533	
OPVAL420	2	3	28.5	.02884	
OPVAL400	2	4	28.5	.02700	
OPVAL400	2	5	28.5	.02700	
OPVAL550	2	6	27.7	.04110	
OPVAL570	2	7	27.6	.04306	
OPVAL575	2	8	27.6	.04355	
OPVAL585	2	9	27.5	.04453	
OPVAL650	2	10	27.0	.05115	
OPVAL770	2	11	26.0	.06379	
OPVAL890	2	12	24.6	.07699	
OPVAL940	2	13	23.9	.08242	
OPVAL942	2	14	23.9	.08264	
OPVAL948	2	15	23.8	.08328	
OPVAL950	2	16	23.8	.08350	
OPVAL950	2	17	23.8	.08350	
OPVAL910	2	18	24.4	.07918	
OPVAL905	2	19	24.4	.07864	
OPVAL902	2	20	24.5	.07832	
OPVAL900	2	21	24.5	.07810	
OPVAL900	2	22	24.5	.07810	
OPVAL570	2	23	276.0	.04306	
OPVAL950	2	24	237.5	.08350	
OPVAL850	2	25	25.1	.07255	1590.
OPVAL NA	2	26	22.74	.09005	1590.
OPVAL NA	2	27	23.2	.10800	65.
OPVAL950	2	28	23.2	.10800	65.
OPVAL NA	2	29	27.4	.0182	65.
OPVAL 300	2	30	27.4	.0182	65.
OPVAL 226	3	1	29.4	.01206	65.
OPVAL 492	3	2	28.0	.03546	65.
OPVAL 600	3	3	27.4	.0460	65.
OPVAL 600	3	4	27.4	.0460	65.
OPVAL 600	3	5	27.4	.0460	65.
OPVAL 600	3	6	27.4	.0460	65.
OPVAL 600	3	7	27.4	.0460	65.
OPVAL 600	3	8	27.4	.0460	65.
OPVAL 600	3	9	27.4	.0460	65.
OPVAL 600	3	10	27.4	.0460	65.
OPVAL 600	3	11	27.4	.0460	65.
OPVAL 600	3	12	27.4	.0460	65.
OPVAL 600	3	13	27.4	.0460	65.
OPVAL 600	3	14	27.4	.0460	65.
OPVAL 600	3	15	27.4	.0460	65.
OPVAL 600	3	16	27.4	.0460	65.

FORM 126-P-130 NEW 7-82

079T000008
51

OPVAL 600	3	17	27.4	.0460				65.
OPVAL 600	3	18	27.4	.0460				65.
OPVAL 600	3	19	27.4	.0460				65.
OPVAL 600	3	20	27.4	.0460				65.
OPVAL 600	3	21	27.4	.0460				65.
OPVAL 600	3	22	27.4	.0460				65.
OPVAL 600	3	23	274.0	.0460				65.
OPVAL 600	3	24	274.0	.0460				
OPVAL 70	3	25	29.9					1590.
OPVAL NA	3	26	22.74					1590.
OPVAL NA	3	27	25.6	.0624				65.
OPVAL 600	3	28	25.6	.0624				65.
OPVAL NA	3	29	27.4	.0182				65.
OPVAL 300	3	30	27.4	.0182				65.
ANCHOR		1						
RUN	1	2		5.0		1.0	1.0	
RUN	2	3		1.489		2.0	2.0	
RUN	3	4		-1.667		3.0	3.0	
RUN	4	5		-.646		4.0	4.0	
RUN	5	6		-1.896		5.0	5.0	
RUN	3	7		5.146		6.0	6.0	
TEE	7	800						
RUN	7	9		1.417		8.0	8.0	
REDUCER	9	10		1.666		9.0	9.0	
RUN	10	8001		5.097		10.0	10.0	
RUN	8001	8002		5.097		10.0	10.0	
RUN	8002	11		5.097		10.0	10.0	
RUN	11	8003		5.083		11.0	11.0	
RUN	8003	8004		5.083		11.0	11.0	
RUN	8004	12		5.083		11.0	11.0	
RUN	12	8005		5.083		12.0	12.0	
RUN	8005	8006		5.083		12.0	12.0	
RUN	8006	13		5.083		12.0	12.0	
RESTRAINT		13	100000.		100000.			
RUN	13	14		0.667		13.0	13.0	
REDUCER	14	15		1.666		14.0	14.0	
RUN	15	16		1.417		15.0	15.0	
TEE	16	1700						
RUN	16	18		5.563		17.0	17.0	
ELBOW	18	19	24.0			18.0	18.0	
RUN	19	20	-4.0			19.0	19.0	
REDUCER	20	21	-1.0			20.0	20.0	
RUN	21	22	-0.646			21.0	21.0	
REDUCER	22	23	-1.333			22.0	22.0	
RUN	7	800	1.083			23.0	23.0	
RUN	800	8	0.958			7.0	7.0	
RUN	16	1700	1.083			24.0	24.0	
RUN	1700	17	1.709			16.0	16.0	
RUN	23	25	-1.375			25.0	25.0	
RUN	25	105	-1.500			25.0	25.0	
RESTRAINT		105		1.0				
CWEIGHT		105		10.0				
RUN	105	106	-0.25					
RESTRAINT		106			50000.			
CWEIGHT		106		10.0				
RUN	106	110	-4.396			25.0	25.0	
RUN	110	115	-1.5					
RUN	115	120	-1.5					
RUN	120	122	-1.00					
SNUBBE		122		2.				
CWEIGH		122		15.0				
RUN	122	123	-0.25					

079T000008
52

RESTRAINT		123		1.0			
CWEIGHT		123		10.0			
RUN	123	125	-1.25				
ELBOW	125	130					
RUN	130	135		-1.5			
SNUBBER		135	2.				
CWEIGHT		135		15.0			
RUN	135	138		-0.25			
RESTRAINT		138			50000.		
CWEIGHT		138		10.0			
RUN	138	139		-18.031			
RESTRAINT		139			50000.		
CWEIGHT		139		10.0			
RUN	139	140		-0.25			
SNUBBER		140	2.				
CWEIGHT		140		15.0			
RUN	140	142		-2.875			
RUN	142	144		-3.297			
ELBOW	144	145					
RUN	145	148	1.5				
RESTRAINT		148		1.0			
CWEIGHT		148		10.0			
RUN	148	150	3.0				
RUN	150	155	1.0				
RUN	155	160	1.0				
RUN	160	162	1.75				
SNUBBER		162		2.			
CWEIGHT		162		15.0			
RUN	162	163	4.75				
RESTRAINT		163		1.0			
CWEIGHT		163		10.0			
RUN	163	165	1.0				
ELBOW	165	170					
RUN	170	172		-3.0			
RESTRAINT		172			50000.		
CWEIGHT		172		10.0			
RUN	172	173		-3.0			
RESTRAINT		173	50000.				
CWEIGHT		173		10.0			
RUN	173	175		-14.0			
RESTRAINT		175			50000.		
CWEIGHT		175		10.0			
RUN	175	177		-2.422			
RUN	177	180		-3.781			
ELBOW	180	185					
RUN	185	190	-2.0				
RUN	190	195	-4.0				
ANCHOR		195	-12.0	17.417			
RUN	17	295	4.5			31.0	28.0
REDUCER	295	310	.667			28.0	
RUN	310	320	2.0				
RUN	320	330	2.0				
RUN	330	335	1.041				
RESTRAINT		335		1.0			
RUN	335	340	3.0				
ELBOW	340	350					
RUN	350	360		-2.25			
RESTRAINT		360			50000.		
CWEIGHT		360		10.0			
RUN	360	361		-0.25			
SNUBBER		361	2.				
CWEIGHT		361		15.0			

FORM 126-P-130 NEW 7-82

RUN	361	365		-16.75			
RESTRAINT		365			50000.		
CWEIGHT		365		10.0			
RUN	365	369		-0.25			
SNUBBER		369	2.				
CWEIGHT		369		10.0			
RUN	369	370		-3.5			
ELBOW	370	380					
RUN	380	382	-1.0				
SNUBBER		382		2.			
CWEIGHT		382		15.0			
RUN	382	385	-4.5				
RESTRAINT		385		1.0			
CWEIGHT		385		10.0			
RUN	385	390	-5.5				
ELBOW	390	400					
RUN	400	405		-1.25			
RESTRAINT		405	50000.				
CWEIGHT		405		10.0			
RUN	405	406		-.25			
RESTRAINT		406			50000.		
CWEIGHT		406		10.0			
RUN	406	408		-10.0			
SNUBBER		408	2.				
CWEIGHT		408		15.0			
RUN	408	410		-6.0			
RESTRAINT		410			50000.		
CWEIGHT		410		10.0			
RUN	410	420		-6.343			
ELBOW	420	430					
RUN	430	435	1.0				
RESTRAINT		435		50000.			
CWEIGHT		435		10.0			
RUN	435	440	4.5				
RUN	440	450	5.5				
ANCHOR		450	16.0	17.416			
RUN	8	495	2.541			33.0	30.0
REDUCER	495	510	1.416			30.0	
ELBOW	510	520					
RUN	520	530			4.0		
ELBOW	530	540					
RUN	540	550	2.5				
RUN	550	560	2.0				
RUN	560	570	2.0				
RUN	570	575	1.0			30.0	
RESTRAINT		575		1.0			
RUN	575	580	1.5				
ELBOW	580	590					
RUN	590	600			-4.0		
ELBOW	600	610					
RUN	610	620	2.25				
RUN	620	630	2.25				
ANCHOR		630	19.5	11.635			
RUN	450	1450			5.5	34.0	28.0
ELBOW	1450	1460					
RUN	1460	1465	4.75				
RUN	1465	1467	3.5				
SNUBBER		1467			2.		
CWEIGHT		1467		15.0			
RUN	1467	1468	0.25				
RES IT		1468		50000.			
CWE		1468		10.0			

```
RUN          1468 1470   1.00
ELBOW        1470 1480
RUN          1480 1485                       5.5
RUN          1485 1490                       5.5
ELBOW        1490 1495
RUN          1495 1500   -1.0
RESTRAINT         1500             50000.
CWEIGHT           1500               10.0
RUN          1500 1502   -2.5
RUN          1502 1503   -2.5
RUN          1503 1505   -3.5
ELBOW        1505 1510
RUN          1510 1520                       5.5
ANCHOR            1520   16.0     17.416    22.0
MASSPT               2   1.0        1.0      1.0
MASSPT               9   1.0        1.0      1.0
MASSPT              18   1.0        1.0      1.0
MASSPT              20   1.0        1.0      1.0
MASSPT              22   1.0        1.0      1.0
MASSPT              25   1.0        1.0      1.0
MASSPT             140   1.0        1.0      1.0
MASSPT             150   1.0        1.0      1.0
MASSPT             160   1.0        1.0      1.0
MASSPT             180   1.0        1.0      1.0
MASSPT              17   1.0        1.0      1.0
MASSPT             295   1.0        1.0      1.0
MASSPT             340   1.0        1.0      1.0
MASSPT             370   1.0        1.0      1.0
MASSPT             420   1.0        1.0      1.0
MASSPT             390   1.0        1.0      1.0
MASSPT             510   1.0        1.0      1.0
MASSPT             530   1.0        1.0      1.0
MASSPT             550   1.0        1.0      1.0
MASSPT             570   1.0        1.0      1.0
MASSPT             580   1.0        1.0      1.0
MASSPT             600   1.0        1.0      1.0
STRESS7
9CASES          1
10CASES         2     3     4
ALLDONE
IAT6140 JOB ORIGIN FROM GROUP=RM206    , DSP=IJP, DEVICE=INTRDR  , 000
13:59:39 IAT4401  LOCATE FOR STEP=A         DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
13:59:39 IAT4402 UNIT=3350    ,VOL(S)=CVTSOK
13:59:39 IAT4401  LOCATE FOR STEP=G         DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
13:59:39 IAT4402 UNIT=3350    ,VOL(S)=CVTSOK
13:59:39 IAT4401  LOCATE FOR STEP=G         DD=FT11F001 DSN=$WW232.SOLAR.WINDD
13:59:39 IAT4402 UNIT=3350    ,VOL(S)=AVTSOA
13:59:39 IAT4401  LOCATE FOR STEP=G         DD=FT12F001 DSN=$WW232.SOLAR.WINDY
13:59:39 IAT4402 UNIT=3350    ,VOL(S)=AVTSOA
13:59:39 IAT4401  LOCATE FOR STEP=G         DD=FT15F001 DSN=$WW232.CARRIZO.DEADWT.DATA
13:59:39 IAT4402 UNIT=3350    ,VOL(S)=AVTSOA
13:59:39 IAT4401  LOCATE FOR STEP=ELTEMP    DD=STEPLIB  DSN=$WW049.ELTEMP.LOAD
13:59:39 IAT4402 UNIT=3350    ,VOL(S)=CVTSOK
13:59:40 USES      CVTSOK           D $WW049.NUPIPE.LOAD
13:59:40 USES      AVTSOA           D $WW232.SOLAR.WINDD
13:59:40 IAT5200 JOB 3245 ($WW232E2) IN SETUP ON MAIN=C        P=03 LOCAL
13:59:40 IAT5210 J=3245 STEPLIB  USING D CVTSOK ON 528   $WW049.NUPIPE.LOAD
13:59:40 IAT5210 J=3245 FT11F001 USING D AVTSOA ON 520   $WW232.SOLAR.WINDD
13:59:44 IAT2000 JOB 3245 $WW232E2 SELECTED L       GRP=BIG
13:59:44 L R= $WW232E2 NEF995I $WW232E2 STARTED, 2/10/83,13.59.44 ASID=00012
13:59:45 L R= $WW232E2 IEF403I $WW232E2 - STARTED - TIME=13.59.44
14:00:59 L R= $WW232E2 +IH0002I STOP       1
```

FORM 126-P-130 NEW 7-82

```
14:01:00 L R= $WW232E2 IEF404I $WW232E2 - ENDED - TIME=14.01.00
14:01:00 L R= $WW232E2 NEF996I $WW232E2 ENDED,  2/10/83,B.U.=     1.1229 *0716935    ,3033-L3,JOB CC= 001
14:01:04 IAT5400 JOB 3245 ($WW232E2) IN BREAKDOWN
/$WW232E2 JOB 'GURSAHANI LB30130340*0716935         005  5001003037', *
/ REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
/*MAIN ORG=RM206                                                    00000300
/* THESE THREE ARE FOR XEROX OUTPUT                                 00000500
/*FORMAT PR,DDNAME=SYSMSG,DEST=RM271PR3,FCB=JB10,COPIES=1           00000600
/*FORMAT PR,DDNAME=FT66F001,DEST=RM271PR3,FCB=JB10,COPIES=1         00000700
/*FORMAT PR,DDNAME=FT06F001,DEST=RM271PR3,FCB=JB10,COPIES=1         00000800
/* THESE THREE ARE FOR MICROFICHE OUTPUT                            00001300
/*FORMAT PR,DDNAME=SYSMSG,DEST=RM001PR5,FORMS=FICHE,COPIES=1        00001400
/*FORMAT PR,DDNAME=SYSPRINT,DEST=RM001PR5,FORMS=FICHE,COPIES=1      00001500
/*FORMAT PR,DDNAME=SYSUT2,DEST=RM001PR5,FORMS=FICHE,COPIES=1        00001600
/ EXEC ROCKPIPE,PROG=SMALL
/G.FT11F001 DD DSN=$WW232.SOLAR.WINDD,DISP=SHR
/G.FT12F001 DD VOL=REF=$WW232.REFER,DISP=(,CATLG),
/ SPACE=(TRK,(20,20),RLSE),DCB=(RECFM=VBS,BLKSIZE=19069),
/ DSN=$WW232.SOLAR.WINDY
/G.SYSIN DD DSN=$WW232.CARRIZO.DEADWT.DATA,DISP=SHR
  1      //$WW232E2 JOB 'GURSAHANI LB30130340*0716935         005  5001003037', *
         // REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
         *** THESE THREE ARE FOR XEROX OUTPUT                                 00000500
         *** THESE THREE ARE FOR MICROFICHE OUTPUT                            00001300
  2      // EXEC ROCKPIPE,PROG=SMALL
  3      XXROCKPIPE PROC DSN='$WW049.NUPIPE.LOAD',PROG=SMALL,C=10,
         XX PROGA=SEVEN,B=19069,PROGE=OPT2,DSNE='$WW049.ELTEMP.LOAD'
         *** AL HROMJAK ROCKWELL INTERNATIONAL, ESG. COMNET 393-3318
         *** FT50F001 FOR 7-SPECTRA NODE ACCELERATIONS.
         *** IN BOTH STEPS, FT66 CONTAINS DIAGNOSTIC OUTPUT.
         *** FT66F001 IN G STEP CONTAINS TIME SPENT IN MAJOR PROGRAM PHASES.
         *** FT16F001 DUMMIED WHEN P STEP DELETED.
         *** FT17F001, FT18F001, FT19F001, FT20F001 ADDED FOR SNUBBER ITERATIONS
  4      XXA EXEC PGM=&PROGA
         *** THIS STEP READS THE 7 SPECTRA AND TRANSLATES THEM TO A NEW POINT
         ***  NEW SPECTRA WRITTEN  ON FT01F001
  5      XXSTEPLIB DD DSN=&DSN,DISP=SHR
  6      XXFT01F001 DD UNIT=SYSDA,DSN=&&SPEC,SPACE=(TRK,(10),RLSE),DISP=(,PASS),
         XX DCB=(RECFM=F,LRECL=80,BLKSIZE=80)
  7      XXFT05F001 DD DDNAME=SYSIN
  8      XXFT06F001 DD SYSOUT=*
  9      XXFT66F001 DD DUMMY,DCB=(RECFM=VBA,BLKSIZE=2020)
 10      XXG EXEC PGM=&PROG
         *** THIS STEP EXECUTES ROCKPIPE. LOAD CASES, 7-SPECTRA (IF ANY), AND
         *** GEOMETRY ARE READ FROM UNIT FT15'S 3 CONCATANATED DATA SETS. LOAD
         *** CASES TO BE DELETED FROM PRINTING ARE DETECTED AND THE CASE NO.'S
         *** MADE PLUS. ALL 3 FILES FROM FT15 ARE WRITTEN ON FT05 AS ONE FILE TO
         *** BE READ BY NUPIPE.
 11      XXSTEPLIB DD DSN=&DSN,DISP=SHR
 12      XXFT01F001 DD UNIT=SYSDA,DCB=(RECFM=VBS,BLKSIZE=&B),
         XX SPACE=(CYL,(&C,&C))
 13      XXFT02F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
 14      XXFT03F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
 15      XXFT04F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
 16      XXFT05F001 DD UNIT=SYSDA,SPACE=(80,(20000)),
         XX DCB=(RECFM=FB,LRECL=80,BLKSIZE=19040)
 17      XXFT06F001 DD SYSOUT=*
 18      XXFT07F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
 19      XXFT08F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
 20      XXFT09F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
 21      XXFT10F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C      )
 22      //G.FT11F001 DD DSN=$WW232.SOLAR.WINDD,DISP=SHR
```

FORM 126-P-130 NEW 7-82

079T000008
56

```
 P R O G R A M   I N P U T  D A T A
CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET
CONTROL                 2.0       1.0                                       4.0
FLEXAN        1    1     4.0                        1.0        1.0
 X-DIRECTION 30 MPH WIND
FLEXAN        2    1     4.0                        3.0        1.0
 Z-DIRECTION 30 MPH WIND
MODFLEX       3  1 2   1.0       1.0       3.0                 1.0
 MAXIMUM OF X AND Z ABSOLUTE 30 MPH WIND
MODFLEX       4  3 1   9.0       0.0       1.0                 1.0
 MAXIMUM OF X AND Z ABSOLUTE 90 MPH WIND
FLEXAN        5    1    17.0                                   1.0
 DEADWEIGHT
ACCEL                 .4        .2667        .4
XSECTN             1   54.22     0.721     812.0       29.9
XSECTN             2   30.94     0.721     705.1       29.9
XSECTN             3   21.5      1.0       580.1       29.9        0.0
XSECTN             4   19.0      1.0       859.8       29.9        0.0
XSECTN             5   12.81     1.0       370.3       29.9        0.0
XSECTN             6   26.0      1.97      993.2       29.9        0.0
XSECTN             7   12.75     .562      51.7        29.9        0.0
XSECTN             8   26.0      1.97      993.2       29.9        0.0
XSECTN             9   21.0      0.86      546.6       29.9        0.0
XSECTN            10   18.0      0.75      433.8       29.9        0.0
XSECTN            11   18.0      0.75      433.8       29.9        0.0
XSECTN            12   18.0      0.75      433.8       29.9        0.0
XSECTN            13   18.0      0.75      433.8       29.9        0.0
XSECTN            14   21.0      0.86       546.6      29.9        0.0
XSECTN            15   26.0      1.97      1002.0      29.9        0.0
XSECTN            16   12.75     .562       92.1       29.9        0.0
XSECTN            17   26.0      1.97      1002.0      29.9        0.0
XSECTN            18   24.0      1.0        524.4      29.9        0.0
XSECTN            19   26.0      1.97       927.5      29.9        0.0
XSECTN            20   21.5      1.0        596.4      29.9        0.0
XSECTN            21   19.0      1.0        859.8      29.9        0.0
XSECTN            22   12.81     1.0        376.9      29.9        0.0
XSECTN800         23   12.75      0.562      51.7      299.        0.0
XSECT1700         24   12.75      0.562      89.8      299.        0.0
XSECTN            25  6.625      0.864       85.5     29.9       1590.
XSECTN NA         26  6.625      0.864                29.9       1590.
XSECTN NA         27  12.75      0.406       175.     28.3         65.
XSECTN            28  6.625      0.280       98.5     28.3         65.
XSECTN NA         29  12.75      0.406       130.     27.9         65.
XSECTN            30  6.625      0.280       53.4     27.9         65.
XSECTN            31  12.75      0.687     218.8      28.3         65.
XSECTN NA         32  6.625      0.280                27.9         65.
XSECTN            33  12.75      0.687     218.8      27.9         65.
XSECTN            34  10.75      0.365      154.6     28.3         65.
OPVAL225      1    1    29.4     .01198
OPVAL435      1    2    28.4     .03022
OPVAL470      1    3    28.2     .03344
OPVAL450      1    4    28.3     .03160
OPVAL450      1    5    28.3     .03160
OPVAL620      1    6    27.2     .04086
OPVAL620      1    7    27.2     .04086
OPVAL625      1    8    27.2     .04858
OPVAL640      1    9    27.1     .05012
OPVAL705      1   10    26.6     .05684
OPVAL865      1   11    24.9     .07422
OPVAL1010     1   12    22.7     .09005
```

FORM 126-P-130 NEW 7-82

079T000008
57

OPVAL 1050	1	13	21.7	.09465	
OPVAL 1055	1	14	21.6	.09523	
OPVAL 1057	1	15	21.5	.09546	
OPVAL 1065	1	16	21.3	.09638	
OPVAL 1055	1	17	21.6	.09523	
OPVAL 1025	1	18	22.4	.09178	
OPVAL 1020	1	19	22.5	.09120	
OPVAL 1020	1	20	22.5	.09120	
OPVAL 1015	1	21	22.6	.09063	
OPVAL 1015	1	22	22.6	.09063	
OPVAL800	1	23	273.0	.04703	
OPVAL 1065	1	24	213.0	.09638	
OPVAL 1015	1	25	22.60	.09063	1590.
OPVAL NA	1	26	22.74	.09005	1590.
OPVAL NA	1	27	22.4	.12364	65.
OPVAL 1065	1	28	22.4	.12364	65.
OPVAL NA	1	29	25.61	.04703	65.
OPVAL 610	1	30	25.61	.04703	65.
OPVAL201	2	1	29.5	.00998	
OPVAL381	2	2	29.1	.02533	
OPVAL420	2	3	28.5	.02884	
OPVAL400	2	4	28.5	.02700	
OPVAL400	2	5	28.5	.02700	
OPVAL550	2	6	27.7	.04110	
OPVAL570	2	7	27.6	.04306	
OPVAL575	2	8	27.6	.04355	
OPVAL585	2	9	27.5	.04453	
OPVAL650	2	10	27.0	.05115	
OPVAL770	2	11	26.0	.06379	
OPVAL890	2	12	24.6	.07699	
OPVAL940	2	13	23.9	.08242	
OPVAL942	2	14	23.9	.08264	
OPVAL948	2	15	23.8	.08328	
OPVAL950	2	16	23.8	.08350	
OPVAL950	2	17	23.8	.08350	
OPVAL910	2	18	24.4	.07918	
OPVAL905	2	19	24.4	.07864	
OPVAL902	2	20	24.5	.07832	
OPVAL900	2	21	24.5	.07810	
OPVAL900	2	22	24.5	.07810	
OPVAL570	2	23	276.0	.04306	
OPVAL950	2	24	237.5	.08350	
OPVAL850	2	25	25.1	.07255	1590.
OPVAL NA	2	26	22.74	.09005	1590.
OPVAL NA	2	27	23.2	.10800	65.
OPVAL950	2	28	23.2	.10800	65.
OPVAL NA	2	29	27.4	.0182	65.
OPVAL 300	2	30	27.4	.0182	65.
OPVAL 226	3	1	29.4	.01206	65.
OPVAL 492	3	2	28.0	.03546	65.
OPVAL 600	3	3	27.4	.0460	65.
OPVAL 600	3	4	27.4	.0460	65.
OPVAL 600	3	5	27.4	.0460	65.
OPVAL 600	3	6	27.4	.0460	65.
OPVAL 600	3	7	27.4	.0460	65.
OPVAL 600	3	8	27.4	.0460	65.
OPVAL 600	3	9	27.4	.0460	65.
OPVAL 600	3	10	27.4	.0460	65.
OPVAL 600	3	11	27.4	.0460	65.
OPV[illegible]0	3	12	27.4	.0460	[illegible].
OPV[illegible]0	3	13	27.4	.0460	[illegible].
OPV[illegible]0	3	14	27.4	.0460	[illegible].

FORM 126-P-130 NEW 7-82

079T000008

OPVAL 600	3	15	27.4	.0460			65.
OPVAL 600	3	16	27.4	.0460			65.
OPVAL 600	3	17	27.4	.0460			65.
OPVAL 600	3	18	27.4	.0460			65.
OPVAL 600	3	19	27.4	.0460			65.
OPVAL 600	3	20	27.4	.0460			65.
OPVAL 600	3	21	27.4	.0460			65.
OPVAL 600	3	22	27.4	.0460			65.
OPVAL 600	3	23	274.0	.0460			65.
OPVAL 600	3	24	274.0	.0460			
OPVAL 70	3	25	29.9				1590.
OPVAL NA	3	26	22.74				1590.
OPVAL NA	3	27	25.6	.0624			65.
OPVAL 600	3	28	25.6	.0624			65.
OPVAL NA	3	29	27.4	.0182			65.
OPVAL 300	3	30	27.4	.0182			65.
ANCHOR		1					
RUN *	1	2		5.0		1.0	1.0
RUN	2	3		1.489		2.0	2.0
RUN	3	4		-1.667		3.0	3.0
RUN	4	5		-.646		4.0	4.0
RUN	5	6		-1.896		5.0	5.0
RUN	3	7		5.146		6.0	6.0
TEE	7	800					
RUN	7	9		1.417		8.0	8.0
REDUCER	9	10		1.666		9.0	9.0
RUN	10	8001		5.097		10.0	10.0
RUN	8001	8002		5.097		10.0	10.0
RUN	8002	11		5.097		10.0	10.0
RUN	11	8003		5.083		11.0	11.0
RUN	8003	8004		5.083		11.0	11.0
RUN	8004	12		5.083		11.0	11.0
RUN	12	8005		5.083		12.0	12.0
RUN	8005	8006		5.083		12.0	12.0
RUN	8006	13		5.083		12.0	12.0
RESTRAINT		13	100000.		100000.		
RUN	13	14		0.667		13.0	13.0
REDUCER	14	15		1.666		14.0	14.0
RUN	15	16		1.417		15.0	15.0
TEE	16	1700					
RUN	16	18		5.563		17.0	17.0
ELBOW	18	19	24.0			18.0	18.0
RUN	19	20	-4.0			19.0	19.0
REDUCER	20	21	-1.0			20.0	20.0
RUN	21	22	-0.646			21.0	21.0
REDUCER	22	23	-1.333			22.0	22.0
RUN	7	800	1.083			23.0	23.0
RUN	800	8	0.958			7.0	7.0
RUN	16	1700	1.083			24.0	24.0
RUN	1700	17	1.709			16.0	16.0
RUN	23	25	-1.375			25.0	25.0
RUN	25	105	-1.500			25.0	25.0
RESTRAINT		105		1.0			
CWEIGHT		105		10.0			
RUN	105	106	-0.25				
RESTRAINT		106			50000.		
CWEIGHT		106		10.0			
RUN	106	110	-4.396			25.0	25.0
RUN	110	115	-1.5				
RUN	115	120	-1.5				
RUN	120	122	-1.00				
SNUBBER		122		17000.			

CWEIGHT		122		15.0			
RUN	122	123	-0.25				
RESTRAINT		123		1.0			
CWEIGHT		123		10.0			
RUN	123	125	-1.25				
ELBOW	125	130					
RUN	130	135		-1.5			
SNUBBER		135	25000.				
CWEIGHT		135		15.0			
RUN	135	138		-0.25			
RESTRAINT		138			50000.		
CWEIGHT		138		10.0			
RUN	138	139		-18.031			
RESTRAINT		139			50000.		
CWEIGHT		139		10.0			
RUN	139	140		-0.25			
SNUBBER		140	25000.				
CWEIGHT		140		15.0			
RUN	140	142		-2.875			
RUN	142	144		-3.297			
ELBOW	144	145					
RUN	145	148	1.5				
RESTRAINT		148		1.0			
CWEIGHT		148		10.0			
RUN	148	150	3.0				
RUN	150	155	1.0				
RUN	155	160	1.0				
RUN	160	162	1.75				
SNUBBER		162		17000.			
CWEIGHT		162		15.0			
RUN	162	163	4.75				
RESTRAINT		163		1.0			
CWEIGHT		163		10.0			
RUN	163	165	1.0				
ELBOW	165	170					
RUN	170	172		-3.0			
RESTRAINT		172			50000.		
CWEIGHT		172		10.0			
RUN	172	173		-3.0			
RESTRAINT		173	50000.				
CWEIGHT		173		10.0			
RUN	173	175		-14.0			
RESTRAINT		175			50000.		
CWEIGHT		175		10.0			
RUN	175	177		-2.422			
RUN	177	180		-3.781			
ELBOW	180	185					
RUN	185	190	-2.0				
RUN	190	195	-4.0				
ANCHOR		195	-12.0	17.417			
RUN	17	295	4.5			31.0	28.0
REDUCER	295	310	.667			28.0	
RUN	310	320	2.0				
RUN	320	330	2.0				
RUN	330	335	1.041				
RESTRAINT		335		1.0			
RUN	335	340	3.0				
ELBOW	340	350					
RUN	350	360		-2.25			
RESTI		360			50000.		
CWEI		360		10.0			
RUN	360	361		-0.25			

SNUBBER		361	17000.				
CWEIGHT		361		15.0			
RUN	361	365		-16.75			
RESTRAINT		365			50000.		
CWEIGHT		365		10.0			
RUN	365	369		-0.25			
SNUBBER		369	17000.				
CWEIGHT		369		10.0			
RUN	369	370		-3.5			
ELBOW	370	380					
RUN	380	382	-1.0				
SNUBBER		382		17000.			
CWEIGHT		382.		15.0			
RUN	382	385	-4.5				
RESTRAINT		385		1.0			
CWEIGHT		385		10.0			
RUN	385	390	-5.5				
ELBOW	390	400					
RUN	400	405		-1.25			
RESTRAINT		405	50000.				
CWEIGHT		405		10.0			
RUN	405	406		-.25			
RESTRAINT		406			50000.		
CWEIGHT		406		10.0			
RUN	406	408		-10.0			
SNUBBER		408	17000.				
CWEIGHT		408		15.0			
RUN	408	410		-6.0			
RESTRAINT		410			50000.		
CWEIGHT		410		10.0			
RUN	410	420		-6.343			
ELBOW	420	430					
RUN	430	435	1.0				
RESTRAINT		435		50000.			
CWEIGHT		435		10.0			
RUN	435	440	4.5				
RUN	440	450	5.5				
ANCHOR		450	16.0	17.416			
RUN	8	495	2.541			33.0	30.0
REDUCER	495	510	1.416			30.0	
ELBOW	510	520					
RUN	520	530			4.0		
ELBOW	530	540					
RUN	540	550	2.5				
RUN	550	560	2.0				
RUN	560	570	2.0				
RUN	570	575	1.0			30.0	
RESTRAINT		575		1.0			
RUN	575	580	1.5				
ELBOW	580	590					
RUN	590	600			-4.0		
ELBOW	600	610					
RUN	610	620	2.25				
RUN	620	630	2.25				
ANCHOR		630	19.5	11.635			
RUN	450	1450			5.5	34.0	28.0
ELBOW	1450	1460					
RUN	1460	1465	4.75				
RUN	1465	1467	3.5				
SNUBBER		1467			17000.		
CWEIGHT		1467		15.0			
RUN	1467	1468	0.25				

FORM 126-P-130 NEW 7-82

079T1000008
61

RESTRAINT		1468		50000.	
CWEIGHT		1468		10.0	
RUN	1468	1470	1.00		
ELBOW	1470	1480			
RUN	1480	1485			5.5
RUN	1485	1490			5.5
ELBOW	1490	1495			
RUN	1495	1500	-1.0		
RESTRAINT		1500		50000.	
CWEIGHT		1500		10.0	
RUN	1500	1502	-2.5		
RUN	1502	1503	-2.5		
RUN	1503	1505	-3.5		
ELBOW	1505	1510			
RUN	1510	1520			5.5
ANCHOR		1520	16.0	17.416	22.0
MASSPT		2	1.0	1.0	1.0
MASSPT		9	1.0	1.0	1.0
MASSPT		18	1.0	1.0	1.0
MASSPT		20	1.0	1.0	1.0
MASSPT		22	1.0	1.0	1.0
MASSPT		25	1.0	1.0	1.0
MASSPT		140	1.0	1.0	1.0
MASSPT		150	1.0	1.0	1.0
MASSPT		160	1.0	1.0	1.0
MASSPT		180	1.0	1.0	1.0
MASSPT		17	1.0	1.0	1.0
MASSPT		295	1.0	1.0	1.0
MASSPT		340	1.0	1.0	1.0
MASSPT		370	1.0	1.0	1.0
MASSPT		420	1.0	1.0	1.0
MASSPT		390	1.0	1.0	1.0
MASSPT		510	1.0	1.0	1.0
MASSPT		530	1.0	1.0	1.0
MASSPT		550	1.0	1.0	1.0
MASSPT		570	1.0	1.0	1.0
MASSPT		580	1.0	1.0	1.0
MASSPT		600	1.0	1.0	1.0
STRESS7					
9CASES	5		4		
ALLDONE					

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 3.188 SEC.

4 PREVIOUS CASES BEING READ FROM TAPE11

ORIG NO.	DATE	CASE TITLE
1	02/10/83	X-DIRECTION 30 MPH WIND
2	02/10/83	Z-DIRECTION 30 MPH WIND
3	02/10/83	MAXIMUM OF X AND Z ABSOLUTE 30 MPH WIND
4	02/10/83	MAXIMUM OF X AND Z ABSOLUTE 90 MPH WIND

0079T1000008
63

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 3.502 SEC.

SAVING CASES ON TAPE12

CASE NO.	DATE	CASE TITLE
1	02/10/83	X-DIRECTION 30 MPH WIND
2	02/10/83	Z-DIRECTION 30 MPH WIND
3	02/10/83	MAXIMUM OF X AND Z ABSOLUTE 30 MPH WIND
4	02/10/83	MAXIMUM OF X AND Z ABSOLUTE 90 MPH WIND
5	02/10/83	DEADWEIGHT

FORM 126-P-130 NEW 7-82

079T1000008
64

```
 ****     **        ****     ****     ****     ****
******    **       ******   ******   ******   ******
**    *   **       **  **   **       **           **
**        **       **  **    ****     ****     ****
**    *   **       ******       **       **   **
******    ******   ******   ******   ******   ******
 ****     ******   **  **    ****     ****    ******
```


079TI000008 65

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 3.959 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	1	1.000	35.	811.	0.	35.
	2	1.000	34.	498.	0.	34.
RUN	2	1.000	106.	1562.	0.	106.
	3	1.000	105.	1302.	0.	105.
RUN	3	1.000	0.	51.	0.	0.
	4	1.000	0.	16.	0.	0.
RUN	4	1.000	0.	20.	0.	0.
	5	1.000	0.	10.	0.	0.
RUN	5	1.000	0.	24.	0.	0.
	6	1.000	0.	0.	0.	0.
RUN	3	1.000	61.	772.	0.	61.
	7	1.119	58.	381.	0.	58.
RUN	7	1.119	5.	312.	0.	5.
	9	1.000	5.	255.	0.	5.
REDUCE	9	2.000	23.	1246.	0.	23.
	10	2.000	19.	959.	0.	19.
RUN	10	1.000	20.	1000.	0.	20.
	8001	1.000	8.	367.	0.	8.
RUN	8001	1.000	8.	367.	0.	8.
	8002	1.000	5.	480.	0.	5.
RUN	8002	1.000	5.	480.	0.	5.
	11	1.000	17.	714.	0.	17.
RUN	11	1.000	17.	714.	0.	17.
	8003	1.000	29.	763.	0.	29.
RUN	8003	1.000	29.	763.	0.	29.
	8004	1.000	41.	681.	0.	41.
RUN	8004	1.000	41.	681.	0.	41.
	12	1.000	53.	767.	0.	53.

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 3.976 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	12	1.000	53.	767.	0.	53.
	8005	1.000	65.	1348.	0.	65.
RUN	8005	1.000	65.	1348.	0.	65.
	8006	1.000	77.	2315.	0.	77.
RUN	8006	1.000	77.	2315.	0.	77.
	13	1.000	89.	3580.	0.	89.
RUN	13	1.000	89.	3580.	0.	89.
	14	1.000	92.	3197.	0.	92.
REDUCE	14	2.000	88.	3068.	0.	88.
	15	2.000	96.	2172.	0.	96.
RUN	15	1.000	20.	444.	0.	20.
	16	1.119	21.	296.	0.	21.
RUN	16	1.119	1.	281.	0.	1.
	18	1.000	1.	112.	0.	1.
ELBOW	18	2.809	6.	508.	0.	6.
	19	2.809	322.	446.	0.	322.
RUN	19	1.000	71.	98.	0.	71.
	20	1.000	93.	108.	0.	93.
REDUCE	20	2.000	378.	440.	0.	378.
	21	2.000	355.	404.	0.	355.
RUN	21	1.000	307.	349.	0.	307.
	22	1.000	277.	315.	0.	277.
REDUCE	22	2.000	965.	1097.	0.	965.
	23	2.000	633.	777.	0.	633.
RUN	7	1.119	650.	1488.	0.	650.
	800	1.000	531.	1226.	0.	531.
RUN	800	1.000	531.	1226.	0.	531.
	8	1.000	368.	852.	0.	368.

079TI000008
67

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 3.993 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	16	1.119	246.	1243.	0.	246.
	1700	1.000	359.	1203.	0.	359.
RUN	1700	1.000	359.	1203.	0.	359.
	17	1.000	452.	892.	0.	452.
RUN	23	1.000	5100.	5569.	0.	5100.
	25	1.000	3762.	4433.	0.	3762.
RUN	25	1.000	3762.	4433.	0.	3762.
	105	1.000	3892.	4891.	0.	3892.
RUN	105	1.000	3892.	4891.	0.	3892.
	106	1.000	3834.	4897.	0.	3834.
RUN	106	1.000	3834.	4897.	0.	3834.
	110	1.000	3306.	4312.	0.	3306.
RUN	110	1.000	3306.	4312.	0.	3306.
	115	1.000	3327.	4528.	0.	3327.
RUN	115	1.000	3327.	4528.	0.	3327.
	120	1.000	3451.	4861.	0.	3451.
RUN	120	1.000	3451.	4861.	0.	3451.
	122	1.000	3591.	5139.	0.	3591.
RUN	122	1.000	3591.	5139.	0.	3591.
	123	1.000	3635.	5218.	0.	3635.
RUN	123	1.000	3635.	5218.	0.	3635.
	125	1.000	3280.	4933.	0.	3280.
ELBOW	125	1.000	3280.	4933.	0.	3280.
	130	1.000	3304.	4689.	0.	3304.
RUN	130	1.000	3304.	4689.	0.	3304.
	135	1.000	3289.	4325.	0.	3289.
RUN	135	1.000	3289.	4325.	0.	3289.
	138	1.000	3285.	4211.	0.	3285.

0791000008
68

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 4.010 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	138	1.000	3285.	4211.	0.	3285.
	139	1.000	3169.	5317.	0.	3169.
RUN	139	1.000	3169.	5317.	0.	3169.
	140	1.000	3174.	5225.	0.	3174.
RUN	140	1.000	3174.	5225.	0.	3174.
	142	1.000	3231.	4236.	0.	3231.
RUN	142	1.000	3231.	4236.	0.	3231.
	144	1.000	3282.	3720.	0.	3282.
ELBOW	144	1.000	3282.	3720.	0.	3282.
	145	1.000	3200.	3782.	0.	3200.
RUN	145	1.000	3200.	3782.	0.	3200.
	148	1.000	3634.	4284.	0.	3634.
RUN	148	1.000	3634.	4284.	0.	3634.
	150	1.000	3155.	4172.	0.	3155.
RUN	150	1.000	3155.	4172.	0.	3155.
	155	1.000	3087.	4214.	0.	3087.
RUN	155	1.000	3087.	4214.	0.	3087.
	160	1.000	3064.	4290.	0.	3064.
RUN	160	1.000	3064.	4290.	0.	3064.
	162	1.000	3133.	4512.	0.	3133.
RUN	162	1.000	3133.	4512.	0.	3133.
	163	1.000	4063.	5893.	0.	4063.
RUN	163	1.000	4063.	5893.	0.	4063.
	165	1.000	3754.	5618.	0.	3754.
ELBOW	165	1.000	3754.	5618.	0.	3754.
	170	1.000	3262.	4608.	0.	3262.
RUN	170	1.000	3262.	4608.	0.	3262.
	172	1.000	3307.	4124.	0.	3307.

0791I000008 69

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 4.026 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	172	1.000	3307.	4124.	0.	3307.
	173	1.000	3366.	6994.	0.	3366.
RUN	173	1.000	3366.	6994.	0.	3366.
	175	1.000	3085.	3738.	0.	3085.
RUN	175	1.000	3085.	3738.	0.	3085.
	177	1.000	3146.	3829.	0.	3146.
RUN	177	1.000	3146.	3829.	0.	3146.
	180	1.000	3223.	3746.	0.	3223.
ELBOW	180	1.000	3223.	3746.	0.	3223.
	185	1.000	3251.	3582.	0.	3251.
RUN	185	1.000	3251.	3582.	0.	3251.
	190	1.000	3196.	3313.	0.	3196.
RUN	190	1.000	3196.	3313.	0.	3196.
	195	1.000	3554.	4384.	0.	3554.
RUN	17	1.000	679.	1046.	0.	679.
	295	1.000	490.	783.	0.	490.
REDUCE	295	2.000	2888.	6786.	0.	2888.
	310	2.000	1802.	5964.	0.	1802.
RUN	310	1.000	1330.	4104.	0.	1330.
	320	1.000	1965.	4995.	0.	1965.
RUN	320	1.000	1965.	4995.	0.	1965.
	330	1.000	5025.	7908.	0.	5025.
RUN	330	1.000	5025.	7908.	0.	5025.
	335	1.000	6829.	9514.	0.	6829.
RUN	335	1.000	6829.	9514.	0.	6829.
	340	1.000	420.	2717.	0.	420.
ELBOW	340	2.267	445.	4350.	0.	445.
	350	2.267	3486.	5257.	0.	3486.

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 4.043 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	350	1.000	2209.	3251.	0.	2209.
	360	1.000	2001.	3724.	0.	2001.
RUN	360	1.000	2001.	3724.	0.	2001.
	361	1.000	1966.	3749.	0.	1966.
RUN	361	1.000	1966.	3749.	0.	1966.
	365	1.000	1133.	5218.	0.	1133.
RUN	365	1.000	1133.	5218.	0.	1133.
	369	1.000	1168.	4870.	0.	1168.
RUN	369	1.000	1168.	4870.	0.	1168.
	370	1.000	1550.	2252.	0.	1550.
ELBOW	370	2.267	2366.	3560.	0.	2366.
	380	2.267	1945.	5341.	0.	1945.
RUN	380	1.000	1302.	3300.	0.	1302.
	382	1.000	1161.	3205.	0.	1161.
RUN	382	1.000	1161.	3205.	0.	1161.
	385	1.000	3667.	6163.	0.	3667.
RUN	385	1.000	3667.	6163.	0.	3667.
	390	1.000	479.	1730.	0.	479.
ELBOW	390	2.267	545.	2672.	0.	545.
	400	2.267	1124.	6452.	0.	1124.
RUN	400	1.000	820.	3954.	0.	820.
	405	1.000	889.	5557.	0.	889.
RUN	405	1.000	889.	5557.	0.	889.
	406	1.000	875.	5157.	0.	875.
RUN	406	1.000	875.	5157.	0.	875.
	408	1.000	472.	5698.	0.	472.
RUN	408	1.000	472.	5698.	0.	472.
	410	1.000	818.	6290.	0.	818.

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 4.059 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	410	1.000	818.	6290.	0.	818.
	420	1.000	1141.	2893.	0.	1141.
ELBOW	420	2.267	1671.	4649.	0.	1671.
	430	2.267	2704.	7676.	0.	2704.
RUN	430	1.000	1749.	4674.	0.	1749.
	435	1.000	2494.	5452.	0.	2494.
RUN	435	1.000	2494.	5452.	0.	2494.
	440	1.000	807.	2030.	0.	807.
RUN	440	1.000	807.	2030.	0.	807.
	450	1.000	538.	4826.	0.	538.
RUN	8	1.000	609.	1013.	0.	609.
	495	1.000	403.	476.	0.	403.
REDUCE	495	2.000	1728.	2710.	0.	1728.
	510	2.000	1621.	2828.	0.	1621.
ELBOW	510	2.267	1786.	3154.	0.	1786.
	520	2.267	1378.	2227.	0.	1378.
RUN	520	1.000	969.	1468.	0.	969.
	530	1.000	733.	1459.	0.	733.
ELBOW	530	2.267	978.	2210.	0.	978.
	540	2.267	1249.	2619.	0.	1249.
RUN	540	1.000	893.	1699.	0.	893.
	550	1.000	958.	1366.	0.	958.
RUN	550	1.000	958.	1366.	0.	958.
	560	1.000	819.	1313.	0.	819.
RUN	560	1.000	819.	1313.	0.	819.
	570	1.000	743.	1249.	0.	743.
RUN	570	1.000	743.	1249.	0.	743.
	575	1.000	987.	1721.	0.	987.

079TI000008
72

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 4.076 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	575	1.000	987.	1721.	0.	987.
	580	1.000	794.	1699.	0.	794.
ELBOW	580	2.267	1081.	2619.	0.	1081.
	590	2.267	607.	1964.	0.	607.
RUN	590	1.000	516.	1314.	0.	516.
	600	1.000	611.	1165.	0.	611.
ELBOW	600	2.267	769.	1711.	0.	769.
	610	2.267	769.	2186.	0.	769.
RUN	610	1.000	611.	1444.	0.	611.
	620	1.000	685.	1526.	0.	685.
RUN	620	1.000	685.	1526.	0.	685.
	630	1.000	1146.	3984.	0.	1146.
RUN	450	1.000	2328.	5736.	0.	2328.
	1450	1.000	699.	2333.	0.	699.
ELBOW	1450	2.606	910.	4104.	0.	910.
	1460	2.606	1028.	3591.	0.	1028.
RUN	1460	1.000	760.	2071.	0.	760.
	1465	1.000	877.	1425.	0.	877.
RUN	1465	1.000	877.	1425.	0.	877.
	1467	1.000	701.	2573.	0.	701.
RUN	1467	1.000	701.	2573.	0.	701.
	1468	1.000	775.	2719.	0.	775.
RUN	1468	1.000	775.	2719.	0.	775.
	1470	1.000	869.	2745.	0.	869.
ELBOW	1470	2.606	1242.	4909.	0.	1242.
	1480	2.606	1302.	4563.	0.	1302.
RUN	1480	1.000	900.	2568.	0.	900.
	1485	1.000	1442.	1852.	0.	1442.

0797I000008 73

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 4.093 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	1485	1.000	1442.	1852.	0.	1442.
	1490	1.000	901.	2568.	0.	901.
ELBOW	1490	2.606	1304.	4563.	0.	1304.
	1495	2.606	1253.	4905.	0.	1253.
RUN	1495	1.000	875.	2743.	0.	875.
	1500	1.000	780.	2718.	0.	780.
RUN	1500	1.000	780.	2718.	0.	780.
	1502	1.000	734.	1811.	0.	734.
RUN	1502	1.000	734.	1811.	0.	734.
	1503	1.000	913.	1292.	0.	913.
RUN	1503	1.000	913.	1292.	0.	913.
	1505	1.000	754.	2068.	0.	754.
ELBOW	1505	2.606	1016.	3586.	0.	1016.
	1510	2.606	905.	4105.	0.	905.
RUN	1510	1.000	697.	2334.	0.	697.
	1520	1.000	2327.	5707.	0.	2327.

079T000008
74

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 4.129 SEC.

T A B L E O F C O N T E N T S


```
IAT6140 JOB ORIGIN FROM GROUP=RM206    , DSP=IJP, DEVICE=INTRDR  , 000
14:18:29 IAT4401  LOCATE FOR STEP=A        DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
14:18:29 IAT4402 UNIT=3350    ,VOL(S)=CVTSOK
14:18:29 IAT4401  LOCATE FOR STEP=G        DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
14:18:29 IAT4402 UNIT=3350    ,VOL(S)=CVTSOK
14:18:29 IAT4401  LOCATE FOR STEP=G        DD=FT11F001 DSN=$WW232.SOLAR.WINDY
14:18:29 IAT4402 UNIT=3350    ,VOL(S)=AVTSOA
14:18:29 IAT4401  LOCATE FOR STEP=G        DD=FT15F001 DSN=$WW232.CARRIZO.TOTAL.DATA
14:18:29 IAT4402 UNIT=3350    ,VOL(S)=AVTSOA
14:18:29 IAT4401  LOCATE FOR STEP=ELTEMP   DD=STEPLIB  DSN=$WW049.ELTEMP.LOAD
14:18:29 IAT4402 UNIT=3350    ,VOL(S)=CVTSOK
14:18:30 USES     CVTSOK          D $WW049.NUPIPE.LOAD
14:18:30 USES     AVTSOA          D $WW232.SOLAR.WINDY
14:18:30 IAT5200 JOB 3592 ($WW232E3) IN SETUP ON MAIN=C       P=03 LOCAL
14:18:30 IAT5210 J=3592 STEPLIB  USING D CVTSOK ON 528   $WW049.NUPIPE.LOAD
14:18:30 IAT5210 J=3592 FT11F001 USING D AVTSOA ON 520   $WW232.SOLAR.WINDY
14:20:15 IAT2000 JOB 3592 $WW232E3 SELECTED L       GRP=BIG
14:20:16 L R= $WW232E3 NEF995I $WW232E3 STARTED, 2/10/83,14.20.16 ASID=00012
14:20:16 L R= $WW232E3 IEF403I $WW232E3 - STARTED - TIME=14.20.16
14:27:45 L R= $WW232E3 +IH0002I STOP      1
14:27:48 L R= $WW232E3 IEF404I $WW232E3 - ENDED - TIME=14.27.46
14:27:48 L R= $WW232E3 NEF996I $WW232E3 ENDED,  2/10/83,B.U.=     5.7812 *0716935    ,3033-L3,JOB CC= 001
14:27:52 IAT5400 JOB 3592 ($WW232E3) IN BREAKDOWN
/$WW232E3 JOB 'GURSAHANI LB30130340*0716935          005  5001003037', *
/ REGION=4500K,TIME=5,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
/*MAIN ORG=RM206                                                  00000300
/* THESE THREE ARE FOR XEROX OUTPUT                               00000500
/*FORMAT PR,DDNAME=SYSMSG,DEST=RM271PR3,FCB=JB10,COPIES=1         00000600
/*FORMAT PR,DDNAME=FT66F001,DEST=RM271PR3,FCB=JB10,COPIES=1       00000700
/*FORMAT PR,DDNAME=FT06F001,DEST=RM271PR3,FCB=JB10,COPIES=1       00000800
/* THESE THREE ARE FOR MICROFICHE OUTPUT                          00001300
/*FORMAT PR,DDNAME=SYSMSG,DEST=RM001PR5,FORMS=FICHE,COPIES=1      00001400
/*FORMAT PR,DDNAME=SYSPRINT,DEST=RM001PR5,FORMS=FICHE,COPIES=1    00001500
/*FORMAT PR,DDNAME=SYSUT2,DEST=RM001PR5,FORMS=FICHE,COPIES=1      00001600
/ EXEC ROCKPIPE,PROG=SMALL
/G.FT11F001 DD DSN=$WW232.SOLAR.WINDY,DISP=SHR
/G.SYSIN DD DSN=$WW232.CARRIZO.TOTAL.DATA,DISP=SHR
   1      //$WW232E3 JOB 'GURSAHANI LB30130340*0716935          005  5001003037', *
          // REGION=4500K,TIME=5,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
          *** THESE THREE ARE FOR XEROX OUTPUT                              00000500
          *** THESE THREE ARE FOR MICROFICHE OUTPUT                         00001300
   2      // EXEC ROCKPIPE,PROG=SMALL
   3      XXROCKPIPE PROC DSN='$WW049.NUPIPE.LOAD',PROG=SMALL,C=10,
          XX PROGA=SEVEN,B=19069,PROGE=OPT2,DSNE='$WW049.ELTEMP.LOAD'
          *** AL HROMJAK ROCKWELL INTERNATIONAL, ESG. COMNET 393-3318
```

FORM 126-P-130 NEW 7-82

0791T000008
75

```
  P R O G R A M    I N P U T   D A T A
CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET
CONTROL                  2.0       1.0                                5.0
FLEXAN        1    1      4.0                      1.0
 X-DIRECTION 30 MPH WIND
FLEXAN        2   . 1     4.0                      3.0
 Z-DIRECTION 30 MPH WIND
MODFLEX       3   1 2   1.0       1.0       3.0
 MAXIMUM OF X AND Z ABSOLUTE 30 MPH WIND
MODFLEX       4   3 1   9.0       0.0       1.0
 MAXIMUM OF X AND Z ABSOLUTE 90 MPH WIND
FLEXAN        5    1     17.0
 DEADWEIGHT
FLEXAN        6    1     2.0
 TE1 (THERMAL AT THE DESIGN TEMPERATURE)
FLEXAN        7    2     2.0
 TE2 (THERMAL OVERNIGHT SHUTDOWN)
FLEXAN        8    3     2.0
 TE3 (SG AND NA INLET AT 600, NA OUTLET AT 300 AND STEAM PIPING AT 70)
FLEXAN        9    1     4.0                        1.0
 OBE X - DIRECTION AT .4G
FLEXAN       10    1     4.0                        2.0
 OBE Y - DIRECTION AT .2667G
FLEXAN       11    1     4.0                        3.0
 OBE Z - DIRECTION AT .4G
MODFLEX      12  5 6    1.0       1.0
 DWT(SIGN) + TE1(SIGN)  DIRECT COMBINATION
MODFLEX      13  5 7    1.0       1.0
 DWT(SIGN) + TE2(SIGN)  DIRECT COMBINATION
MODFLEX      14  5 8    1.0       1.0
 DWT(SIGN) + TE3(SIGN)  DIRECT COMBINATION
MODFLEX      15  911    1.0       1.0      3.0
 MAXIMUM OF X-OBE(ABS) AND Z-OBE(ABS)
MODFLEX      16 1015    1.0       1.0      1.0
 Y(ABS) + MAXIMUM OF X(ABS) AND Z(ABS)  CALL THIS  "TOTAL OBE"
MODFLEX      17  316    1.0       1.0      1.0
 TOTAL OBE + WIND LOAD (30MPH)
MODFLEX      18  517    1.0       1.0      1.0
 DWT + TOTAL OBE + WIND LOAD (30MPH)
MODFLEX      19 1217    1.0       1.0      1.0
 (DWT + TE1)ABS + TOTAL OBE + WIND LOAD (30MPH)
MODFLEX      20  5 4    1.0       1.0      1.0
 DWT + 90MPH WIND
MODFLEX      21 13 4    1.0       1.0      1.0
 (DWT + TE2)ABS + 90MPH WIND
MODFLEX      22 14 4    1.0       1.0      1.0
 (DWT + TE3)ABS + 90MPH WIND
MODFLEX      23 12 3    1.0       1.0      1.0
 (DWT + TE1)ABS + 30MPH WIND
MODFLEX      24  5 3    1.0       1.0      1.0
 DWT + 30MPH WIND
MODFLEX      25 13 3    1.0       1.0      1.0
 DWT + 30MPH WIND + TE2
MODFLEX      26 2516    1.0       1.0      1.0
 DWT + 30MPH WIND + TE2 + OBE
MODFLEX      27 14 3    1.0       1.0      1.0
 DWT + TE3 + 30PMH WIND
MODFLE       28 1627    1.0       1.0      1.0
 DWT +      + TOTAL OBE + 30MPH WIND
ACCEL                  .4        .2667       .4
```

FORM 126-P-130 NEW 7-82

079TI000008
76

XSECTN		1	54.22	0.721	812.0	29.9	
XSECTN		2	30.94	0.721	705.1	29.9	
XSECTN		3	21.5	1.0	580.1	29.9	0.0
XSECTN		4	19.0	1.0	859.8	29.9	0.0
XSECTN		5	12.81	1.0	370.3	29.9	0.0
XSECTN		6	26.0	1.97	993.2	29.9	0.0
XSECTN		7	12.75	.562	51.7	29.9	0.0
XSECTN		8	26.0	1.97	993.2	29.9	0.0
XSECTN		9	21.0	0.86	546.6	29.9	0.0
XSECTN		10	18.0	0.75	433.8	29.9	0.0
XSECTN		11	18.0	0.75	433.8	29.9	0.0
XSECTN		12	18.0	0.75	433.8	29.9	0.0
XSECTN		13	18.0	0.75	433.8	29.9	0.0
XSECTN		14	21.0	0.86	546.6	29.9	0.0
XSECTN		15	26.0	1.97	1002.0	29.9	0.0
XSECTN		16	12.75	.562	92.1	29.9	0.0
XSECTN		17	26.0	1.97	1002.0	29.9	0.0
XSECTN		18	24.0	1.0	524.4	29.9	0.0
XSECTN		19	26.0	1.97	927.5	29.9	0.0
XSECTN		20	21.5	1.0	596.4	29.9	0.0
XSECTN		21	19.0	1.0	859.8	29.9	0.0
XSECTN		22	12.81	1.0	376.9	29.9	0.0
XSECTN800		23	12.75	0.562	51.7	299.	0.0
XSECT1700		24	12.75	0.562	89.8	299.	0.0
XSECTN		25	6.625	0.864	85.5	29.9	1590.
XSECTN NA		26	6.625	0.864		29.9	1590.
XSECTN NA		27	12.75	0.406	175.	28.3	65.
XSECTN		28	6.625	0.280	98.5	28.3	65.
XSECTN NA		29	12.75	0.406	130.	27.9	65.
XSECTN		30	6.625	0.280	53.4	27.9	65.
XSECTN		31	12.75	0.687	218.8	28.3	65.
XSECTN NA		32	6.625	0.280		27.9	65.
XSECTN		33	12.75	0.687	218.8	27.9	65.
XSECTN		34	10.75	0.365	154.6	28.3	65.
OPVAL225	1	1	29.4	.01198			
OPVAL435	1	2	28.4	.03022			
OPVAL470	1	3	28.2	.03344			
OPVAL450	1	4	28.3	.03160			
OPVAL450	1	5	28.3	.03160			
OPVAL587	1	6	27.5	.04473			
OPVAL620	1	7	27.2	.04086			
OPVAL625	1	8	27.2	.04858			
OPVAL640	1	9	27.1	.05012			
OPVAL705	1	10	26.6	.05684			
OPVAL865	1	11	24.9	.07422			
OPVAL1010	1	12	22.7	.09005			
OPVAL1050	1	13	21.7	.09465			
OPVAL1055	1	14	21.6	.09523			
OPVAL1057	1	15	21.5	.09546			
OPVAL1065	1	16	21.3	.09638			
OPVAL1055	1	17	21.6	.09523			
OPVAL1025	1	18	22.4	.09178			
OPVAL1020	1	19	22.5	.09120			
OPVAL1020	1	20	22.5	.09120			
OPVAL1015	1	21	22.6	.09063			
OPVAL1015	1	22	22.6	.09063			
OPVAL800	1	23	273.0	.04703			
OPVAL1065	1	24	213.0	.09638			
OPVAL1015	1	25	22.60	.09063			1590.
OPVAL NA	1	26	22.74	.09005			1590.
OPVAL NA	1	27	22.4	.12364			65.
OPVAL1065	1	28	22.4	.12364			65.

FORM 126-P-130 NEW 7-82

OPVAL NA	1	29	25.61	.04703	65.
OPVAL 610	1	30	25.61	.04703	65.
OPVAL201	2	1	29.5	.00998	
OPVAL381	2	2	29.1	.02533	
OPVAL420	2	3	28.5	.02884	
OPVAL400	2	4	28.5	.02700	
OPVAL400	2	5	28.5	.02700	
OPVAL550	2	6	27.7	.04110	
OPVAL570	2	7	27.6	.04306	
OPVAL575	2	8	27.6	.04355	
OPVAL585	2	9	27.5	.04453	
OPVAL650	2	10	27.0	.05115	
OPVAL770	2	11	26.0	.06379	
OPVAL890	2	12	24.6	.07699	
OPVAL940	2	13	23.9	.08242	
OPVAL942	2	14	23.9	.08264	
OPVAL948	2	15	23.8	.08328	
OPVAL950	2	16	23.8	.08350	
OPVAL950	2	17	23.8	.08350	
OPVAL910	2	18	24.4	.07918	
OPVAL905	2	19	24.4	.07864	
OPVAL902	2	20	24.5	.07832	
OPVAL900	2	21	24.5	.07810	
OPVAL900	2	22	24.5	.07810	
OPVAL570	2	23	276.0	.04306	
OPVAL950	2	24	237.5	.08350	
OPVAL850	2	25	25.1	.07255	1590.
OPVAL NA	2	26	22.74	.09005	1590.
OPVAL NA	2	27	23.2	.10800	65.
OPVAL950	2	28	23.2	.10800	65.
OPVAL NA	2	29	27.4	.0182	65.
OPVAL 300	2	30	27.4	.0182	65.
OPVAL 226	3	1	29.4	.01206	65.
OPVAL 492	3	2	28.0	.03546	65.
OPVAL 600	3	3	27.4	.0460	65.
OPVAL 600	3	4	27.4	.0460	65.
OPVAL 600	3	5	27.4	.0460	65.
OPVAL 600	3	6	27.4	.0460	65.
OPVAL 600	3	7	27.4	.0460	65.
OPVAL 600	3	8	27.4	.0460	65.
OPVAL 600	3	9	27.4	.0460	65.
OPVAL 600	3	10	27.4	.0460	65.
OPVAL 600	3	11	27.4	.0460	65.
OPVAL 600	3	12	27.4	.0460	65.
OPVAL 600	3	13	27.4	.0460	65.
OPVAL 600	3	14	27.4	.0460	65.
OPVAL 600	3	15	27.4	.0460	65.
OPVAL 600	3	16	27.4	.0460	65.
OPVAL 600	3	17	27.4	.0460	65.
OPVAL 600	3	18	27.4	.0460	65.
OPVAL 600	3	19	27.4	.0460	65.
OPVAL 600	3	20	27.4	.0460	65.
OPVAL 600	3	21	27.4	.0460	65.
OPVAL 600	3	22	27.4	.0460	65.
OPVAL 600	3	23	274.0	.0460	65.
OPVAL 600	3	24	274.0	.0460	
OPVAL 70	3	25	29.9		1590.
OPVAL NA	3	26	22.74		1590.
OPVAL NA	3	27	25.6	.0624	65.
OPVAL	3	28	25.6	.0624	65.
OPVAL	3	29	27.4	.0182	
OPVAL	3	30	27.4	.0182	

ANCHOR		1					
RUN	1	2		5.0		1.0	1.0
RUN	2	3		1.489		2.0	2.0
RUN	3	4		-1.667		3.0	3.0
RUN	4	5		-.646		4.0	4.0
RUN	5	6		-1.896		5.0	5.0
RUN	3	7		5.146		6.0	6.0
TEE	7	800					
RUN	7	9		1.417		8.0	8.0
REDUCER	9	10		1.666		9.0	9.0
RUN	10	8001		5.097		10.0	10.0
RUN	8001	8002		5.097		10.0	10.0
RUN	8002	11		5.097		10.0	10.0
RUN	11	8003		5.083		11.0	11.0
RUN	8003	8004		5.083		11.0	11.0
RUN	8004	12		5.083		11.0	11.0
RUN	12	8005		5.083		12.0	12.0
RUN	8005	8006		5.083		12.0	12.0
RUN	8006	13		5.083		12.0	12.0
RESTRAINT		13	100000.		100000.		
RUN	13	14		0.667		13.0	13.0
REDUCER	14	15		1.666		14.0	14.0
RUN	15	16		1.417		15.0	15.0
TEE	16	1700					
RUN	16	18		5.563		17.0	17.0
ELBOW	18	19	24.0			18.0	18.0
RUN	19	20	-4.0			19.0	19.0
REDUCER	20	21	-1.0			20.0	20.0
RUN	21	22	-0.646			21.0	21.0
REDUCER	22	23	-1.333			22.0	22.0
RUN	7	800	1.083			23.0	23.0
RUN	800	8	0.958			7.0	7.0
RUN	16	1700	1.083			24.0	24.0
RUN	1700	17	1.709			16.0	16.0
RUN	23	25	-1.375			25.0	25.0
RUN	25	105	-1.500			25.0	25.0
RESTRAINT		105		1.0			
CWEIGHT		105		10.0			
RUN	105	106	-0.25				
RESTRAINT		106			50000.		
CWEIGHT		106		10.0			
RUN	106	110	-4.396			25.0	25.0
RUN	110	115	-1.5				
RUN	115	120	-1.5				
RUN	120	122	-1.00				
SNUBBER		122		17000.			
CWEIGHT		122		15.0			
RUN	122	123	-0.25				
RESTRAINT		123		1.0			
CWEIGHT		123		10.0			
RUN	123	125	-1.25				
ELBOW	125	130					
RUN	130	135		-1.5			
SNUBBER		135	25000.				
CWEIGHT		135		15.0			
RUN	135	138		-0.25			
RESTRAINT		138			50000.		
CWEIGHT		138		10.0			
RUN	138	139		-18.031			
RESTRAINT		139			50000.		
CWEIGHT		139		10.0			
RUN	139	140		-0.25			

SNUBBER		140	25000.				
CWEIGHT		140		15.0			
RUN	140	142		-2.875			
RUN	142	144		-3.297			
ELBOW	144	145					
RUN	145	148	1.5				
RESTRAINT		148		1.0			
CWEIGHT		148		10.0			
RUN	148	150	3.0				
RUN	150	155	1.0				
RUN	155	160	1.0				
RUN	160	162	1.75				
SNUBBER		162		17000.			
CWEIGHT		162		15.0			
RUN	162	163	4.75				
RESTRAINT		163		1.0			
CWEIGHT		163		10.0			
RUN	163	165	1.0				
ELBOW	165	170					
RUN	170	172		-3.0			
RESTRAINT		172			50000.		
CWEIGHT		172		10.0			
RUN	172	173		-3.0			
RESTRAINT		173	50000.				
CWEIGHT		173		10.0			
RUN	173	175		-14.0			
RESTRAINT		175			50000.		
CWEIGHT		175		10.0			
RUN	175	177		-2.422			
RUN	177	180		-3.781			
ELBOW	180	185					
RUN	185	190	-2.0				
RUN	190	195	-4.0				
ANCHOR		195	-12.0	17.417			
RUN	17	295	4.5			31.0	28.0
REDUCER	295	310	.667			28.0	
RUN	310	320	2.0				
RUN	320	330	2.0				
RUN	330	335	1.041				
RESTRAINT		335		1.0			
RUN	335	340	3.0				
ELBOW	340	350					
RUN	350	360		-2.25			
RESTRAINT		360			50000.		
CWEIGHT		360		10.0			
RUN	360	361		-0.25			
SNUBBER		361	17000.				
CWEIGHT		361		15.0			
RUN	361	365		-16.75			
RESTRAINT		365			50000.		
CWEIGHT		365		10.0			
RUN	365	369		-0.25			
SNUBBER		369	17000.				
CWEIGHT		369		10.0			
RUN	369	370		-3.5			
ELBOW	370	380					
RUN	380	382	-1.0				
SNUBBER		382		17000.			
CWEIGHT		382		15.0			
RUN	382	385	-4.5				
RESTRA		385		1.0			
CWEIGH.		385		10.0			

RUN	385	390	-5.5				
ELBOW	390	400					
RUN	400	405		-1.25			
RESTRAINT		405	50000.				
CWEIGHT		405		10.0			
RUN	405	406		-.25			
RESTRAINT		406			50000.		
CWEIGHT		406		10.0			
RUN	406	408		-10.0			
SNUBBER		408	17000.				
CWEIGHT		408		15.0			
RUN	408	410		-6.0			
RESTRAINT		410			50000.		
CWEIGHT		410		10.0,			
RUN	410	420		-6.343			
ELBOW	420	430					
RUN	430	435	1.0				
RESTRAINT		435		50000.			
CWEIGHT		435		10.0			
RUN	435	440	4.5				
RUN	440	450	5.5				
ANCHOR		450	16.0	17.416			
RUN	8	495	2.541			33.0	30.0
REDUCER	495	510	1.416			30.0	
ELBOW	510	520					
RUN	520	530			4.0		
ELBOW	530	540					
RUN	540	550	2.5				
RUN	550	560	2.0				
RUN	560	570	2.0				
RUN	570	575	1.0			30.0	
RESTRAINT		575		1.0			
RUN	575	580	1.5				
ELBOW	580	590					
RUN	590	600			-4.0		
ELBOW	600	610					
RUN	610	620	2.25				
RUN	620	630	2.25				
ANCHOR		630	19.5	11.635			
RUN	450	1450			5.5	34.0	28.0
ELBOW	1450	1460					
RUN	1460	1465	4.75				
RUN	1465	1467	3.5				
SNUBBER		1467			17000.		
CWEIGHT		1467		15.0			
RUN	1467	1468	0.25				
RESTRAINT		1468		50000.			
CWEIGHT		1468		10.0			
RUN	1468	1470	1.00				
ELBOW	1470	1480					
RUN	1480	1485			5.5		
RUN	1485	1490			5.5		
ELBOW	1490	1495					
RUN	1495	1500	-1.0				
RESTRAINT		1500		50000.			
CWEIGHT		1500		10.0			
RUN	1500	1502	-2.5				
RUN	1502	1503	-2.5				
RUN	1503	1505	-3.5				
ELBOW	1505	1510					
RUN	1510	1520			5.5		
ANCHOR		1520	16.0	17.416	22.0		

```
MASSPT          2   1.0       1.0       1.0
MASSPT          9   1.0       1.0       1.0
MASSPT         18   1.0       1.0       1.0
MASSPT         20   1.0       1.0       1.0
MASSPT         22   1.0       1.0       1.0
MASSPT         25   1.0       1.0       1.0
MASSPT        140   1.0       1.0       1.0
MASSPT        150   1.0       1.0       1.0
MASSPT        160   1.0       1.0       1.0
MASSPT        180   1.0       1.0       1.0
MASSPT         17   1.0       1.0       1.0
MASSPT        295   1.0       1.0       1.0
MASSPT        340   1.0       1.0       1.0
MASSPT        370   1.0       1.0       1.0
MASSPT        420   1.0       1.0       1.0
MASSPT        390   1.0       1.0       1.0
MASSPT        510   1.0       1.0       1.0
MASSPT        530   1.0       1.0       1.0
MASSPT        550   1.0       1.0       1.0
MASSPT        570   1.0       1.0       1.0
MASSPT        580   1.0       1.0       1.0
MASSPT        600   1.0       1.0       1.0
STRESS7
9CASES    24         16
10CASES    6    7     8
ALLDONE
REPORT
IEDIT
OEDIT      1
B1LOADCS   3    4    5    6    7    8   12   13   14   16   18   19   20   21
B1LOADCS  22   23   24   25   26   27   28
B1NODES    1    2    3    7    8    9   10   11   12   13   14   15   16   17
B1NODES   18   19   20   21   22   23
B1THERMLC -1
ALLDONE
```

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 17.444 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	1	1.000	113.	1520.	230.	343.
	2	1.000	78.	983.	160.	238.
RUN	2	1.000	244.	3081.	523.	767.
	3	1.000	214.	2633.	456.	670.
RUN	3	1.000	6.	92.	0.	6.
	4	1.000	2.	28.	0.	2.
RUN	4	1.000	2.	37.	0.	2.
	5	1.000	1.	19.	0.	1.
RUN	5	1.000	3.	44.	0.	3.
	6	1.000	0.	0.	0.	0.
RUN	3	1.000	126.	1558.	271.	397.
	7	1.119	82.	885.	239.	320.
RUN	7	1.119	37.	826.	201.	238.
	9	1.000	30.	693.	164.	194.
REDUCE	9	2.000	148.	3388.	1070.	1218.
	10	2.000	114.	2698.	952.	1065.
RUN	10	1.000	118.	2811.	744.	862.
	8001	1.000	45.	958.	461.	507.
RUN	8001	1.000	45.	958.	461.	507.
	8002	1.000	58.	508.	179.	236.
RUN	8002	1.000	58.	508.	179.	236.
	11	1.000	90.	1441.	118.	208.
RUN	11	1.000	90.	1441.	119.	209.
	8003	1.000	97.	1920.	386.	483.
RUN	8003	1.000	97.	1920.	386.	483.
	8004	1.000	87.	1949.	668.	755.
RUN	8004	1.000	87.	1949.	668.	755.
	12	1.000	126.	1593.	950.	1076.

079TI000008
83

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 17.462 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	12	1.000	126.	1593.	950.	1076.
	8005	1.000	207.	847.	1232.	1439.
RUN	8005	1.000	207.	847.	1232.	1439.
	8006	1.000	323.	1016.	1513.	1837.
RUN	8006	1.000	323.	1016.	1513.	1837.
	13	1.000	471.	2867.	1795.	2266.
RUN	13	1.000	471.	2867.	1795.	2266.
	14	1.000	431.	2552.	1812.	2243.
REDUCE	14	2.000	414.	2449.	2318.	2732.
	15	2.000	321.	1734.	2371.	2692.
RUN	15	1.000	66.	354.	364.	429.
	16	1.119	50.	244.	415.	465.
RUN	16	1.119	32.	262.	446.	478.
	18	1.000	13.	107.	417.	430.
ELBOW	18	2.809	61.	484.	2519.	2580.
	19	2.809	332.	542.	2293.	2625.
RUN	19	1.000	73.	120.	380.	453.
	20	1.000	94.	132.	332.	426.
REDUCE	20	2.000	383.	535.	1796.	2179.
	21	2.000	359.	492.	1666.	2025.
RUN	21	1.000	310.	425.	1081.	1391.
	22	1.000	279.	379.	1026.	1306.
REDUCE	22	2.000	974.	1322.	4768.	5742.
	23	2.000	635.	841.	4249.	4884.
RUN	7	1.119	658.	1054.	1415.	2073.
	800	1.000	538.	873.	1381.	1920.
RUN	800	1.000	538.	873.	1386.	1925.
	8	1.000	374.	621.	1357.	1732.

079TI000008
84

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 17.479 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	16	1.119	282.	943.	1543.	1824.
	1700	1.000	386.	991.	1432.	1818.
RUN	1700	1.000	386.	991.	1432.	1818.
	17	1.000	472.	912.	1257.	1729.
RUN	23	1.000	5108.	5775.	9468.	14577.
	25	1.000	3780.	3975.	8273.	12053.
RUN	25	1.000	3780.	3975.	8273.	12053.
	105	1.000	3935.	4542.	6969.	10905.
RUN	105	1.000	3935.	4542.	6969.	10905.
	106	1.000	3883.	4598.	6752.	10635.
RUN	106	1.000	3883.	4598.	6752.	10635.
	110	1.000	3416.	3809.	2937.	6353.
RUN	110	1.000	3416.	3809.	2937.	6353.
	115	1.000	3460.	3946.	1635.	5095.
RUN	115	1.000	3460.	3946.	1635.	5095.
	120	1.000	3607.	4257.	333.	3941.
RUN	120	1.000	3607.	4257.	333.	3941.
	122	1.000	3762.	4540.	743.	4505.
RUN	122	1.000	3762.	4540.	743.	4505.
	123	1.000	3810.	4522.	945.	4755.
RUN	123	1.000	3810.	4522.	945.	4755.
	125	1.000	3463.	4047.	1351.	4814.
ELBOW	125	1.000	3463.	4047.	1351.	4814.
	130	1.000	3458.	3802.	2094.	5552.
RUN	130	1.000	3458.	3802.	2094.	5552.
	135	1.000	3404.	3908.	2228.	5633.
RUN	135	1.000	3404.	3908.	2228.	5633.
	138	1.000	3387.	3845.	2273.	5660.

FORM 126-P-130 NEW 7-82

079TI000008 85

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 17.497 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	138	1.000	3387.	3845.	2273.	5660.
	139	1.000	3388.	4303.	5570.	8958.
RUN	139	1.000	3388.	4303.	5570.	8958.
	140	1.000	3383.	4275.	5618.	9000.
RUN	140	1.000	3383.	4275.	5618.	9000.
	142	1.000	3340.	3632.	6160.	9500.
RUN	142	1.000	3340.	3632.	6160.	9500.
	144	1.000	3307.	3970.	6641.	9948.
ELBOW	144	1.000	3307.	3970.	6641.	9948.
	145	1.000	3216.	3954.	6133.	9349.
RUN	145	1.000	3216.	3954.	6133.	9349.
	148	1.000	3653.	4354.	5483.	9136.
RUN	148	1.000	3653.	4354.	5483.	9136.
	150	1.000	3242.	3840.	2999.	6241.
RUN	150	1.000	3242.	3840.	2999.	6241.
	155	1.000	3200.	3845.	2187.	5387.
RUN	155	1.000	3200.	3845.	2187.	5387.
	160	1.000	3196.	3885.	1374.	4570.
RUN	160	1.000	3196.	3885.	1374.	4570.
	162	1.000	3274.	4047.	363.	3638.
RUN	162	1.000	3274.	4047.	363.	3638.
	163	1.000	4259.	4789.	4477.	8736.
RUN	163	1.000	4259.	4789.	4477.	8736.
	165	1.000	3953.	4499.	4694.	8647.
ELBOW	165	1.000	3953.	4499.	4694.	8647.
	170	1.000	3407.	3898.	5202.	8608.
RUN	170	1.000	3407.	3898.	5202.	8608.
	172	1.000	3388.	3688.	4777.	8165.

0791000008 86

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 17.515 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	172	1.000	3388.	3688.	4777.	8165.
	173	1.000	3768.	4768.	4210.	7978.
RUN	173	1.000	3768.	4768.	4210.	7978.
	175	1.000	3154.	3907.	2109.	5264.
RUN	175	1.000	3154.	3907.	2109.	5264.
	177	1.000	3219.	3890.	1844.	5063.
RUN	177	1.000	3219.	3890.	1844.	5063.
	180	1.000	3275.	3734.	1511.	4787.
ELBOW	180	1.000	3275.	3734.	1511.	4787.
	185	1.000	3280.	3706.	1344.	4624.
RUN	185	1.000	3280.	3706.	1344.	4624.
	190	1.000	3205.	3551.	1608.	4813.
RUN	190	1.000	3205.	3551.	1608.	4813.
	195	1.000	3613.	5477.	5072.	8684.
RUN	17	1.000	695.	1063.	975.	1671.
	295	1.000	510.	733.	621.	1131.
REDUCE	295	2.000	3161.	6120.	11010.	14171.
	310	2.000	2105.	4932.	10078.	12183.
RUN	310	1.000	1532.	3416.	5039.	6571.
	320	1.000	2177.	3783.	3641.	5818.
RUN	320	1.000	2177.	3783.	3641.	5818.
	330	1.000	5238.	6495.	2243.	7481.
RUN	330	1.000	5238.	6495.	2243.	7481.
	335	1.000	7047.	8176.	1515.	8563.
RUN	335	1.000	7047.	8176.	1515.	8563.
	340	1.000	673.	1612.	561.	1234.
ELBOW	340	2.267	875.	2472.	1271.	2146.
	350	2.267	3672.	4477.	2420.	6092.

079T1000008
87

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 17.532 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	350	1.000	2318.	2792.	1068.	3386.
	360	1.000	2132.	3107.	1255.	3388.
RUN	360	1.000	2132.	3107.	1255.	3388.
	361	1.000	2131.	3162.	1287.	3417.
RUN	361	1.000	2131.	3162.	1287.	3417.
	365	1.000	1527.	2538.	3664.	5191.
RUN	365	1.000	1527.	2538.	3664.	5191.
	369	1.000	1525.	2407.	3704.	5229.
RUN	369	1.000	1525.	2407.	3704.	5229.
	370	1.000	1609.	2082.	4143.	5752.
ELBOW	370	2.267	2465.	3270.	9391.	11856.
	380	2.267	2262.	3255.	8469.	10731.
RUN	380	1.000	1489.	2073.	3736.	5225.
	382	1.000	1348.	2092.	3561.	4909.
RUN	382	1.000	1348.	2092.	3561.	4909.
	385	1.000	3813.	4736.	825.	4638.
RUN	385	1.000	3813.	4736.	825.	4638.
	390	1.000	600.	1088.	2942.	3542.
ELBOW	390	2.267	751.	1581.	6668.	7419.
	400	2.267	1709.	2429.	7593.	9303.
RUN	400	1.000	1164.	1587.	3350.	4514.
	405	1.000	1406.	2118.	3270.	4676.
RUN	405	1.000	1406.	2118.	3270.	4676.
	406	1.000	1347.	1999.	3241.	4588.
RUN	406	1.000	1347.	1999.	3241.	4588.
	408	1.000	1049.	1727.	2059.	3108.
RUN	408	1.000	1049.	1727.	2059.	3108.
	410	1.000	1349.	3173.	1950.	3299.

0791000008
88

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 17.550 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	410	1.000	1349.	3173.	1950.	3299.
	420	1.000	1322.	1871.	1909.	3231.
ELBOW	420	2.267	1978.	2912.	4327.	6305.
	430	2.267	3226.	4600.	3372.	6599.
RUN	430	1.000	2056.	2864.	1488.	3544.
	435	1.000	2803.	3853.	1453.	4255.
RUN	435	1.000	2803.	3853.	1453.	4255.
	440	1.000	920.	1258.	517.	1437.
RUN	440	1.000	920.	1258.	517.	1437.
	450	1.000	926.	2620.	739.	1665.
RUN	8	1.000	614.	820.	1123.	1737.
	495	1.000	404.	488.	1062.	1466.
REDUCE	495	2.000	1743.	2867.	18833.	20576.
	510	2.000	1635.	2653.	18556.	20191.
ELBOW	510	2.267	1802.	2955.	21029.	22831.
	520	2.267	1394.	2288.	14187.	15582.
RUN	520	1.000	979.	1504.	6259.	7238.
	530	1.000	751.	1056.	3757.	4508.
ELBOW	530	2.267	1007.	1527.	8516.	9523.
	540	2.267	1275.	1809.	15109.	16384.
RUN	540	1.000	908.	1223.	6666.	7574.
	550	1.000	965.	1317.	6913.	7879.
RUN	550	1.000	965.	1317.	6913.	7879.
	560	1.000	827.	1217.	7231.	8058.
RUN	560	1.000	827.	1217.	7231.	8058.
	570	1.000	751.	1171.	7581.	8332.
RUN	570	1.000	751.	1171.	7581.	8332.
	575	1.000	996.	1456.	7767.	8763.

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 17.568 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	575	1.000	996.	1456.	7767.	8763.
	580	1.000	811.	1316.	7911.	8722.
ELBOW	580	2.267	1109.	1968.	17931.	19040.
	590	2.267	662.	1375.	11753.	12416.
RUN	590	1.000	548.	967.	5185.	5733.
	600	1.000	624.	1099.	4680.	5304.
ELBOW	600	2.267	791.	1599.	10609.	11400.
	610	2.267	811.	1889.	16872.	17684.
RUN	610	1.000	636.	1270.	7444.	8079.
	620	1.000	706.	1373.	7252.	7958.
RUN	620	1.000	706.	1373.	7252.	7958.
	630	1.000	1218.	2660.	7007.	8225.
RUN	450	1.000	2367.	4299.	8054.	10421.
	1450	1.000	764.	1085.	8054.	8818.
ELBOW	1450	2.606	1037.	1663.	20993.	22030.
	1460	2.606	1098.	1772.	15512.	16610.
RUN	1460	1.000	795.	1140.	5951.	6747.
	1465	1.000	881.	1039.	64.	945.
RUN	1465	1.000	881.	1039.	64.	945.
	1467	1.000	783.	950.	5824.	6608.
RUN	1467	1.000	783.	950.	5824.	6608.
	1468	1.000	845.	1092.	6245.	7090.
RUN	1468	1.000	845.	1092.	6245.	7090.
	1470	1.000	921.	1110.	5824.	6746.
ELBOW	1470	2.606	1344.	1712.	15181.	16525.
	1480	2.606	1378.	2218.	20662.	22040.
RUN	1480	1.000	939.	1368.	7927.	8866.
	1485	1.000	1443.	1793.	7927.	9371.

0791000008 06

CARRIZO MSG PLUS STEAM PIPING PLUS NA INLET AND OUTLET ELAPSED CPU = 17.584 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	1485	1.000	1443.	1793.	7927.	9371.
	1490	1.000	940.	1235.	7927.	8867.
ELBOW	1490	2.606	1380.	1957.	20662.	22042.
	1495	2.606	1353.	2182.	15181.	16534.
RUN	1495	1.000	926.	1350.	5824.	6750.
	1500	1.000	849.	1266.	6245.	7094.
RUN	1500	1.000	849.	1266.	6245.	7094.
	1502	1.000	761.	1104.	2039.	2800.
RUN	1502	1.000	761.	1104.	2039.	2800.
	1503	1.000	915.	1138.	2166.	3081.
RUN	1503	1.000	915.	1138.	2166.	3081.
	1505	1.000	790.	1132.	5952.	6741.
ELBOW	1505	2.606	1087.	1756.	15513.	16600.
	1510	2.606	1034.	1734.	20994.	22028.
RUN	1510	1.000	763.	1121.	8054.	8817.
	1520	1.000	2364.	4287.	8054.	10419.

REPORT

```
IAT6140 JOB ORIGIN FROM GROUP=RM206    , DSP=IJP, DEVICE=INTRDR  , 000
08:35:52 IAT4401  LOCATE FOR STEP=A          DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
08:35:52 IAT4402 UNIT=3350    ,VOL(S)=CVTSOK
08:35:52 IAT4401  LOCATE FOR STEP=G          DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
08:35:52 IAT4402 UNIT=3350    ,VOL(S)=CVTSOK
08:35:52 IAT4401  LOCATE FOR STEP=G          DD=FT15F001 DSN=$WW232.CARRIZO.DISPLACE.DATA
08:35:52 IAT4402 UNIT=3350    ,VOL(S)=AVTSOA
08:35:52 IAT4401  LOCATE FOR STEP=G          DD=FT69F001 DSN=$WW049.ROCKPIPE.USERS
08:35:52 IAT4402 UNIT=3350    ,VOL(S)=CVTSOK
08:35:52 IAT4401  LOCATE FOR STEP=ELTEMP     DD=STEPLIB  DSN=$WW049.ELTEMP.LOAD
08:35:52 IAT4402 UNIT=3350    ,VOL(S)=CVTSOK
08:35:53 USES     CVTSOK  01 093128 D $WW049.NUPIPE.LOAD
08:35:53 USES     AVTSOA  01 093128 D $WW232.CARRIZO.DISPLACE.DATA
08:35:53 IAT5200 JOB 2507 ($WW232T1) IN SETUP ON MAIN=C       P=03 LOCAL
08:35:53 IAT5210 J=2507 STEPLIB  USING D CVTSOK ON 528    $WW049.NUPIPE.LOAD
08:35:53 IAT5210 J=2507 FT15F001 USING D AVTSOA ON 520    $WW232.CARRIZO.DISPLACE.DATA
08:35:58 IAT2000 JOB 2507 $WW232T1 SELECTED C         GRP=BIG
08:36:00 C R= $WW232T1 NEF995I $WW232T1 STARTED, 3/09/83,08.35.56 ASID=00081
08:36:00 C R= $WW232T1 IEF403I $WW232T1 - STARTED - TIME=08.35.56
08:36:49 C R= $WW232T1 +IH0002I STOP       1
08:36:50 C R= $WW232T1 IEF404I $WW232T1 - ENDED - TIME=08.36.47
08:36:50 C R= $WW232T1 NEF996I $WW232T1 ENDED,  3/09/83,B.U.=       .9776 *0716935    ,3081-C3,JOB CC= 001
08:36:52 IAT5400 JOB 2507 ($WW232T1) IN BREAKDOWN
/$WW232T1 JOB 'GURSAHANI LB30130340*0716935         005  5001003037', *
/ REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
/*MAIN ORG=RM005                                                  00000300
/ EXEC ROCKPIPE,PROG=SMALL
/G.SYSIN DD DSN=$WW232.CARRIZO.DISPLACE.DATA,DISP=SHR
   1      //$WW232T1 JOB 'GURSAHANI LB30130340*0716935         005  5001003037', *
          // REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
   2      // EXEC ROCKPIPE,PROG=SMALL
   3      XXROCKPIPE PROC DSN='$WW049.NUPIPE.LOAD',PROG=SMALL,C=10,
          XX PROGA=SEVEN,B=19069,PROGE=OPT2,DSNE='$WW049.ELTEMP.LOAD',
          XX USERS='$WW049.ROCKPIPE.USERS'
          *** AL HROMJAK ROCKWELL INTERNATIONAL, ESG. COMNET 393-3318
          *** FT50F001 FOR 7-SPECTRA NODE ACCELERATIONS.
          *** IN BOTH STEPS, FT66 CONTAINS DIAGNOSTIC OUTPUT.
          *** FT66F001 IN G STEP CONTAINS TIME SPENT IN MAJOR PROGRAM PHASES.
          *** FT16F001 DUMMIED WHEN P STEP DELETED.
          *** FT17F001, FT18F001, FT19F001, FT20F001 ADDED FOR SNUBBER ITERATIONS
   4      XXA EXEC PGM=&PROGA
          *** THIS STEP READS THE 7 SPECTRA AND TRANSLATES THEM TO A NEW POINT
          ***  NEW SPECTRA WRITTEN  ON FT01F001
   5      XXSTEPLIB DD DSN=&DSN,DISP=SHR
   6      XXFT01F001 DD UNIT=SYSDA,DSN=&&SPEC,SPACE=(TRK,(10),RLSE),DISP=(,PASS),
          XX DCB=(RECFM=F,LRECL=80,BLKSIZE=80)
   7      XXFT05F001 DD DDNAME=SYSIN
   8      XXFT06F001 DD SYSOUT=*
   9      XXFT66F001 DD DUMMY,DCB=(RECFM=VBA,BLKSIZE=2020)
  10      XXG EXEC PGM=&PROG
          *** THIS STEP EXECUTES ROCKPIPE. LOAD CASES, 7-SPECTRA (IF ANY), AND
          *** GEOMETRY ARE READ FROM UNIT FT15'S 3 CONCATANATED DATA SETS. LOAD
          *** CASES TO BE DELETED FROM PRINTING ARE DETECTED AND THE CASE NO.'S
          *** MADE PLUS. ALL 3 FILES FROM FT15 ARE WRITTEN ON FT05 AS ONE FILE TO
          *** BE READ BY NUPIPE.
  11      XXSTEPLIB DD DSN=&DSN,DISP=SHR
  12      XXFT01F001 DD UNIT=SYSDA,DCB=(RECFM=VBS,BLKSIZE=&B),
          XX SPACE=(CYL,(&C,&C))
  13      XXFT02F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
  14      ~~FT03F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
  15        FT04F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&
FORM 126        7-82
```

O R I G I N A L   I N P U T   B Y   GURSAHANI   O N   03/09/83   A T   08:36:12   W I T H   P R I O R I T Y   3

CARRIZO RUN FOR DETERMINING SG NOZZLE MOVEMENTS

CONTROL			2.0				
FLEXAN	1	1	2.0				
TE1 (THERMAL AT THE DESIGN TEMPERATURE)							
FLEXAN	2	2	2.0				
TE2 (THERMAL OVERNIGHT SHUTDOWN)							
FLEXAN	3	3	2.0				
TE3 (SG AND NA INLET AT 600. NA OUTLET AT 300 AND STEAM PIPING AT 70)							
XSECTN		1	54.22	0.721	812.0	29.9	
XSECTN		2	30.94	0.721	705.1	29.9	
XSECTN		3	21.5	1.0	580.1	29.9	0.0
XSECTN		4	19.0	1.0	859.8	29.9	0.0
XSECTN		5	12.81	1.0	370.3	29.9	0.0
XSECTN		6	26.0	1.97	993.2	29.9	0.0
XSECTN		7	12.75	.562	51.7	29.9	0.0
XSECTN		8	26.0	1.97	993.2	29.9	0.0
XSECTN		9	21.0	0.86	546.6	29.9	0.0
XSECTN		10	18.0	0.75	433.8	29.9	0.0
XSECTN		11	18.0	0.75	433.8	29.9	0.0
XSECTN		12	18.0	0.75	433.8	29.9	0.0
XSECTN		13	18.0	0.75	433.8	29.9	0.0
XSECTN		14	21.0	0.86	546.6	29.9	0.0
XSECTN		15	26.0	1.97	1002.0	29.9	0.0
XSECTN		16	12.75	.562	92.1	29.9	0.0
XSECTN		17	26.0	1.97	1002.0	29.9	0.0
XSECTN		18	24.0	1.0	524.4	29.9	0.0
XSECTN		19	26.0	1.97	927.5	29.9	0.0
XSECTN		20	21.5	1.0	596.4	29.9	0.0
XSECTN		21	19.0	1.0	859.8	29.9	0.0
XSECTN		22	12.81	1.0	376.9	29.9	0.0
XSECTN800		23	12.75	0.562	51.7	299.	0.0
XSECT1700		24	12.75	0.562	89.8	299.	0.0
XSECTN		25	6.625	0.864	85.5	29.9	1590.
XSECTN NA		26	6.625	0.864		29.9	1590.
XSECTN NA		27	12.75	0.406	175.	28.3	65.
XSECTN		28	6.625	0.280	98.5	28.3	65.
XSECTN NA		29	12.75	0.406	130.	27.9	65.
XSECTN		30	6.625	0.280	53.4	27.9	65.
XSECTN		31	12.75	0.687	218.8	28.3	65.
XSECTN NA		32	6.625	0.280		27.9	65.
XSECTN		33	12.75	0.687	218.8	27.9	65.
XSECTN		34	10.75	0.365	154.6	28.3	65.
OPVAL225	1	1	29.4	.01198			
OPVAL435	1	2	28.4	.03022			
OPVAL470	1	3	28.2	.03344			
OPVAL450	1	4	28.3	.03160			
OPVAL450	1	5	28.3	.03160			
OPVAL587	1	6	27.5	.04473			
OPVAL620	1	7	27.2	.04086			
OPVAL625	1	8	27.2	.04858			
OPVAL640	1	9	27.1	.05012			
OPVAL705	1	10	26.6	.05684			
OPVAL865	1	11	24.9	.07422			
OPVAL1010	1	12	22.7	.09005			
OPVAL1050	1	13	21.7	.09465			
OPVAL1055	1	14	21.6	.09523			
OPVAL1057	1	15	21.5	.09546			
OPVAL1065	1	16	21.3	.09638			
OPVAL1055	1	17	21.6	.09523			

FORM 126-P-130 NEW 7-82

OPVAL1025	1	18	22.4	.09178		60
OPVAL1020	1	19	22.5	.09120		61
OPVAL1020	1	20	22.5	.09120		62
OPVAL1015	1	21	22.6	.09063		63
OPVAL1015	1	22	22.6	.09063		64
OPVAL800	1	23	273.0	.04703		65
OPVAL1065	1	24	213.0	.09638		66
OPVAL1015	1	25	22.60	.09063	1590.	67
OPVAL NA	1	26	22.74	.09005	1590.	68
OPVAL NA	1	27	22.4	.12364	65.	69
OPVAL1065	1	28	22.4	.12364	65.	70
OPVAL NA	1	29	25.61	.04703	65.	71
OPVAL 610	1	30	25.61	.04703	65.	72
OPVAL201	2	1	29.5	.00998		73
OPVAL381	2	2	29.1	.02533		74
OPVAL420	2	3	28.5	.02884		75
OPVAL400	2	4	28.5	.02700		76
OPVAL400	2	5	28.5	.02700		77
OPVAL550	2	6	27.7	.04110		78
OPVAL570	2	7	27.6	.04306		79
OPVAL575	2	8	27.6	.04355		80
OPVAL585	2	9	27.5	.04453		81
OPVAL650	2	10	27.0	.05115		82
OPVAL770	2	11	26.0	.06379		83
OPVAL890	2	12	24.6	.07699		84
OPVAL940	2	13	23.9	.08242		85
OPVAL942	2	14	23.9	.08264		86
OPVAL948	2	15	23.8	.08328		87
OPVAL950	2	16	23.8	.08350		88
OPVAL950	2	17	23.8	.08350		89
OPVAL910	2	18	24.4	.07918		90
OPVAL905	2	19	24.4	.07864		91
OPVAL902	2	20	24.5	.07832		92
OPVAL900	2	21	24.5	.07810		93
OPVAL900	2	22	24.5	.07810		94
OPVAL570	2	23	276.0	.04306		95
OPVAL950	2	24	237.5	.08350		96
OPVAL850	2	25	25.1	.07255	1590.	97
OPVAL NA	2	26	22.74	.09005	1590.	98
OPVAL NA	2	27	23.2	.10800	65.	99
OPVAL950	2	28	23.2	.10800	65.	100
OPVAL NA	2	29	27.4	.0182	65.	101
OPVAL 300	2	30	27.4	.0182	65.	102
OPVAL 226	3	1	29.4	.01206	65.	103
OPVAL 492	3	2	28.0	.03546	65.	104
OPVAL 600	3	3	27.4	.0460	65.	105
OPVAL 600	3	4	27.4	.0460	65.	106
OPVAL 600	3	5	27.4	.0460	65.	107
OPVAL 600	3	6	27.4	.0460	65.	108
OPVAL 600	3	7	27.4	.0460	65.	109
OPVAL 600	3	8	27.4	.0460	65.	110
OPVAL 600	3	9	27.4	.0460	65.	111
OPVAL 600	3	10	27.4	.0460	65.	112
OPVAL 600	3	11	27.4	.0460	65.	113
OPVAL 600	3	12	27.4	.0460	65.	114
OPVAL 600	3	13	27.4	.0460	65.	115
OPVAL 600	3	14	27.4	.0460	65.	116
OPVAL 600	3	15	27.4	.0460	65.	117
OPVAL 600	3	16	27.4	.0460	65.	118
OPVAL 600	3	17	27.4	.0460	65.	119
OPVA	3	18	27.4	.0460	65	120
OPVA	3	19	27.4	.0460		121

FORM NEW 7-82

OPVAL 600	3	20	27.4	.0460			65.	122
OPVAL 600	3	21	27.4	.0460			65.	123
OPVAL 600	3	22	27.4	.0460			65.	124
OPVAL 600	3	23	274.0	.0460			65.	125
OPVAL 600	3	24	274.0	.0460				126
OPVAL 70	3	25	29.9				1590.	127
OPVAL NA	3	26	22.74				1590.	128
OPVAL NA	3	27	25.6	.0624			65.	129
OPVAL 600	3	28	25.6	.0624			65.	130
OPVAL NA	3	29	27.4	.0182			65.	131
OPVAL 300	3	30	27.4	.0182			65.	132
ANCHOR		1						133
RUN	1	2		5.0		1.0	1.0	134
RUN	2	3		1.489		2.0	2.0	135
RUN	3	4		-1.667		3.0	3.0	136
RUN	4	5		-.646		4.0	4.0	137
RUN	5	6		-1.896		5.0	5.0	138
RUN	3	7		5.146		6.0	6.0	139
TEE	7	800						140
RUN	7	9		1.417		8.0	8.0	141
REDUCER	9	10		1.666		9.0	9.0	142
RUN	10	11		15.291		10.0	10.0	143
RUN	11	12		15.250		11.0	11.0	144
RUN	12	13		15.250		12.0	12.0	145
RESTRAINT		13	100000.		100000.			146
RUN	13	14		0.667		13.0	13.0	147
REDUCER	14	15		1.666		14.0	14.0	148
RUN	15	16		1.417		15.0	15.0	149
TEE	16	1700						150
RUN	16	18		5.563		17.0	17.0	151
ELBOW	18	19	24.0			18.0	18.0	152
RUN	19	20	-4.0			19.0	19.0	153
REDUCER	20	21	-1.0			20.0	20.0	154
RUN	21	22	-0.646			21.0	21.0	155
REDUCER	22	23	-1.333			22.0	22.0	156
RUN	7	800	1.083			23.0	23.0	157
RUN	800	8	0.958			7.0	7.0	158
RUN	16	1700	1.083			24.0	24.0	159
RUN	1700	17	1.709			16.0	16.0	160
STRESS7								161
10CASES	1	2	3					162
ALLDONE								163

079T000008
95

...CASE NO. 1 TE1 (THERMAL AT THE DESIGN TEMPERATURE)
CARRIZO RUN FOR DETERMINING SG NOZZLE MOVEMENTS GURSAHANI ELAPSED CPU = 1.235 SEC.

		FORCES (LBS)			MOMENTS (IN-LBS)			DEFLECTIONS (IN)			ROTATIONS (RAD)		
MEMBER	END	FX	FY	FZ	MX	MY	MZ	DX	DY	DZ	RX	RY	RZ
RUN	16	0.	-0.	0.	0.	0.	-0.	-0.000	4.219	0.0	0.0	0.0	0.0000
	18	-0.	0.	0.	0.	0.	-0.	-0.000	4.558	0.0	0.0	0.0	0.0000
ELBOW	18	0.	-0.	0.	0.	0.	0.	-0.000	4.558	0.0	0.0	0.0	0.0000
	8001	-0.	0.	0.	0.	0.	-0.	-0.054	4.688	0.0	0.0	0.0	0.0000
ELBOW	8001	-0.	-0.	0.	0.	0.	0.	-0.054	4.688	0.0	0.0	0.0	0.0000
	19	0.	0.	0.	0.	0.	-0.	-0.184	4.742	0.0	0.0	0.0	0.0000
RUN	19	0.	-0.	0.	0.	0.	0.	-0.184	4.742	0.0	0.0	0.0	0.0000
	20	-0.	0.	0.	0.	0.	-0.	-0.366	4.742	0.0	0.0	0.0	0.0000
REDUCE	20	0.	-0.	0.	0.	0.	0.	-0.366	4.742	0.0	0.0	0.0	0.0000
	21	-0.	0.	0.	0.	0.	0.	-0.457	4.742	0.0	0.0	0.0	0.0000
RUN	21	0.	-0.	0.	0.	0.	0.	-0.457	4.742	0.0	0.0	0.0	0.0000
	22	0.	0.	0.	0.	0.	0.	-0.516	4.742	0.0	0.0	0.0	0.0000
REDUCE	22	-0.	-0.	0.	0.	0.	0.	-0.516	4.742	0.0	0.0	0.0	0.0000
	23	0.	0.	0.	0.	0.	0.	-0.637	4.742	0.0	0.0	0.0	0.0000
RUN	7	0.	0.	0.	0.	0.	0.	0.000	0.335	0.0	0.0	0.0	-0.0000
	800	-0.	-0.	0.	0.	0.	-0.	0.051	0.335	0.0	0.0	0.0	-0.0000
RUN	800	-0.	0.	0.	0.	0.	-0.	0.051	0.335	0.0	0.0	0.0	-0.0000
	8	0.	-0.	0.	0.	0.	0.	0.090	0.335	0.0	0.0	0.0	-0.0000
RUN	16	0.	-0.	0.	0.	0.	-0.	-0.000	4.219	0.0	0.0	0.0	0.0000
	1700	-0.	0.	0.	0.	0.	-0.	0.104	4.219	0.0	0.0	0.0	0.0000
RUN	1700	-0.	-0.	0.	0.	0.	0.	0.104	4.219	0.0	0.0	0.0	0.0000
	17	0.	0.	0.	0.	0.	-0.	0.269	4.219	0.0	0.0	0.0	0.0000

0079T1000008 96

...CASE NO. 2 TE2 (THERMAL OVERNIGHT SHUTDOWN)

CARRIZO RUN FOR DETERMINING SG NOZZLE MOVEMENTS GURSAHANI ELAPSED CPU = 1.608 SEC.

		FORCES (LBS)			MOMENTS (IN-LBS)			DEFLECTIONS (IN)			ROTATIONS (RAD)		
MEMBER	END	FX	FY	FZ	MX	MY	MZ	DX	DY	DZ	RX	RY	RZ
RUN	16	0.	-0.	0.	0.	0.	-0.	-0.000	3.675	0.0	0.0	0.0	0.0000
	18	-0.	0.	0.	0.	0.	-0.	-0.000	3.972	0.0	0.0	0.0	0.0000
ELBOW	18	0.	-0.	0.	0.	0.	0.	-0.000	3.972	0.0	0.0	0.0	0.0000
	8001	-0.	0.	0.	0.	0.	-0.	-0.046	4.084	0.0	0.0	0.0	0.0000
ELBOW	8001	0.	-0.	0.	0.	0.	0.	-0.046	4.084	0.0	0.0	0.0	0.0000
	19	-0.	0.	0.	0.	0.	-0.	-0.158	4.131	0.0	0.0	0.0	0.0000
RUN	19	0.	-0.	0.	0.	0.	0.	-0.158	4.131	0.0	0.0	0.0	0.0000
	20	-0.	0.	0.	0.	0.	-0.	-0.316	4.131	0.0	0.0	0.0	0.0000
REDUCE	20	0.	-0.	0.	0.	0.	0.	-0.316	4.131	0.0	0.0	0.0	0.0000
	21	-0.	0.	0.	0.	0.	0.	-0.394	4.131	0.0	0.0	0.0	0.0000
RUN	21	0.	-0.	0.	0.	0.	0.	-0.394	4.131	0.0	0.0	0.0	0.0000
	22	-0.	0.	0.	0.	0.	0.	-0.444	4.131	0.0	0.0	0.0	0.0000
REDUCE	22	-0.	-0.	0.	0.	0.	0.	-0.444	4.131	0.0	0.0	0.0	0.0000
	23	0.	0.	0.	0.	0.	0.	-0.549	4.131	0.0	0.0	0.0	0.0000
RUN	7	0.	-0.	0.	0.	0.	-0.	0.000	0.299	0.0	0.0	0.0	-0.0000
	800	-0.	0.	0.	0.	0.	-0.	0.047	0.299	0.0	0.0	0.0	-0.0000
RUN	800	-0.	-0.	0.	0.	0.	0.	0.047	0.299	0.0	0.0	0.0	-0.0000
	8	0.	0.	0.	0.	0.	-0.	0.088	0.299	0.0	0.0	0.0	-0.0000
RUN	16	-0.	-0.	0.	0.	0.	-0.	-0.000	3.675	0.0	0.0	0.0	0.0000
	1700	0.	0.	0.	0.	0.	-0.	0.090	3.675	0.0	0.0	0.0	0.0000
RUN	1700	-0.	-0.	0.	0.	0.	-0.	0.090	3.675	0.0	0.0	0.0	0.0000
	17	0.	0.	0.	0.	0.	-0.	0.233	3.675	0.0	0.0	0.0	0.0000

079T1000008
97

FORM 126-P-130 NEW 7-82

		FORCES (LBS)			MOMENTS (IN-LBS)			DEFLECTIONS (IN)			ROTATIONS (RAD)		
MEMBER	END	FX	FY	FZ	MX	MY	MZ	DX	DY	DZ	RX	RY	RZ
RUN	16	0.	0.	0.	0.	0.	-0.	-0.000	2.771	0.0	0.0	0.0	0.0000
	18	-0.	-0.	0.	0.	0.	-0.	-0.000	2.934	0.0	0.0	0.0	0.0000
ELBOW	18	0.	-0.	0.	0.	0.	0.	-0.000	2.934	0.0	0.0	0.0	0.0000
	8001	-0.	0.	0.	0.	0.	-0.	-0.027	2.999	0.0	0.0	0.0	0.0000
ELBOW	8001	-0.	-0.	0.	0.	0.	0.	-0.027	2.999	0.0	0.0	0.0	0.0000
	19	0.	0.	0.	0.	0.	-0.	-0.092	3.026	0.0	0.0	0.0	0.0000
RUN	19	0.	-0.	0.	0.	0.	0.	-0.092	3.026	0.0	0.0	0.0	0.0000
	20	-0.	0.	0.	0.	0.	-0.	-0.184	3.026	0.0	0.0	0.0	0.0000
REDUCE	20	0.	-0.	0.	0.	0.	0.	-0.184	3.026	0.0	0.0	0.0	0.0000
	21	-0.	0.	0.	0.	0.	-0.	-0.230	3.026	0.0	0.0	0.0	0.0000
RUN	21	0.	-0.	0.	0.	0.	0.	-0.230	3.026	0.0	0.0	0.0	0.0000
	22	-0.	0.	0.	0.	0.	0.	-0.260	3.026	0.0	0.0	0.0	0.0000
REDUCE	22	-0.	-0.	0.	0.	0.	0.	-0.260	3.026	0.0	0.0	0.0	0.0000
	23	0.	0.	0.	0.	0.	0.	-0.321	3.026	0.0	0.0	0.0	0.0000
RUN	7	0.	-0.	0.	0.	0.	-0.	0.000	0.350	0.0	0.0	0.0	-0.0000
	800	-0.	0.	0.	0.	0.	0.	0.050	0.350	0.0	0.0	0.0	-0.0000
RUN	800	-0.	-0.	0.	0.	0.	0.	0.050	0.350	0.0	0.0	0.0	-0.0000
	8	0.	0.	0.	0.	0.	-0.	0.094	0.350	0.0	0.0	0.0	-0.0000
RUN	16	-0.	-0.	0.	0.	0.	0.	-0.000	2.771	0.0	0.0	0.0	0.0000
	1700	0.	0.	0.	0.	0.	-0.	0.050	2.771	0.0	0.0	0.0	0.0000
RUN	1700	-0.	-0.	0.	0.	0.	-0.	0.050	2.771	0.0	0.0	0.0	0.0000
	17	0.	0.	0.	0.	0.	-0.	0.128	2.771	0.0	0.0	0.0	0.0000

```
*****************************************************************************************************************
*  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  *
*****************************************************************************************************************

//$WW232B1 JOB 'GURSAHANI LB30731160*0716935          4444449    ', *00000100
// TIME=(02,00),REGION=1500K,NOTIFY=$WW232,MSGCLASS=A,MSGLEVEL=1        00000200
//*MAIN ORG=RM005                                                       00000300
//*  THIS IS DATASET $WW232.PRINT.EDIT.CNTL                             00000400
//* THESE THREE ARE FOR XEROX OUTPUT                                    00000500
//*FORMAT PR,DDNAME=SYSMSG,DEST=RM006PR3,FCB=JB10,COPIES=1              00000600
//*FORMAT PR,DDNAME=SYSPRINT,DEST=RM006PR3,FCB=JB10,COPIES=1            00000700
//*FORMAT PR,DDNAME=SYSUT2,DEST=RM006PR3,FCB=JB10,COPIES=1              00000800
//* THESE THREE ARE FOR NORMAL OUTPUT                                   00000900
//* //*FORMAT PR,DDNAME=SYSMSG,DEST=RM005,COPIES=1                      00001000
//* //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM005,COPIES=1                    00001100
//* //*FORMAT PR,DDNAME=SYSUT2,DEST=RM005,COPIES=1                      00001200
//* THESE THREE ARE FOR MICROFICHE OUTPUT                               00001300
//* //*FORMAT PR,DDNAME=SYSMSG,DEST=RM001PR5,FORMS=FICHE,COPIES=1       00001400
//* //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM001PR5,FORMS=FICHE,COPIES=1     00001500
//* //*FORMAT PR,DDNAME=SYSUT2,DEST=RM001PR5,FORMS=FICHE,COPIES=1       00001600
// EXEC PGM=IEBGENER                                                    00001700
//SYSPRINT DD SYSOUT=A                                                  00001800
//SYSIN DD DUMMY                                                        00001900
//SYSUT1 DD DSN=$WW232.AAS1.CLASS.T.DATA,DISP=SHR                       00002000
//SYSUT2 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330)             00002100
    1     //$WW232B1 JOB 'GURSAHANI LB30731160*0716935          4444449    ', *00000100
          // TIME=(02,00),REGION=1500K,NOTIFY=$WW232,MSGCLASS=A,MSGLEVEL=1        00000200
          ***  THIS IS DATASET $WW232.PRINT.EDIT.CNTL                           00000400
          *** THESE THREE ARE FOR XEROX OUTPUT                                  00000500
          *** THESE THREE ARE FOR NORMAL OUTPUT                                 00000900
          *** //*FORMAT PR,DDNAME=SYSMSG,DEST=RM005,COPIES=1                    00001000
          *** //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM005,COPIES=1                  00001100
          *** //*FORMAT PR,DDNAME=SYSUT2,DEST=RM005,COPIES=1                    00001200
          *** THESE THREE ARE FOR MICROFICHE OUTPUT                             00001300
          *** //*FORMAT PR,DDNAME=SYSMSG,DEST=RM001PR5,FORMS=FICHE,COPIES=1     00001400
          *** //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM001PR5,FORMS=FICHE,COPIES=1   00001500
          *** //*FORMAT PR,DDNAME=SYSUT2,DEST=RM001PR5,FORMS=FICHE,COPIES=1     00001600
    2     // EXEC PGM=IEBGENER                                                  00001700
    3     //SYSPRINT DD SYSOUT=A                                                00001800
    4     //SYSIN DD DUMMY                                                      00001900
    5     //SYSUT1 DD DSN=$WW232.AAS1.CLASS.T.DATA,DISP=SHR                     00002000
    6     //SYSUT2 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330)           00002100
```

FORM 120-P-130 NEW 7-82

```
*******************************************************************************************
*  JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG  *
*******************************************************************************************

IAT6140 JOB ORIGIN FROM GROUP=RM206    , DSP=IJP, DEVICE=INTRDR   , 000
11:05:15 IAT4401  LOCATE FOR STEP=           DD=SYSUT1   DSN=$WW232.N1.DATA
11:05:15 IAT4402 UNIT=3350     ,VOL(S)=AVTSOA
11:05:15 IAT4401  LOCATE FOR STEP=           DD=SYSUT1   DSN=$WW232.N2.DATA
11:05:15 IAT4402 UNIT=3350     ,VOL(S)=AVTSOA
11:05:15 USES     AVTSOA             D $WW232.N1.DATA
11:05:16 IAT5200 JOB 1343 ($WW232P2) IN SETUP ON MAIN=L        P=09 LOCAL
11:05:16 IAT5210 J=1343 SYSUT1   USING D AVTSOA ON 520   $WW232.N1.DATA
11:05:56 IAT2000 JOB 1343 $WW232P2 SELECTED I          GRP=JS3BATCH
11:05:57 I R= $WW232P2 NEF995I $WW232P2 STARTED, 4/05/83,11.03.29 ASID=00038
11:05:57 I R= $WW232P2 IEF403I $WW232P2 - STARTED - TIME=11.03.29
11:06:04 I R= $WW232P2 IEF404I $WW232P2 - ENDED - TIME=11.03.36
11:06:04 I R= $WW232P2 NEF996I $WW232P2 ENDED,  4/05/83,B.U.=      .0498 *0716935   ,3081-I3,JOB CC= 000
11:06:05 IAT5400 JOB 1343 ($WW232P2) IN BREAKDOWN
```

079T1000008
100

FORM 126-F ... 7-82

```
*************************************************************************************************************
*  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  JESJCL  *
*************************************************************************************************************

//$WW232P2 JOB 'GURSAHANI LB30731160*0716935            4444449     ', *00000100
// TIME=(02,00),REGION=1500K,NOTIFY=$WW232,MSGCLASS=A,MSGLEVEL=1        00000200
//*MAIN ORG=RM005                                                       00000300
//*  THIS IS DATASET $WW232.PRINT.EDIT.CNTL                             00000400
//* THESE THREE ARE FOR XEROX OUTPUT                                    00000500
//*FORMAT PR,DDNAME=SYSMSG,DEST=RM271PR3,FCB=JB10,COPIES=1              00000600
//*FORMAT PR,DDNAME=SYSPRINT,DEST=RM271PR3,FCB=JB10,COPIES=1            00000700
//*FORMAT PR,DDNAME=SYSUT2,DEST=RM271PR3,FCB=JB10,COPIES=1              00000800
//* THESE THREE ARE FOR NORMAL OUTPUT                                   00000900
//* //*FORMAT PR,DDNAME=SYSMSG,DEST=RM005,COPIES=1                      00001000
//* //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM005,COPIES=1                    00001100
//* //*FORMAT PR,DDNAME=SYSUT2,DEST=RM005,COPIES=1                      00001200
//* THESE THREE ARE FOR MICROFICHE OUTPUT                               00001300
//* //*FORMAT PR,DDNAME=SYSMSG,DEST=RM001PR5,FORMS=FICHE,COPIES=1       00001400
//* //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM001PR5,FORMS=FICHE,COPIES=1     00001500
//* //*FORMAT PR,DDNAME=SYSUT2,DEST=RM001PR5,FORMS=FICHE,COPIES=1       00001600
// EXEC PGM=IEBGENER                                                    00001700
//SYSPRINT DD SYSOUT=A                                                  00001800
//SYSIN DD DUMMY                                                        00001900
//SYSUT1 DD DSN=$WW232.N1.DATA,DISP=SHR                                 00002000
//       DD DSN=$WW232.N2.DATA,DISP=SHR                                 00002100
//SYSUT2 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330)             00002300
    1     //$WW232P2 JOB 'GURSAHANI LB30731160*0716935            4444449     ', *00000100
          // TIME=(02,00),REGION=1500K,NOTIFY=$WW232,MSGCLASS=A,MSGLEVEL=1        00000200
          ***  THIS IS DATASET $WW232.PRINT.EDIT.CNTL                             00000400
          *** THESE THREE ARE FOR XEROX OUTPUT                                    00000500
          *** THESE THREE ARE FOR NORMAL OUTPUT                                   00000900
          *** //*FORMAT PR,DDNAME=SYSMSG,DEST=RM005,COPIES=1                      00001000
          *** //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM005,COPIES=1                    00001100
          *** //*FORMAT PR,DDNAME=SYSUT2,DEST=RM005,COPIES=1                      00001200
          *** THESE THREE ARE FOR MICROFICHE OUTPUT                               00001300
          *** //*FORMAT PR,DDNAME=SYSMSG,DEST=RM001PR5,FORMS=FICHE,COPIES=1       00001400
          *** //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM001PR5,FORMS=FICHE,COPIES=1     00001500
          *** //*FORMAT PR,DDNAME=SYSUT2,DEST=RM001PR5,FORMS=FICHE,COPIES=1       00001600
    2     // EXEC PGM=IEBGENER                                                    00001700
    3     //SYSPRINT DD SYSOUT=A                                                  00001800
    4     //SYSIN DD DUMMY                                                        00001900
    5     //SYSUT1 DD DSN=$WW232.N1.DATA,DISP=SHR                                 00002000
    6     //       DD DSN=$WW232.N2.DATA,DISP=SHR                                 00002100
    7     //SYSUT2 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330)             00002300
```

079T1000008
101

```
***************************************************************************************************************
*  SYSMSG SYSMSG SYSMSG SYSMSG SYSMSG SYSMSG SYSMSG SYSMSG SYSMSG SYSMSG SYSMSG SYSMSG SYSMSG SYSMSG SYSMSG  *
***************************************************************************************************************

IEF236I ALLOC. FOR $WW232P2
IEF237I JES3 ALLOCATED TO SYSPRINT
IEF237I DMY  ALLOCATED TO SYSIN
IEF237I 520  ALLOCATED TO SYSUT1
IEF237I 520  ALLOCATED TO
IEF237I 520  ALLOCATED TO SYS00141
IEF237I JES3 ALLOCATED TO SYSUT2
IEF142I $WW232P2 - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYSPRINT                                    SYSOUT
IEF285I   $WW232.N1.DATA                              KEPT
IEF285I   VOL SER NOS= AVTSOA.
IEF285I   $WW232.N2.DATA                              KEPT
IEF285I   VOL SER NOS= AVTSOA.
IEF285I   SYSCTLG.VAVTSOA                             KEPT
IEF285I   VOL SER NOS= AVTSOA.
IEF285I   SYSUT2                                      SYSOUT
IEF373I STEP /        / START 83095.1103
IEF374I STEP /        / STOP  83095.1103 CPU    0MIN 00.13SEC SRB    0MIN 00.01SEC VIRT    80K SYS   172K
NEF980I ******************************************************************************************************
NEF981I *  STEP=          ,CPU=     .0022MIN,I/O BU=     .0044,BILLING UNITS=      .0498, CC=0000           *
NEF982I *                                                                                                    *
NEF983I *  I/O COUNTS 520=       6, 520=       4, 520=       0,                                              *
NEF980I ******************************************************************************************************
IEF375I  JOB /$WW232P2/ START 83095.1103
IEF376I  JOB /$WW232P2/ STOP  83095.1103 CPU    0MIN 00.13SEC SRB    0MIN 00.01SEC
NEF980I ******************************************************************************************************
NEF991I *  $WW232P2 ENDED,CPU=     .0022MIN,I/O BU=     .0044,BILLING UNITS=      .0498,SERV LEVEL=3.00      *
NEF992I *                  TOD=  11.03.36,DATE=   4/05/83,MACHINE=3081-I3,VS2 RELEASE=03.8,SYSRES=AZMVSI     *
NEF980I ******************************************************************************************************
```

079T1000008
102

```
IAT6140 JOB ORIGIN FROM GROUP=RM206    , DSP=IJP, DEVICE=INTRDR  , 000
09:22:41 IAT4401  LOCATE FOR STEP=A         DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
09:22:41 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
09:22:41 IAT4401  LOCATE FOR STEP=G         DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
09:22:41 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
09:22:41 IAT4401  LOCATE FOR STEP=G         DD=FT15F001 DSN=$WW232.CARRIZO.TURBIN.STEAM.DATA
09:22:41 IAT4402 UNIT=3350     ,VOL(S)=AVTSOA
09:22:41 IAT4401  LOCATE FOR STEP=G         DD=FT69F001 DSN=$WW049.ROCKPIPE.USERS
09:22:41 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
09:22:41 IAT4401  LOCATE FOR STEP=ELTEMP    DD=STEPLIB  DSN=$WW049.ELTEMP.LOAD
09:22:41 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
09:22:42 USES      CVTSOK  01 017402 D $WW049.NUPIPE.LOAD
09:22:42 USES      AVTSOA  01 017402 D $WW232.CARRIZO.TURBIN.STEAM.DATA
09:22:42 IAT5200 JOB 3422 ($WW232T2) IN SETUP ON MAIN=C        P=03 LOCAL
09:22:42 IAT5210 J=3422 STEPLIB  USING D CVTSOK ON 528   $WW049.NUPIPE.LOAD
09:22:42 IAT5210 J=3422 FT15F001 USING D AVTSOA ON 520   $WW232.CARRIZO.TURBIN.STEAM.DATA
09:22:48 IAT2000 JOB 3422 $WW232T2 SELECTED C        GRP=BIG
09:22:49 C R= $WW232T2 NEF995I $WW232T2 STARTED, 3/09/83,09.22.46 ASID=00077
09:22:49 C R= $WW232T2 IEF403I $WW232T2 - STARTED - TIME=09.22.46
09:25:57 C R= $WW232T2 +IH0002I STOP      1
09:25:57 C R= $WW232T2 IEF404I $WW232T2 - ENDED - TIME=09.25.54
09:25:57 C R= $WW232T2 NEF996I $WW232T2 ENDED,  3/09/83,B.U.=     4.9709 *0716935    ,3081-C3,JOB CC= 001
09:25:58 IAT5400 JOB 3422 ($WW232T2) IN BREAKDOWN
/$WW232T2 JOB 'GURSAHANI LB30130340*0716935        005  5001003037', *
/ REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
/*MAIN ORG=RM005                                                     00000300
/ EXEC ROCKPIPE,PROG=SMALL
/G.SYSIN DD DSN=$WW232.CARRIZO.TURBIN.STEAM.DATA,DISP=SHR
   1      //$WW232T2 JOB 'GURSAHANI LB30130340*0716935        005  5001003037', *
          // REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
   2      // EXEC ROCKPIPE,PROG=SMALL
```

079T000008
103

FORM 126-P-130 NEW 7-82

```
O R I G I N A L   I N P U T   B Y   GURSAHANI   O N  03/09/83  A T   09:23:03  W I T H  P R I O R I T Y  3
CARRIZO MSG PLUS STEAM PIPING UPTO TURBINE PLUS NA INLET AND OUTLET
CONTROL                  2.0        1.0
FLEXAN         1    1    2.0
 TE1 (THERMAL AT THE DESIGN TEMPERATURE NORMAL )
FLEXAN        -2    2    2.0
 TE1 (THERMAL AT THE DESIGN TEMPERATURE SG 1 DOWN)
FLEXAN        -3    3    2.0
 TE1 (THERMAL AT THE DESIGN TEMPERATURE SG 2 DOWN)
FLEXAN        -4    4    2.0
 TE1 (THERMAL AT THE DESIGN TEMPERATURE SG 3 DOWN)
FLEXAN        -5    5    2.0
 TE2 (THERMAL OVERNIGHT SHUTDOWN ,NORMAL)
FLEXAN        -6    6    2.0
 TE2 (THERMAL OVERNIGHT SHUTDOWN ,SG 1 DOWN)
FLEXAN        -7    7    2.0
 TE2 (THERMAL OVERNIGHT SHUTDOWN ,SG 2 DOWN)
FLEXAN        -8    8    2.0
 TE2 (THERMAL OVERNIGHT SHUTDOWN ,SG 3 DOWN)
FLEXAN        -9    9    2.0
 TE3 (SG AND NA INLET AT 600, NA OUTLET AT 300 AND STEAM PIPING AT 70)
FLEXAN        10    1   17.0
 DEADWEIGHT
XSECTN              1  54.22    0.721     812.0       29.9
XSECTN              2  30.94    0.721     705.1       29.9
XSECTN              3  21.5     1.0       580.1       29.9       0.0
XSECTN              4  19.0     1.0       859.8       29.9       0.0
XSECTN              5  12.81    1.0       370.3       29.9       0.0
XSECTN              6  26.0     1.97      993.2       29.9       0.0
XSECTN              7  12.75    .562      51.7        29.9       0.0
XSECTN              8  26.0     1.97      993.2       29.9       0.0
XSECTN              9  21.0     0.86      546.6       29.9       0.0
XSECTN             10  18.0     0.75      433.8       29.9       0.0
XSECTN             11  18.0     0.75      433.8       29.9       0.0
XSECTN             12  18.0     0.75      433.8       29.9       0.0
XSECTN             13  18.0     0.75      433.8       29.9       0.0
XSECTN             14  21.0     0.86       546.6      29.9       0.0
XSECTN             15  26.0     1.97      1002.0      29.9       0.0
XSECTN             16  12.75    .562        92.1      29.9       0.0
XSECTN             17  26.0     1.97      1002.0      29.9       0.0
XSECTN             18  24.0     1.0        524.4      29.9       0.0
XSECTN             19  26.0     1.97       927.5      29.9       0.0
XSECTN             20  21.5     1.0        596.4      29.9       0.0
XSECTN             21  19.0     1.0       859.8       29.9       0.0
XSECTN             22  12.81    1.0        376.9      29.9       0.0
XSECTN800          23  12.75     0.562      51.7      299.       0.0
XSECT1700          24  12.75     0.562      89.8      299.       0.0
XSECTN             25 6.625     0.864      85.5      29.9      1590.
XSECTN NA          26 6.625     0.864                29.9      1590.
XSECTN NA          27 12.75     0.406      175.      28.3        65.
XSECTN             28 6.625     0.280      98.5      28.3        65.
XSECTN NA          29 12.75     0.406      130.      27.9        65.
XSECTN             30 6.625     0.280      53.4      27.9        65.
XSECTN             31 12.75     0.687    218.8       28.3        65.
XSECTN NA          32 6.625     0.280                27.9        65.
XSECTN             33 12.75     0.687    218.8       27.9        65.
XSECTN             34 10.75     0.365      154.6     28.3        65.
XSEC               35 10.75     1.40       199.1     28.3        --
OPVA           1    1    29.4   .01198
OPVA_ ..._     1    2    28.4   .03022
```
FORM 126-P-130 NEW 7-82

OPVAL470	1	.3	28.2	.03344		60
OPVAL450	1	4	28.3	.03160		61
OPVAL450	1	5	28.3	.03160		62
OPVAL587	1	6	27.5	.04473		63
OPVAL620	1	7	27.2	.04086		64
OPVAL625	1	8	27.2	.04858		65
OPVAL640	1	9	27.1	.05012		66
OPVAL705	1	10	26.6	.05684		67
OPVAL865	1	11	24.9	.07422		68
OPVAL1010	1	12	22.7	.09005		69
OPVAL1050	1	13	21.7	.09465		70
OPVAL1055	1	14	21.6	.09523		71
OPVAL1057	1	15	21.5	.09546		72
OPVAL1065	1	16	21.3	.09638		73
OPVAL1055	1	17	21.6	.09523		74
OPVAL1025	1	18	22.4	.09178		75
OPVAL1020	1	19	22.5	.09120		76
OPVAL1020	1	20	22.5	.09120		77
OPVAL1015	1	21	22.6	.09063		78
OPVAL1015	1	22	22.6	.09063		79
OPVAL800	1	23	273.0	.04703		80
OPVAL1065	1	24	213.0	.09638		81
OPVAL1015	1	25	22.60	.09063	1590.	82
OPVAL NA	1	26	22.74	.09005	1590.	83
OPVAL NA	1	27	22.4	.12364	65.	84
OPVAL1065	1	28	22.4	.12364	65.	85
OPVAL NA	1	29	25.61	.04703	65.	86
OPVAL 610	1	30	25.61	.04703	65.	87
OPVAL1015	1	31	22.60	.09063	1590.	88
OPVAL1015	1	32	22.60	.09063	1590.	89
OPVAL1015	1	33	22.60	.09063	1590.	90
OPVAL225	2	1	29.4	.01198		91
OPVAL435	2	2	28.4	.03022		92
OPVAL470	2	3	28.2	.03344		93
OPVAL450	2	4	28.3	.03160		94
OPVAL450	2	5	28.3	.03160		95
OPVAL587	2	6	27.5	.04473		96
OPVAL620	2	7	27.2	.04086		97
OPVAL625	2	8	27.2	.04858		98
OPVAL640	2	9	27.1	.05012		99
OPVAL705	2	10	26.6	.05684		100
OPVAL865	2	11	24.9	.07422		101
OPVAL1010	2	12	22.7	.09005		102
OPVAL1050	2	13	21.7	.09465		103
OPVAL1055	2	14	21.6	.09523		104
OPVAL1057	2	15	21.5	.09546		105
OPVAL1065	2	16	21.3	.09638		106
OPVAL1055	2	17	21.6	.09523		107
OPVAL1025	2	18	22.4	.09178		108
OPVAL1020	2	19	22.5	.09120		109
OPVAL1020	2	20	22.5	.09120		110
OPVAL1015	2	21	22.6	.09063		111
OPVAL1015	2	22	22.6	.09063		112
OPVAL800	2	23	273.0	.04703		113
OPVAL1065	2	24	213.0	.09638		114
OPVAL1015	2	25	22.60	.09063	1590.	115
OPVAL NA	2	26	22.74	.09005	1590.	116
OPVAL NA	2	27	22.4	.12364	65.	117
OPVAL1065	2	28	22.4	.12364	65.	118
OPVAL NA	2	29	25.61	.04703	65.	119
OPVAL 610	2	30	25.61	.04703	65.	120
OPVAL1015	2	31	22.60	.09063	1590.	121

FORM 125-P-130 NEW 7-82

OPVAL1015	2	32	22.60	.09063	1590.	122
OPVAL 600	2	33	27.4	.04600		123
OPVAL225	3	1	29.4	.01198		124
OPVAL435	3	2	28.4	.03022		125
OPVAL470	3	3	28.2	.03344		126
OPVAL450	3	4	28.3	.03160		127
OPVAL450	3	5	28.3	.03160		128
OPVAL587	3	6	27.5	.04473		129
OPVAL620	3	7	27.2	.04086		130
OPVAL625	3	8	27.2	.04858		131
OPVAL640	3	9	27.1	.05012		132
OPVAL705	3	10	26.6	.05684		133
OPVAL865	3	11	24.9	.07422		134
OPVAL1010	3	12	22.7	.09005		135
OPVAL1050	3	13	21.7	.09465		136
OPVAL1055	3	14	21.6	.09523		137
OPVAL1057	3	15	21.5	.09546		138
OPVAL1065	3	16	21.3	.09638		139
OPVAL1055	3	17	21.6	.09523		140
OPVAL1025	3	18	22.4	.09178		141
OPVAL1020	3	19	22.5	.09120		142
OPVAL1020	3	20	22.5	.09120		143
OPVAL1015	3	21	22.6	.09063		144
OPVAL1015	3	22	22.6	.09063		145
OPVAL800	3	23	273.0	.04703		146
OPVAL1065	3	24	213.0	.09638		147
OPVAL1015	3	25	22.60	.09063	1590.	148
OPVAL NA	3	26	22.74	.09005	1590.	149
OPVAL NA	3	27	22.4	.12364	65.	150
OPVAL1065	3	28	22.4	.12364	65.	151
OPVAL NA	3	29	25.61	.04703	65.	152
OPVAL 610	3	30	25.61	.04703	65.	153
OPVAL1015	3	31	22.60	.09063	1590.	154
OPVAL 600	3	32	27.4	.0460		155
OPVAL1015	3	33	22.60	.09063	1590.	156
OPVAL225	4	1	29.4	.01198		157
OPVAL435	4	2	28.4	.03022		158
OPVAL470	4	3	28.2	.03344		159
OPVAL450	4	4	28.3	.03160		160
OPVAL450	4	5	28.3	.03160		161
OPVAL587	4	6	27.5	.04473		162
OPVAL620	4	7	27.2	.04086		163
OPVAL625	4	8	27.2	.04858		164
OPVAL640	4	9	27.1	.05012		165
OPVAL705	4	10	26.6	.05684		166
OPVAL865	4	11	24.9	.07422		167
OPVAL1010	4	12	22.7	.09005		168
OPVAL1050	4	13	21.7	.09465		169
OPVAL1055	4	14	21.6	.09523		170
OPVAL1057	4	15	21.5	.09546		171
OPVAL1065	4	16	21.3	.09638		172
OPVAL1055	4	17	21.6	.09523		173
OPVAL1025	4	18	22.4	.09178		174
OPVAL1020	4	19	22.5	.09120		175
OPVAL1020	4	20	22.5	.09120		176
OPVAL1015	4	21	22.6	.09063		177
OPVAL1015	4	22	22.6	.09063		178
OPVAL800	4	23	273.0	.04703		179
OPVAL1065	4	24	213.0	.09638		180
OPVAL1C[illegible]	4	25	22.60	.09063	1590.	181
OPVAL [illegible]	4	26	22.74	.09005	15	182
OPVAL [illegible]	4	27	22.4	.12364		183

OPVAL1065	4	28	22.4	.12364	65.	184
OPVAL NA	4	29	25.61	.04703	65.	185
OPVAL 610	4	30	25.61	.04703	65.	186
OPVAL 600	4	31	27.4	.0460		187
OPVAL1015	4	32	22.60	.09063	1590.	188
OPVAL1015	4	33	22.60	.09063	1590.	189
OPVAL201	5	1	29.5	.00998		190
OPVAL381	5	2	29.1	.02533		191
OPVAL420	5	3	28.5	.02884		192
OPVAL400	5	4	28.5	.02700		193
OPVAL400	5	5	28.5	.02700		194
OPVAL550	5	6	27.7	.04110		195
OPVAL570	5	7	27.6	.04306		196
OPVAL575	5	8	27.6	.04355		197
OPVAL585	5	9	27.5	.04453		198
OPVAL650	5	10	27.0	.05115		199
OPVAL770	5	11	26.0	.06379		200
OPVAL890	5	12	24.6	.07699		201
OPVAL940	5	13	23.9	.08242		202
OPVAL942	5	14	23.9	.08264		203
OPVAL948	5	15	23.8	.08328		204
OPVAL950	5	16	23.8	.08350		205
OPVAL950	5	17	23.8	.08350		206
OPVAL910	5	18	24.4	.07918		207
OPVAL905	5	19	24.4	.07864		208
OPVAL902	5	20	24.5	.07832		209
OPVAL900	5	21	24.5	.07810		210
OPVAL900	5	22	24.5	.07810		211
OPVAL570	5	23	276.0	.04306		212
OPVAL950	5	24	237.5	.08350		213
OPVAL850	5	25	25.1	.07255	1590.	214
OPVAL NA	5	26	22.74	.09005	1590.	215
OPVAL NA	5	27	23.2	.10800	65.	216
OPVAL950	5	28	23.2	.10800	65.	217
OPVAL NA	5	29	27.4	.0182	65.	218
OPVAL 300	5	30	27.4	.0182	65.	219
OPVAL850	5	31	25.1	.07255	1590.	220
OPVAL850	5	32	25.1	.07255	1590.	221
OPVAL850	5	33	25.1	.07255	1590.	222
OPVAL201	6	1	29.5	.00998		223
OPVAL381	6	2	29.1	.02533		224
OPVAL420	6	3	28.5	.02884		225
OPVAL400	6	4	28.5	.02700		226
OPVAL400	6	5	28.5	.02700		227
OPVAL550	6	6	27.7	.04110		228
OPVAL570	6	7	27.6	.04306		229
OPVAL575	6	8	27.6	.04355		230
OPVAL585	6	9	27.5	.04453		231
OPVAL650	6	10	27.0	.05115		232
OPVAL770	6	11	26.0	.06379		233
OPVAL890	6	12	24.6	.07699		234
OPVAL940	6	13	23.9	.08242		235
OPVAL942	6	14	23.9	.08264		236
OPVAL948	6	15	23.8	.08328		237
OPVAL950	6	16	23.8	.08350		238
OPVAL950	6	17	23.8	.08350		239
OPVAL910	6	18	24.4	.07918		240
OPVAL905	6	19	24.4	.07864		241
OPVAL902	6	20	24.5	.07832		242
OPVAL900	6	21	24.5	.07810		243
OPVAL900	6	22	24.5	.07810		244
OPVAL570	6	23	276.0	.04306		245

OPVAL950	6	24	237.5	.08350		246
OPVAL850	6	25	25.1	.07255	1590.	247
OPVAL NA	6	26	22.74	.09005	1590.	248
OPVAL NA	6	27	23.2	.10800	65.	249
OPVAL950	6	28	23.2	.10800	65.	250
OPVAL NA	6	29	27.4	.0182	65.	251
OPVAL 300	6	30	27.4	.0182	65.	252
OPVAL850	6	31	25.1	.07255	1590.	253
OPVAL850	6	32	25.1	.07255	1590.	254
OPVAL600	6	33	27.4	.04600		255
OPVAL201	7	1	29.5	.00998		256
OPVAL381	7	2	29.1	.02533		257
OPVAL420	7	3	28.5	.02884		258
OPVAL400	7	4	28.5	.02700		259
OPVAL400	7	5	28.5	.02700		260
OPVAL550	7	6	27.7	.04110		261
OPVAL570	7	7	27.6	.04306		262
OPVAL575	7	8	27.6	.04355		263
OPVAL585	7	9	27.5	.04453		264
OPVAL650	7	10	27.0	.05115		265
OPVAL770	7	11	26.0	.06379		266
OPVAL890	7	12	24.6	.07699		267
OPVAL940	7	13	23.9	.08242		268
OPVAL942	7	14	23.9	.08264		269
OPVAL948	7	15	23.8	.08328		270
OPVAL950	7	16	23.8	.08350		271
OPVAL950	7	17	23.8	.08350		272
OPVAL910	7	18	24.4	.07918		273
OPVAL905	7	19	24.4	.07864		274
OPVAL902	7	20	24.5	.07832		275
OPVAL900	7	21	24.5	.07810		276
OPVAL900	7	22	24.5	.07810		277
OPVAL570	7	23	276.0	.04306		278
OPVAL950	7	24	237.5	.08350		279
OPVAL850	7	25	25.1	.07255	1590.	280
OPVAL NA	7	26	22.74	.09005	1590.	281
OPVAL NA	7	27	23.2	.10800	65.	282
OPVAL950	7	28	23.2	.10800	65.	283
OPVAL NA	7	29	27.4	.0182	65.	284
OPVAL 300	7	30	27.4	.0182	65.	285
OPVAL850	7	31	25.1	.07255	1590.	286
OPVAL600	7	32	27.4	.04600		287
OPVAL850	7	33	25.1	.07255	1590.	288
OPVAL201	8	1	29.5	.00998		289
OPVAL381	8	2	29.1	.02533		290
OPVAL420	8	3	28.5	.02884		291
OPVAL400	8	4	28.5	.02700		292
OPVAL400	8	5	28.5	.02700		293
OPVAL550	8	6	27.7	.04110		294
OPVAL570	8	7	27.6	.04306		295
OPVAL575	8	8	27.6	.04355		296
OPVAL585	8	9	27.5	.04453		297
OPVAL650	8	10	27.0	.05115		298
OPVAL770	8	11	26.0	.06379		299
OPVAL890	8	12	24.6	.07699		300
OPVAL940	8	13	23.9	.08242		301
OPVAL942	8	14	23.9	.08264		302
OPVAL948	8	15	23.8	.08328		303
OPVAL950	8	16	23.8	.08350		304
OPVAL95	8	17	23.8	.08350		305
OPVAL9	8	18	24.4	.07918		306
OPVAL9(	8	19	24.4	.07864		307

079T100008 108

OPVAL902	8	20	24.5	.07832				308
OPVAL900	8	21	24.5	.07810				309
OPVAL900	8	22	24.5	.07810				310
OPVAL570	8	23	276.0	.04306				311
OPVAL950	8	24	237.5	.08350				312
OPVAL850	8	25	25.1	.07255			1590.	313
OPVAL NA	8	26	22.74	.09005			1590.	314
OPVAL NA	8	27	23.2	.10800			65.	315
OPVAL950	8	28	23.2	.10800			65.	316
OPVAL NA	8	29	27.4	.0182			65.	317
OPVAL 300	8	30	27.4	.0182			65.	318
OPVAL 600	8	31	27.4	.0460				319
OPVAL850	8	32	25.1	.07255			1590.	320
OPVAL850	8	33	25.1	.07255			1590.	321
OPVAL 226	9	1	29.4	.01206			65.	322
OPVAL 492	9	2	28.0	.03546			65.	323
OPVAL 600	9	3	27.4	.0460			65.	324
OPVAL 600	9	4	27.4	.0460			65.	325
OPVAL 600	9	5	27.4	.0460			65.	326
OPVAL 600	9	6	27.4	.0460			65.	327
OPVAL 600	9	7	27.4	.0460			65.	328
OPVAL 600	9	8	27.4	.0460			65.	329
OPVAL 600	9	9	27.4	.0460			65.	330
OPVAL 600	9	10	27.4	.0460			65.	331
OPVAL 600	9	11	27.4	.0460			65.	332
OPVAL 600	9	12	27.4	.0460			65.	333
OPVAL 600	9	13	27.4	.0460			65.	334
OPVAL 600	9	14	27.4	.0460			65.	335
OPVAL 600	9	15	27.4	.0460			65.	336
OPVAL 600	9	16	27.4	.0460			65.	337
OPVAL 600	9	17	27.4	.0460			65.	338
OPVAL 600	9	18	27.4	.0460			65.	339
OPVAL 600	9	19	27.4	.0460			65.	340
OPVAL 600	9	20	27.4	.0460			65.	341
OPVAL 600	9	21	27.4	.0460			65.	342
OPVAL 600	9	22	27.4	.0460			65.	343
OPVAL 600	9	23	274.0	.0460			65.	344
OPVAL 600	9	24	274.0	.0460				345
OPVAL 70	9	25	29.9				1590.	346
OPVAL NA	9	26	22.74				1590.	347
OPVAL NA	9	27	25.6	.0624			65.	348
OPVAL 600	9	28	25.6	.0624			65.	349
OPVAL NA	9	29	27.4	.0182			65.	350
OPVAL 300	9	30	27.4	.0182			65.	351
OPVAL 70	9	31	29.9				1590.	352
OPVAL 70	9	32	29.9				1590.	353
OPVAL 70	9	33	29.9				1590.	354
ANCHOR		7300	-94.75	19.917	27.5			355
RUN	7300	7295		-2.0		35.0	25.0	356
ELBOW	-7295	7290						357
RUN	7290	7287	3.0					358
ELBOW	-7287	7286						359
RUN	7286	7285	4.0	-4.0				360
ELBOW	-7285	7284						361
RUN	7284	7283	1.25					362
RESTRAINT		7283		1.0				363
RUN	7283	7282	1.00					364
VALVE	7282	7280	1.0					365
CWEIGHT		7280		1500.				366
VALVE	7280	7275	1.0					367
RUN	7275	7270	2.0					368
ELBOW	-7270	7265						369

RUN	7265	7260	9.75		-9.75			370
RESTRAINT		7260		1.0				371
ELBOW	-7260	7255						372
RUN	7255	7250	25.75					373
RESTRAINT		7250		1.0				374
ELBOW	-7250	7245						375
RUN	7245	7240		3.5	-17.75			376
ELBOW	-7240	7235						377
RESTRAINT		7235		1.0				378
RUN	7235	7230	6.292					379
RUN	7230	7220	0.708					380
TEE	7220	7225						381
RUN	7220	7225			0.667	25.0	31.0	382
RUN	7225	215			11.333			383
RUN	215	213			10.000			384
RESTRAINT		213		1.0				385
RUN	213	211			11.0			386
RUN	211	209			11.0			387
RESTRAINT		209		1.0				388
ELBOW	- 209	208						389
RUN	208	207	5.0					390
ELBOW	- 207	206						391
RUN	206	205			-16.0			392
RESTRAINT		205		1.0				393
ELBOW	- 205	204						394
RUN	204	203	16.5					395
ELBOW	- 203	202						396
RESTRAINT		202		1.0				397
RUN	202	200			16.0			398
ELBOW	- 200	198						399
RUN	198	195	5.5					400
RESTRAINT		195		50000.	50000.			401
RUN	195	190	6.0					402
ELBOW	- 190	180						403
RUN	180	178		2.0				404
RESTRAINT		178	50000.					405
RUN	178	177		1.781				406
RUN	177	175		2.422				407
RESTRAINT		175			50000.			408
CWEIGHT		175		10.0				409
RUN	175	173		14.0				410
RESTRAINT		173	50000.					411
CWEIGHT		173		10.0				412
RUN	173	172		3.0				413
RESTRAINT		172			50000.			414
CWEIGHT		172		10.0				415
RUN	172	170		3.0				416
ELBOW	- 170	165						417
RUN	165	163	-1.0					418
RESTRAINT		163		1.0				419
CWEIGHT		163		10.0				420
RUN	163	162	-4.75					421
SNUBBER		162		17000.				422
CWEIGHT		162		15.0				423
RUN	162	148	-6.75					424
RESTRAINT		148		1.0				425
CWEIGHT		148		10.0				426
RUN	148	145	-1.5					427
ELBOW	- 145	144						428
RUN	144	140		6.172				429
SNUBBER		140	25000.					430
CWEIGHT		140		15.0				431

RUN	140	139		0.25				432
RESTRAINT		139			50000.			433
CWEIGHT		139		10.0				434
RUN	139	138		18.031				435
RESTRAINT		138			50000.			436
CWEIGHT		138		10.0				437
RUN	138	135		0.25				438
SNUBBER		135	25000.					439
CWEIGHT		135		15.0				440
RUN	135	130		1.5				441
ELBOW	- 130	125						442
RUN	125	123	1.25					443
RESTRAINT		123		1.0				444
CWEIGHT		123		10.0				445
RUN	123	122	0.25					446
SNUBBER		122		17000.				447
CWEIGHT		122		15.0				448
RUN	122	106	8.396					449
RESTRAINT		106			50000.			450
CWEIGHT		106		10.0				451
RUN	106	105	0.25					452
RESTRAINT		105		1.0				453
CWEIGHT		105		10.0				454
RUN	105	25	1.5					455
RUN	25	23	1.375					456
ANCHOR		23						457
STDISPL	1	23	-.637	4.742				458
STDISPL	2	23	-.637	4.742				459
STDISPL	3	23	-.637	4.742				460
STDISPL	4	23						461
STDISPL	5	23	-.549	4.131				462
STDISPL	6	23	-.549	4.131				463
STDISPL	7	23	-.549	4.131				464
STDISPL	8	23						465
STDISPL	9	23	-.321	3.026				466
RUN	7220	2215	0.708			35.0	25.0	467
RUN	2215	2212	3.583					468
RESTRAINT		2212		1.0				469
RUN	2212	2210	0.708					470
TEE	2210	2212						471
RUN	2210	2207			0.708		32.0	472
REDUCER	2207	2206			0.583	25.0		473
RUN	2206	2205			22.709			474
RESTRAINT		2205		1.0				475
ELBOW	-2205	2204						476
RUN	2204	2203	2.0					477
ELBOW	-2203	2202						478
RUN	2202	2201			-21.5			479
RESTRAINT		2201		1.0				480
ELBOW	-2201	2200						481
RUN	2200	2199	17.5					482
ELBOW	-2199	2198						483
RESTRAINT		2198		1.0				484
RUN	2198	2197			19.5			485
ELBOW	-2197	2196						486
RUN	2196	2195	2.5					487
RESTRAINT		2195		50000.	50000.			488
RUN	2195	2190	6.0					489
ELBOW	-2190	2180						490
RUN	2180	2178		2.0				491
RESTRAINT		2178	50000.					492
RUN	2178	2177		1.781				493

FORM 126-P-130 NEW 7-82

079TI00008
111

RUN	2177	2175		2.422				494
RESTRAINT		2175			50000.			495
CWEIGHT		2175		10.0				496
RUN	2175	2173		14.0				497
RESTRAINT		2173	50000.					498
CWEIGHT		2173		10.0				499
RUN	2173	2172		3.0				500
RESTRAINT		2172			50000.			501
CWEIGHT		2172		10.0				502
RUN	2172	2170		3.0				503
ELBOW	-2170	2165						504
RUN	2165	2163	-1.0					505
RESTRAINT		2163		1.0				506
CWEIGHT		2163		10.0				507
RUN	2163	2162	-4.75					508
SNUBBER		2162		17000.				509
CWEIGHT		2162		15.0				510
RUN	2162	2148	-6.75					511
RESTRAINT		2148		1.0				512
CWEIGHT		2148		10.0				513
RUN	2148	2145	-1.5					514
ELBOW	-2145	2144						515
RUN	2144	2140		6.172				516
SNUBBER		2140	25000.					517
CWEIGHT		2140		15.0				518
RUN	2140	2139		0.25				519
RESTRAINT		2139			50000.			520
CWEIGHT		2139		10.0				521
RUN	2139	2138		18.031				522
RESTRAINT		2138			50000.			523
CWEIGHT		2138		10.0				524
RUN	2138	2135		0.25				525
SNUBBER		2135	25000.					526
CWEIGHT		2135		15.0				527
RUN	2135	2130		1.5				528
ELBOW	-2130	2125						529
RUN	2125	2123	1.25					530
RESTRAINT		2123		1.0				531
CWEIGHT		2123		10.0				532
RUN	2123	2122	0.25					533
SNUBBER		2122		17000.				534
CWEIGHT		2122		15.0				535
RUN	2122	2106	8.396					536
RESTRAINT		2106			50000.			537
CWEIGHT		2106		10.0				538
RUN	2106	2105	0.25					539
RESTRAINT		2105		1.0				540
CWEIGHT		2105		10.0				541
RUN	2105	2025	1.5					542
RUN	2025	2023	1.375					543
ANCHOR		2023						544
STDISPL	1	2023	-.637	4.742				545
STDISPL	2	2023	-.637	4.742				546
STDISPL	3	2023						547
STDISPL	4	2023	-.637	4.742				548
STDISPL	5	2023	-.549	4.131				549
STDISPL	6	2023	-.549	4.131				550
STDISPL	7	2023						551
STDISPL	8	2023	-.549	4.131				552
STDISPL	9	2023	-.321	3.026				553
RUN	210	2211			-0.708	35.0	33.	554
REDUCER	211	3230			-0.583	25.0		555

Type						
RUN	3230	3225			-14.709	556
RESTRAINT		3225		1.0		557
ELBOW	-3225	3220				558
RUN	3220	3215	16.5			559
ELBOW	-3215	3210				560
RESTRAINT		3210		1.0		561
RUN	3210	3205			16.0	562
ELBOW	-3205	3200				563
RUN	3200	3195	5.5			564
RESTRAINT		3195		50000.	50000.	565
RUN	3195	3190	6.0			566
ELBOW	-3190	3180				567
RUN	3180	3178		2.0		568
RESTRAINT		3178	50000.			569
RUN	3178	3177		1.781		570
RUN	3177	3175		2.422		571
RESTRAINT		3175			50000.	572
CWEIGHT		3175		10.0		573
RUN	3175	3173		14.0		574
RESTRAINT		3173	50000.			575
CWEIGHT		3173		10.0		576
RUN	3173	3172		3.0		577
RESTRAINT		3172			50000.	578
CWEIGHT		3172		10.0		579
RUN	3172	3170		3.0		580
ELBOW	-3170	3165				581
RUN	3165	3163	-1.0			582
RESTRAINT		3163		1.0		583
CWEIGHT		3163		10.0		584
RUN	3163	3162	-4.75			585
SNUBBER		3162		17000.		586
CWEIGHT		3162		15.0		587
RUN	3162	3148	-6.75			588
RESTRAINT		3148		1.0		589
CWEIGHT		3148		10.0		590
RUN	3148	3145	-1.5			591
ELBOW	-3145	3144				592
RUN	3144	3140		6.172		593
SNUBBER		3140	25000.			594
CWEIGHT		3140		15.0		595
RUN	3140	3139		0.25		596
RESTRAINT		3139			50000.	597
CWEIGHT		3139		10.0		598
RUN	3139	3138		18.031		599
RESTRAINT		3138			50000.	600
CWEIGHT		3138		10.0		601
RUN	3138	3135		0.25		602
SNUBBER		3135	25000.			603
CWEIGHT		3135		15.0		604
RUN	3135	3130		1.5		605
ELBOW	-3130	3125				606
RUN	3125	3123	1.25			607
RESTRAINT		3123		1.0		608
CWEIGHT		3123		10.0		609
RUN	3123	3122	0.25			610
SNUBBER		3122		17000.		611
CWEIGHT		3122		15.0		612
RUN	3122	3106	8.396			613
RESTRAINT		3106			50000.	614
CWEIGHT		3106		10.0		615
RUN	3106	3105	0.25			616
RESTRAINT		3105		1.0		617

CWEIGHT		3105				10.0				618
RUN	3105	3025	1.5							619
RUN	3025	3023		1.375						620
ANCHOR		3023								621
STDISPL	1	3023		-.637		4.742				622
STDISPL	2	3023								623
STDISPL	3	3023		-.637		4.742				624
STDISPL	4	3023		-.637		4.742				625
STDISPL	5	3023		-.549		4.131				626
STDISPL	6	3023								627
STDISPL	7	3023		-.549		4.131				628
STDISPL	8	3023		-.549		4.131				629
STDISPL	9	3023		-.321		3.026				630
STRESS7										631
9CASES	10									632
10CASES	1	2	3	4	5	6	7	8	9	633
ALLDONE										634
REPORT										635
IEDIT										636
OEDIT	1									637
B1NODES	23	2023	3023	2210	7220					638
B1THERMLC	-1									639
ALLDONE										640

NUPIPE-IIM - NUCLEAR SERVICES CORPORATION PIPING ANALYSIS PROGRAM - VERSION 1.4

CARRIZO MSG PLUS STEAM PIPING UPTO TURBINE PLUS NA INLET AND OUTLET

TABLE B-1

INTERFACE LOAD SUMMARY

NODE NO. 23

LOAD	TRANSLATIONAL FORCE (KIP)			ROTATIONAL FORCE (IN-KIP)		
CASE	FX	FY	FZ	MX	MY	MZ
1	5.922D-02	-4.381D-02	2.695D-03	-.4295	1.767D-02	15.48
2	5.916D-02	-4.319D-02	2.190D-03	-.3473	1.512D-02	15.41
3	5.952D-02	-4.643D-02	2.390D-03	-.3798	1.617D-02	15.81
4	-.2727	1.140	5.072D-03	-.8753	3.984D-02	-156.1
5	9.130D-02	-.1860	2.246D-03	-.3711	1.696D-02	34.58
6	9.129D-02	-.1858	1.912D-03	-.3146	1.494D-02	34.57
7	9.173D-02	-.1898	2.045D-03	-.3370	1.577D-02	35.06
8	-.2730	1.142	3.847D-03	-.6623	3.076D-02	-156.4
9	.4106	-1.585	-4.608D-04	8.043D-02	-4.780D-03	223.1
10	-3.979D-02	-.3135	-2.220D-04	1.205D-02	-2.514D-03	2.485

NOTE: 1) FORCES ARE THOSE IMPOSED ON THE INTERFACE IN THE LOCAL COORDINATE SYSTEM OF THE CONNECTING ELEMENT

 /03/09/83

CARRIZO MSG PLUS STEAM PIPING UPTO TURBINE PLUS NA INLET AND OUTLET

TABLE B-1

INTERFACE LOAD SUMMARY

NODE NO. 2023

LOAD CASE	TRANSLATIONAL FORCE (KIP) FX	FY	FZ	ROTATIONAL FORCE (IN-KIP) MX	MY	MZ
1	5.886D-02	-3.589D-02	1.075D-02	-1.730	6.257D-02	14.54
2	5.945D-02	-4.120D-02	1.014D-02	-1.630	5.979D-02	15.20
3	-.2741	1.156	1.184D-02	-2.052	8.991D-02	-158.1
4	5.908D-02	-3.757D-02	1.057D-02	-1.701	6.189D-02	14.75
5	9.085D-02	-.1785	9.049D-03	-1.515	6.050D-02	33.68
6	9.161D-02	-.1854	8.600D-03	-1.439	5.793D-02	34.54
7	-.2741	1.156	9.757D-03	-1.690	7.446D-02	-158.0
8	9.122D-02	-.1817	8.950D-03	-1.498	6.004D-02	34.08
9	.4102	-1.581	-4.371D-04	7.684D-02	-4.361D-03	222.6
10	-3.950D-02	-.3286	1.639D-04	-9.709D-03	1.856D-03	2.639

NOTE: 1) FORCES ARE THOSE IMPOSED ON THE INTERFACE IN THE LOCAL COORDINATE SYSTEM OF THE CONNECTING ELEMENT

NUPIPE-IIM - NUCLEAR SERVICES CORPORATION PIPING ANALYSIS PROGRAM - VERSION 1.4

CARRIZO MSG PLUS STEAM PIPING UPTO TURBINE PLUS NA INLET AND OUTLET

TABLE B-1

INTERFACE LOAD SUMMARY

NODE NO. 3023

LOAD	TRANSLATIONAL FORCE (KIP)			ROTATIONAL FORCE (IN-KIP)		
CASE	FX	FY	FZ	MX	MY	MZ
1	5.677D-02	-1.065D-02	1.523D-02	-2.453	8.791D-02	11.44
2	-.2778	1.194	1.496D-02	-2.594	.1130	-162.8
3	5.717D-02	-1.336D-02	1.502D-02	-2.417	8.770D-02	11.79
4	5.663D-02	-8.488D-03	1.500D-02	-2.414	8.721D-02	11.18
5	8.907D-02	-.1578	1.283D-02	-2.150	8.479D-02	31.13
6	-.2773	1.188	1.251D-02	-2.169	9.471D-02	-162.0
7	8.972D-02	-.1634	1.266D-02	-2.121	8.421D-02	31.83
8	8.900D-02	-.1568	1.272D-02	-2.130	8.444D-02	31.01
9	.4122	-1.598	-3.448D-04	6.086D-02	-3.366D-03	224.8
10	-3.973D-02	-.3164	-2.836D-04	1.414D-02	-3.211D-03	2.515

NOTE: 1) FORCES ARE THOSE IMPOSED ON THE INTERFACE IN THE LOCAL COORDINATE SYSTEM OF THE CONNECTING ELEMENT

/03/09/83

FORM 126-P-130 NEW 7-82

079T1000008
117

NUPIPE-IIM - NUCLEAR SERVICES CORPORATION PIPING ANALYSIS PROGRAM - VERSION 1.4

CARRIZO MSG PLUS STEAM PIPING UPTO TURBINE PLUS NA INLET AND OUTLET

TABLE B-1

INTERFACE LOAD SUMMARY

NODE NO. 2210

LOAD CASE	TRANSLATIONAL FORCE (KIP) FX	FY	FZ	ROTATIONAL FORCE (IN-KIP) MX	MY	MZ
1	-.5623	-6.005D-02	-1.397	8.322	58.68	-22.17
2	-.6562	-1.062D-02	-1.373	17.11	43.89	-20.07
3	-.4778	-8.063D-02	-1.489	11.22	80.08	-23.72
4	-.4832	-6.354D-02	-1.471	8.734	76.05	-21.49
5	-.4968	-5.641D-02	-1.236	5.796	51.65	-19.83
6	-.5263	2.267D-03	-1.177	14.92	42.11	-16.35
7	-.4518	-8.045D-02	-1.287	9.287	63.30	-21.68
8	-.4503	-6.013D-02	-1.278	6.399	61.59	-18.96
9	5.162D-03	-3.515D-02	1.738D-02	-16.38	-.4662	-2.467
10	-2.249D-03	-.8066	-5.067D-03	2.486	.4220	-17.49

NOTE: 1) FORCES ARE THOSE IMPOSED ON THE INTERFACE IN THE LOCAL COORDINATE SYSTEM OF THE CONNECTING ELEMENT

0791000008 118

FORM 126-1 7-82

CARRIZO MSG PLUS STEAM PIPING UPTO TURBINE PLUS NA INLET AND OUTLET

TABLE B-1

INTERFACE LOAD SUMMARY

NODE NO. 7220

LOAD	TRANSLATIONAL FORCE (KIP)			ROTATIONAL FORCE (IN-KIP)		
CASE	FX	FY	FZ	MX	MY	MZ
1	-2.243	-.1079	.8681	-22.02	-154.0	-20.69
2	-2.237	-7.341D-02	.9066	-18.62	-166.1	-28.99
3	-2.295	-7.833D-02	.9508	-31.83	-151.2	-26.37
4	-2.348	-.1189	.7558	-19.60	-131.4	-22.54
5	-1.984	-.1026	.7666	-19.08	-136.5	-16.33
6	-1.938	-6.188D-02	.7639	-14.24	-143.1	-24.92
7	-1.983	-6.463D-02	.8075	-30.32	-129.9	-21.82
8	-2.047	-.1165	.7006	-15.90	-123.9	-18.91
9	2.919D-02	-7.471D-02	-8.104D-03	4.054	2.572	20.90
10	-5.365D-03	.8803	2.168D-03	-11.99	.1985	35.80

NOTE: 1) FORCES ARE THOSE IMPOSED ON THE INTERFACE IN THE LOCAL COORDINATE SYSTEM OF THE CONNECTING ELEMENT

079T100008 119

NUPIPE-IIM - NUCLEAR SERVICES CORPORATION PIPING ANALYSIS PROGRAM - VERSION 1.4

CARRIZO MSG PLUS STEAM PIPING UPTO TURBINE PLUS NA INLET AND OUTLET

TABLE B-1

INTERFACE LOAD SUMMARY

NODE NO. 7300

LOAD	TRANSLATIONAL FORCE (KIP)			ROTATIONAL FORCE (IN-KIP)		
CASE	FX	FY	FZ	MX	MY	MZ
1	.1215	-2.672	.7313	-91.36	-78.02	-185.9
2	8.825D-02	-2.673	.7337	-80.64	-64.22	-172.1
3	9.848D-02	-2.735	.7901	-74.73	-79.34	-178.8
4	9.833D-02	-2.683	.8348	-57.58	-85.05	-177.2
5	.1188	-2.365	.6455	-81.52	-70.69	-169.4
6	7.990D-02	-2.323	.6217	-78.69	-52.92	-150.8
7	8.933D-02	-2.372	.6721	-71.54	-69.67	-156.4
8	8.999D-02	-2.357	.7095	-59.41	-76.51	-157.0
9	.1159	3.544D-02	-4.073D-03	3.981	-17.49	-49.05
10	.1143	-6.061D-03	3.372D-03	.3700	14.13	14.85

NOTE: 1) FORCES ARE THOSE IMPOSED ON THE INTERFACE IN THE LOCAL COORDINATE SYSTEM OF THE CONNECTING ELEMENT

O R I G I N A L   I N P U T   B Y   GURSAHANI   O N   04/04/83   A T   10:53:13   W I T H   P R I O R I T Y   3

CARRIZO MSG PLUS STEAM PIPING UPTO TURBINE [redacted]

CONTROL			2.0	1.0			
FLEXAN	1	1	2.0				
TE1 (THERMAL AT THE DESIGN TEMPERATURE)							
FLEXAN	2	2	2.0				
TE2 (OVERNIGHT SHUTDOWN)							
FLEXAN	3	3	2.0				
TE3 (LONG TERM SHUTDOWN)							
XSECTN		1	54.22	0.721	812.0	29.9	
XSECTN		2	30.94	0.721	705.1	29.9	
XSECTN		3	21.5	1.0	580.1	29.9	0.0
XSECTN		4	19.0	1.0	859.8	29.9	0.0
XSECTN		5	12.81	1.0	370.3	29.9	0.0
XSECTN		6	26.0	1.97	993.2	29.9	0.0
XSECTN		7	12.75	.562	51.7	29.9	0.0
XSECTN		8	26.0	1.97	993.2	29.9	0.0
XSECTN		9	21.0	0.86	546.6	29.9	0.0
XSECTN		10	18.0	0.75	433.8	29.9	0.0
XSECTN		11	18.0	0.75	433.8	29.9	0.0
XSECTN		12	18.0	0.75	433.8	29.9	0.0
XSECTN		13	18.0	0.75	433.8	29.9	0.0
XSECTN		14	21.0	0.86	546.6	29.9	0.0
XSECTN		15	26.0	1.97	1002.0	29.9	0.0
XSECTN		16	12.75	.562	92.1	29.9	0.0
XSECTN		17	26.0	1.97	1002.0	29.9	0.0
XSECTN		18	24.0	1.0	524.4	29.9	0.0
XSECTN		19	26.0	1.97	927.5	29.9	0.0
XSECTN		20	21.5	1.0	596.4	29.9	0.0
XSECTN		21	19.0	1.0	859.8	29.9	0.0
XSECTN		22	12.81	1.0	376.9	29.9	0.0
XSECTN800		23	12.75	0.562	51.7	299.	0.0
XSECT1700		24	12.75	0.562	89.8	299.	0.0
XSECTN		25	6.625	0.864	85.5	29.9	1590.
XSECTN NA		26	6.625	0.864		29.9	1590.
XSECTN NA		27	12.75	0.406	175.	28.3	65.
XSECTN		28	6.625	0.280	98.5	28.3	65.
XSECTN NA		29	12.75	0.406	130.	27.9	65.
XSECTN		30	6.625	0.280	53.4	27.9	65.
XSECTN		31	12.75	0.687	218.8	28.3	65.
XSECTN NA		32	6.625	0.280		27.9	65.
XSECTN		33	12.75	0.687	218.8	27.9	65.
XSECTN		34	10.75	0.365	154.6	28.3	65.
XSECTN		35	10.75	1.40	199.1	28.3	1590.
OPVAL225	1	1	29.4	.01198			
OPVAL435	1	2	28.4	.03022			
OPVAL470	1	3	28.2	.03344			
OPVAL450	1	4	28.3	.03160			
OPVAL450	1	5	28.3	.03160			
OPVAL587	1	6	27.5	.04473			
OPVAL620	1	7	27.2	.04086			
OPVAL625	1	8	27.2	.04858			
OPVAL640	1	9	27.1	.05012			
OPVAL705	1	10	26.6	.05684			
OPVAL865	1	11	24.9	.07422			
OPVAL1010	1	12	22.7	.09005			
OPVAL1050	1	13	21.7	.09465			
OPVAL1055	1	14	21.6	.09523			
OPVAL1057	1	15	21.5	.09546			
OPVAL1065	1	16	21.3	.09638			

FORM 138-F-130 NEW 7-82

OPVAL1055	1	17	21.6	.09523		60
OPVAL1025	1	18	22.4	.09178		61
OPVAL1020	1	19	22.5	.09120		62
OPVAL1020	1	20	22.5	.09120		63
OPVAL1015	1	21	22.6	.09063		64
OPVAL1015	1	22	22.6	.09063		65
OPVAL800	1	23	273.0	.04703		66
OPVAL1065	1	24	213.0	.09638		67
OPVAL1015	1	25	22.60	.09063	1590.	68
OPVAL NA	1	26	22.74	.09005	1590.	69
OPVAL NA	1	27	22.4	.12364	65.	70
OPVAL1065	1	28	22.4	.12364	65.	71
OPVAL NA	1	29	25.61	.04703	65.	72
OPVAL 610	1	30	25.61	.04703	65.	73
OPVAL1015	1	31	22.60	.09063	1590.	74
OPVAL1015	1	32	22.60	.09063	1590.	75
OPVAL1015	1	33	22.60	.09063	1590.	76
OPVAL201	2	1	29.5	.00998		77
OPVAL381	2	2	29.1	.02533		78
OPVAL420	2	3	28.5	.02884		79
OPVAL400	2	4	28.5	.02700		80
OPVAL400	2	5	28.5	.02700		81
OPVAL550	2	6	27.7	.04110		82
OPVAL570	2	7	27.6	.04306		83
OPVAL575	2	8	27.6	.04355		84
OPVAL585	2	9	27.5	.04453		85
OPVAL650	2	10	27.0	.05115		86
OPVAL770	2	11	26.0	.06379		87
OPVAL890	2	12	24.6	.07699		88
OPVAL940	2	13	23.9	.08242		89
OPVAL942	2	14	23.9	.08264		90
OPVAL948	2	15	23.8	.08328		91
OPVAL950	2	16	23.8	.08350		92
OPVAL950	2	17	23.8	.08350		93
OPVAL910	2	18	24.4	.07918		94
OPVAL905	2	19	24.4	.07864		95
OPVAL902	2	20	24.5	.07832		96
OPVAL900	2	21	24.5	.07810		97
OPVAL900	2	22	24.5	.07810		98
OPVAL570	2	23	276.0	.04306		99
OPVAL950	2	24	237.5	.08350		100
OPVAL850	2	25	25.1	.07255	1590.	101
OPVAL NA	2	26	22.74	.09005	1590.	102
OPVAL NA	2	27	23.2	.10800	65.	103
OPVAL950	2	28	23.2	.10800	65.	104
OPVAL NA	2	29	27.4	.0182	65.	105
OPVAL 300	2	30	27.4	.0182	65.	106
OPVAL850	2	31	25.1	.07255	1590.	107
OPVAL850	2	32	25.1	.07255	1590.	108
OPVAL850	2	33	25.1	.07255	1590.	109
OPVAL 226	3	1	29.4	.01206	65.	110
OPVAL 492	3	2	28.0	.03546	65.	111
OPVAL 600	3	3	27.4	.0460	65.	112
OPVAL 600	3	4	27.4	.0460	65.	113
OPVAL 600	3	5	27.4	.0460	65.	114
OPVAL 600	3	6	27.4	.0460	65.	115
OPVAL 600	3	7	27.4	.0460	65.	116
OPVAL 600	3	8	27.4	.0460	65.	117
OPVAL 600	3	9	27.4	.0460	65.	118
OPVAL 600	3	10	27.4	.0460	65.	119
OPVAL	3	11	27.4	.0460	[illegible]	120
OPVAL	3	12	27.4	.0460		121

FORM NEW 7-82

079TI000008
122

OPVAL 600	3	13	27.4	.0460			65.	122
OPVAL 600	3	14	27.4	.0460			65.	123
OPVAL 600	3	15	27.4	.0460			65.	124
OPVAL 600	3	16	27.4	.0460			65.	125
OPVAL 600	3	17	27.4	.0460			65.	126
OPVAL 600	3	18	27.4	.0460			65.	127
OPVAL 600	3	19	27.4	.0460			65.	128
OPVAL 600	3	20	27.4	.0460			65.	129
OPVAL 600	3	21	27.4	.0460			65.	130
OPVAL 600	3	22	27.4	.0460			65.	131
OPVAL 600	3	23	274.0	.0460			65.	132
OPVAL 600	3	24	274.0	.0460				133
OPVAL 70	3	25	29.9				1590.	134
OPVAL NA	3	26	22.74				1590.	135
OPVAL NA	3	27	25.6	.0624			65.	136
OPVAL 600	3	28	25.6	.0624			65.	137
OPVAL NA	3	29	27.4	.0182			65.	138
OPVAL 300	3	30	27.4	.0182			65.	139
OPVAL 70	3	31	29.9				1590.	140
OPVAL 70	3	32	29.9				1590.	141
OPVAL 70	3	33	29.9				1590.	142
ANCHOR		7300	-94.75	19.917	27.5			143
RUN	7300	7295		-2.0		35.0	25.0	144
ELBOW	-7295	7290						145
RUN	7290	7287	3.0					146
ELBOW	-7287	7286	30.0					147
RUN	7286	7285	4.0	-4.0				148
ELBOW	-7285	7284						149
RUN	7284	7283	1.25					150
RESTRAINT		7283		1.0				151
RUN	7283	7282	1.00					152
VALVE	7282	7280	1.0					153
CWEIGHT		7280		1500.				154
VALVE	7280	7275	1.0					155
RUN	7275	7273	1.0					156
RUN	7273	7270	1.0					157
ELBOW	-7270	7265						158
RUN	7265	7263	6.75		-6.75			159
RESTRAINT		7263		1.0				160
RUN	7263	7260	3.0		-3.0			161
ELBOW	-7260	7255	30.0					162
RUN	7255	7253	23.00					163
RESTRAINT		7253		1.0				164
RUN	7253	7250	2.75					165
ELBOW	-7250	7245	30.0					166
RUN	7245	7240		3.5	-17.75			167
ELBOW	-7240	7235	30.0					168
RUN	7235	7230	2.292					169
RUN	7230	7220	0.708					170
TEE	7220	7228						171
RUN	7220	7228			0.667	25.0	31.0	172
RUN	7228	215			11.333			173
RUN	215	213			10.000			174
RESTRAINT		213		1.0				175
RUN	213	212			5.0			176
RUN	212	211			6.0			177
RUN	211	210			11.0			178
ELBOW	- 210	209	30.0					179
RUN	209	208	3.0					180
RESTRAINT		208		1.0				181
RUN	208	207	3.0					182
ELBOW	- 207	206	30.0					183

FORM 126-P-130 NEW 7-82

079T000008
123

RUN	206	197			-13.0		
RESTRAINT		197		1.0			
RUN	197	205			-3.0		
ELBOW	-205	204	30.0				
RUN	204	203	19.5				
ELBOW	-203	202	30.0				
RUN	202	201			4.0		
RESTRAINT		201		1.0			
RUN	201	200			12.0		
ELBOW	-200	198	30.0				
RUN	198	195	5.5				
ANCHOR		195					
RUN	7220	2225	0.708			35.0	25.0
RUN	2225	2224	2.50				
RESTRAINT		2224		1.0			
RUN	2224	2222	2.083				
RUN	2222	2220	0.708				
TEE	2220	2217					
RUN	2220	2217			0.708	25.0	32.0
RUN	2217	2216			0.583	25.0	
RUN	2216	2210			19.709		
RESTRAINT		2210		1.0			
RUN	2210	2205			3.0		
ELBOW	-2205	2204	30.0				
RUN	2204	6203	3.0				
RUN	6203	2203	3.0				
ELBOW	-2203	2202	30.0				
RUN	2202	2209			-18.5		
RESTRAINT		2209		1.0			
RUN	2209	2201			-3.0		
ELBOW	-2201	2200	30.0				
RUN	2200	2199	16.5				
ELBOW	-2199	2198	30.0				
RUN	2198	2207			3.0		
RESTRAINT		2207		1.0			
RUN	2207	2197			16.5		
ELBOW	-2197	2195	30.0				
DUMMY	2197	2195	1.0				
ANCHOR		2195					
RUN	2220	2221	0.708			35.0	33.0
REDUCER	2221	3230	3.083			25.0	
ELBOW	-3230	3228	30.0				
RUN	3228	3225			-22.0		
ELBOW	-3225	3220	30.0				
RUN	3220	3215	15.709				
ELBOW	-3215	3210	30.0				
RUN	3210	3208			2.0		
RESTRAINT		3208		1.0			
RUN	3208	3207			10.0		
RUN	3207	3205			10.0		
ELBOW	-3205	3200	30.0				
RUN	3200	3195	5.5				
ANCHOR		3195					
STRESS7							
10CASES	1	2	3				
ALLDONE							

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	7300	1.000	3052.	3052.	2550.	5602.
	7295	1.000	3052.	3052.	2189.	5241.
ELBOW	7295	1.000	3052.	3052.	2189.	5241.
	7290	1.000	3052.	3052.	1614.	4666.
RUN	7290	1.000	3052.	3052.	1614.	4666.
	7287	1.000	3052.	3052.	1636.	4689.
ELBOW	7287	1.000	3052.	3052.	1636.	4689.
	7286	1.000	3052.	3052.	1417.	4469.
RUN	7286	1.000	3052.	3052.	1417.	4469.
	7285	1.000	3052.	3052.	1278.	4331.
ELBOW	7285	1.000	3052.	3052.	1278.	4331.
	7284	1.000	3052.	3052.	1455.	4507.
RUN	7284	1.000	3052.	3052.	1455.	4507.
	7283	1.000	3052.	3052.	1558.	4611.
RUN	7283	1.000	3052.	3052.	1558.	4611.
	7282	1.000	3052.	3052.	1700.	4752.
RUN	7275	1.000	3052.	3052.	1984.	5036.
	7273	1.000	3052.	3052.	2127.	5179.
RUN	7273	1.000	3052.	3052.	2127.	5179.
	7270	1.000	3052.	3052.	2196.	5248.
ELBOW	7270	1.000	3052.	3052.	2196.	5248.
	7265	1.000	3052.	3052.	2159.	5211.
RUN	7265	1.000	3052.	3052.	2159.	5211.
	7263	1.000	3052.	3052.	718.	3770.
RUN	7263	1.000	3052.	3052.	718.	3770.
	7260	1.000	3052.	3052.	1026.	4078.
ELBOW	7260	1.000	3052.	3052.	1026.	4078.
	7255	1.000	3052.	3052.	1106.	4158.

079TI000008
125

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	7255	1.000	3052.	3052.	1106.	4158.
	7253	1.000	3052.	3052.	2646.	5698.
RUN	7253	1.000	3052.	3052.	2646.	5698.
	7250	1.000	3052.	3052.	2680.	5733.
ELBOW	7250	1.000	3052.	3052.	2680.	5733.
	7245	1.000	3052.	3052.	1906.	4958.
RUN	7245	1.000	3052.	3052.	1906.	4958.
	7240	1.000	3052.	3052.	4305.	7357.
ELBOW	7240	1.000	3052.	3052.	4305.	7357.
	7235	1.000	3052.	3052.	5092.	8144.
RUN	7235	1.000	3052.	3052.	5092.	8144.
	7230	1.000	3052.	3052.	5122.	8174.
RUN	7230	1.000	3052.	3052.	5122.	8174.
	7220	1.000	3052.	3052.	5019.	8072.
RUN	7220	1.000	3048.	3048.	9177.	12225.
	7228	1.000	3048.	3048.	8935.	11983.
RUN	7228	1.000	3048.	3048.	8935.	11983.
	215	1.000	3048.	3048.	4814.	7862.
RUN	215	1.000	3048.	3048.	4814.	7862.
	213	1.000	3048.	3048.	1193.	4241.
RUN	213	1.000	3048.	3048.	1193.	4241.
	212	1.000	3048.	3048.	687.	3735.
RUN	212	1.000	3048.	3048.	687.	3735.
	211	1.000	3048.	3048.	2840.	5888.
RUN	211	1.000	3048.	3048.	2840.	5888.
	210	1.000	3048.	3048.	5927.	8975.
ELBOW	210	1.000	3048.	3048.	5927.	8975.
	209	1.000	3048.	3048.	6410.	9458.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	209	1.000	3048.	3048.	6410.	9458.
	208	1.000	3048.	3048.	6325.	9373.
RUN	208	1.000	3048.	3048.	6325.	9373.
	207	1.000	3048.	3048.	6240.	9287.
ELBOW	207	1.000	3048.	3048.	6240.	9287.
	206	1.000	3048.	3048.	4905.	7952.
RUN	206	1.000	3048.	3048.	4905.	7952.
	197	1.000	3048.	3048.	1098.	4146.
RUN	197	1.000	3048.	3048.	1098.	4146.
	205	1.000	3048.	3048.	919.	3967.
ELBOW	205	1.000	3048.	3048.	919.	3967.
	204	1.000	3048.	3048.	470.	3518.
RUN	204	1.000	3048.	3048.	470.	3518.
	203	1.000	3048.	3048.	2908.	5956.
ELBOW	203	1.000	3048.	3048.	2908.	5956.
	202	1.000	3048.	3048.	2424.	5472.
RUN	202	1.000	3048.	3048.	2424.	5472.
	201	1.000	3048.	3048.	1879.	4927.
RUN	201	1.000	3048.	3048.	1879.	4927.
	200	1.000	3048.	3048.	1582.	4630.
ELBOW	200	1.000	3048.	3048.	1582.	4630.
	198	1.000	3048.	3048.	2065.	5113.
RUN	198	1.000	3048.	3048.	2065.	5113.
	195	1.000	3048.	3048.	1554.	4602.
RUN	7220	1.000	3052.	3052.	2991.	6043.
	2225	1.000	3052.	3052.	2862.	5914.
RUN	2225	1.000	3052.	3052.	2862.	5914.
	2224	1.000	3052.	3052.	2406.	5459.

079TI000008
127

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	2224	1.000	3052.	3052.	2406.	5459.
	2222	1.000	3052.	3052.	2027.	5079.
RUN	2222	1.000	3052.	3052.	2027.	5079.
	2220	1.000	3052.	3052.	1898.	4951.
RUN	2220	1.000	3048.	3048.	12364.	15412.
	2217	1.000	3048.	3048.	11757.	14805.
RUN	2217	1.000	3048.	3048.	11757.	14805.
	2216	1.000	3048.	3048.	11257.	14305.
RUN	2216	1.000	3048.	3048.	11257.	14305.
	2210	1.000	3048.	3048.	5679.	8727.
RUN	2210	1.000	3048.	3048.	5679.	8727.
	2205	1.000	3048.	3048.	6107.	9155.
ELBOW	2205	1.000	3048.	3048.	6107.	9155.
	2204	1.000	3048.	3048.	8896.	11944.
RUN	2204	1.000	3048.	3048.	8896.	11944.
	6203	1.000	3048.	3048.	9026.	12074.
RUN	6203	1.000	3048.	3048.	9026.	12074.
	2203	1.000	3048.	3048.	9156.	12204.
ELBOW	2203	1.000	3048.	3048.	9156.	12204.
	2202	1.000	3048.	3048.	7662.	10710.
RUN	2202	1.000	3048.	3048.	7662.	10710.
	2209	1.000	3048.	3048.	6079.	9127.
RUN	2209	1.000	3048.	3048.	6079.	9127.
	2201	1.000	3048.	3048.	6508.	9556.
ELBOW	2201	1.000	3048.	3048.	6508.	9556.
	2200	1.000	3048.	3048.	7998.	11046.
RUN	2200	1.000	3048.	3048.	7998.	11046.
	2199	1.000	3048.	3048.	4996.	8044.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
ELBOW	2199	1.000	3048.	3048.	4996.	8044.
	2198	1.000	3048.	3048.	2203.	5250.
RUN	2198	1.000	3048.	3048.	2203.	5250.
	2207	1.000	3048.	3048.	1775.	4823.
RUN	2207	1.000	3048.	3048.	1775.	4823.
	2197	1.000	3048.	3048.	10244.	13292.
ELBOW	2197	1.000	3048.	3048.	10244.	13292.
	2195	1.000	3048.	3048.	13042.	16090.
RUN	2220	1.000	3052.	3052.	887.	3939.
	2221	1.000	3052.	3052.	971.	4023.
REDUCE	2221	2.000	3048.	3048.	8760.	11808.
	3230	2.000	3048.	3048.	9389.	12437.
ELBOW	3230	1.000	3048.	3048.	4695.	7743.
	3228	1.000	3048.	3048.	3910.	6958.
RUN	3228	1.000	3048.	3048.	3910.	6958.
	3225	1.000	3048.	3048.	10924.	13972.
ELBOW	3225	1.000	3048.	3048.	10924.	13972.
	3220	1.000	3048.	3048.	11691.	14739.
RUN	3220	1.000	3048.	3048.	11691.	14739.
	3215	1.000	3048.	3048.	5704.	8752.
ELBOW	3215	1.000	3048.	3048.	5704.	8752.
	3210	1.000	3048.	3048.	2146.	5194.
RUN	3210	1.000	3048.	3048.	2146.	5194.
	3208	1.000	3048.	3048.	2579.	5627.
RUN	3208	1.000	3048.	3048.	2579.	5627.
	3207	1.000	3048.	3048.	6110.	9158.
RUN	3207	1.000	3048.	3048.	6110.	9158.
	3205	1.000	3048.	3048.	12618.	15666.

079TI000008
129

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
ELBOW	3205	1.000	3048.	3048.	12618.	15666.
	3200	1.000	3048.	3048.	16184.	19232.
RUN	3200	1.000	3048.	3048.	16184.	19232.
	3195	1.000	3048.	3048.	17861.	20909.

079T1000008
130

John Gegan
11/04/82

079TI000008
131

30 MW SOLAR CARRIZO PLAIN
MAIN STEAM PIPE DESIGN CONDITION
JBG 11-1-82

T-G INLET MAX OPERATING PRESSURE — 1450 PSIG, 1465 PSIA
1000°F
1491.2 H

MAIN STEAM LINE PRESSURE DROP — 50 PSI
TEMPERATURE DROP — 3°F

STEAM GENERATOR OUTLET
MAX OPERATING PRESSURE — 1500 PSIG, 1515 PSIA
1003°F
1491.3 H

MAIN STEAM PIPE DESIGN

MAX OPERATING PRESSURE + 5% MARGIN BELOW SAFETY VALVE SET PRESSURE

1500 + 75 = 1575 PSIG

STEAM GENERATOR OUTLET SAFETY VALVE SETTING 1575 PSIG

MAX OPERATING TEMPERATURE 1003°F

1500 SPECIAL CLASS VALVE PER B16.34-81 AT 1575 PSIG
ALLOWABLE = 1011°F
∴ DESIGN = 1010°F

DESIGN 1575 PSIG
1010°F
(USE SPECIAL CLASS 1500 VALVES)

1015°F Design

TABLE 1
LIST OF MATERIAL SPECIFICATIONS
Applicable ASTM Specifications

Group 1 Materials		Forgings		Castings		Plates		Bars and Shapes		Tubular Products	
Material Group No.	Nominal Designation Steel	Spec.–Grade	Notes	Spec.–Grade	Notes	Spec.–Grade	Notes	Spec.–Grade	Notes	Spec.–Grade	Notes
1.1	Carbon	A 105 A 350-LF2	(1)(3)	A 216-WCB	(1)	A 515-70 A 516-70	(1) (1)	A 105 A 350-LF2 A 675-70 A 696 Gr.B	(1)(3) (1)(8)(5)	A 672-B70 A 672-C70	
	C-Mn-Si					A537 Cl.1					
1.2	Carbon			A 216-WCC	(1)					A 106-C	(1)
	2-1/2 Ni			A 352-LC2		A 203-B					
	3-1/2 Ni	A 350-LF3		A 352-LC3		A 203-E		A 350-LF3			
1.3	Carbon			A 352-LCB		A 515-65 A 516-65	(1) (1)	A 675-65	(1)(8)(5)	A 672-B65 A 672-C65	
	2-1/2 Ni					A 203-A					
	3-1/2 Ni					A 203-D					
1.4	Carbon	A 350-LF1				A 515-60 A 516-60	(1)	A 675-60 A 350-LF1 A 696 Gr.C	(1)(5)	A 106-B A 672-B60 A 672-C60	(1)
1.5	C-1/2 Mo	A182-F1	(2)	A 217-WC1 A 352-LC1	(2)(4)	A 204-A A 204-B	(2) (2)	A 182-F1	(2)	A 691-CM70	
1.6	C-1/2 Mo									A 335-P1 A 369-FP1	(2) (2)
	1/2 Cr-1/2 Mo					A 387-2 Cl.1 A 387-2 Cl.2				A 691-1/2 CR	
	1 Cr-1/2 Mo					A 387-12Cl. 1					
1.7	C-1/2 Mo					A 204-C	(2)			A 691-CM75	
	1/2 Cr-1/2 Mo	A 182-F2						A 182-F2			
	Ni-Cr-1/2 Mo			A 217-WC4	(4)						
	Ni-Cr-1 Mo			A 217-WC5	(4)						
1.8	1 Cr-1/2 Mo					A 387-12 Cl.2				A 691-1 CR A 335-P12 A 369-FP12	(4)
	1-1/4 Cr-1/2 Mo					A 387-11 Cl.1				A 691-1-1/4 CR A 335-P11 A 369-FP11	
	2-1/4 Cr-1 Mo					A 387-22 Cl.1				A 691-2-1/4 CR A 335-P22 A 369-FP22	
1.9	1 Cr-1/2 Mo	A 182-F12	(4)					A 182-F12	(4)		
	1-1/4 Cr-1/2 Mo	A 182-F11	(4)	A 217-WC6	(4)	A 387-11 Cl.2		A 182-F11 A 739-B11	(4)		
1.10	2-1/4 Cr-1 Mo	A 182-F22		A217-WC9	(4)	A 387-22 Cl.2		A 182-F22 A 739-B22			
1.11	3 Cr-1 Mo	A 182-F21				A 387-21 Cl.2		A 182-F21			
	Mn-1/2 Mo					A 302-A & B A 302-C & D	(2) (2)				
	Mn-Si					A 537 Cl.2					
1.12	5 Cr-1/2 Mo					A 387-5 Cl.1 A 387-5 Cl.2				A 691-5 CR A 335-P5 A 335-P5b A 369-FP5	
1.13	5 Cr-1/2 Mo	A 182-F5a A 182-F5		A 217-C5	(4)			A 182-F5a A 182-F5			
1.14	9 Cr-1 Mo	A 182-F9		A 217-C12	(4)			A 182-F9			

See Notes on p. 21.

TABLE 2-1.10
RATINGS FOR GROUP 1.10 MATERIALS

A 182-F22(c) A 217-WC9(j) A 387-22 Cl.2(c) A 739-B22(c)

NOTES:

(c) Permissible, but not recommended for prolonged usage above about 1100°F.

(j) Not to be used over 1100°F.

TABLE 2-1.10A – STANDARD CLASS VALVES – FLANGED AND BUTTWELDING END

Temperature, °F	Working Pressure by Classes, psig							
	150	300	400	600	900	1500	2500	4500
–20 to 100	290	750	1000	1500	2250	3750	6250	11250
200	260	715	955	1430	2150	3580	5965	10740
300	230	675	905	1355	2030	3385	5640	10150
400	200	650	865	1295	1945	3240	5400	9720
500	170	640	855	1280	1920	3200	5330	9595
600	140	605	805	1210	1815	3025	5040	9070
650	125	590	785	1175	1765	2940	4905	8825
700	110	570	755	1135	1705	2840	4730	8515
750	95	530	710	1065	1595	2660	4430	7970
800	80	510	675	1015	1525	2540	4230	7610
850	65	485	650	975	1460	2435	4060	7305
900	50	450	600	900	1350	2245	3745	6740
950	35	380	505	755	1130	1885	3145	5660
1000	20	270	355	535	805	1340	2230	4010
1050	20(1)	200	265	400	595	995	1660	2985
1100	20(1)	115	150	225	340	565	945	1700
1150	20(1)	105	140	205	310	515	860	1545
1200	20(1)	55	75	110	165	275	460	825

NOTE:

(1) For welding end valves only. Flanged end ratings terminate at 1000°F.

TABLE 2-1.10B – SPECIAL CLASS BUTTWELDING END VALVES ONLY

Temperature, °F	Working Pressure by Classes, psig							
	150	300	400	600	900	1500	2500	4500
–20 to 100	290	750	1000	1500	2250	3750	6250	11250
200	290	750	1000	1500	2250	3750	6250	11250
300	290	750	1000	1500	2250	3750	6250	11250
400	290	750	1000	1500	2250	3750	6250	11250
500	285	740	985	1475	2210	3685	6145	11060
600	285	740	985	1475	2210	3685	6145	11060
650	285	740	985	1475	2210	3685	6145	11060
700	280	735	980	1465	2200	3665	6110	10995
750	280	730	970	1460	2185	3645	6070	10930
800	275	720	960	1440	2160	3600	6000	10800
850	260	680	905	1355	2030	3385	5645	10160
900	230	600	800	1200	1800	3000	5000	9000
950	180	470	630	945	1415	2360	3930	7070
1000	130	335	445	670	1005	1670	2785	5015
1050	95	250	330	500	745	1245	2070	3730
1100	55	140	190	285	425	710	1180	2120
1150	50	130	170	260	385	645	1070	1930
1200	25	70	90	140	205	345	570	1030

GENERAL COMPUTATION SHEET

SUBJECT: Steam Piping for 30MW Solar

MADE BY R.N. Drury DATE 10/22/82 CHECKED BY ______ APPROVED BY ______

Valves are ANSI 2500 lb class

valve size	valve weight (lb)	actuator weight	notes
2			gate valves
2½	100		
3	170		
4	335		
6	840		
8	1440		
10	2490		
2		n.q.	check valves - tilting disk
2½			
3	425		
4	450		
6	600		
8	1200		
10	2100		
2			stop check valves y pattern
2½	175		
3	405		
4	600		
6	980		
8	1700		
10	3500		

based on Crane Valve catalog

PACIFIC GAS AND ELECTRIC COMPANY

GENERAL COMPUTATION SHEET

079TI000008

135

SUBJECT

MADE BY R.M.Drury DATE 11/3/82 CHECKED BY APPROVED BY

For steam at 1575 psig and 1010°F $v = 0.5166\ ft^3/lbm$

Main Steam Header W = 269730 lb/hr of steam

10" pipe velocity = 112 ft/sec Δp = 5.56 psi/100ft of pipe

8" 176 17.1

Steam Line from Sodium Heat Exchanger W = 89910 lb/hr

6" pipe velocity = 101 ft/sec Δp = 7.35 psi/100ft of pipe

4" 238 63.1

Insulation Weight for Steam Piping

assumes 14 lb/ft³ Calcium Silicate with 0.016" smooth aluminum finish

nominal pipe size	Insulation Thickness	lb/ft of pipe
2	5.0	12.0
2½	5.0	12.8
3	5.5	16.0
4	6.0	20.2
6	6.0	24.2
8	6.5	31.3
10	7.0	39.4

Use 1500 lb. Special Class valves or 2500 lb Standard Class valves

PACIFIC GAS AND ELECTRIC COMPANY

GENERAL COMPUTATION SHEET

079TI000008
136

SUBJECT: Pipe Sizing for Main Steam Lines -- 30MW Solar

MADE BY: RNDrury DATE: 1/ /82 CHECKED BY: ______ APPROVED BY: ______

P = 1515 psia
T = 1003 °F
v = 0.5352 ft³/lb

Main Steam Header

269730 lb/hr of steam

for 10" pipe steam velocity = [illegible] ft/sec ΔP_{100} = 8.836 psi/100ft

8" pipe steam velocity = [illegible] ft/sec ΔP_{100} = 27.221

Steam Line from Sodium Heat Exchanger

89910 lb/hr of steam

for 6" pipe steam velocity = 101.5 ft/sec ΔP_{100} = 12.60 psi/100ft

4" pipe steam velocity = 214.6 ft/sec ΔP_{100} = 106.59 psi/100ft

Insulation Weight for Steam Piping

based on 14 lb/ft³ Calcium Silicate with 0.016 smooth aluminum finish

nominal pipe size	Insulation Thickness	lb/ft of pipe
2	5.0	12.0
2½	5.0	12.8
3	5.5	16.0
4	6.0	20.2
6	6.0	24.2
8	6.5	31.3
10	7.0	39.4

Thickness based on proposed Potrero 7 Standard

Main Steam Piping for 30MW Solar

MADE BY PMDrury DATE 11/3/82 CHECKED BY APPROVED BY

Design Conditions: 1575 psig
1010 °F

Piping Material: 2¼ Cr-1 Mo seamless pipe, ANSI A 335 Grade P22. Supplimentary requirements S1 to S4 and full ultrasonic test on pipe 2½" and over.

Maximum allowable stress = 7400 psi

Allowable stress reduced to 0.9 due to cyclic loading of pipe (>10,000 cycles over 30 year plant life, both thermal, pressure, and dead load)

Allowable stress = 6660 psi

Corrosion allowance = 0.0625" (1/16")

$y = 0.4$

$$t_{min} = \frac{P D_o}{2(SE + Py)} + A$$

$$= 0.1080 D_o + 0.0625$$

$$t_{nom} = \frac{t_{min}}{0.875}$$

nominal Pipe Size	D_o	minimum wall (in)	required nominal wall (in)	use	id	flow area (in²)
2	2.375	0.319	0.365	XXS	1.503	1.774
2½	2.875	0.373	0.426	XXS	1.771	2.464
3	3.500	0.441	0.504	XXS	2.300	4.15
4	4.500	0.549	0.627	XXS	3.152	7.80
6	6.625	0.778	0.889	fabricated *	4.846	18.45
8	8.625	0.994	1.136	fabricated	6.353	31.69
10	10.750	1.224	1.400	fabricated	7.953	49.67

* = standard pipe size and wall exists heavier than this

Steam Piping for 30 MW Solar Plant

MADE BY R.M. Drury DATE 1/ /82 CHECKED BY APPROVED BY

Design Conditions: 1575 psig
1050°F

Piping Material: 2¼ Cr-1 Mo seamless pipe ANSI A335, Grade P22. Supplimentary requirements S1 to S4 and full ultrasonic test on pipe 2½" and over

Maximum allowable stress = 5800 psi at 1050°F

Allowable stress reduced to 0.9 due to thermal cycling (>10,000 cycles over 30 year plant life)

Allowable stress = 5220 psi

Corrosion allowance = 0.0625 $y = 0.4$

$$t_{min} = \frac{P D_o}{2(SE + Py)} + A$$

$$= 0.135\, D_o + 0.0625$$

$$t_{nom} = \frac{t_{min}}{0.875}$$

Nominal Pipe Size	OD	minimum wall (in)	minimum nominal wall (in)	notes	ID	flow area (in²)
2	2.375	0.382	0.437	XXS pipe	1.503	1.774
2½	2.875	0.450	0.514	XXS pipe	1.771	2.46
3	3.500	0.534	0.610	fabricated*	2.280	5.54
4	4.500	0.668	0.764	fabricated*	2.972	8.97
6	6.625	0.954	1.091	fabricated*	4.443	18.97
8	8.625	1.224	1.398	fabricated	5.829	26.69
10	10.750	1.510	1.725	fabricated	7.300	41.85

* A standard pipe wall thickness is listed in excess of the minimum nominal wall. Cost should be concidered as it will probably be specially fabricated in either case.

APPENDIX 6.2
INPUT AND OUTPUT DATA FOR STEAM GENERATOR PUMP DISCHARGE AND CONNECTED PIPING

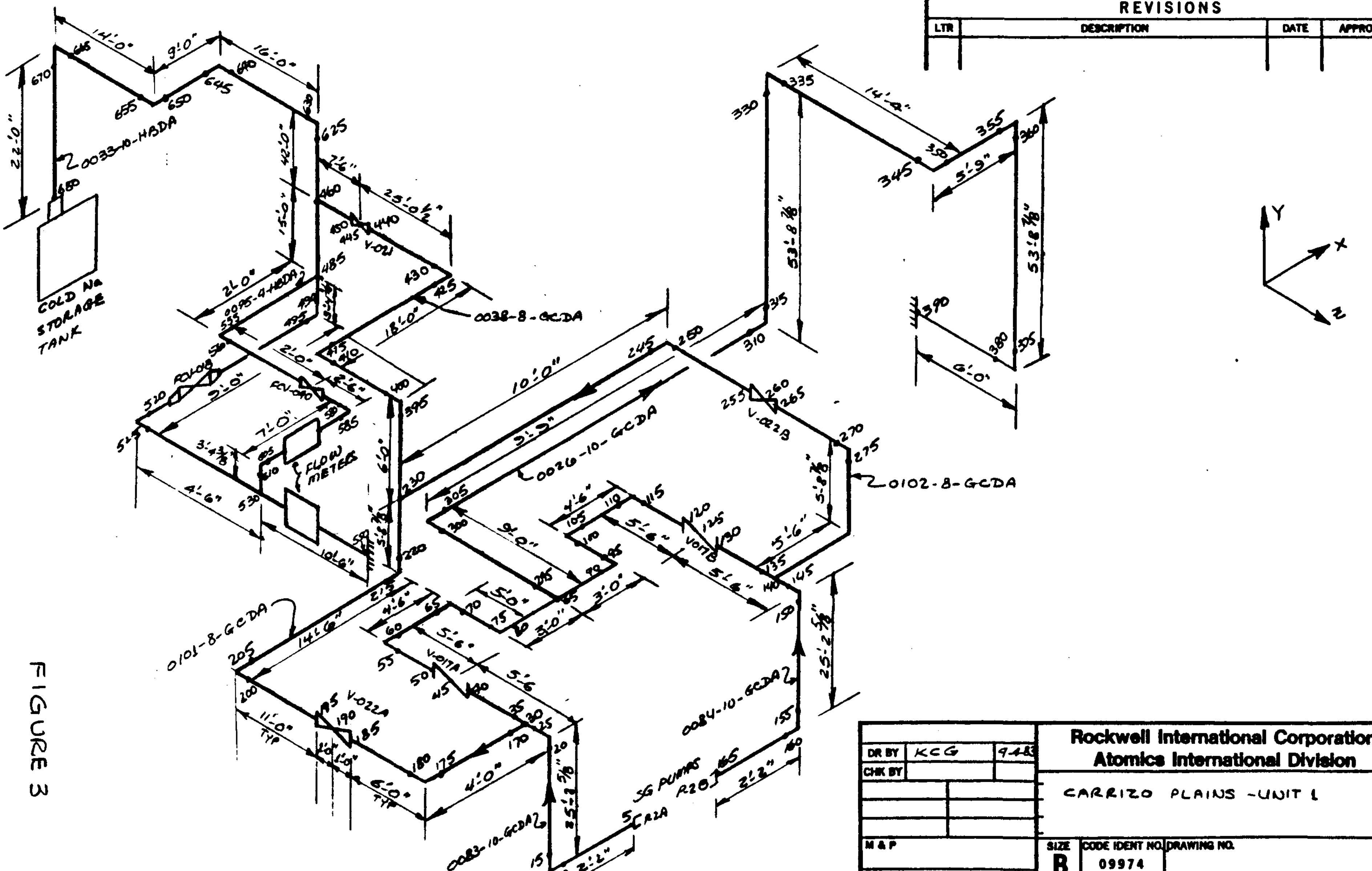


FIGURE 3

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

Rockwell International Corporation
Atomics International Division

CARRIZO PLAINS - UNIT 1

DR BY KCG 9-4-83
CHK BY
M & P
STRESS

SIZE B | CODE IDENT NO. 09974 | DRAWING NO.
SCALE | SHEET 1 OF 1

4-76 DIETERICH-POST 1000H ISO

FORM 735-V-2 REV. 3-73

079T1000008
140

PREPARED BY: KC	Rockwell International Energy Systems Group	PAGE NO. 141 OF
CHECKED BY:		REPORT NO. 079TI000008
DATE: 2/24/83		MODEL NO.

TABLE B-1
INPUT DATA

SYSTEM	T-1 Cold tank inlet	REFERENCE		
		NO.	REV.	PAGE
Line Number	0033-10-HBDA			
Design Temperature	650° F			
Design Pressure	65 psi			
Normal Operating Temperature	610° F			
Normal operating Pressure	65 psi			
Pipe O.D.^{x}/schedule	10.75 / Sch 40			
Pipe Thickness^{x}	0.365			
Pipe Material	CS			
Insulation Type				
Weight of Pipe Lbs/Ft	40.48			
weight of contents Lbs/ft	.9 x 34.1 = 30.69			
Weight of Insulation Lbs/ft	-			
Total Weight^{x} Lbs/ft	71.2			
E_c^{x}	27.9 x 10^{6} psi			
Seismic Category	I			

N 152-R-2 REV. 8-78

PREPARED BY: KCG	Rockwell International Energy Systems Group	142 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
DATE: 3/24/83		MODEL NO.

TABLE B-1

INPUT DATA

SYSTEM	Steam Generator Pump Discharge	REFERENCE		
		NO.	REV.	PAGE
Line Number	0026-10-GCDA 0083-10-GCDA 0084-10-GCDA			
Design Temperature	1100° F			
Design Pressure	65 psi			
Normal Operating Temperature	1100 °F			
Normal operating Pressure	65 psi			
Pipe O.D.[x]/schedule	10.75" / sch. 40			
Pipe Thickness x	0.365"			
Pipe Material	SS 304			
Insulation Type	Cal. Silicate 6" thick			
Weight of Pipe LBS/Ft	40.48 lbs / ft			
weight of contents Lbs/ft	$.9 \times 34.1 = 30.69$			
Weight of Insulation Lbs / ft	$\frac{\pi}{4}(22.75^2 - 10.75^2)\frac{14}{144}$ $= 30.7$			
Total Weight[x] Lbs / ft	101.9 lbs / ft			
E_c[x]	28.3×10^6 psi			
Seismic Category	II			

PREPARED BY: KCS	Rockwell International Energy Systems Group	PAGE NO. 143 OF
CHECKED BY:		REPORT NO. 079TI000008
DATE: 3/24/83		MODEL NO.

TABLE B-1

INPUT DATA

SYSTEM	Steam Gen. Pump Discharge Emergency Drain	REFERENCE NO.	REFERENCE REV.	REFERENCE PAGE
Line Number	0038-8-GEDA			
Design Temperature	1100° F			
Design Pressure	65 psi			
Normal Operating Temperature	1055° F			
Normal Operating Pressure	65 psi			
Pipe O.D.^x /schedule	8.625 / sch 40			
Pipe Thickness ^x	0.322			
Pipe Material	SS 304			
Insulation Type	—			
Weight of Pipe Lbs/Ft	28.55			
Weight of contents Lbs/ft	.9 x 21.69 = 19.5			
Weight of Insulation Lbs/ft	—			
Total Weight ^x Lbs/ft	48.1			
E_e ^x	28.3×10^6 psi			
Seismic Category	I			

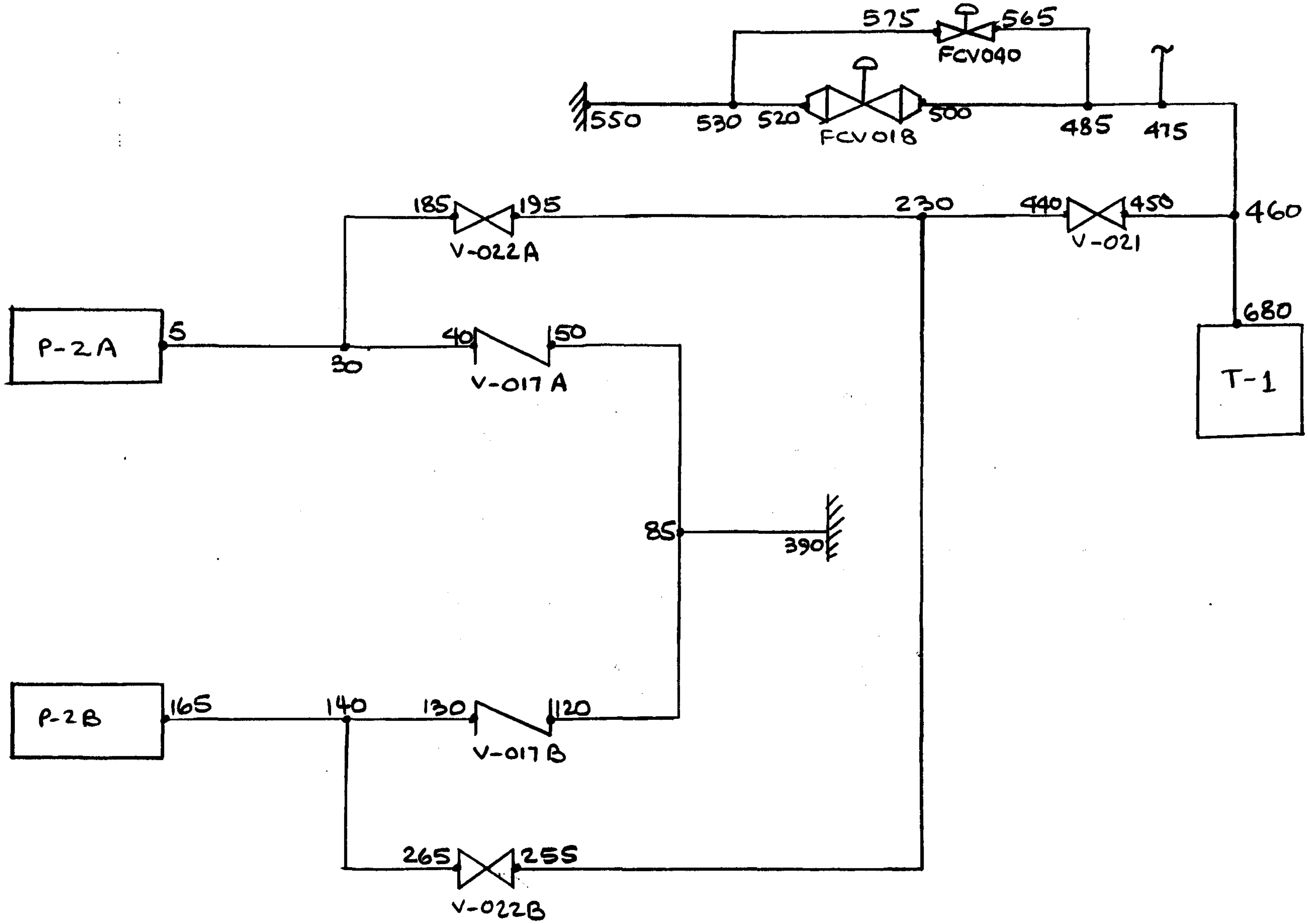
N 152-R-2 REV. 8-78

PREPARED BY: KC	Rockwell International Energy Systems Group	PAGE NO. 144 OF
CHECKED BY:		REPORT NO. 079TI000008
DATE: 3/24/83		MODEL NO.

TABLE B-1

INPUT DATA

SYSTEM	Bypass	REFERENCE NO.	REFERENCE REV.	REFERENCE PAGE
Line Number	0095-4-HBDA			
Design Temperature	610°F			
Design Pressure	65 psi			
Normal Operating Temperature	610° F			
Normal operating Pressure	65 psi			
Pipe O.D. x /schedule	4.5 / sch 40			
Pipe Thickness x	0.237			
Pipe Material	SS304			
Insulation Type				
Weight of Pipe Lbs/Ft	10.79			
Weight of contents Lbs/ft	5.51 x .9 = 4.96			
Weight of Insulation Lbs/ft	–			
Total Weight x Lbs/ft	15.7			
E_e x.	28.3×10^6 psi			
Seismic Category	III			



PREPARED BY: KC

CHECKED BY:

DATE: 3/21/83

Rockwell International

Energy Systems Group

PAGE NO. 145 OF

REPORT NO. 079TI000008

MODEL NO.

N 152-R-2 REV. 8-78

TABLE 8-2

THERMAL OPERATION MODES

Mode Number	Type	Description	XNOP	Temp. °F	Applicable Section From Node	Applicable Section To Node	E x 10^-6 psi	α ΔT in/ft.
1	N	Normal operating	1	1100	5	30	21.8	.1284
			2	↓	30	85	↓	↓
			3	↓	85	140	↓	↓
			4	↓	140	165	↓	↓
			5	↓	85	390	↓	↓
			6	400	30	230	26.6	.0380
			7	↓	140	230	↓	↓
			8	↓	230	460	↓	↓
			9	650	460	680	25.25	.05115
			10	↓	460	485	↓	↓
			11	↓	485	500-530	↓	↓
			12	↓	530	550	↓	↓
			13	400	485	565-530	27.0	.0270

Notes:
- N = Normal Operating Condition
- U = Upset Operating Condition
- T = Testing Condition
- E = Emergency condition
- F = Faulted Condition
- D = Design Condition

PREPARED BY: KCR	Rockwell International Energy Systems Group	147 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
DATE: 3/24/83		MODEL NO.

TABLE B-2

THERMAL OPERATION MODES

Mode Number	Type	Description	XNOP	Temp. °F	Applicable Section From Node	Applicable Section To Node	E x 10^-6 psi	α ΔT in/ft.
2		Pump 2B down line at ambient	1	1100	5	30	21.8	.1284
			2	1100	30	85	21.8	.1284
			3	70	85	140	28.3	0
			4	70	140	165	28.3	0
			5	1100	85	390	21.8	.1284
			6	400	30	230	26.6	.0380
			7	↓	140	230	↓	↓
			8		230	460		
			9	650	460	680	25.25	.05115
			10	↓	460	485	↓	↓
			11		485	500-530		
			12		530	550		
			13	400	485	565-530	27.0	.0270

Notes:
N = Normal Operating Condition
U = Upset Operating Condition
T = Testing Condition
E = Emergency condition
F = Faulted Condition
D = Design Condition

TABLE B-2

THERMAL OPERATION MODES

Mode Number	Type	Description	XNOP	Temp. °F	Applicable Section From Node	Applicable Section To Node	E x 10^-6 psi	α ΔT in/ft.
3	F	Hot drain thru both loops	1	1100	5	30	21.8	·1284
			2	400	30	85	26.6	·0380
			3	400	85	140	26.6	·0380
			4	1100	140	165	21.8	·1284
			5	400	85	390	26.6	·0380
			6	1100	30	230	~1.8 26.6	·1284
			7	↓	140	230	↓	↓
			8	↓	230	460	↓	↓
			9	↓	460	680	23.4	·1004
			10	650	460	485	25.25	·05115
			11	↓	485	500-530	↓	↓
			12	↓	530	550	↓	↓
			13	400	485	565-530	27.0	·0270

Notes:
N = Normal Operating Condition
U = Upset Operating Condition
T = Testing Condition
E = Emergency condition
F = Faulted Condition
D = Design Condition

PREPARED BY: KCG	Rockwell International Energy Systems Group	149 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
DATE: 3/24/83		MODEL NO.

TABLE B-2
THERMAL OPERATION MODES

Mode Number	Type	Description	XNOP	Temp. °F	Applicable Section From Node	Applicable Section To Node	E x 10⁻⁶ psi	α ΔT in/ft.
4	F	Hot drain thru one loop V-022B Closed	1	1100	5	30	21.8	.1284
			2	400	30	85	26.6	.0380
			3	↓	85	140	↓	↓
			4	↓	140	165	↓	↓
			5	↓	85	390	↓	↓
			6	1100	30	230	21.8	.1284
			7	400	140	230	26.6	.0380
			8	1100	230	460	21.8	.1284
			9	1100	460	680	23.4	.1004
			10	650	460	485	25.25	.05115
			11	↓	485	500-530	↓	↓
			12	↓	530	550	↓	↓
			13	450	485	565-530	27.0	.0270

Notes:
- N = Normal Operating Condition
- U = Upset Operating Condition
- T = Testing Condition
- E = Emergency condition
- F = Faulted Condition
- D = Design Condition

N 152-R-2 REV. 8-78

TABLE B-2

THERMAL OPERATION MODES

Mode Number	Type	Description	XNOP	Temp. °F	Applicable Section From Node	Applicable Section To Node	$E \times 10^{-6}$ psi	$\alpha \Delta T$ in/ft.
5	F	Hot drain thru one loop V-022 A closed	1	400	5	30	26.6	.0380
			2	↓	30	85	↓	↓
			3	↓	85	140	↓	↓
			4	1100	140	165	21.8	.1284
			5	400	85	390	26.6	.0380
			6	400	30	230	26.6	.0380
			7	1100	140	230	21.8	.1284
			8	1100	230	460	21.8	.1284
			9	1100	460	680	23.4	.1004
			10	650	460	485	25.23	.05115
			11	↓	485	500-530	↓	↓
			12	↓	530	550	↓	↓
			13	450	485	565-530	27.0	.0270

Notes: N = Normal Operating Condition
U = Upset Operating Condition
T = Testing Condition
E = Emergency condition
F = Faulted Condition
D = Design Condition

PREPARED BY: KCR	Rockwell International Energy Systems Group	151 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
DATE: 3/24/83		MODEL NO.

TABLE B-2

THERMAL OPERATION MODES

Mode Number	Type	Description	XNOP	Temp. °F	Applicable Section From Node	Applicable Section To Node	E x 10⁻⁶ psi	α ΔT in/ft.
6		Startup valve FCV040 & FCV018 open	1	1100	5	30	21.8	.0380
			2		30	85		
			3		85	140		
			4		140	165		
			5		85	390		
			6	400	30	230	26.6	.0380
			7		140	230		
			8		230	460		
			9	650	460	680	25.25	.05115
			10		460	485		
			11		485	500-530		
			12		530	550		
			13		485	565-530		

Notes:
- N = Normal Operating Condition
- U = Upset Operating Condition
- T = Testing Condition
- E = Emergency condition
- F = Faulted Condition
- D = Design Condition

TABLE B-2
THERMAL OPERATION MODES

Mode Number	Type	Description	XNOP	Temp. °F	Applicable Section From Node	Applicable Section To Node	E x 10⁻⁶ psi	α ΔT in/ft.
7	N		1	1100	5	30	21.8	.1284
			2		30	85		
			3		85	140		
			4		140	165		
			5		85	390		
			6	650	30	230	25.15	.0687
			7		140	230		
			8		230	460		
			9	650	460	680	25.25	.05115
			10		460	485		
			11		485	500-530		
			12		530	550		
			13	400	485	565-530	27.0	.0270

Notes:
N = Normal Operating Condition
U = Upset Operating Condition
T = Testing Condition
E = Emergency condition
F = Faulted Condition
D = Design Condition

KCG
3/25/83

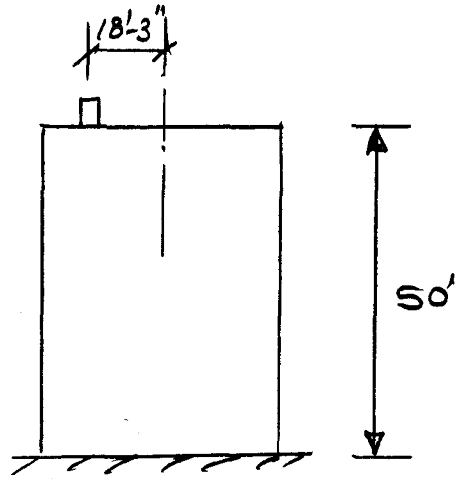
Calculation of Thermal Nozzle Movements at Cold Sodium Storage Tank

079TI000008
153

Node point 680.

Temperature : 610°F.

Material = Carbon Steel.



$\Delta_Y = \frac{4.703}{100} \times 50 = 2.352''$ ↑

$\Delta_{radial} = \frac{4.703}{100} \times 18.25$

$= .858''$

$\Delta_x = .858 \cos 48° = .574''$

$\Delta_z = .858 \sin 48° = .638''$

Calculation of Allowable Stress.

SS 304. At 1100° F.

$S_c = 18.7$ ksi

$S_h = 7.7$ ksi.

$S_A = f\,(1.25 S_c + .25 S_h)$ (1) of 102.3.2 ANSI B31.1

$f = 1$ since no. of cycles < 7000

$S_A = 1\,(1.25 \times 18.7 + .25 \times 7.7)$

$= 25.3$ ksi.

SA 53 GR.B Carbon Steel

$S_c = 15.0$ ksi.

S_h @ 650°F = 15 ksi

$S_A = (1.25 + .25)\,15 = 22.5$ ksi.

Lines 0033-10-HBDA AND 0095-4-HBDA (Nodes 460 thru 680 are carbon steel, Rest are SS304.

```
*************************************************************************************************************
*  JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG JESMSG  *
*************************************************************************************************************

 IAT6140 JOB ORIGIN FROM GROUP=RM206    , DSP=IJP, DEVICE=INTRDR  , 000
 16:45:08 IAT4401  LOCATE FOR STEP=         DD=SYSUT1   DSN=$WW232.N1.DATA
 16:45:08 IAT4402 UNIT=3350    ,VOL(S)=AVTSOA
 16:45:08 IAT4401  LOCATE FOR STEP=         DD=SYSUT1   DSN=$WW232.N2.DATA
 16:45:08 IAT4402 UNIT=3350    ,VOL(S)=AVTSOA
 16:45:11 USES     AVTSOA           D $WW232.N1.DATA
 16:45:13 IAT5200 JOB 0277 ($WW232P3) IN SETUP ON MAIN=L       P=09 LOCAL
 16:45:13 IAT5210 J=0277 SYSUT1   USING D AVTSOA ON 520   $WW232.N1.DATA
 16:45:27 IAT2000 JOB 0277 $WW232P3 SELECTED C        GRP=JS3BATCH
 16:45:28 C R= $WW232P3 NEF995I $WW232P3 STARTED, 4/05/83,16.43.21 ASID=00039
 16:45:28 C R= $WW232P3 IEF403I $WW232P3 - STARTED - TIME=16.43.21
 16:45:33 C R= $WW232P3 IEF404I $WW232P3 - ENDED - TIME=16.43.27
 16:45:33 C R= $WW232P3 NEF996I $WW232P3 ENDED,  4/05/83,B.U.=      .0489 *0716935   ,3081-C3,JOB CC= 000
 16:45:34 IAT5400 JOB 0277 ($WW232P3) IN BREAKDOWN
```

```
******************************************************************************************************
*  JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL JESJCL  *
******************************************************************************************************

//$WW232P3 JOB 'GURSAHANI LB30731160*0716935              4444449    ', *00000100
// TIME=(02,00),REGION=1500K,NOTIFY=$WW232,MSGCLASS=A,MSGLEVEL=1         00000200
//*MAIN ORG=RM005                                                         00000300
//*  THIS IS DATASET $WW232.PRINT.EDIT.CNTL                               00000400
//* THESE THREE ARE FOR XEROX OUTPUT                                      00000500
//*FORMAT PR,DDNAME=SYSMSG,DEST=RM271PR3,FCB=JB10,COPIES=1                00000600
//*FORMAT PR,DDNAME=SYSPRINT,DEST=RM271PR3,FCB=JB10,COPIES=1              00000700
//*FORMAT PR,DDNAME=SYSUT2,DEST=RM271PR3,FCB=JB10,COPIES=1                00000800
//* THESE THREE ARE FOR NORMAL OUTPUT                                     00000900
//* //*FORMAT PR,DDNAME=SYSMSG,DEST=RM005,COPIES=1                        00001000
//* //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM005,COPIES=1                      00001100
//* //*FORMAT PR,DDNAME=SYSUT2,DEST=RM005,COPIES=1                        00001200
//* THESE THREE ARE FOR MICROFICHE OUTPUT                                 00001300
//* //*FORMAT PR,DDNAME=SYSMSG,DEST=RM001PR5,FORMS=FICHE,COPIES=1         00001400
//* //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM001PR5,FORMS=FICHE,COPIES=1       00001500
//* //*FORMAT PR,DDNAME=SYSUT2,DEST=RM001PR5,FORMS=FICHE,COPIES=1         00001600
// EXEC PGM=IEBGENER                                                      00001700
//SYSPRINT DD SYSOUT=A                                                    00001800
//SYSIN DD DUMMY                                                          00001900
//SYSUT1 DD DSN=$WW232.N1.DATA,DISP=SHR                                   00002000
//       DD DSN=$WW232.N2.DATA,DISP=SHR                                   00002100
//SYSUT2 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330)               00002200
   1      //$WW232P3 JOB 'GURSAHANI LB30731160*0716935              4444449    ', *00000100
          // TIME=(02,00),REGION=1500K,NOTIFY=$WW232,MSGCLASS=A,MSGLEVEL=1         00000200
          ***  THIS IS DATASET $WW232.PRINT.EDIT.CNTL                              00000400
          *** THESE THREE ARE FOR XEROX OUTPUT                                     00000500
          *** THESE THREE ARE FOR NORMAL OUTPUT                                    00000900
          *** //*FORMAT PR,DDNAME=SYSMSG,DEST=RM005,COPIES=1                       00001000
          *** //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM005,COPIES=1                     00001100
          *** //*FORMAT PR,DDNAME=SYSUT2,DEST=RM005,COPIES=1                       00001200
          *** THESE THREE ARE FOR MICROFICHE OUTPUT                                00001300
          *** //*FORMAT PR,DDNAME=SYSMSG,DEST=RM001PR5,FORMS=FICHE,COPIES=1        00001400
          *** //*FORMAT PR,DDNAME=SYSPRINT,DEST=RM001PR5,FORMS=FICHE,COPIES=1      00001500
          *** //*FORMAT PR,DDNAME=SYSUT2,DEST=RM001PR5,FORMS=FICHE,COPIES=1        00001600
   2      // EXEC PGM=IEBGENER                                                     00001700
   3      //SYSPRINT DD SYSOUT=A                                                   00001800
   4      //SYSIN DD DUMMY                                                         00001900
   5      //SYSUT1 DD DSN=$WW232.N1.DATA,DISP=SHR                                  00002000
   6      //       DD DSN=$WW232.N2.DATA,DISP=SHR                                  00002100
   7      //SYSUT2 DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=1330)              00002200
```

079T1000008
156

```
IAT6140 JOB ORIGIN FROM GROUP=RM206    , DSP=IJP, DEVICE=INTRDR  , 000
14:05:51 IAT4401  LOCATE FOR STEP=A         DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
14:05:51 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
14:05:51 IAT4401  LOCATE FOR STEP=G         DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
14:05:51 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
14:05:51 IAT4401  LOCATE FOR STEP=G         DD=FT15F001 DSN=$WW232.CARRIZO.SGPUMP.DISCHARG.DATA
14:05:51 IAT4402 UNIT=3350     ,VOL(S)=AVTSOA
14:05:51 IAT4401  LOCATE FOR STEP=G         DD=FT69F001 DSN=$WW049.ROCKPIPE.USERS
14:05:51 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
14:05:51 IAT4401  LOCATE FOR STEP=ELTEMP    DD=STEPLIB  DSN=$WW049.ELTEMP.LOAD
14:05:51 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
14:05:52 USES     CVTSOK           D $WW049.NUPIPE.LOAD
14:05:52 USES     AVTSOA           D $WW232.CARRIZO.SGPUMP.DISCHARG.DATA
14:05:52 IAT5200 JOB 2372 ($WW232B1) IN SETUP ON MAIN=C        P=03 LOCAL
14:05:52 IAT5210 J=2372 STEPLIB  USING D CVTSOK ON 528   $WW049.NUPIPE.LOAD
14:05:52 IAT5210 J=2372 FT15F001 USING D AVTSOA ON 520   $WW232.CARRIZO.SGPUMP.DISCHARG.DATA
14:05:56 IAT2000 JOB 2372 $WW232B1 SELECTED I        GRP=BIG
14:05:57 I R= $WW232B1 NEF995I $WW232B1 STARTED, 3/30/83,14.03.22 ASID=00050
14:05:57 I R= $WW232B1 IEF403I $WW232B1 - STARTED - TIME=14.03.22
14:07:17 I R= $WW232B1 +IH0002I STOP       1
14:07:18 I R= $WW232B1 IEF404I $WW232B1 - ENDED - TIME=14.04.42
14:07:18 I R= $WW232B1 NEF996I $WW232B1 ENDED,  3/30/83,B.U.=      4.3540 *0716935    ,3081-I3,JOB CC= 001
14:07:19 IAT5400 JOB 2372 ($WW232B1) IN BREAKDOWN
/$WW232B1 JOB 'GURSAHANI LB30130340*0716935         005  5001003037', *
/ REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
/*MAIN ORG=RM005                                                    00000300
/ EXEC ROCKPIPE,PROG=SMALL
/G.SYSIN DD DSN=$WW232.CARRIZO.SGPUMP.DISCHARG.DATA,DISP=SHR
   1      //$WW232B1 JOB 'GURSAHANI LB30130340*0716935         005  5001003037', *
          // REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
   2      // EXEC ROCKPIPE,PROG=SMALL
   3      XXROCKPIPE PROC DSN='$WW049.NUPIPE.LOAD',PROG=SMALL,C=10,
          XX PROGA=SEVEN,B=19069,PROGE=OPT2,DSNE='$WW049.ELTEMP.LOAD',
          XX USERS='$WW049.ROCKPIPE.USERS'
```

079TI000008
157

FORM 126-P-130 NEW 7-82

```
O R I G I N A L   I N P U T   B Y   GURSAHANI    O N  03/30/83  A T    14:03:28  W I T H  P R I O R I T Y  3
STEAM GENERATOR PUMP DISCHARGE AND CONNECTED PIPING                                              1
CONTROL                    2.0                                                                   2
FLEXAN         1     1     2.0                                                                   3
   NORMAL OPERATING WITH BOTH PUMPS ON                                                           4
FLEXAN         2     2     2.0                                                                   5
   PUMP 2B DOWN LINE AT AMBIENT                                                                  6
FLEXAN         3     3     2.0                                                                   7
   HOT DRAIN THRU BOTH LOOPS                                                                     8
FLEXAN         4     4     2.0                                                                   9
   HOT DRAIN THRU ONE LOOP V-022B CLOSED                                                        10
FLEXAN         5     5     2.0                                                                  11
   HOT DRAIN THRU ONE LOOP V-022A CLOSED                                                        12
FLEXAN         6     6     2.0                                                                  13
   STARTING VALVE FCV040 AND FCV 018 OPEN                                                       14
FLEXAN         7     7     2.0                                                                  15
   NORMAL OPERATING WITH BOTH PUMPS ON , EMERGENCY OUTLET LINES AT 650F                          16
XSECTN               1     12.75      .375      93.7      28.3       67.0                       17
XSECTN               2     10.75      .365     101.9      28.3       67.0                       18
XSECTN               3     10.75      .365      71.2      28.3       67.0                       19
XSECTN               4      8.625     .322      48.1      28.3       67.0                       20
XSECTN               5      4.5       .237      15.7      28.3       67.0                       21
OPVAL          1     1    21.8       .1284                           67.0                       22
OPVAL          1     2    21.8       .1284                           67.0                       23
OPVAL          1     3    21.8       .1284                           67.0                       24
OPVAL          1     4    21.8       .1284                           67.0                       25
OPVAL          1     5    21.8       .1284                           67.0                       26
OPVAL          1     6    26.6       .0380                           67.0                       27
OPVAL          1     7    26.6       .0380                           67.0                       28
OPVAL          1     8    26.6       .0380                           67.0                       29
OPVAL          1     9    25.25      .05115                          67.0                       30
OPVAL          1    10    25.25      .05115                          67.0                       31
OPVAL          1    11    25.25      .05115                          67.0                       32
OPVAL          1    12    25.25      .05115                          67.0                       33
OPVAL          1    13    27.0       .0270                           67.0                       34
OPVAL          2     1    21.8       .1284                           67.0                       35
OPVAL          2     2    21.8       .1284                           67.0                       36
OPVAL          2     3    28.3                                       67.0                       37
OPVAL          2     4    28.3                                       67.0                       38
OPVAL          2     5    21.8       .1284                           67.0                       39
OPVAL          2     6    26.6       .0380                           67.0                       40
OPVAL          2     7    26.6       .0380                           67.0                       41
OPVAL          2     8    26.6       .0380                           67.0                       42
OPVAL          2     9    25.25      .05115                          67.0                       43
OPVAL          2    10    25.25      .05115                          67.0                       44
OPVAL          2    11    25.25      .05115                          67.0                       45
OPVAL          2    12    25.25      .05115                          67.0                       46
OPVAL          2    13    27.0       .0270                           67.0                       47
OPVAL          3     1    21.8       .1284                           67.0                       48
OPVAL          3     2    26.6       .0380                           67.0                       49
OPVAL          3     3    26.6       .0380                           67.0                       50
OPVAL          3     4    21.8       .1284                           67.0                       51
OPVAL          3     5    26.6       .0380                           67.0                       52
OPVAL          3     6    21.8       .1284                           67.0                       53
OPVAL          3     7    21.8       .1284                           67.0                       54
OPVAL          3     8    21.8       .1284                           67.0                       55
OPVAL          3     9    23.4       .1004                           67.0                       56
OPVAL          3    10    25.25      .05115                          67.0                       57
OPVAL          3    11    25.25      .05115                                                     58
OPVAL          3    12    25.25      .05115                                                     59
```

FORM EW 7-82

OPVAL	3	13	27.0	.0270			67.0	60
OPVAL	4	1	21.8	.1284			67.0	61
OPVAL	4	2	26.6	.0380			67.0	62
OPVAL	4	3	26.6	.0380			67.0	63
OPVAL	4	4	26.6	.0380			67.0	64
OPVAL	4	5	26.6	.0380			67.0	65
OPVAL	4	6	21.8	.1284			67.0	66
OPVAL	4	7	26.6	.0380			67.0	67
OPVAL	4	8	21.8	.1284			67.0	68
OPVAL	4	9	23.4	.1004			67.0	69
OPVAL	4	10	25.25	.05115			67.0	70
OPVAL	4	11	25.25	.05115			67.0	71
OPVAL	4	12	25.25	.05115			67.0	72
OPVAL	4	13	27.0	.0270			67.0	73
OPVAL	5	1	26.6	.0380			67.0	74
OPVAL	5	2	26.6	.0380			67.0	75
OPVAL	5	3	26.6	.0380			67.0	76
OPVAL	5	4	21.8	.1284			67.0	77
OPVAL	5	5	26.6	.0380			67.0	78
OPVAL	5	6	26.6	.0380			67.0	79
OPVAL	5	7	21.8	.1284			67.0	80
OPVAL	5	8	21.8	.1284			67.0	81
OPVAL	5	9	23.4	.1004			67.0	82
OPVAL	5	10	25.25	.05115			67.0	83
OPVAL	5	11	25.25	.05115			67.0	84
OPVAL	5	12	25.25	.05115			67.0	85
OPVAL	5	13	27.0	.0270			67.0	86
OPVAL	6	1	21.8	.1284			67.0	87
OPVAL	6	2	21.8	.1284			67.0	88
OPVAL	6	3	21.8	.1284			67.0	89
OPVAL	6	4	21.8	.1284			67.0	90
OPVAL	6	5	21.8	.1284			67.0	91
OPVAL	6	6	26.6	.0380			67.0	92
OPVAL	6	7	26.6	.0380			67.0	93
OPVAL	6	8	26.6	.0380			67.0	94
OPVAL	6	9	25.25	.05115			67.0	95
OPVAL	6	10	25.25	.05115			67.0	96
OPVAL	6	11	25.25	.05115			67.0	97
OPVAL	6	12	25.25	.05115			67.0	98
OPVAL	6	13	25.25	.05115			67.0	99
OPVAL	7	1	21.8	.1284			67.0	100
OPVAL	7	2	21.8	.1284			67.0	101
OPVAL	7	3	21.8	.1284			67.0	102
OPVAL	7	4	21.8	.1284			67.0	103
OPVAL	7	5	21.8	.1284			67.0	104
OPVAL	7	6	25.15	.0687			67.0	105
OPVAL	7	7	25.15	.0687			67.0	106
OPVAL	7	8	25.15	.0687			67.0	107
OPVAL	7	9	25.25	.05115			67.0	108
OPVAL	7	10	25.25	.05115			67.0	109
OPVAL	7	11	25.25	.05115			67.0	110
OPVAL	7	12	25.25	.05115			67.0	111
OPVAL	7	13	27.0	.0270			67.0	112
ANCHOR		5	-1.833	993.042	0.0			113
STDISPL	1	5	-.28	-1.66				114
STDISPL	2	5	-.28	-1.66				115
STDISPL	3	5	-.28	-1.66				116
STDISPL	4	5	-.28	-1.66				117
STDISPL	5	5						118
STDISPL	6	5	-.28	-1.66				119
STDISPL	7	5	-.28	-1.66				120
RUN	5	10	-2.167			2.0	1.0	121

FORM 126-P-130 NEW 7-82

079TI000008
159

ELBOW	-	10	15						122
RUN		15	18		12.609				123
RUN		18	20		12.609				124
ELBOW	-	20	25						125
RUN		25	30			-1.958			126
TEE		30	170						127
RUN		30	35			-0.708		2.0	128
RUN		35	40			-1.834			129
VALVE		40	45			-1.0			130
VALVE		45	50			-1.0			131
RUN		50	55			-4.5			132
ELBOW	-	55	60						133
RUN		60	65	4.5					134
ELBOW	-	65	70						135
RUN		70	75			5.0			136
ELBOW	-	75	80						137
RUN		80	85	3.0					138
TEE		85	295						139
RUN		85	90	3.0				3.0	140
ELBOW	-	90	95						141
RUN		95	100			-5.0			142
ELBOW	-	100	105						143
RUN		105	110	4.5					144
ELBOW	-	110	115						145
RUN		115	120			4.5			146
VALVE		120	125			1.0			147
VALVE		125	130			1.0			148
RUN		130	135			1.834			149
RUN		135	140			0.708			150
TEE		140	290						151
RUN		140	145			1.958		4.0	152
ELBOW	-	145	150						153
RUN		150	153		-12.609				154
RUN		153	155		-12.609				155
ELBOW	-	155	160						156
RUN		160	165	-2.167					157
ANCHOR			165	8.833	993.042				158
STDISPL		1	165	.28	-1.66				159
STDISPL		2	165						160
STDISPL		3	165	.28	-1.66				161
STDISPL		4	165						162
STDISPL		5	165	.28	-1.66				163
STDISPL		6	165	.28	-1.66				164
STDISPL		7	165	.28	-1.66				165
RUN		30	170	-.667			4.0	6.0	166
RUN		170	175	-3.333					167
ELBOW	-	175	180						168
RUN		180	185			-6.0			169
VALVE		185	190			-1.0			170
VALVE		190	195			-1.0			171
RUN		195	200			-11.0			172
ELBOW	-	200	205						173
RUN		205	210	7.25					174
RUN		210	215	7.25					175
ELBOW	-	215	220						176
RUN		220	225		5.156				177
RUN		225	230		.583				178
TEE		230	240						179
RUN		230	240	.583				7.0	180
RUN		240	245	9.417					181
ELBOW		245	250						182
RUN		250	255			11.0			183

FORM 126 7-83

VALVE	255	260			1.0			184
VALVE	260	265			1.0			185
RUN	265	270			6.0			186
ELBOW	- 270	275						187
RUN	275	280		-5.739				188
ELBOW	- 280	285						189
RUN	285	290	-4.833					190
RUN	290	140	-.667					191
RUN	85	295			-.708	2.0	5.0	192
RUN	295	300			-8.292			193
ELBOW	- 300	305						194
RUN	305	310	9.75					195
ELBOW	- 310	315						196
RUN	315	320		17.913				197
RUN	320	325		17.913				198
RUN	325	330		17.913				199
ELBOW	- 330	335						200
RUN	335	340			7.0			201
RUN	340	345			7.333			202
ELBOW	- 345	350						203
RUN	350	355	5.75					204
ELBOW	- 355	360						205
RUN	360	365		-17.913				206
RUN	365	370		-17.913				207
RUN	370	375		-17.913				208
ELBOW	- 375	380						209
RUN	380	390			-6.0			210
ANCHOR		390	19.0	1018.260	-6.667			211
RUN	230	235		.583		4.0	8.0	212
RUN	235	395		5.417				213
ELBOW	- 395	400						214
RUN	400	405			-6.25			215
RUN	405	410			-6.25			216
ELBOW	- 410	415						217
RUN	415	420	9.0					218
RUN	420	425	9.0					219
ELBOW	- 425	430						220
RUN	430	435			-12.0			221
RUN	435	440			-11.542			222
VALVE	440	445			-1.5			223
VALVE	445	450			-1.5			224
RUN	450	455			-5.333			225
RUN	455	460			-.667			226
TEE	460	455						227
RUN	460	615		.708		3.0	9.0	228
RUN	615	620		20.292				229
RUN	620	625		21.0				230
ELBOW	- 625	630						231
RUN	630	635			-8.0			232
RUN	635	640			-8.0			233
ELBOW	- 640	645						234
RUN	645	650	-9.0					235
ELBOW	- 650	655						236
RUN	655	660			-7.0			237
RUN	660	665			-7.0			238
ELBOW	- 665	670						239
RUN	670	675		-11.0				240
RUN	675	680		-11.0				241
ANCHOR		680	15.5	1050.0	-96.0			242
STDISPL	1	680	.574	2.352	.638			243
STDISPL	2	680	.574	2.352	.638			244
STDISPL	3	680	.574	2.352	.638			245

STDISPL	4	680	.574		2.352		.638								246
STDISPL	5	680	.574		2.352		.638								247
STDISPL	6	680	.574		2.352		.638								248
STDISPL	7	680	.574		2.352		.638								249
RUN	460	465			-.708						10.0				250
RUN	465	470			-.584										251
RUN	470	475			-.708										252
RUN	475	480			-.708										253
RUN	480	485			-12.292										254
RUN	485	490			-3.365						11.0				255
ELBOW	- 490	495													256
RUN	495	500	-3.916												257
REDUCER	500	505	-.667												258
VALVE	505	510	-1.25						1.0						259
VALVE	510	515	-1.25												260
REDUCER	515	520	-1.917						3.0						261
ELBOW	- 520	525													262
RUN	525	530					4.5								263
RUN	530	535					2.25				12.0				264
VALVE	535	540					3.0								265
VALVE	540	545					3.0								266
RUN	545	550					2.25								267
ANCHOR		550	15.5		1011.635		-51.0								268
BRANCH	485	555	-2.0						5.0		13.0				269
ELBOW	- 555	560													270
RUN	560	565					2.0								271
VALVE	565	570					0.5								272
VALVE	570	575					0.5								273
RUN	575	580					1.5								274
ELBOW	- 580	585													275
RUN	585	590	-2.0												276
VALVE	590	595	-1.5												277
VALVE	595	600	-1.5												278
RUN	600	605	-2.0												279
ELBOW	- 605	610													280
RUN	610	530			-3.365										281
STRESS7															282
10CASES	1	2	6	7											283
ALLDONE															284
REPORT															285
IEDIT															286
OEDIT	1														287
B1NODES	40	50	120	130	185	195	255	265	440	450	500	520	565	575	288
B1THERMLC	-1														289
ALLDONE															290

079T000008
162

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	5	1.000	493.	493.	3047.	3540.
	10	1.000	493.	493.	2979.	3473.
ELBOW	10	2.606	493.	493.	7765.	8259.
	15	2.606	493.	493.	7014.	7507.
RUN	15	1.000	493.	493.	2691.	3184.
	18	1.000	493.	493.	1455.	1948.
RUN	18	1.000	493.	493.	1455.	1948.
	20	1.000	493.	493.	2711.	3204.
ELBOW	20	2.606	493.	493.	7066.	7560.
	25	2.606	493.	493.	6786.	7279.
RUN	25	1.000	493.	493.	2603.	3097.
	30	1.969	493.	493.	4785.	5278.
RUN	30	1.969	493.	493.	4860.	5353.
	35	1.000	493.	493.	2331.	2824.
RUN	35	1.000	493.	493.	2331.	2824.
	40	1.000	493.	493.	2069.	2562.
RUN	50	1.000	493.	493.	1986.	2479.
	55	1.000	493.	493.	2336.	2829.
ELBOW	55	2.606	493.	493.	6088.	6581.
	60	2.606	493.	493.	5867.	6360.
RUN	60	1.000	493.	493.	2251.	2744.
	65	1.000	493.	493.	1811.	2304.
ELBOW	65	2.606	493.	493.	4720.	5214.
	70	2.606	493.	493.	3191.	3684.
RUN	70	1.000	493.	493.	1224.	1718.
	75	1.000	493.	493.	577.	1071.
ELBOW	75	2.606	493.	493.	1505.	1998.
	80	2.606	493.	493.	1483.	1976.

079TI000008
163

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	80	1.000	493.	493.	569.	1062.
	85	1.969	493.	493.	2091.	2584.
RUN	85	1.969	493.	493.	2226.	2719.
	90	1.000	493.	493.	775.	1268.
ELBOW	90	2.606	493.	493.	2019.	2512.
	95	2.606	493.	493.	1748.	2241.
RUN	95	1.000	493.	493.	670.	1164.
	100	1.000	493.	493.	1290.	1783.
ELBOW	100	2.606	493.	493.	3361.	3855.
	105	2.606	493.	493.	4716.	5210.
RUN	105	1.000	493.	493.	1809.	2303.
	110	1.000	493.	493.	2126.	2619.
ELBOW	110	2.606	493.	493.	5541.	6034.
	115	2.606	493.	493.	5458.	5951.
RUN	115	1.000	493.	493.	2094.	2587.
	120	1.000	493.	493.	1596.	2089.
RUN	130	1.000	493.	493.	1638.	2132.
	135	1.000	493.	493.	1916.	2409.
RUN	135	1.000	493.	493.	1916.	2409.
	140	1.969	493.	493.	4092.	4585.
RUN	140	1.969	493.	493.	4018.	4511.
	145	1.000	493.	493.	2217.	2710.
ELBOW	145	2.606	493.	493.	5778.	6271.
	150	2.606	493.	493.	6302.	6795.
RUN	150	1.000	493.	493.	2418.	2911.
	153	1.000	493.	493.	1362.	1855.
RUN	153	1.000	493.	493.	1362.	1855.
	155	1.000	493.	493.	2461.	2955.

079T1000008
164

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
ELBOW	155	2.606	493.	493.	6416.	6909.
	160	2.606	493.	493.	6784.	7278.
RUN	160	1.000	493.	493.	2603.	3096.
	165	1.000	493.	493.	2601.	3094.
RUN	30	1.969	449.	449.	2452.	2900.
	170	1.000	449.	449.	1392.	1841.
RUN	170	1.000	449.	449.	1392.	1841.
	175	1.000	449.	449.	1326.	1775.
ELBOW	175	2.440	449.	449.	3235.	3684.
	180	2.440	449.	449.	3018.	3467.
RUN	180	1.000	449.	449.	1237.	1686.
	185	1.000	449.	449.	913.	1362.
RUN	195	1.000	449.	449.	866.	1314.
	200	1.000	449.	449.	1171.	1619.
ELBOW	200	2.440	449.	449.	2856.	3305.
	205	2.440	449.	449.	2692.	3141.
RUN	205	1.000	449.	449.	1104.	1552.
	210	1.000	449.	449.	994.	1443.
RUN	210	1.000	449.	449.	994.	1443.
	215	1.000	449.	449.	1390.	1838.
ELBOW	215	2.440	449.	449.	3390.	3839.
	220	2.440	449.	449.	3626.	4075.
RUN	220	1.000	449.	449.	1486.	1935.
	225	1.000	449.	449.	1431.	1880.
RUN	225	1.000	449.	449.	1431.	1880.
	230	1.844	449.	449.	2672.	3121.
RUN	230	1.844	449.	449.	6256.	6705.
	240	1.000	449.	449.	3235.	3683.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	240	1.000	449.	449.	3235.	3683.
	245	1.000	449.	449.	1213.	1661.
ELBOW	245	2.440	449.	449.	2959.	3407.
	250	2.440	449.	449.	2239.	2687.
RUN	250	1.000	449.	449.	918.	1366.
	255	1.000	449.	449.	866.	1315.
RUN	265	1.000	449.	449.	1139.	1588.
	270	1.000	449.	449.	1843.	2291.
ELBOW	270	2.440	449.	449.	4496.	4945.
	275	2.440	449.	449.	4574.	5023.
RUN	275	1.000	449.	449.	1875.	2323.
	280	1.000	449.	449.	1854.	2302.
ELBOW	280	2.440	449.	449.	4523.	4972.
	285	2.440	449.	449.	4137.	4586.
RUN	285	1.000	449.	449.	1696.	2144.
	290	1.000	449.	449.	1016.	1464.
RUN	290	1.000	449.	449.	1016.	1464.
	140	1.969	449.	449.	1578.	2027.
RUN	85	1.969	493.	493.	4492.	4985.
	295	1.000	493.	493.	2273.	2766.
RUN	295	1.000	493.	493.	2273.	2766.
	300	1.000	493.	493.	2371.	2864.
ELBOW	300	2.606	493.	493.	6179.	6672.
	305	2.606	493.	493.	5938.	6432.
RUN	305	1.000	493.	493.	2278.	2772.
	310	1.000	493.	493.	1559.	2053.
ELBOW	310	2.606	493.	493.	4064.	4557.
	315	2.606	493.	493.	3869.	4362.

079T000008
166

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	315	1.000	493.	493.	1484.	1978.
	320	1.000	493.	493.	1123.	1616.
RUN	320	1.000	493.	493.	1123.	1616.
	325	1.000	493.	493.	1164.	1658.
RUN	325	1.000	493.	493.	1164.	1658.
	330	1.000	493.	493.	1535.	2028.
ELBOW	330	2.606	493.	493.	4001.	4494.
	335	2.606	493.	493.	3669.	4162.
RUN	335	1.000	493.	493.	1408.	1901.
	340	1.000	493.	493.	944.	1437.
RUN	340	1.000	493.	493.	944.	1437.
	345	1.000	493.	493.	1230.	1723.
ELBOW	345	2.606	493.	493.	3205.	3699.
	350	2.606	493.	493.	3253.	3747.
RUN	350	1.000	493.	493.	1248.	1742.
	355	1.000	493.	493.	1093.	1586.
ELBOW	355	2.606	493.	493.	2849.	3342.
	360	2.606	493.	493.	3023.	3516.
RUN	360	1.000	493.	493.	1160.	1653.
	365	1.000	493.	493.	1240.	1734.
RUN	365	1.000	493.	493.	1240.	1734.
	370	1.000	493.	493.	1635.	2129.
RUN	370	1.000	493.	493.	1635.	2129.
	375	1.000	493.	493.	2041.	2535.
ELBOW	375	2.606	493.	493.	5321.	5814.
	380	2.606	493.	493.	5024.	5517.
RUN	380	1.000	493.	493.	1927.	2421.
	390	1.000	493.	493.	1780.	2273.

079T1000008
167

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	230	1.844	449.	449.	3659.	4107.
	235	1.000	449.	449.	1998.	2446.
RUN	235	1.000	449.	449.	1998.	2446.
	395	1.000	449.	449.	2982.	3431.
ELBOW	395	2.440	449.	449.	7276.	7725.
	400	2.440	449.	449.	8111.	8560.
RUN	400	1.000	449.	449.	3324.	3773.
	405	1.000	449.	449.	3458.	3906.
RUN	405	1.000	449.	449.	3458.	3906.
	410	1.000	449.	449.	3857.	4306.
ELBOW	410	2.440	449.	449.	9411.	9859.
	415	2.440	449.	449.	8591.	9039.
RUN	415	1.000	449.	449.	3521.	3970.
	420	1.000	449.	449.	876.	1325.
RUN	420	1.000	449.	449.	876.	1325.
	425	1.000	449.	449.	3857.	4305.
ELBOW	425	2.440	449.	449.	9410.	9858.
	430	2.440	449.	449.	10101.	10550.
RUN	430	1.000	449.	449.	4140.	4589.
	435	1.000	449.	449.	2756.	3205.
RUN	435	1.000	449.	449.	2756.	3205.
	440	1.000	449.	449.	2662.	3111.
RUN	450	1.000	449.	449.	2924.	3372.
	455	1.000	449.	449.	3573.	4022.
RUN	455	1.000	449.	449.	3573.	4022.
	460	1.969	449.	449.	6368.	6817.
RUN	460	1.969	493.	493.	7415.	7908.
	615	1.000	493.	493.	3680.	4174.

0797I000008
168

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	615	1.000	493.	493.	3680.	4174.
	620	1.000	493.	493.	1241.	1734.
RUN	620	1.000	493.	493.	1241.	1734.
	625	1.000	493.	493.	1322.	1816.
ELBOW	625	2.606	493.	493.	3446.	3940.
	630	2.606	493.	493.	3738.	4231.
RUN	630	1.000	493.	493.	1434.	1927.
	635	1.000	493.	493.	1250.	1744.
RUN	635	1.000	493.	493.	1250.	1744.
	640	1.000	493.	493.	1069.	1563.
ELBOW	640	2.606	493.	493.	2787.	3281.
	645	2.606	493.	493.	2588.	3082.
RUN	645	1.000	493.	493.	993.	1486.
	650	1.000	493.	493.	1152.	1646.
ELBOW	650	2.606	493.	493.	3003.	3497.
	655	2.606	493.	493.	3172.	3665.
RUN	655	1.000	493.	493.	1217.	1710.
	660	1.000	493.	493.	1101.	1594.
RUN	660	1.000	493.	493.	1101.	1594.
	665	1.000	493.	493.	998.	1491.
ELBOW	665	2.606	493.	493.	2600.	3093.
	670	2.606	493.	493.	2345.	2839.
RUN	670	1.000	493.	493.	900.	1393.
	675	1.000	493.	493.	1134.	1628.
RUN	675	1.000	493.	493.	1134.	1628.
	680	1.000	493.	493.	2293.	2786.
RUN	460	1.969	493.	493.	3557.	4051.
	465	1.000	493.	493.	1731.	2224.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	465	1.000	493.	493.	1731.	2224.
	470	1.000	493.	493.	1670.	2163.
RUN	470	1.000	493.	493.	1670.	2163.
	475	1.000	493.	493.	1598.	2092.
RUN	475	1.000	493.	493.	1598.	2092.
	480	1.000	493.	493.	1530.	2024.
RUN	480	1.000	493.	493.	1530.	2024.
	485	1.000	493.	493.	1365.	1859.
RUN	485	1.000	493.	493.	1104.	1597.
	490	1.000	493.	493.	817.	1310.
ELBOW	490	2.606	493.	493.	2129.	2622.
	495	2.606	493.	493.	1922.	2416.
RUN	495	1.000	493.	493.	737.	1231.
	500	1.000	493.	493.	719.	1213.
REDUCE	500	2.000	493.	493.	1439.	1932.
	505	2.000	493.	493.	1439.	1932.
REDUCE	515	2.000	493.	493.	1474.	1967.
	520	2.000	493.	493.	1492.	1985.
ELBOW	520	2.606	493.	493.	1944.	2437.
	525	2.606	493.	493.	1963.	2456.
RUN	525	1.000	493.	493.	753.	1246.
	530	1.000	493.	493.	1092.	1585.
RUN	530	1.000	493.	493.	1685.	2178.
	535	1.000	493.	493.	1549.	2042.
RUN	545	1.000	493.	493.	1274.	1767.
	550	1.000	493.	493.	1218.	1711.
BRANCH	485	1.000	318.	318.	3180.	3498.
	555	1.000	318.	318.	4510.	4828.

079TI000008
170

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
ELBOW	555	1.953	318.	318.	8809.	9127.
	560	1.953	318.	318.	7467.	7785.
RUN	560	1.000	318.	318.	3823.	4141.
	565	1.000	318.	318.	754.	1072.
RUN	575	1.000	318.	318.	2406.	2724.
	580	1.000	318.	318.	4762.	5080.
ELBOW	580	1.953	318.	318.	9302.	9620.
	585	1.953	318.	318.	10536.	10854.
RUN	585	1.000	318.	318.	5394.	5712.
	590	1.000	318.	318.	3746.	4065.
RUN	600	1.000	318.	318.	1593.	1911.
	605	1.000	318.	318.	2471.	2789.
ELBOW	605	1.953	318.	318.	4826.	5144.
	610	1.953	318.	318.	4165.	4483.
RUN	610	1.000	318.	318.	2132.	2450.
	530	1.000	318.	318.	6892.	7210.

REPORT

079T1000008
171

APPENDIX 6.3

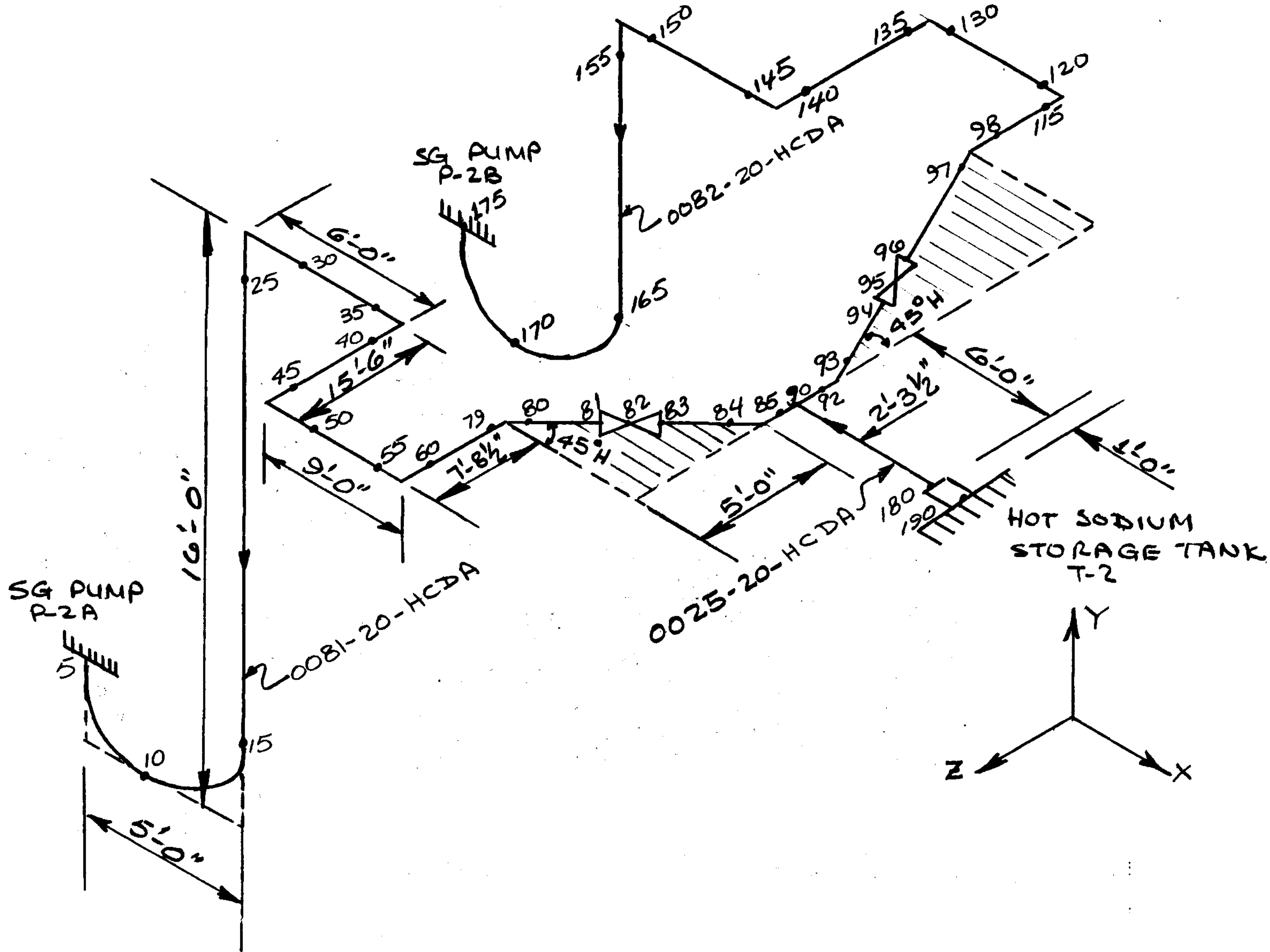
INPUT AND OUTPUT DATA FOR SG PUMP SUCTION PIPING

Rockwell International
Energy Systems Group

PAGE NO. 173 OF
REPORT NO. 079TI000008
MODEL NO.

CARRIZO PLAINS UNIT 1

PREPARED BY: KC
CHECKED BY:
DATE: 4-4-83



S.G. PUMP SUCTION

FIGURE 4

N 152-R-2 REV. 8-78

PREPARED BY: KCG	Rockwell International Energy Systems Group	PAGE NO. 174 OF
CHECKED BY:		REPORT NO. 079TI000008
DATE: 4/5/83		MODEL NO.

TABLE B-1

INPUT DATA

SYSTEM	SG Pump Suction	REFERENCE		
		NO.	REV.	PAGE
Line Number	0081-20-HCDA 0082-20-HCDA 0025-20-HCDA			
Design Temperature	1100°F			
Design Pressure	65 psi			
Normal Operating Temperature	1055°F			
Normal Operating Pressure	65 psi			
Pipe O.D. /schedule	20" /Sch. 20			
Pipe Thickness ×	0.375"			
Pipe Material	SS 304			
Insulation Type	–			
Weight of Pipe Lbs/Ft	78.6			
Weight of contents Lbs/ft	.9 ×126 = 113.4			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(32^2 - 20^2) \times \frac{14}{144} = 47.6$			
Total Weight × Lbs/ft	239.6			
E_c ×	28.3×10^6 psi			
Seismic Category	III			

N 152-R-2 REV. 8-78

```
IAT6140 JOB ORIGIN FROM GROUP=RM206    , DSP=IJP, DEVICE=INTRDR   , 000
11:16:47 IAT4401  LOCATE FOR STEP=A        DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
11:16:47 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
11:16:47 IAT4401  LOCATE FOR STEP=G        DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
11:16:47 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
11:16:47 IAT4401  LOCATE FOR STEP=G        DD=FT15F001 DSN=$WW232.CARRIZO.SUCTION.DATA
11:16:47 IAT4402 UNIT=3350     ,VOL(S)=AVTSOA
11:16:47 IAT4401  LOCATE FOR STEP=ELTEMP   DD=STEPLIB  DSN=$WW049.ELTEMP.LOAD
11:16:47 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
11:16:48 USES     CVTSOK  01 026492 D $WW049.NUPIPE.LOAD
11:16:48 USES     AVTSOA  01 026492 D $WW232.CARRIZO.SUCTION.DATA
11:16:48 IAT5200 JOB 0931 ($WW232C3) IN SETUP ON MAIN=C       P=07 LOCAL
11:16:48 IAT5210 J=0931 STEPLIB  USING D CVTSOK ON 528    $WW049.NUPIPE.LOAD
11:16:48 IAT5210 J=0931 FT15F001 USING D AVTSOA ON 520    $WW232.CARRIZO.SUCTION.DATA
12:05:08 IAT2000 JOB 0931 $WW232C3 SELECTED I         GRP=BIG
12:05:09 I R= $WW232C3 NEF995I $WW232C3 STARTED, 2/17/83,12.06.23 ASID=00048
12:05:09 I R= $WW232C3 IEF403I $WW232C3 - STARTED - TIME=12.06.23
12:05:55 I R= $WW232C3 +IH0002I STOP       1
12:05:56 I R= $WW232C3 IEF404I $WW232C3 - ENDED - TIME=12.07.10
12:05:56 I R= $WW232C3 NEF996I $WW232C3 ENDED,  2/17/83,B.U.=       .9755 *0716935    ,3081-13,JOB CC= 001
12:05:57 IAT5400 JOB 0931 ($WW232C3) IN BREAKDOWN
/$WW232C3 JOB 'GURSAHANI LB30130340*0716935          005   5001007037', *
/ REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
/*MAIN ORG=RM005                                                00000300
/ EXEC ROCKPIPE,PROG=SMALL
/G.SYSIN DD DSN=$WW232.CARRIZO.SUCTION.DATA,DISP=SHR
    1      //$WW232C3 JOB 'GURSAHANI LB30130340*0716935          005   5001007037', *
           // REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
    2      // EXEC ROCKPIPE,PROG=SMALL
    3      XXROCKPIPE PROC DSN='$WW049.NUPIPE.LOAD',PROG=SMALL,C=10,
           XX PROGA=SEVEN,B=19069,PROGE=OPT2,DSNE='$WW049.ELTEMP.LOAD'
           *** AL HROMJAK ROCKWELL INTERNATIONAL, ESG. COMNET 393-3318
           *** FT50F001 FOR 7-SPECTRA NODE ACCELERATIONS.
           *** IN BOTH STEPS, FT66 CONTAINS DIAGNOSTIC OUTPUT.
           *** FT66F001 IN G STEP CONTAINS TIME SPENT IN MAJOR PROGRAM PHASES.
           *** FT16F001 DUMMIED WHEN P STEP DELETED.
           *** FT17F001, FT18F001, FT19F001, FT20F001 ADDED FOR SNUBBER ITERATIONS
    4      XXA EXEC PGM=&PROGA
           *** THIS STEP READS THE 7 SPECTRA AND TRANSLATES THEM TO A NEW POINT
           ***  NEW SPECTRA WRITTEN  ON FT01F001
    5      XXSTEPLIB DD DSN=&DSN,DISP=SHR
    6      XXFT01F001 DD UNIT=SYSDA,DSN=&&SPEC,SPACE=(TRK,(10),RLSE),DISP=(,PASS),
           XX DCB=(RECFM=F,LRECL=80,BLKSIZE=80)
    7      XXFT05F001 DD DDNAME=SYSIN
    8      XXFT06F001 DD SYSOUT=*
    9      XXFT66F001 DD DUMMY,DCB=(RECFM=VBA,BLKSIZE=2020)
   10      XXG EXEC PGM=&PROG
           *** THIS STEP EXECUTES ROCKPIPE. LOAD CASES, 7-SPECTRA (IF ANY), AND
           *** GEOMETRY ARE READ FROM UNIT FT15'S 3 CONCATANATED DATA SETS. LOAD
           *** CASES TO BE DELETED FROM PRINTING ARE DETECTED AND THE CASE NO.'S
           *** MADE PLUS. ALL 3 FILES FROM FT15 ARE WRITTEN ON FT05 AS ONE FILE TO
           *** BE READ BY NUPIPE.
   11      XXSTEPLIB DD DSN=&DSN,DISP=SHR
   12      XXFT01F001 DD UNIT=SYSDA,DCB=(RECFM=VBS,BLKSIZE=&B),
           XX SPACE=(CYL,(&C,&C))
   13      XXFT02F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
   14      XXFT03F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
   15      XXFT04F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
   16      XXFT05F001 DD UNIT=SYSDA,SPACE=(80,(20000)),
           XX DCB=(RECFM=FB,LRECL=80,BLKSIZE=19040)
   17      XXFT06F001 DD SYSOUT=*
```
FORM 126-P-130 NEW 7-82

079T1000008
175

P R O G R A M   I N P U T   D A T A

CARRIZO SG PUMP SUCTION

CONTROL			2.0	1.0				
FLEXAN	1	1	2.0					
THERMAL AT 1100F								
FLEXAN	2	2	2.0					
THERMAL WITH ONE PUMP DOWN AND LINE AT 400F								
FLEXAN	3	3	2.0					
THERMAL WITH ONE PUMP DOWN AND LINE AT AMBIENT								
XSECTN		1	20.00	0.375	240.0	28.3		65.
XSECTN		2	20.00	0.500	240.0	28.3		65.
OPVAL1100	1	1	22.2	.1284				65.
OPVAL1100	1	2	22.2	.1284				65.
OPVAL1100	1	3	22.2	.1284				65.
OPVAL1100	2	1	22.2	.1284				65.
OPVAL 400	2	2	26.6	.0380				65.
OPVAL1100	2	3	22.2	.1284				65.
OPVAL1100	3	1	22.2	.1284				65.
OPVAL 70	3	2	28.3					65.
OPVAL1100	3	3	22.2	.1284				65.
ANCHOR		5						
DUMMY	5	10		-1.0		1.0	1.0	
ELBOW	5	10				1.0	1.0	
DUMMY	5	10	1.0					
DUMMY	10	15	1.0					
ELBOW	10	15						
DUMMY	10	15		1.0				
RUN	15	20		5.5				
RUN	20	25		8.0				
ELBOW	25	30						
RUN	30	35	6.0					
ELBOW	35	40						
RUN	40	45			15.5			
ELBOW	45	50						
RUN	50	55	9.0					
ELBOW	55	60						
RUN	60	65			-6.708			
RUN	65	70			-1.0			
RUN	70	75			-1.0			
RUN	75	79			-3.0			
ELBOW	79	80						
GRUN	80	81	2.0		-2.0			
VALVE	81	82	0.5		-0.5			
CWEIGHT		82		2000.0				
VALVE	82	83	0.5		-0.5			
GRUN	83	84	2.0		-2.0			
ELBOW	84	85						
GRUN	85	90			-2.292			
TEE	90	180						
RUN	90	180	6.0					3.0
RUN	180	190	1.0			2.0		
ANCHOR		190	32.0	13.5	-3.5			
RUN	90	92			-2.292	1.0		2.0
ELBOW	92	93						
RUN	93	94	-2.0		-2.0			
VALVE	94	95	-0.5		-0.5			
CWEIGHT*		95		2000.0				
VALVE	95	96	-0.5		-0.5			
RUN	96	97	-2.0		-2.0			
ELBOW	97	98						

FORM 126-P-130 NEW 7-82

079TI000008
176

RUN	98	100			-3.0
RUN	100	105			-1.0
RUN	105	110			-1.0
RUN	110	115			-6.708
ELBOW	115	120			
RUN	120	125	-4.5		
RUN	125	130	-4.5		
ELBOW	130	135			
RUN	135	140			15.5
ELBOW	140	145			
RUN	145	150	-6.0		
ELBOW	150	155			
RUN	155	160		-8.0	
RUN	160	165		-8.0	
ELBOW	165	170			
DUMMY	165	170	-1.0		
DUMMY	170	175	-1.0		
ELBOW	170	175			
DUMMY	170	175		1.0	
ANCHOR		175			-7.0
STDISPL	1	5		-1.6548	
STDISPL	1	190	-2.758	0.2758	
STDISPL	1	175		-1.6548	
STDISPL	2	5		-1.6548	
STDISPL	2	190	-2.758	0.2758	
STDISPL	2	175		0.0	
STDISPL	3	5		-1.6548	
STDISPL	3	190	-2.758	0.2758	
STDISPL	3	175		0.0	
STRESS7					
1OCASES	1	2	3		
ALLDONE					

079T000008
177

CARRIZO SG PUMP SUCTION ELAPSED CPU = 2.304 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
ELBOW	5	3.768	867.	867.	9571.	10437.
	10	3.768	867.	867.	16121.	16988.
ELBOW	10	3.768	867.	867.	16121.	16988.
	15	3.768	867.	867.	14038.	14904.
RUN	15	1.000	867.	867.	3725.	4592.
	20	1.000	867.	867.	2018.	2885.
RUN	20	1.000	867.	867.	2018.	2885.
	25	1.000	867.	867.	3282.	4149.
ELBOW	25	3.768	867.	867.	12368.	13234.
	30	3.768	867.	867.	15336.	16203.
RUN	30	1.000	867.	867.	4070.	4936.
	35	1.000	867.	867.	3960.	4826.
ELBOW	35	3.768	867.	867.	14922.	15788.
	40	3.768	867.	867.	10751.	11617.
RUN	40	1.000	867.	867.	2853.	3720.
	45	1.000	867.	867.	5089.	5956.
ELBOW	45	3.768	867.	867.	19177.	20044.
	50	3.768	867.	867.	22303.	23170.
RUN	50	1.000	867.	867.	5918.	6785.
	55	1.000	867.	867.	5340.	6207.
ELBOW	55	3.768	867.	867.	20124.	20990.
	60	3.768	867.	867.	13879.	14746.
RUN	60	1.000	867.	867.	3683.	4550.
	65	1.000	867.	867.	1469.	2336.
RUN	65	1.000	867.	867.	1469.	2336.
	70	1.000	867.	867.	1019.	1886.
RUN	70	1.000	867.	867.	1019.	1886.
	75	1.000	867.	867.	748.	1614.

079TI000008
178

CARRIZO SG PUMP SUCTION ELAPSED CPU = 2.314 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	75	1.000	867.	867.	748.	1614.
	79	1.000	867.	867.	1228.	2095.
ELBOW	79	3.768	867.	867.	4627.	5494.
	80	3.768	867.	867.	8095.	8962.
GRUN	80	1.800	867.	867.	3867.	4733.
	81	1.800	867.	867.	5294.	6161.
GRUN	83	1.800	867.	867.	6470.	7337.
	84	1.800	867.	867.	7992.	8858.
ELBOW	84	3.768	867.	867.	16731.	17598.
	85	3.768	867.	867.	20727.	21594.
GRUN	85	1.800	867.	867.	9901.	10767.
	90	2.956	867.	867.	18300.	19167.
RUN	90	2.956	867.	867.	4861.	5728.
	180	1.000	867.	867.	4186.	5053.
RUN	180	1.000	650.	650.	3180.	3830.
	190	1.000	650.	650.	3507.	4157.
RUN	90	2.956	867.	867.	18300.	19167.
	92	1.000	867.	867.	5500.	6367.
ELBOW	92	3.768	867.	867.	20727.	21594.
	93	3.768	867.	867.	16731.	17598.
RUN	93	1.000	867.	867.	4440.	5306.
	94	1.000	867.	867.	3595.	4461.
RUN	96	1.000	867.	867.	2941.	3808.
	97	1.000	867.	867.	2148.	3015.
ELBOW	97	3.768	867.	867.	8095.	8962.
	98	3.768	867.	867.	4627.	5494.
RUN	98	1.000	867.	867.	1228.	2095.
	100	1.000	867.	867.	732.	1598.

079T000008
179

CARRIZO SG PUMP SUCTION ELAPSED CPU = 2.326 SEC.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	100	1.000	867.	867.	732.	1598.
	105	1.000	867.	867.	980.	1846.
RUN	105	1.000	867.	867.	980.	1846.
	110	1.000	867.	867.	1416.	2282.
RUN	110	1.000	867.	867.	1416.	2282.
	115	1.000	867.	867.	3633.	4499.
ELBOW	115	3.768	867.	867.	13690.	14556.
	120	3.768	867.	867.	20044.	20911.
RUN	120	1.000	867.	867.	5319.	6186.
	125	1.000	867.	867.	5605.	6472.
RUN	125	1.000	867.	867.	5605.	6472.
	130	1.000	867.	867.	5918.	6785.
ELBOW	130	3.768	867.	867.	22303.	23170.
	135	3.768	867.	867.	19177.	20044.
RUN	135	1.000	867.	867.	5089.	5956.
	140	1.000	867.	867.	2853.	3720.
ELBOW	140	3.768	867.	867.	10751.	11617.
	145	3.768	867.	867.	14922.	15788.
RUN	145	1.000	867.	867.	3960.	4826.
	150	1.000	867.	867.	4070.	4936.
ELBOW	150	3.768	867.	867.	15336.	16203.
	155	3.768	867.	867.	12368.	13234.
RUN	155	1.000	867.	867.	3282.	4149.
	160	1.000	867.	867.	2013.	2880.
RUN	160	1.000	867.	867.	2013.	2880.
	165	1.000	867.	867.	3725.	4592.
ELBOW	165	3.768	867.	867.	14038.	14904.
	170	3.768	867.	867.	16121.	16988.

CARRIZO SG PUMP SUCTION ELAPSED CPU = 2.337 SEC.

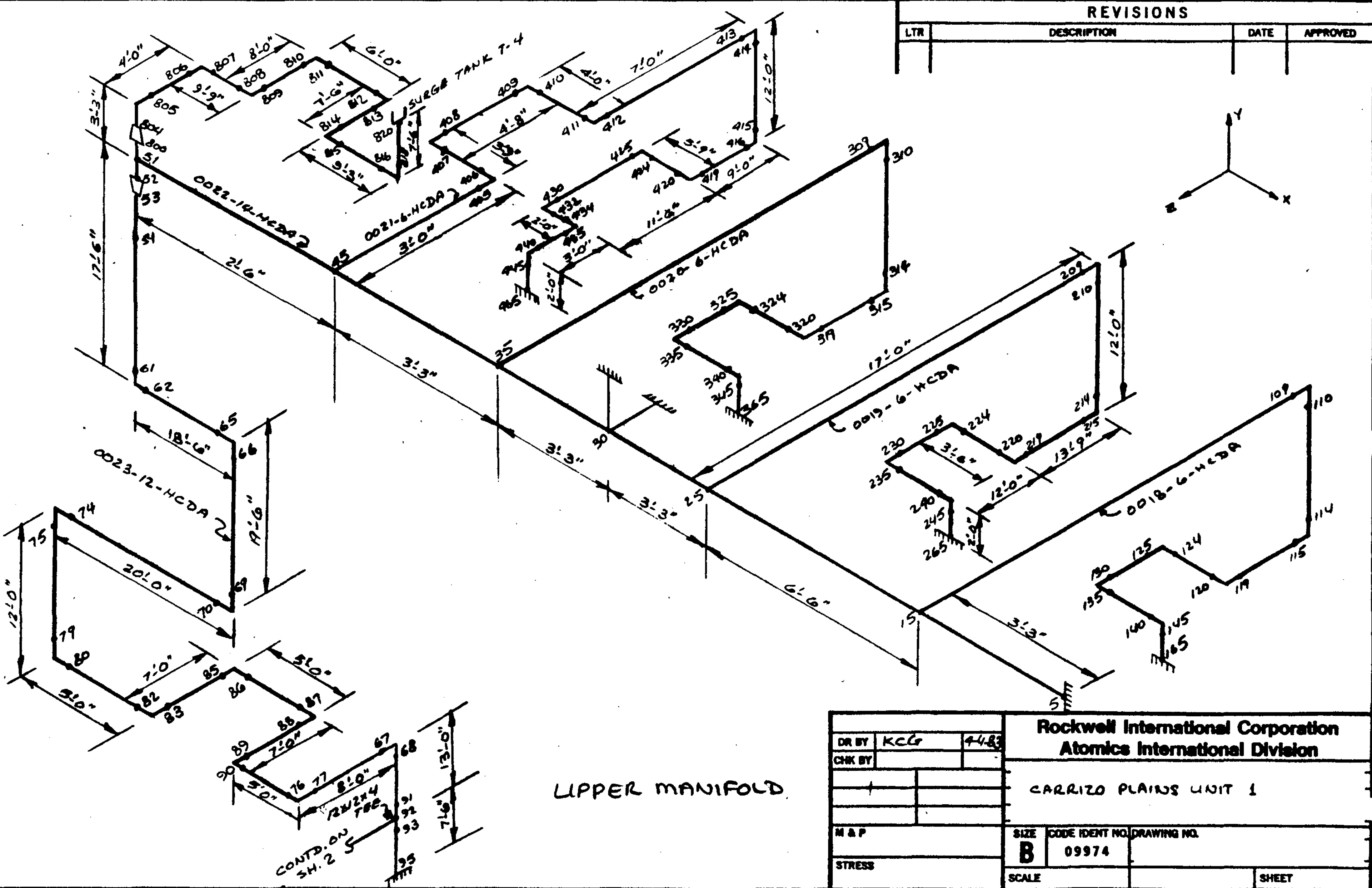
ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
ELBOW	170	3.768	867.	867.	16121.	16988.
	175	3.768	867.	867.	9541.	10407.

079T000008
181

APPENDIX 6.4
INPUT AND OUTPUT DATA FOR NA PIPING TO AND FROM RECEIVER
(LOWER AND UPPER MANIFOLD)

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

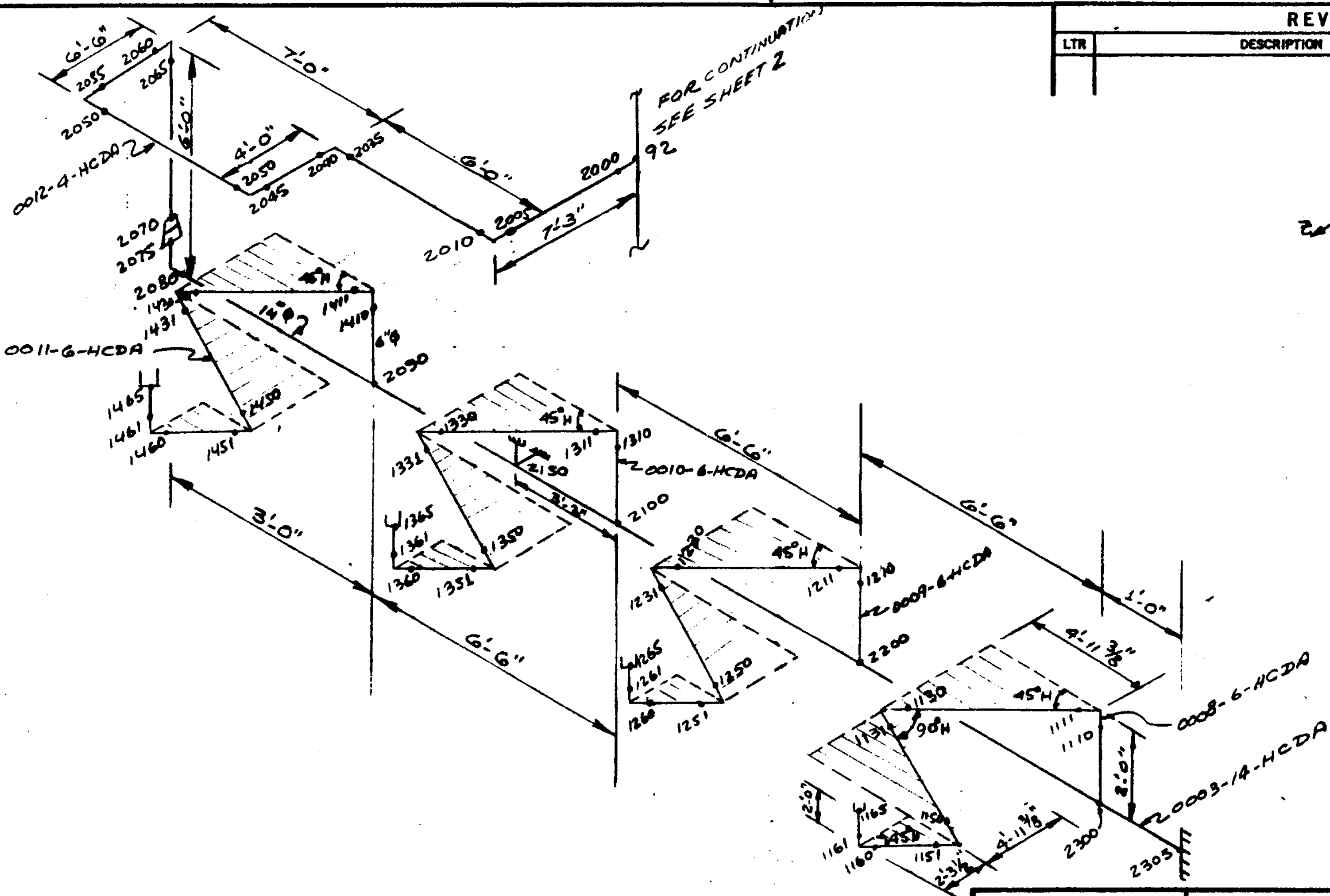


UPPER MANIFOLD

DR BY KCG 4-4-83	Rockwell International Corporation Atomics International Division
CHK BY	
	CARRIZO PLAINS UNIT 1
M & P	SIZE B — CODE IDENT NO. 09974 — DRAWING NO.
STRESS	SCALE — SHEET

LTR	DESCRIPTION	DATE	APPROVED

REVISIONS



LOWER MANIFOLD

DR BY	KCG	3-15-83
CHK BY		
M & P		
STRESS		

Rockwell International Corporation
Atomics International Division

CARRIZO PLAINS - UNIT 1

SIZE	CODE IDENT NO.	DRAWING NO.
B	09974	
SCALE		SHEET 2 of 2

4-76 DIETERICH-POST ISO

FORM 736-V-2 REV. 3-73

0791000008
184-

TABLE B-1
INPUT DATA

SYSTEM	Na Outlet from Receiver	REFERENCE		
		NO.	REV.	PAGE
Line Number	0022-14-HCDA			
Design Temperature	1100°F			
Design Pressure	65 psi			
Normal Operating Temperature	1055°F			
Normal operating Pressure	65 psi			
Pipe O.D./schedule x	14" / std.			
Pipe Thickness x	0.375"			
Pipe Material	SS 304			
Insulation Type	Cal-Silicate 12" thick			
Weight of Pipe Lbs/Ft	55			
weight of contents Lbs/ft	$.9 \times 59.7 = 53.7$			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(38^2-14^2) \times \frac{14}{144} = 95.3$			
Total Weight x Lbs/ft	204 lbs/ft			
E_e x	28.3×10^6 psi			
Seismic Category	II			

TABLE B-1

INPUT DATA

SYSTEM	Na Outlet	REFERENCE NO.	REFERENCE REV.	REFERENCE PAGE
Line Number	0023-12-HCDA			
Design Temperature	1100° F			
Design Pressure	65 psi			
Normal Operating Temperature	1055° F			
Normal operating Pressure	65 psi			
Pipe O.D./schedule ×	12.75" / Sch 40S			
Pipe Thickness ×	0.375"			
Pipe Material	SS 304			
Insulation Type	12" thick Cal. Silicate			
Weight of Pipe Lbs/Ft	49.56			
Weight of Contents Lbs/ft	.9 × 49.0 = 44.1			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(36.75^2 - 12.75^2)\frac{14}{144} = 90.71$			
Total Weight × Lbs/ft	184.4 lbs/ft.			
E_c ×	28.3×10^6 psi			
Seismic Category	II			

PREPARED BY: KC	Rockwell International Energy Systems Group	187 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
DATE: 4-4-83		MODEL NO.

TABLE B-1
INPUT DATA

SYSTEM	Na outlet from the Receiver	REFERENCE		
		NO.	REV.	PAGE
Line Number	0018 thru 0021-6-HCDA			
Design Temperature	1100°F			
Design Pressure	65 psi			
Normal Operating Temperature	1055°F			
Normal operating Pressure	65 psi			
Pipe O.D./schedule x	6.625"/Sch. 40			
Pipe Thickness x	0.280"			
Pipe Material	SS 304			
Insulation Type	12" Thick Cal. Silicate			
Weight of Pipe Lbs/Ft	18.97			
weight of contents Lbs/ft	.9 X 12.51 = 11.26			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(30.625^2-6.625^2)\frac{14}{144}$ = 68.26			
Total Weight x Lbs/ft	98.5 lbs/ft			
E_c x	28.3×10^6 psi			
Seismic Category	II			

TABLE B-1

INPUT DATA

SYSTEM	INLET HEADER FOR RECEIVER	REFERENCE		
		NO.	REV.	PAGE
Line Number	0003-14-HCDA			
Design Temperature	610° F			
Design Pressure	65 psi			
Normal Operating Temperature	610° F			
Normal operating Pressure	65 psi			
Pipe O.D./schedule ×	14.0" / Sch 20			
Pipe Thickness ×	.375"			
Pipe Material	SS 304			
Insulation Type	-			
Weight of Pipe Lbs/Ft	55.0			
weight of contents Lbs/ft	.9 × 59.7 = 53.7			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(38^2-12^2)\frac{14}{144}=95.3$			
Total Weight × Lbs/ft	204.0			
E_c ×	28.3×10^6 psi			
Seismic Category	III			

PREPARED BY: KG	Rockwell International Energy Systems Group	PAGE NO. 189 OF
CHECKED BY:		REPORT NO. 079TI000008
DATE: 2/18/83		MODEL NO.

TABLE B-1
INPUT DATA

SYSTEM	Na Lines to Receiver	REFERENCE		
		NO.	REV.	PAGE
Line Number	0004-6-HCDA THRU 0011-6-HCDA			
Design Temperature	610°F			
Design Pressure	65 psi			
Normal Operating Temperature	610°F			
Normal operating Pressure	65 psi			
Pipe O.D.×/schedule	6.625"/ Sch 40			
Pipe Thickness×	0.280"			
Pipe Material	SS 304			
Insulation Type	—			
Weight of Pipe LBS/Ft	18.97			
Weight of contents Lbs/ft	.9 × 12.51 = 11.26			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(18.625^2-6.625^2)\frac{14}{144}$ = 23.14			
Total Weight× Lbs/ft	53.4 lbs/ft			
E_e×	28.3×10^6 psi			
Seismic Category	III			

N 152-R-2 REV. 8-78

PREPARED BY: KC[illegible]	Rockwell International Energy Systems Group	190 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
DATE: 3/18/83		MODEL NO.

TABLE B-1
INPUT DATA

SYSTEM	Receiver Bypass	REFERENCE		
		NO.	REV.	PAGE
Line Number	0012-4-HCDA			
Design Temperature	610° F			
Design Pressure	65 psi			
Normal operating Temperature	610° F			
Normal operating Pressure	65 psi			
Pipe O.D./schedule	4.5"/Sch 40			
Pipe Thickness	0.237"			
Pipe Material	SS304			
Insulation Type	-			
Weight of Pipe Lbs/Ft	10.79			
weight of contents Lbs/ft	.9 x 5.51 = 4.96			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(16.5^2 - 4.5^2)\frac{14}{144} = 19.24$			
Total Weight Lbs/ft	35.0			
E_e	28.3×10^6 psi			
Seismic Category	III			

N 152-R-2 REV. 8-78

Weldolet SIF:

14" × 6" weldolet

$h = 3.3 \frac{\bar{T}}{r_2}$ (from Bonney Forge Catalogue)

$\bar{T}$ = nominal wall thickness of run pipe

$= .375"$

r_2 = mean radius of run pipe

$= \frac{14 - .375}{2} = 6.18125"$

$h = \frac{3.3 \times .375}{6.18125} = .182$

$i = \frac{.9}{h^{2/3}} = \frac{.9}{(.182)^{2/3}}$

$= 2.806$

Allowable stress for SA-312, TP304 stainless steel.
For piping in and out of Receiver

$S_A = f\,(1.25 S_c + 0.25 S_h)$

f is a function equivalent full temperature cycles.

$N = N_E + r_1^5 N_1 + r_2^5 N_2$

N_E = cycles corresponding to 1100°F to 70°F

= 30 (assumed)

N_1 = 22,000 cycles

N_2 = 28,000 cycles

$\Delta T_E = 1100° - 70 = 1030°\,F$

$\Delta T_1 = 1100° - 400° = 700°\,F$

$\Delta T_2 = 1100° - 610° = 490°\,F$

$$N = 30 + \left(\frac{\Delta T_1}{\Delta T_E}\right)^5 22000 + \left(\frac{\Delta T_2}{\Delta T_E}\right)^5 28000$$

$$= 30 + \left(\frac{700}{1030}\right)^5 \cdot 22000 + \left(\frac{490}{1030}\right)^5 \cdot 28000$$

$$= 30 + 3190 + 683$$

$$= 3903 < 7000 \text{ cycles}$$

Therefore $f = 1.0$.

$S_c = 18.7$ ksi

$S_{h\,@1100°F} = 8.8$ ksi

$S_A = 1.0\,(1.25 \times 18.7 + 0.25 \times 8.8)$

$= 25.575$ ksi

$S_h + S_A = 34.375$ ksi

$S_{h\,@618°F} = 11.36$ ksi

$S_A = 1.0\,(1.25 \times 18.7 + 0.25 \times 11.36)$

$= 26{,}215$ psi

```
IAT6140 JOB ORIGIN FROM GROUP=RM206    , DSP=IJP, DEVICE=INTRDR   , 000
11:52:47 IAT4401  LOCATE FOR STEP=A           DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
11:52:47 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
11:52:47 IAT4401  LOCATE FOR STEP=G           DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
11:52:47 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
11:52:47 IAT4401  LOCATE FOR STEP=G           DD=FT15F001 DSN=$WW232.CARRIZO.UPPER.LOWER.MANIFOLD.DATA
11:52:47 IAT4402 UNIT=3350     ,VOL(S)=AVTSOA
11:52:47 IAT4401  LOCATE FOR STEP=G           DD=FT69F001 DSN=$WW049.ROCKPIPE.USERS
11:52:47 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
11:52:47 IAT4401  LOCATE FOR STEP=ELTEMP      DD=STEPLIB  DSN=$WW049.ELTEMP.LOAD
11:52:47 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
11:52:48 USES       CVTSOK  08 015920 D $WW049.NUPIPE.LOAD
11:52:48 USES       AVTSOA  08 015920 D $WW232.CARRIZO.UPPER.LOWER.MANIFOLD.DATA
11:52:48 IAT5200 JOB 2381 ($WW232U1) IN SETUP ON MAIN=C        P=03 LOCAL
11:52:48 IAT5210 J=2381 STEPLIB  USING D CVTSOK ON 528    $WW049.NUPIPE.LOAD
11:52:48 IAT5210 J=2381 FT15F001 USING D AVTSOA ON 520    $WW232.CARRIZO.UPPER.LOWER.MANIFOLD.DATA
11:52:52 IAT2000 JOB 2381 $WW232U1 SELECTED C         GRP=BIG
11:52:53 C R= $WW232U1 NEF995I $WW232U1 STARTED, 4/14/83,11.50.46 ASID=00071
11:52:53 C R= $WW232U1 IEF403I $WW232U1 - STARTED - TIME=11.50.46
11:54:09 C R= $WW232U1 +IH0002I STOP       1
11:54:09 C R= $WW232U1 IEF404I $WW232U1 - ENDED - TIME=11.52.02
11:54:09 C R= $WW232U1 NEF996I $WW232U1 ENDED,  4/14/83,B.U.=      1.4253 *0716935    ,3081-C3,JOB CC= 001
11:54:10 IAT5400 JOB 2381 ($WW232U1) IN BREAKDOWN
/$WW232U1 JOB 'GURSAHANI LB30130340*0716935         005  5001003037', *
/ REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
/*MAIN ORG=RM005                                                     00000300
/ EXEC ROCKPIPE,PROG=SMALL
/G.SYSIN DD DSN=$WW232.CARRIZO.UPPER.LOWER.MANIFOLD.DATA,DISP=SHR
   1      //$WW232U1 JOB 'GURSAHANI LB30130340*0716935         005  5001003037', *
          // REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
   2      // EXEC ROCKPIPE,PROG=SMALL
   3      XXROCKPIPE PROC DSN='$WW049.NUPIPE.LOAD',PROG=SMALL,C=10,
          XX PROGA=SEVEN,B=19069,PROGE=OPT2,DSNE='$WW049.ELTEMP.LOAD',
          XX USERS='$WW049.ROCKPIPE.USERS'
          *** AL HROMJAK ROCKWELL INTERNATIONAL, ESG. COMNET 393-3318
          *** FT50F001 FOR 7-SPECTRA NODE ACCELERATIONS.
          *** IN BOTH STEPS, FT66 CONTAINS DIAGNOSTIC OUTPUT.
          *** FT66F001 IN G STEP CONTAINS TIME SPENT IN MAJOR PROGRAM PHASES.
          *** FT16F001 DUMMIED WHEN P STEP DELETED.
          *** FT17F001, FT18F001, FT19F001, FT20F001 ADDED FOR SNUBBER ITERATIONS
   4      XXA EXEC PGM=&PROGA
          *** THIS STEP READS THE 7 SPECTRA AND TRANSLATES THEM TO A NEW POINT
          ***  NEW SPECTRA WRITTEN  ON FT01F001
   5      XXSTEPLIB DD DSN=&DSN,DISP=SHR
   6      XXFT01F001 DD UNIT=SYSDA,DSN=&&SPEC,SPACE=(TRK,(10),RLSE),DISP=(,PASS),
          XX DCB=(RECFM=F,LRECL=80,BLKSIZE=80)
   7      XXFT05F001 DD DDNAME=SYSIN
   8      XXFT06F001 DD SYSOUT=*
   9      XXFT66F001 DD DUMMY,DCB=(RECFM=VBA,BLKSIZE=2020)
  10      XXG EXEC PGM=&PROG
          *** THIS STEP EXECUTES ROCKPIPE. LOAD CASES, 7-SPECTRA (IF ANY), AND
          *** GEOMETRY ARE READ FROM UNIT FT15'S 3 CONCATANATED DATA SETS. LOAD
          *** CASES TO BE DELETED FROM PRINTING ARE DETECTED AND THE CASE NO.'S
          *** MADE PLUS. ALL 3 FILES FROM FT15 ARE WRITTEN ON FT05 AS ONE FILE TO
          *** BE READ BY NUPIPE.
  11      XXSTEPLIB DD DSN=&DSN,DISP=SHR
  12      XXFT01F001 DD UNIT=SYSDA,DCB=(RECFM=VBS,BLKSIZE=&B),
          XX SPACE=(CYL,(&C,&C))
  13      XXFT02F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
  14        FT03F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
  15        FT04F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&
```

O R I G I N A L   I N P U T   B Y   GURSAHANI   O N   04/14/83   A T   11:51:27   W I T H   P R I O R I T Y   3

CARRIZO OUTLETS FROM RECEIVER ,UPPER MANIFOLD AND LOWER MANIFOLD

CONTROL			2.0	1.0			
FLEXAN	1	1	2.0				
THERMAL AT DESIGN TEMPERATURE							
XSECTN		1	14.00	0.375	204.0	28.3	65.
XSECTN		2	6.625	0.280	98.5	28.3	65.
XSECTN		3	12.75	0.375	184.4	28.3	65.
XSECTN		4	12.75	0.375	128.5	28.3	65.
XSECTN		5	6.625	0.280	53.4	28.3	65.
XSECTN		6	4.5	0.237	35.0	28.3	65.
OPVAL1100	1	1	21.8	.1284			65.
OPVAL 610	1	2	25.34	.06366			65.
ANCHOR		5					
RUN	5	15	-3.25			1.0	1.0
TEE	15	105					
RUN	15	20	-3.25				
RUN	20	25	-3.25				
TEE	25	205					
RUN	25	30	-3.25				
RESTRAINT		30		50000.	50000.		
RUN	30	35	-3.25				
TEE	35	305					
RUN	35	40	-1.5				
RUN	40	45	-1.75				
TEE	45	405					
RUN	45	51	-2.5				
TEE	51	45					
RUN	51	52		-0.917			
REDUCER	52	53		-1.083		3.0	
RUN	53	54		-4.0			
RUN	54	61		-11.5			
ELBOW -	61	62					
RUN	62	65	18.5				
ELBOW -	65	66					
RUN	66	69		-19.5			
ELBOW -	69	70					
RUN	70	74	-20.0				
ELBOW -	74	75					
RUN	75	79		-12.0			
ELBOW -	79	80					
RUN	80	82	5.0				
ELBOW -	82	83					
RUN	83	85			-7.0		
ELBOW -	85	86					
RUN	86	87	5.0				
ELBOW -	87	88					
RUN	88	89			7.0		
ELBOW -	89	90					
RUN	90	76	5.0				
ELBOW -	76	77					
RUN	77	67			-8.0		
ELBOW -	67	68					
RUN	68	91		-12.167			
RUN	91	92		-0.833			
TEE	92	2000					
RUN	92	93		-0.833			
RUN	93	95		-6.667			
ANCHOR		95					
RUN	51	800		0.917		1.0	

FORM 126-P-130 NEW 7-82

079TI000008
195

REDUCER	800	804		2.333		3.0			60
ELBOW	- 804	805							61
RUN	805	806			-4.0				62
ELBOW	- 806	807							63
RESTRAINT		807		1.0					64
RUN	807	808	9.75						65
ELBOW	- 808	809							66
RUN	809	810			-8.0				67
ELBOW	- 810	811							68
RUN	811	812	6.0						69
RESTRAINT		812		1.0					70
ELBOW	- 812	813							71
RUN	813	814			7.5				72
ELBOW	- 814	815							73
RUN	815	816	9.25						74
ELBOW	- 816	818							75
RUN	818	820		7.5					76
ANCHOR		820							77
STDISPL	1	820	-0.75	-1.0					78
RUN	15	105			-3.0	2.0	1.0		79
RESTRAINT		105		1.0					80
RUN	105	109			-14.0				81
RESTRAINT		109		1.0					82
ELBOW	- 109	110							83
RUN	110	114		-12.0					84
ELBOW	- 114	115							85
RUN	115	117			7.0				86
RESTRAINT		117		1.0					87
RUN	117	119			6.75				88
ELBOW	- 119	120							89
RUN	120	124	-3.5						90
ELBOW	- 124	125							91
RUN	125	130			12.0				92
ELBOW	- 130	135							93
RUN	135	140	3.5						94
ELBOW	- 140	145							95
RUN	145	165		-2.0					96
RESTRAINT		165	1.E8	29000.0	1.E8	1.2E7	1.E10	9.1E5	97
STDISPL	1	165		5.1					98
RUN	25	205			-3.0	2.0	1.0		99
RESTRAINT		205		1.0					100
RUN	205	209			-14.0				101
RESTRAINT		209		1.0					102
ELBOW	- 209	210							103
RUN	210	214		-12.0					104
ELBOW	- 214	215							105
RUN	215	217			7.0				106
RESTRAINT		217		1.0					107
RUN	217	219			6.75				108
ELBOW	- 219	220							109
RUN	220	224	-3.5						110
ELBOW	- 224	225							111
RUN	225	230			12.0				112
ELBOW	- 230	235							113
RUN	235	240	3.5						114
ELBOW	- 240	245							115
RUN	245	265		-2.0					116
RESTRAINT		265	1.E8	29000.0	1.E8	1.2E7	1.E10	9.1E5	117
STDISPL	1	265		5.1					118
RUN	35	305			-3.0	2.0	1.0		119
RESTI		305		1.0					120
RUN	305	309			-14.0				121

FORM NEW 7-82

RESTRAINT		309		1.0					122
ELBOW	- 309	310							123
RUN	310	314		-12.0					124
ELBOW	- 314	315							125
RUN	315	317			7.0				126
RESTRAINT		317		1.0					127
RUN	317	319			6.75				128
ELBOW	- 319	320							129
RUN	320	324	-3.5						130
ELBOW	- 324	325							131
RUN	325	330			12.0				132
ELBOW	- 330	335							133
RUN	335	340	3.5						134
ELBOW	- 340	345							135
RUN	345	365		-2.0					136
RESTRAINT		365	1.E8	29000.0	1.E8	1.2E7	1.E10	9.1E5	137
STDISPL	1	365		5.1					138
RUN	45	405			-3.0	2.0	1.0		139
ELBOW	- 405	406							140
RUN	406	407	-3.75						141
ELBOW	- 407	408							142
RUN	408	409			-4.667				143
ELBOW	- 409	410							144
RUN	410	411	4.0						145
ELBOW	- 411	412							146
RUN	412	413			-7.0				147
ELBOW	- 413	414							148
RUN	414	415		-12.0					149
ELBOW	- 415	416							150
RUN	416	417			4.5				151
RESTRAINT		417		1.0					152
RUN	417	419			4.5				153
ELBOW	- 419	420							154
RUN	420	424	-5.75						155
ELBOW	- 424	425							156
RUN	425	430			11.5				157
ELBOW	- 430	432							158
RUN	432	434	2.0						159
ELBOW	- 434	435							160
RUN	435	440			3.0				161
ELBOW	- 440	445							162
RUN	445	465		-2.0					163
RESTRAINT		465	1.E8	29000.0	1.E8	1.2E7	1.E10	9.1E5	164
STDISPL	1	465		5.1					165
RUN	92	2000			.708	6.0			166
RUN	2000	2005			6.542				167
ELBOW	-2005	2010					2.0		168
RUN	2010	2035	-6.0						169
ELBOW	-2035	2040							170
RUN	2040	2045			4.0				171
ELBOW	-2045	2050							172
RUN	2050	2055	-7.0						173
ELBOW	-2055	2060							174
RUN	2060	2065			-6.5				175
ELBOW	-2065	2068							176
RUN	2068	2070		-3.292					177
REDUCER	2070	2072		-.458					178
REDUCER	2072	2075		-2.25		2.0			179
ELBOW	-2075	2080				1.0			180
RUN	2080	2090	3.0						181
TEE	2090	1410	2.806						182
RUN	2090	2095	3.25						183

FORM 126-P-130 NEW 7-82

079T1000008
197

RUN	2095	2100	3.25					184
TEE	2100	1310	2.806					185
RUN	2100	2150	3.25					186
RESTRAINT		2150		50000.	50000.			187
RUN	2150	2200	3.25					188
TEE	2200	1210	2.806					189
RUN	2200	2250	3.25					190
RUN	2250	2300	3.25					191
TEE	2300	1110	2.806					192
RUN	2300	2305	1.0					193
ANCHOR		2305						194
RUN	2300	1110		2.0		5.0	2.0	195
ELBOW	-1110	1111						196
RUN	1111	1130	-4.95		4.95			197
ELBOW	-1130	1131						198
RUN	1131	1150	4.95		4.95			199
ELBOW	-1150	1151						200
RUN	1151	1160	-2.3		2.3			201
ELBOW	-1160	1161						202
RUN	1161	1165		2.0				203
ANCHOR		1165						204
RUN	2200	1210		2.0		5.0	2.0	205
ELBOW	-1210	1211						206
RUN	1211	1230	-4.95		4.95			207
ELBOW	-1230	1231						208
RUN	1231	1250	4.95		4.95			209
ELBOW	-1250	1251						210
RUN	1251	1260	-2.3		2.3			211
ELBOW	-1260	1261						212
RUN	1261	1265		2.0				213
ANCHOR		1265						214
RUN	2100	1310		2.0		5.0	2.0	215
ELBOW	-1310	1311						216
RUN	1311	1330	-4.95		4.95			217
ELBOW	-1330	1331						218
RUN	1331	1350	4.95		4.95			219
ELBOW	-1350	1351						220
RUN	1351	1360	-2.3		2.3			221
ELBOW	-1360	1361						222
RUN	1361	1365		2.0				223
ANCHOR		1365						224
RUN	2090	1410		2.0		5.0	2.0	225
ELBOW	-1410	1411						226
RUN	1411	1430	-4.95		4.95			227
ELBOW	-1430	1431						228
RUN	1431	1450	4.95		4.95			229
ELBOW	-1450	1451						230
RUN	1451	1460	-2.3		2.3			231
ELBOW	-1460	1461						232
RUN	1461	1465		2.0				233
ANCHOR		1465						234
STDISPL	1	1165		-.12				235
STDISPL	1	1265		-.12				236
STDISPL	1	1365		-.12				237
STDISPL	1	1465		-.12				238
STRESS7								239
1OCASES	1							240
ALLDONE								241

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	5	1.000	607.	607.	4220.	4827.
	15	2.317	607.	607.	9023.	9629.
RUN	15	2.317	607.	607.	4987.	5594.
	20	1.000	607.	607.	2174.	2780.
RUN	20	1.000	607.	607.	2174.	2780.
	25	2.317	607.	607.	5560.	6167.
RUN	25	2.317	607.	607.	3536.	4143.
	30	1.000	607.	607.	1671.	2278.
RUN	30	1.000	607.	607.	1671.	2278.
	35	2.317	607.	607.	5338.	5945.
RUN	35	2.317	607.	607.	6473.	7080.
	40	1.000	607.	607.	2956.	3563.
RUN	40	1.000	607.	607.	2956.	3563.
	45	2.317	607.	607.	7553.	8159.
RUN	45	2.317	607.	607.	9428.	10035.
	51	2.317	607.	607.	9714.	10321.
RUN	51	2.317	607.	607.	11046.	11653.
	52	1.000	607.	607.	4735.	5341.
REDUCE	52	2.000	553.	553.	11479.	12031.
	53	2.000	553.	553.	11389.	11942.
RUN	53	1.000	553.	553.	5695.	6247.
	54	1.000	553.	553.	5541.	6094.
RUN	54	1.000	553.	553.	5541.	6094.
	61	1.000	553.	553.	5251.	5803.
ELBOW	61	2.864	553.	553.	15038.	15590.
	62	2.864	553.	553.	12271.	12823.
RUN	62	1.000	553.	553.	4284.	4837.
	65	1.000	553.	553.	5607.	6160.

079TI000008
199

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
ELBOW	65	2.864	553.	553.	16060.	16612.
	66	2.864	553.	553.	18742.	19294.
RUN	66	1.000	553.	553.	6544.	7096.
	69	1.000	553.	553.	6698.	7251.
ELBOW	69	2.864	553.	553.	19185.	19737.
	70	2.864	553.	553.	16601.	17154.
RUN	70	1.000	553.	553.	5796.	6349.
	74	1.000	553.	553.	5138.	5690.
ELBOW	74	2.864	553.	553.	14715.	15267.
	75	2.864	553.	553.	17418.	17970.
RUN	75	1.000	553.	553.	6081.	6634.
	79	1.000	553.	553.	6232.	6784.
ELBOW	79	2.864	553.	553.	17848.	18400.
	80	2.864	553.	553.	15430.	15982.
RUN	80	1.000	553.	553.	5387.	5940.
	82	1.000	553.	553.	4260.	4812.
ELBOW	82	2.864	553.	553.	12201.	12753.
	83	2.864	553.	553.	8561.	9113.
RUN	83	1.000	553.	553.	2989.	3542.
	85	1.000	553.	553.	3021.	3573.
ELBOW	85	2.864	553.	553.	8652.	9204.
	86	2.864	553.	553.	8177.	8729.
RUN	86	1.000	553.	553.	2855.	3407.
	87	1.000	553.	553.	2292.	2844.
ELBOW	87	2.864	553.	553.	6564.	7117.
	88	2.864	553.	553.	3918.	4471.
RUN	88	1.000	553.	553.	1368.	1921.
	89	1.000	553.	553.	1286.	1838.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
ELBOW	89	2.864	553.	553.	3683.	4236.
	90	2.864	553.	553.	7292.	7844.
RUN	90	1.000	553.	553.	2546.	3099.
	76	1.000	553.	553.	3395.	3948.
ELBOW	76	2.864	553.	553.	9724.	10276.
	77	2.864	553.	553.	10821.	11374.
RUN	77	1.000	553.	553.	3778.	4331.
	67	1.000	553.	553.	4066.	4618.
ELBOW	67	2.864	553.	553.	11645.	12197.
	68	2.864	553.	553.	12912.	13465.
RUN	68	1.000	553.	553.	4508.	5061.
	91	1.000	553.	553.	4068.	4621.
RUN	91	1.000	553.	553.	4068.	4621.
	92	2.173	553.	553.	8784.	9337.
RUN	92	2.173	553.	553.	9045.	9597.
	93	1.000	553.	553.	4156.	4708.
RUN	93	1.000	553.	553.	4156.	4708.
	95	1.000	553.	553.	4195.	4748.
RUN	51	2.317	607.	607.	6733.	7340.
	800	1.000	607.	607.	3267.	3874.
REDUCE	800	2.000	553.	553.	7921.	8474.
	804	2.000	553.	553.	8834.	9386.
ELBOW	804	2.864	553.	553.	12650.	13202.
	805	2.864	553.	553.	13463.	14016.
RUN	805	1.000	553.	553.	4701.	5253.
	806	1.000	553.	553.	4422.	4975.
ELBOW	806	2.864	553.	553.	12666.	13218.
	807	2.864	553.	553.	10782.	11335.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	807	1.000	553.	553.	3765.	4317.
	808	1.000	553.	553.	1887.	2439.
ELBOW	808	2.864	553.	553.	5404.	5956.
	809	2.864	553.	553.	3139.	3691.
RUN	809	1.000	553.	553.	1096.	1648.
	810	1.000	553.	553.	4144.	4696.
ELBOW	810	2.864	553.	553.	11867.	12420.
	811	2.864	553.	553.	14504.	15057.
RUN	811	1.000	553.	553.	5064.	5617.
	812	1.000	553.	553.	4678.	5230.
ELBOW	812	2.864	553.	553.	13398.	13950.
	813	2.864	553.	553.	9811.	10364.
RUN	813	1.000	553.	553.	3426.	3978.
	814	1.000	553.	553.	1466.	2019.
ELBOW	814	2.864	553.	553.	4200.	4752.
	815	2.864	553.	553.	7716.	8269.
RUN	815	1.000	553.	553.	2694.	3247.
	816	1.000	553.	553.	4853.	5405.
ELBOW	816	2.864	553.	553.	13898.	14451.
	818	2.864	553.	553.	13132.	13685.
RUN	818	1.000	553.	553.	4585.	5138.
	820	1.000	553.	553.	3852.	4404.
RUN	15	2.317	384.	384.	19380.	19765.
	105	1.000	384.	384.	9039.	9424.
RUN	105	1.000	384.	384.	9039.	9424.
	109	1.000	384.	384.	995.	1379.
ELBOW	109	2.267	384.	384.	2255.	2640.
	110	2.267	384.	384.	4260.	4645.

079T1000008
202

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	110	1.000	384.	384.	1880.	2264.
	114	1.000	384.	384.	10389.	10773.
ELBOW	114	2.267	384.	384.	23548.	23932.
	115	2.267	384.	384.	23733.	24117.
RUN	115	1.000	384.	384.	10471.	10855.
	117	1.000	384.	384.	6008.	6392.
RUN	117	1.000	384.	384.	6008.	6392.
	119	1.000	384.	384.	2047.	2431.
ELBOW	119	2.267	384.	384.	4639.	5024.
	120	2.267	384.	384.	2846.	3231.
RUN	120	1.000	384.	384.	1256.	1640.
	124	1.000	384.	384.	2165.	2550.
ELBOW	124	2.267	384.	384.	4908.	5293.
	125	2.267	384.	384.	6068.	6452.
RUN	125	1.000	384.	384.	2677.	3062.
	130	1.000	384.	384.	7314.	7698.
ELBOW	130	2.267	384.	384.	16577.	16961.
	135	2.267	384.	384.	17438.	17823.
RUN	135	1.000	384.	384.	7693.	8078.
	140	1.000	384.	384.	7762.	8146.
ELBOW	140	2.267	384.	384.	17593.	17977.
	145	2.267	384.	384.	16694.	17078.
RUN	145	1.000	384.	384.	7365.	7750.
	165	1.000	384.	384.	6418.	6803.
RUN	25	2.317	384.	384.	18981.	19366.
	205	1.000	384.	384.	8830.	9214.
RUN	205	1.000	384.	384.	8830.	9214.
	209	1.000	384.	384.	1609.	1993.

079T1000008
203

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
ELBOW	209	2.267	384.	384.	3647.	4031.
	210	2.267	384.	384.	5248.	5632.
RUN	210	1.000	384.	384.	2315.	2700.
	214	1.000	384.	384.	10317.	10701.
ELBOW	214	2.267	384.	384.	23384.	23768.
	215	2.267	384.	384.	23539.	23924.
RUN	215	1.000	384.	384.	10385.	10770.
	217	1.000	384.	384.	5954.	6338.
RUN	217	1.000	384.	384.	5954.	6338.
	219	1.000	384.	384.	2104.	2489.
ELBOW	219	2.267	384.	384.	4769.	5154.
	220	2.267	384.	384.	2999.	3384.
RUN	220	1.000	384.	384.	1323.	1708.
	224	1.000	384.	384.	2040.	2424.
ELBOW	224	2.267	384.	384.	4624.	5008.
	225	2.267	384.	384.	5640.	6024.
RUN	225	1.000	384.	384.	2488.	2873.
	230	1.000	384.	384.	7145.	7529.
ELBOW	230	2.267	384.	384.	16194.	16579.
	235	2.267	384.	384.	17203.	17588.
RUN	235	1.000	384.	384.	7590.	7974.
	240	1.000	384.	384.	7810.	8195.
ELBOW	240	2.267	384.	384.	17703.	18088.
	245	2.267	384.	384.	16996.	17380.
RUN	245	1.000	384.	384.	7498.	7883.
	265	1.000	384.	384.	6622.	7006.
RUN	35	2.317	384.	384.	19578.	19963.
	305	1.000	384.	384.	9143.	9527.

079T1000008
204

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	305	1.000	384.	384.	9143.	9527.
	309	1.000	384.	384.	2184.	2569.
ELBOW	309	2.267	384.	384.	4951.	5335.
	310	2.267	384.	384.	6130.	6515.
RUN	310	1.000	384.	384.	2705.	3089.
	314	1.000	384.	384.	10500.	10885.
ELBOW	314	2.267	384.	384.	23800.	24185.
	315	2.267	384.	384.	23966.	24350.
RUN	315	1.000	384.	384.	10573.	10958.
	317	1.000	384.	384.	6060.	6444.
RUN	317	1.000	384.	384.	6060.	6444.
	319	1.000	384.	384.	2256.	2640.
ELBOW	319	2.267	384.	384.	5112.	5497.
	320	2.267	384.	384.	3311.	3695.
RUN	320	1.000	384.	384.	1461.	1845.
	324	1.000	384.	384.	1973.	2358.
ELBOW	324	2.267	384.	384.	4473.	4857.
	325	2.267	384.	384.	5380.	5765.
RUN	325	1.000	384.	384.	2374.	2758.
	330	1.000	384.	384.	7192.	7576.
ELBOW	330	2.267	384.	384.	16301.	16685.
	335	2.267	384.	384.	17488.	17872.
RUN	335	1.000	384.	384.	7715.	8100.
	340	1.000	384.	384.	8103.	8488.
ELBOW	340	2.267	384.	384.	18367.	18752.
	345	2.267	384.	384.	17823.	18207.
RUN	345	1.000	384.	384.	7863.	8248.
	365	1.000	384.	384.	7020.	7405.

079T1000008
205

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	45	2.317	384.	384.	14166.	14551.
	405	1.000	384.	384.	6411.	6796.
ELBOW	405	2.267	384.	384.	14531.	14916.
	406	2.267	384.	384.	13240.	13625.
RUN	406	1.000	384.	384.	5841.	6226.
	407	1.000	384.	384.	6390.	6774.
ELBOW	407	2.267	384.	384.	14483.	14868.
	408	2.267	384.	384.	14256.	14641.
RUN	408	1.000	384.	384.	6290.	6674.
	409	1.000	384.	384.	4919.	5303.
ELBOW	409	2.267	384.	384.	11149.	11534.
	410	2.267	384.	384.	9344.	9728.
RUN	410	1.000	384.	384.	4122.	4507.
	411	1.000	384.	384.	2472.	2857.
ELBOW	411	2.267	384.	384.	5604.	5988.
	412	2.267	384.	384.	3903.	4288.
RUN	412	1.000	384.	384.	1722.	2107.
	413	1.000	384.	384.	3141.	3525.
ELBOW	413	2.267	384.	384.	7119.	7503.
	414	2.267	384.	384.	9201.	9586.
RUN	414	1.000	384.	384.	4060.	4444.
	415	1.000	384.	384.	10208.	10593.
ELBOW	415	2.267	384.	384.	23139.	23523.
	416	2.267	384.	384.	22927.	23311.
RUN	416	1.000	384.	384.	10115.	10499.
	417	1.000	384.	384.	7371.	7755.
RUN	417	1.000	384.	384.	7371.	7755.
	419	1.000	384.	384.	4928.	5312.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
ELBOW	419	2.267	384.	384.	11170.	11554.
	420	2.267	384.	384.	9368.	9753.
RUN	420	1.000	384.	384.	4133.	4518.
	424	1.000	384.	384.	4135.	4520.
ELBOW	424	2.267	384.	384.	9373.	9757.
	425	2.267	384.	384.	9034.	9419.
RUN	425	1.000	384.	384.	3986.	4370.
	430	1.000	384.	384.	4903.	5287.
ELBOW	430	2.267	384.	384.	11112.	11497.
	432	2.267	384.	384.	12294.	12678.
RUN	432	1.000	384.	384.	5424.	5808.
	434	1.000	384.	384.	5450.	5834.
ELBOW	434	2.267	384.	384.	12352.	12737.
	435	2.267	384.	384.	13973.	14358.
RUN	435	1.000	384.	384.	6165.	6549.
	440	1.000	384.	384.	7367.	7751.
ELBOW	440	2.267	384.	384.	16697.	17082.
	445	2.267	384.	384.	17149.	17534.
RUN	445	1.000	384.	384.	7566.	7951.
	465	1.000	384.	384.	6922.	7306.
RUN	92	2.173	309.	309.	8081.	8390.
	2000	1.000	309.	309.	5541.	5850.
RUN	2000	1.000	309.	309.	5541.	5850.
	2005	1.000	309.	309.	2661.	2969.
ELBOW	2005	1.953	309.	309.	4471.	4780.
	2010	1.953	309.	309.	3828.	4136.
RUN	2010	1.000	309.	309.	1960.	2268.
	2035	1.000	309.	309.	709.	1017.

079T1000008
207

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
ELBOW	2035	1.953	309.	309.	1384.	1693.
	2040	1.953	309.	309.	871.	1179.
RUN	2040	1.000	309.	309.	446.	754.
	2045	1.000	309.	309.	1025.	1333.
ELBOW	2045	1.953	309.	309.	2001.	2310.
	2050	1.953	309.	309.	2627.	2936.
RUN	2050	1.000	309.	309.	1345.	1654.
	2055	1.000	309.	309.	2884.	3193.
ELBOW	2055	1.953	309.	309.	5633.	5942.
	2060	1.953	309.	309.	5501.	5809.
RUN	2060	1.000	309.	309.	2816.	3125.
	2065	1.000	309.	309.	988.	1297.
ELBOW	2065	1.953	309.	309.	1930.	2239.
	2068	1.953	309.	309.	1423.	1732.
RUN	2068	1.000	309.	309.	729.	1037.
	2070	1.000	309.	309.	841.	1149.
REDUCE	2070	2.000	309.	309.	1682.	1990.
	2072	2.000	309.	309.	2075.	2384.
REDUCE	2072	2.000	384.	384.	793.	1177.
	2075	2.000	384.	384.	963.	1348.
ELBOW	2075	2.938	607.	607.	229.	836.
	2080	2.938	607.	607.	403.	1009.
RUN	2080	1.000	607.	607.	137.	744.
	2090	2.806	607.	607.	412.	1018.
RUN	2090	2.806	607.	607.	2881.	3488.
	2095	1.000	607.	607.	345.	952.
RUN	2095	1.000	607.	607.	345.	952.
	2100	2.806	607.	607.	2862.	3468.

079TI000008
208

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	2100	2.806	607.	607.	3047.	3654.
	2150	1.000	607.	607.	3329.	3935.
RUN	2150	1.000	607.	607.	3329.	3935.
	2200	2.806	607.	607.	4395.	5001.
RUN	2200	2.806	607.	607.	6732.	7339.
	2250	1.000	607.	607.	2506.	3112.
RUN	2250	1.000	607.	607.	2506.	3112.
	2300	2.806	607.	607.	7391.	7998.
RUN	2300	2.806	607.	607.	11534.	12141.
	2305	1.000	607.	607.	4766.	5372.
RUN	2300	2.806	384.	384.	19178.	19562.
	1110	1.000	384.	384.	7838.	8222.
ELBOW	1110	2.267	384.	384.	17765.	18149.
	1111	2.267	384.	384.	14882.	15267.
RUN	1111	1.000	384.	384.	6566.	6950.
	1130	1.000	384.	384.	10593.	10978.
ELBOW	1130	2.267	384.	384.	24011.	24395.
	1131	2.267	384.	384.	23648.	24033.
RUN	1131	1.000	384.	384.	10433.	10818.
	1150	1.000	384.	384.	6650.	7034.
ELBOW	1150	2.267	384.	384.	15072.	15456.
	1151	2.267	384.	384.	15608.	15992.
RUN	1151	1.000	384.	384.	6886.	7271.
	1160	1.000	384.	384.	2968.	3353.
ELBOW	1160	2.267	384.	384.	6728.	7113.
	1161	2.267	384.	384.	1988.	2373.
RUN	1161	1.000	384.	384.	877.	1262.
	1165	1.000	384.	384.	5654.	6038.

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	2200	2.806	384.	384.	11432.	11816.
	1210	1.000	384.	384.	3845.	4229.
ELBOW	1210	2.267	384.	384.	8715.	9099.
	1211	2.267	384.	384.	8735.	9120.
RUN	1211	1.000	384.	384.	3854.	4238.
	1230	1.000	384.	384.	10394.	10778.
ELBOW	1230	2.267	384.	384.	23558.	23943.
	1231	2.267	384.	384.	22173.	22558.
RUN	1231	1.000	384.	384.	9782.	10167.
	1250	1.000	384.	384.	6930.	7314.
ELBOW	1250	2.267	384.	384.	15707.	16091.
	1251	2.267	384.	384.	17195.	17580.
RUN	1251	1.000	384.	384.	7586.	7971.
	1260	1.000	384.	384.	4158.	4542.
ELBOW	1260	2.267	384.	384.	9424.	9808.
	1261	2.267	384.	384.	4107.	4491.
RUN	1261	1.000	384.	384.	1812.	2196.
	1265	1.000	384.	384.	5209.	5594.
RUN	2100	2.806	384.	384.	6678.	7063.
	1310	1.000	384.	384.	1308.	1692.
ELBOW	1310	2.267	384.	384.	2964.	3348.
	1311	2.267	384.	384.	7714.	8098.
RUN	1311	1.000	384.	384.	3403.	3788.
	1330	1.000	384.	384.	9360.	9744.
ELBOW	1330	2.267	384.	384.	21215.	21599.
	1331	2.267	384.	384.	18802.	19187.
RUN	1331	1.000	384.	384.	8295.	8680.
	1350	1.000	384.	384.	6715.	7099.

FORM NEW 7-82

079T1000008
210

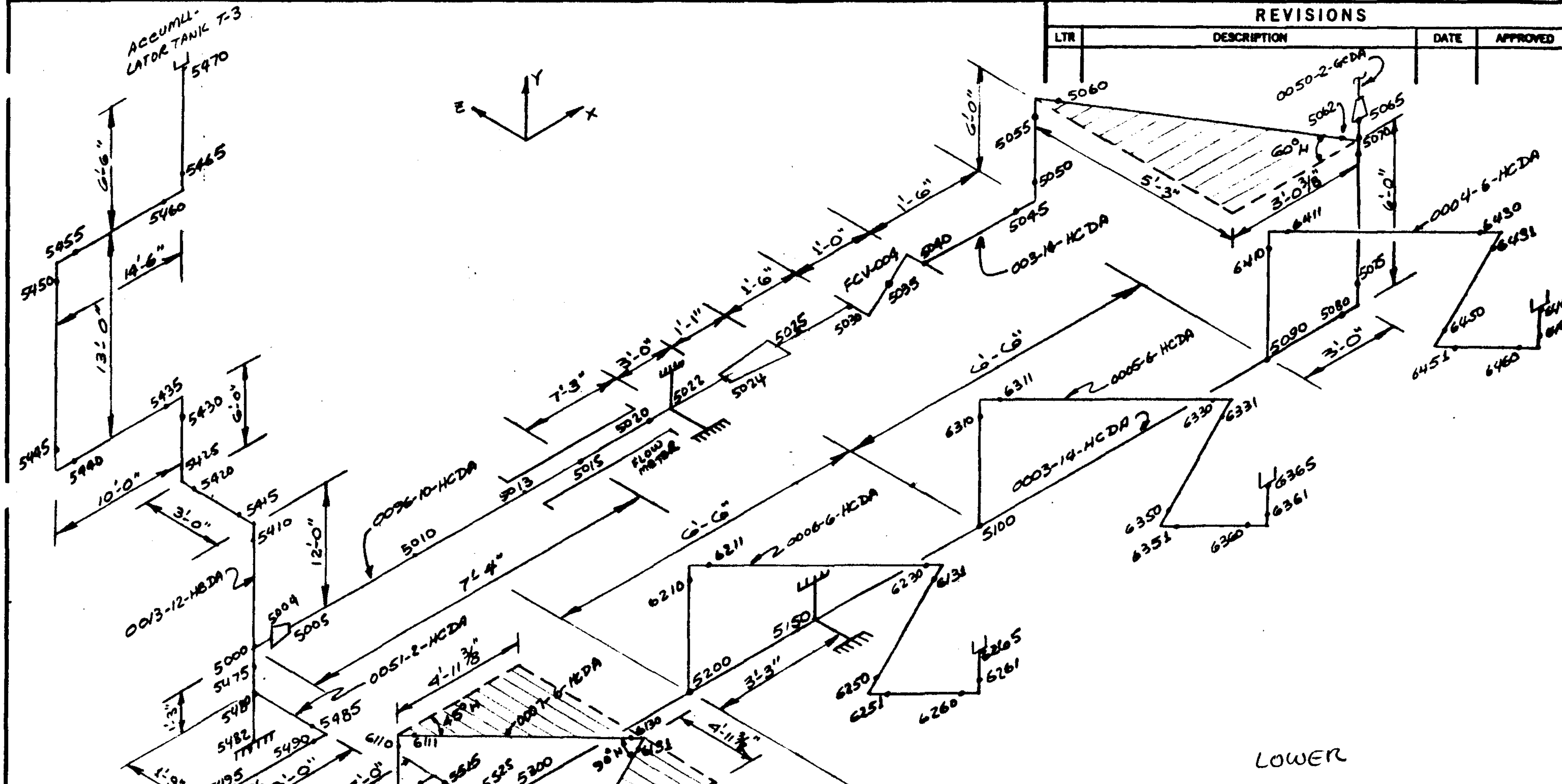
ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
ELBOW	1350	2.267	384.	384.	15220.	15604.
	1351	2.267	384.	384.	17691.	18075.
RUN	1351	1.000	384.	384.	7805.	8189.
	1360	1.000	384.	384.	5695.	6080.
ELBOW	1360	2.267	384.	384.	12909.	13293.
	1361	2.267	384.	384.	9982.	10366.
RUN	1361	1.000	384.	384.	4404.	4788.
	1365	1.000	384.	384.	5873.	6257.
RUN	2090	2.806	384.	384.	12484.	12868.
	1410	1.000	384.	384.	5467.	5851.
ELBOW	1410	2.267	384.	384.	12391.	12776.
	1411	2.267	384.	384.	13774.	14158.
RUN	1411	1.000	384.	384.	6077.	6461.
	1430	1.000	384.	384.	7880.	8265.
ELBOW	1430	2.267	384.	384.	17862.	18246.
	1431	2.267	384.	384.	14562.	14947.
RUN	1431	1.000	384.	384.	6425.	6809.
	1450	1.000	384.	384.	6393.	6777.
ELBOW	1450	2.267	384.	384.	14490.	14875.
	1451	2.267	384.	384.	17822.	18207.
RUN	1451	1.000	384.	384.	7863.	8247.
	1460	1.000	384.	384.	7258.	7643.
ELBOW	1460	2.267	384.	384.	16452.	16836.
	1461	2.267	384.	384.	15562.	15947.
RUN	1461	1.000	384.	384.	6866.	7250.
	1465	1.000	384.	384.	7567.	7952.

079T000008 211

APPENDIX 6.5

INPUT AND OUTPUT DATA FOR NA PIPING TO RECEIVER (LOWER MANIFOLD)



REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

Rockwell International Corporation
Atomics International Division

DR BY	KCG	3/22/8
CHK BY		
M & P		
STRESS		

CARRIZO PLAINS - UNIT 1

SIZE	CODE IDENT NO.	DRAWING NO.
B	09974	
SCALE		SHEET 1 OF 1

4-76 DIETERICH-POST 1000H ISO

FORM 736-V-2 REV. 3-75

0791000008
213

PREPARED BY: KCG	Rockwell International Energy Systems Group	214 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
DATE: 2/18/83		MODEL NO.

TABLE B-1

INPUT DATA

SYSTEM	Na Lines to Receiver	REFERENCE NO.	REFERENCE REV.	REFERENCE PAGE
Line Number	0004-6-HCDA THRU 0011-6-HCDA			
Design Temperature	610° F			
Design Pressure	65 psi			
Normal Operating Temperature	610° F			
Normal operating Pressure	65 psi			
Pipe O.D./schedule ˣ	6.625"/ sch. 40			
Pipe Thickness ˣ	0.280"			
Pipe Material	SS 304			
Insulation Type	—			
Weight of Pipe LBS/Ft	18.97			
Weight of contents Lbs/ft	.9 × 12.51 = 11.26			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(18.625^2 - 6.625^2)\frac{14}{144}$ = 23.14			
Total Weight ˣ Lbs/ft	53.4 lbs/ft			
E_c ˣ	28.3×10^6 psi			
Seismic Category	III			

N 152-R-2 REV. 8-78

PREPARED BY: KLS	Rockwell International Energy Systems Group	215 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
DATE: 2/18/83		MODEL NO.

TABLE B-1

INPUT DATA

SYSTEM	LINE TO ACCUMULATOR TANK T-3	REFERENCE NO.	REFERENCE REV.	REFERENCE PAGE
Line Number	0013-12-HBDA			
Design Temperature	610° F			
Design Pressure	65 psi			
Normal Operating Temperature	610° F			
Normal operating Pressure	65 psi			
Pipe O.D./schedule x	12.75" / std.			
Pipe Thickness x	.375"			
Pipe Material	Carbon Steel			
Insulation Type				
Weight of Pipe Lbs/Ft	49.56			
weight of contents Lbs/ft	.9 × 49 = 44.1			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(24.75^2 - 12.75^2)\frac{14}{144}$ = 34.36			
Total Weight x Lbs/ft	128.0			
E_c x	27.9×10^6 psi			
Seismic Category	III			

PREPARED BY: RCJ	Rockwell International Energy Systems Group	216 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
DATE: 2/18/83		MODEL NO.

TABLE B-1

INPUT DATA

SYSTEM	INLET HEADER FOR RECEIVER	REFERENCE		
		NO.	REV.	PAGE
Line Number	0003-14-HCDA			
Design Temperature	610° F			
Design Pressure	65 psi			
Normal Operating Temperature	610° F			
Normal operating Pressure	65 psi			
Pipe O.D.ˣ/schedule	14.0" / sch 20			
Pipe Thickness ˣ	.375"			
Pipe Material	SS 304			
Insulation Type	-			
Weight of Pipe Lbs/Ft	55.0			
weight of contents Lbs/ft	$.9 \times 59.7 = 53.7$			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(38^2-14^2)\frac{14}{144} = 95.3$			
Total Weight ˣ Lbs/ft	204.0			
E_c ˣ	28.3×10^6 psi			
Seismic Category	III			

N 152-R-2 REV. 8-78

TABLE B-1
INPUT DATA

SYSTEM		REFERENCE		
		NO.	REV.	PAGE
Line Number	0096-10-HCDA.			
Design Temperature	610° F			
Design Pressure	65 psi			
Normal Operating Temperature	610° F			
Normal operating Pressure	65 psi			
Pipe O.D. ×/schedule	10.75 / sch 40			
Pipe Thickness ×	.365"			
Pipe Material	SS304			
Insulation Type	—			
Weight of Pipe LBS/Ft	40.48			
weight of contents Lbs/ft	.9 × 34.1 = 30.69			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(22.75^2 - 10.75^2) \times 14/144 = 30.69$			
Total Weight × Lbs/ft	101.9			
E_e ×	28.3×10^6			
Seismic Category	III			

PREPARED BY: KCJ	Rockwell International Energy Systems Group	218 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
DATE: 8/18/83.		MODEL NO.

TABLE B-1
INPUT DATA

SYSTEM	Bypass	REFERENCE		
		NO.	REV.	PAGE
Line Number	0051-2-HCDA			
Design Temperature	610° F			
Design Pressure	65 psi			
Normal Operating Temperature	610° F			
Normal operating Pressure	65 psi			
Pipe O.D.^x /schedule	2.375" / sch 40			
Pipe Thickness x	.154"			
Pipe Material	SS304			
Insulation Type	–			
Weight of Pipe Lbs/Ft	3,653			
weight of contents Lbs/ft	.9 × 1.455 = 1.310			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(14.375^2 - 2.375^2)\frac{14}{144}$ = 15.3			
Total Weight^x Lbs/ft	20.3			
E_c^x	28.3×10^6			
Seismic Category	III			

N 152-R-2 REV. 8-78

Allowable stress for SA-312, TP304 stainless steel.
For piping in and out of Receiver

$S_A = f\,(1.25 S_c + 0.25 S_h)$

f is a function equivalent full temperature cycles.

$N = N_E + r_1^5 N_1 + r_2^5 N_2$

N_E = cycles corresponding to 1100°F to 70°F

= 30 (assumed)

N_1 = 22,000 cycles

N_2 = 28,000 cycles

$\Delta T_E = 1100° - 70 = 1030°$ F.

$\Delta T_1 = 1100° - 400° = 700°$ F

$\Delta T_2 = 1100° - 610° = 490°$ F

$$N = 30 + \left(\frac{\Delta T_1}{\Delta T_E}\right)^5 22000 + \left(\frac{\Delta T_2}{\Delta T_E}\right)^5 28000$$

$$= 30 + \left(\frac{700}{1030}\right)^5 \cdot 22000 + \left(\frac{490}{1030}\right)^5 \cdot 28000$$

$$= 30 + 3190 + 683$$

$$= 3903 < 7000 \text{ cycles}$$

Therefore $f = 1.0$.

$S_c = 18.7$ ksi

$S_{h\ @\ 1100°F} = 8.8$ ksi

$S_A = 1.0\ (1.25 \times 18.7 + 0.25 \times 8.8)$

$= 25.575$ ksi

$S_h + S_A = 34.375$ ksi

$S_{h\ @\ 618°F} = 11.36$ ksi

$S_A = 1.0(1.25 \times 18.7 + 0.25 \times 11.36)$

$= 26,215$ psi

```
IAT6140 JOB ORIGIN FROM GROUP=RM206   , DSP=IJP, DEVICE=INTRDR  , 000
13:17:01 IAT4401  LOCATE FOR STEP=A         DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
13:17:01 IAT4402 UNIT=3350    ,VOL(S)=CVTSOK
13:17:01 IAT4401  LOCATE FOR STEP=G         DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
13:17:01 IAT4402 UNIT=3350    ,VOL(S)=CVTSOK
13:17:01 IAT4401  LOCATE FOR STEP=G         DD=FT15F001 DSN=$WW232.CARRIZO.LOWER.MANIFOLD.DATA
13:17:01 IAT4402 UNIT=3350    ,VOL(S)=AVTSOA
13:17:01 IAT4401  LOCATE FOR STEP=G         DD=FT69F001 DSN=$WW049.ROCKPIPE.USERS
13:17:01 IAT4402 UNIT=3350    ,VOL(S)=CVTSOK
13:17:01 IAT4401  LOCATE FOR STEP=ELTEMP    DD=STEPLIB  DSN=$WW049.ELTEMP.LOAD
13:17:01 IAT4402 UNIT=3350    ,VOL(S)=CVTSOK
13:17:02 USES     CVTSOK            D $WW049.NUPIPE.LOAD
13:17:02 USES     AVTSOA            D $WW232.CARRIZO.LOWER.MANIFOLD.DATA
13:17:02 IAT5200 JOB 3911 ($WW232U2) IN SETUP ON MAIN=C       P=03 LOCAL
13:17:02 IAT5210 J=3911 STEPLIB  USING D CVTSOK ON 528   $WW049.NUPIPE.LOAD
13:17:02 IAT5210 J=3911 FT15F001 USING D AVTSOA ON 520   $WW232.CARRIZO.LOWER.MANIFOLD.DATA
13:17:07 IAT2000 JOB 3911 $WW232U2 SELECTED I        GRP=BIG
13:17:10 I R= $WW232U2 NEF995I $WW232U2 STARTED, 4/14/83,13.14.54 ASID=00053
13:17:10 I R= $WW232U2 IEF403I $WW232U2 - STARTED - TIME=13.14.54
13:17:35 I R= $WW232U2 +IH0002I STOP       1
13:17:36 I R= $WW232U2 IEF404I $WW232U2 - ENDED - TIME=13.15.20
13:17:36 I R= $WW232U2 NEF996I $WW232U2 ENDED,  4/14/83,B.U.=      1.0078 *0716935    ,3081-I3,JOB CC= 001
13:17:37 IAT5400 JOB 3911 ($WW232U2) IN BREAKDOWN
/$WW232U2 JOB 'GURSAHANI LB30130340*0716935          005  5001003037', *
/ REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
/*MAIN ORG=RM005                                                  00000300
/ EXEC ROCKPIPE,PROG=SMALL
/G.SYSIN DD DSN=$WW232.CARRIZO.LOWER.MANIFOLD.DATA,DISP=SHR
   1      //$WW232U2 JOB 'GURSAHANI LB30130340*0716935          005  5001003037', *
          // REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
   2      // EXEC ROCKPIPE,PROG=SMALL
   3      XXROCKPIPE PROC DSN='$WW049.NUPIPE.LOAD',PROG=SMALL,C=10,
          XX PROGA=SEVEN,B=19069,PROGE=OPT2,DSNE='$WW049.ELTEMP.LOAD',
          XX USERS='$WW049.ROCKPIPE.USERS'
          *** AL HROMJAK ROCKWELL INTERNATIONAL, ESG. COMNET 393-3318
          *** FT50F001 FOR 7-SPECTRA NODE ACCELERATIONS.
          *** IN BOTH STEPS, FT66 CONTAINS DIAGNOSTIC OUTPUT.
          *** FT66F001 IN G STEP CONTAINS TIME SPENT IN MAJOR PROGRAM PHASES.
          *** FT16F001 DUMMIED WHEN P STEP DELETED.
          *** FT17F001, FT18F001, FT19F001, FT20F001 ADDED FOR SNUBBER ITERATIONS
   4      XXA EXEC PGM=&PROGA
          *** THIS STEP READS THE 7 SPECTRA AND TRANSLATES THEM TO A NEW POINT
          ***  NEW SPECTRA WRITTEN  ON FT01F001
   5      XXSTEPLIB DD DSN=&DSN,DISP=SHR
   6      XXFT01F001 DD UNIT=SYSDA,DSN=&&SPEC,SPACE=(TRK,(10),RLSE),DISP=(,PASS),
          XX DCB=(RECFM=F,LRECL=80,BLKSIZE=80)
   7      XXFT05F001 DD DDNAME=SYSIN
   8      XXFT06F001 DD SYSOUT=*
   9      XXFT66F001 DD DUMMY,DCB=(RECFM=VBA,BLKSIZE=2020)
  10      XXG EXEC PGM=&PROG
          *** THIS STEP EXECUTES ROCKPIPE. LOAD CASES, 7-SPECTRA (IF ANY), AND
          *** GEOMETRY ARE READ FROM UNIT FT15'S 3 CONCATANATED DATA SETS. LOAD
          *** CASES TO BE DELETED FROM PRINTING ARE DETECTED AND THE CASE NO.'S
          *** MADE PLUS. ALL 3 FILES FROM FT15 ARE WRITTEN ON FT05 AS ONE FILE TO
          *** BE READ BY NUPIPE.
  11      XXSTEPLIB DD DSN=&DSN,DISP=SHR
  12      XXFT01F001 DD UNIT=SYSDA,DCB=(RECFM=VBS,BLKSIZE=&B),
          XX SPACE=(CYL,(&C,&C))
  13      XXFT02F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
  14      XXFT03F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
  15      XXFT04F001 DD UNIT=SYSDA,DCB=*.FT01F001,SPACE=(CYL,(&C,&C))
```

O R I G I N A L   I N P U T   B Y   GURSAHANI   O N   04/14/83   A T   13:15:03   W I T H   P R I O R I T Y   3

CARRIZO LOWER MANIFOLD AND 14" HEADER UPTO THE TANK								1
CONTROL			2.0	1.0				2
FLEXAN	1	1	2.0					3
THERMAL AT DESIGN TEMPERATURE								4
XSECTN		1	14.00	0.375	204.0	28.3	65.	5
XSECTN		2	12.75	0.375	128.5	28.3	65.	6
XSECTN		3	10.75	0.365	101.9	28.3	65.	7
XSECTN		4	6.625	0.280	53.4	28.3	65.	8
XSECTN		5	2.375	0.154	20.3	28.3	65.	9
XSECTN		6	12.75	0.375	128.5	27.9	65.	10
OPVAL 610	1	1	25.34	.06366			65.	11
OPVAL 610	1	2	25.61	.04702			65.	12
ANCHOR		5310						13
RUN	5310	5305	1.0			1.0	1.0	14
TEE	5305	6110	2.806					15
RUN	5305	5300	3.0					16
TEE	5300	5525	2.806					17
RUN	5300	5200	3.5					18
TEE	5200	6210	2.806					19
RUN	5200	5150	3.25					20
RESTRAINT		5150		50000.	50000.			21
RUN	5150	5100	3.25					22
TEE	5100	6310	2.806					23
RUN	5100	5095	3.25					24
RUN	5095	5090	3.25					25
TEE	5090	6410	2.806					26
RUN	5090	5085	1.5					27
RUN	5085	5080	1.5					28
ELBOW	-5080	5075						29
RUN	5075	5070		6.0				30
TEE	5070	5062	2.806					31
RUN	5070	5065	0.92					32
RUN	5070	5062	-.459		.794			33
RUN	5062	5060	-2.572		4.456			34
ELBOW	-5060	5055						35
RUN	5055	5050		-6.0				36
ELBOW	-5050	5045						37
RUN	5045	5040	-1.5					38
VALVE	5040	5035	-0.5					39
VALVE	5035	5030	-0.5					40
RUN	5030	5025	-1.5					41
REDUCER	5025	5024	-1.083			3.0		42
RUN	5024	5022	-3.0					43
RESTRAINT		5022		50000.	50000.			44
RUN	5022	5020	-5.75					45
VALVE	5020	5015	-1.5					46
VALVE	5015	5013	-1.5					47
RUN	5013	5010	-2.0					48
RUN	5010	5005	-2.333					49
REDUCER	5005	5004	-0.667					50
RUN	5004	5000	-.833			2.0		51
TEE	5000	5004						52
RUN	5000	5475		-0.833		6.0	2.0	53
RUN	5475	5480		-0.417				54
RUN	5480	5482		-0.75				55
ANCHOR		5482						56
RUN	5000	5405		0.833				57
RUN	5405	5410		11.167				58
ELBOW	-5410	5420						59

FORM I   EW 7-82

079T000008
222

DUMMY	5410	5420			1.0			60
DUMMY	5420	5425			1.0			61
ELBOW	-5420	5425						62
RUN	5425	5430		6.0				63
ELBOW	-5430	5435						64
RUN	5435	5440	-10.0					65
ELBOW	-5440	5445						66
RUN	5445	5450		13.0				67
ELBOW	-5450	5455						68
RUN	5455	5460	14.5					69
ELBOW	-5460	5465						70
RUN	5465	5470		6.5				71
ANCHOR		5470						72
STDISPL	1	5470	-.41	-0.55				73
BRANCH	5480	5485			-1.75	5.0	1.0	74
ELBOW	-5485	5490						75
GRUN	5490	5495	-3.0					76
ELBOW	-5495	5496						77
GRUN	5496	5500			-1.75			78
ELBOW	-5500	5503						79
GRUN	5503	5504	2.5					80
VALVE	5504	5505	0.5					81
VALVE	5505	5506	0.5					82
GRUN	5506	5510	6.5					83
ELBOW	-5510	5515						84
GRUN	5515	5520			-1.75			85
ELBOW	-5520	5525						86
GRUN	5525	5300		1.25				87
RUN	5305	6110		2.0		4.0		88
ELBOW	-6110	6111						89
RUN	6111	6130	4.95		-4.95			90
ELBOW	-6130	6131						91
RUN	6131	6150	-4.95		-4.95			92
ELBOW	-6150	6151						93
RUN	6151	6160	2.3		-2.3			94
ELBOW	-6160	6161						95
RUN	6161	6165		2.0				96
ANCHOR		6165						97
RUN	5200	6210		2.0				98
ELBOW	-6210	6211						99
RUN	6211	6230	4.95		-4.95			100
ELBOW	-6230	6231						101
RUN	6231	6250	-4.95		-4.95			102
ELBOW	-6250	6251						103
RUN	6251	6260	2.3		-2.3			104
ELBOW	-6260	6261						105
RUN	6261	6265		2.0				106
ANCHOR		6265						107
RUN	5100	6310		2.0				108
ELBOW	-6310	6311						109
RUN	6311	6330	4.95		-4.95			110
ELBOW	-6330	6331						111
RUN	6331	6350	-4.95		-4.95			112
ELBOW	-6350	6351						113
RUN	6351	6360	2.3		-2.3			114
ELBOW	-6360	6361						115
RUN .	6361	6365		2.0				116
ANCHOR		6365						117
RUN	5090	6410		2.0				118
ELBOW	-6410	6411						119
RUN	6411	6430	4.95		-4.95			120
ELBOW	-6430	6431						121

FORM 126-P-130 NEW 7-82

079TI000008
223

RUN	6431	6450	-4.95		-4.95	122
ELBOW	-6450	6451				123
RUN	6451	6460	2.3		-2.3	124
ELBOW	-6460	6461				125
RUN	6461	6465		2.0		126
ANCHOR		6465				127
STDISPL	1	6165		-.12		128
STDISPL	1	6265		-.12		129
STDISPL	1	6365		-.12		130
STDISPL	1	6465		-.12		131
STRESS7						132
1OCASES	1					133
ALLDONE						134

079TI000008
224

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	5310	1.000	607.	607.	4590.	5196.
	5305	2.806	607.	607.	10439.	11046.
RUN	5305	2.806	607.	607.	6345.	6952.
	5300	2.806	607.	607.	4452.	5059.
RUN	5300	2.806	607.	607.	4506.	5113.
	5200	2.806	607.	607.	2525.	3131.
RUN	5200	2.806	607.	607.	663.	1270.
	5150	1.000	607.	607.	1169.	1775.
RUN	5150	1.000	607.	607.	1169.	1775.
	5100	2.806	607.	607.	2480.	3087.
RUN	5100	2.806	607.	607.	3528.	4135.
	5095	1.000	607.	607.	1400.	2006.
RUN	5095	1.000	607.	607.	1400.	2006.
	5090	2.806	607.	607.	4339.	4946.
RUN	5090	2.806	607.	607.	5229.	5835.
	5085	1.000	607.	607.	1674.	2281.
RUN	5085	1.000	607.	607.	1674.	2281.
	5080	1.000	607.	607.	1687.	2294.
ELBOW	5080	2.938	607.	607.	4956.	5563.
	5075	2.938	607.	607.	2033.	2640.
RUN	5075	1.000	607.	607.	692.	1299.
	5070	2.806	607.	607.	6530.	7137.
RUN	5070	2.806	607.	607.	0.	607.
	5065	1.000	607.	607.	0.	607.
RUN	5070	2.806	607.	607.	6530.	7137.
	5062	1.000	607.	607.	2423.	3030.
RUN	5062	1.000	607.	607.	2423.	3030.
	5060	1.000	607.	607.	2853.	3460.

0791000008
225

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
ELBOW	5060	2.938	607.	607.	8383.	8990.
	5055	2.938	607.	607.	6375.	6982.
RUN	5055	1.000	607.	607.	2170.	2776.
	5050	1.000	607.	607.	1533.	2139.
ELBOW	5050	2.938	607.	607.	4504.	5110.
	5045	2.938	607.	607.	4127.	4734.
RUN	5045	1.000	607.	607.	1405.	2011.
	5040	1.000	607.	607.	1477.	2084.
RUN	5030	1.000	607.	607.	1229.	1836.
	5025	1.000	607.	607.	1152.	1758.
REDUCE	5025	2.000	479.	479.	4073.	4552.
	5024	2.000	479.	479.	4751.	5230.
RUN	5024	1.000	479.	479.	2376.	2854.
	5022	1.000	479.	479.	4262.	4741.
RUN	5022	1.000	479.	479.	4262.	4741.
	5020	1.000	479.	479.	2710.	3188.
RUN	5013	1.000	479.	479.	2335.	2814.
	5010	1.000	479.	479.	2371.	2850.
RUN	5010	1.000	479.	479.	2371.	2850.
	5005	1.000	479.	479.	2695.	3174.
REDUCE	5005	2.000	479.	479.	5391.	5869.
	5004	2.000	479.	479.	5665.	6143.
RUN	5004	1.000	553.	553.	1941.	2494.
	5000	2.173	553.	553.	4505.	5058.
RUN	5000	2.173	553.	553.	3848.	4400.
	5475	1.000	553.	553.	1930.	2482.
RUN	5475	1.000	553.	553.	1930.	2482.
	5480	1.000	553.	553.	2060.	2612.

FORM NEW 7-82

079TI000008
226

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	5480	1.000	553.	553.	2076.	2628.
	5482	1.000	553.	553.	2393.	2945.
RUN	5000	2.173	553.	553.	5669.	6222.
	5405	1.000	553.	553.	2591.	3143.
RUN	5405	1.000	553.	553.	2591.	3143.
	5410	1.000	553.	553.	2456.	3009.
ELBOW	5410	2.864	553.	553.	7034.	7587.
	5420	2.864	553.	553.	6365.	6917.
ELBOW	5420	2.864	553.	553.	6365.	6917.
	5425	2.864	553.	553.	6650.	7202.
RUN	5425	1.000	553.	553.	2322.	2874.
	5430	1.000	553.	553.	2182.	2735.
ELBOW	5430	2.864	553.	553.	6249.	6802.
	5435	2.864	553.	553.	3519.	4071.
RUN	5435	1.000	553.	553.	1229.	1781.
	5440	1.000	553.	553.	3503.	4056.
ELBOW	5440	2.864	553.	553.	10034.	10586.
	5445	2.864	553.	553.	12861.	13413.
RUN	5445	1.000	553.	553.	4490.	5043.
	5450	1.000	553.	553.	4767.	5319.
ELBOW	5450	2.864	553.	553.	13652.	14204.
	5455	2.864	553.	553.	11032.	11585.
RUN	5455	1.000	553.	553.	3852.	4405.
	5460	1.000	553.	553.	3570.	4123.
ELBOW	5460	2.864	553.	553.	10225.	10778.
	5465	2.864	553.	553.	12860.	13413.
RUN	5465	1.000	553.	553.	4490.	5043.
	5470	1.000	553.	553.	4365.	4917.

079T1000008
227

FORM 126-P-130 NEW 7-82

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
BRANCH	5480	1.000	251.	251.	5929.	6179.
	5485	1.000	251.	251.	2509.	2759.
ELBOW	5485	1.732	251.	251.	4346.	4597.
	5490	1.732	251.	251.	3078.	3328.
GRUN	5490	1.800	251.	251.	3198.	3449.
	5495	1.800	251.	251.	832.	1082.
ELBOW	5495	1.732	251.	251.	800.	1051.
	5496	1.732	251.	251.	1346.	1597.
GRUN	5496	1.800	251.	251.	1399.	1649.
	5500	1.800	251.	251.	6295.	6545.
ELBOW	5500	1.732	251.	251.	6058.	6309.
	5503	1.732	251.	251.	6748.	6999.
GRUN	5503	1.800	251.	251.	7011.	7262.
	5504	1.800	251.	251.	4303.	4554.
GRUN	5506	1.800	251.	251.	3106.	3357.
	5510	1.800	251.	251.	4517.	4767.
ELBOW	5510	1.732	251.	251.	4347.	4598.
	5515	1.732	251.	251.	3700.	3951.
GRUN	5515	1.800	251.	251.	3845.	4095.
	5520	1.800	251.	251.	2067.	2318.
ELBOW	5520	1.732	251.	251.	1989.	2240.
	5525	1.732	251.	251.	2475.	2726.
GRUN	5525	1.800	251.	251.	2572.	2822.
	5300	2.806	251.	251.	3447.	3698.
RUN	5305	2.806	384.	384.	19225.	19610.
	6110	1.000	384.	384.	7846.	8231.
ELBOW	6110	2.267	384.	384.	17785.	18169.
	6111	2.267	384.	384.	14877.	15261.

079T000008
228

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	6111	1.000	384.	384.	6563.	6948.
	6130	1.000	384.	384.	10600.	10984.
ELBOW	6130	2.267	384.	384.	24026.	24410.
	6131	2.267	384.	384.	23666.	24050.
RUN	6131	1.000	384.	384.	10441.	10826.
	6150	1.000	384.	384.	6655.	7040.
ELBOW	6150	2.267	384.	384.	15085.	15469.
	6151	2.267	384.	384.	15619.	16004.
RUN	6151	1.000	384.	384.	6891.	7275.
	6160	1.000	384.	384.	2966.	3351.
ELBOW	6160	2.267	384.	384.	6724.	7108.
	6161	2.267	384.	384.	1994.	2378.
RUN	6161	1.000	384.	384.	880.	1264.
	6165	1.000	384.	384.	5665.	6049.
RUN	5200	2.806	384.	384.	12605.	12989.
	6210	1.000	384.	384.	4272.	4656.
ELBOW	6210	2.267	384.	384.	9683.	10067.
	6211	2.267	384.	384.	9084.	9468.
RUN	6211	1.000	384.	384.	4008.	4392.
	6230	1.000	384.	384.	10576.	10961.
ELBOW	6230	2.267	384.	384.	23973.	24357.
	6231	2.267	384.	384.	22651.	23035.
RUN	6231	1.000	384.	384.	9993.	10378.
	6250	1.000	384.	384.	7108.	7493.
ELBOW	6250	2.267	384.	384.	16112.	16496.
	6251	2.267	384.	384.	17542.	17926.
RUN	6251	1.000	384.	384.	7739.	8124.
	6260	1.000	384.	384.	4139.	4524.

079TI000008
229

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
ELBOW	6260	2.267	384.	384.	9382.	9767.
	6261	2.267	384.	384.	3898.	4282.
RUN	6261	1.000	384.	384.	1720.	2104.
	6265	1.000	384.	384.	5396.	5780.
RUN	5100	2.806	384.	384.	8715.	9100.
	6310	1.000	384.	384.	914.	1298.
ELBOW	6310	2.267	384.	384.	2072.	2456.
	6311	2.267	384.	384.	6227.	6611.
RUN	6311	1.000	384.	384.	2747.	3132.
	6330	1.000	384.	384.	10326.	10711.
ELBOW	6330	2.267	384.	384.	23406.	23790.
	6331	2.267	384.	384.	21188.	21573.
RUN	6331	1.000	384.	384.	9348.	9732.
	6350	1.000	384.	384.	7518.	7902.
ELBOW	6350	2.267	384.	384.	17040.	17424.
	6351	2.267	384.	384.	19325.	19709.
RUN	6351	1.000	384.	384.	8526.	8910.
	6360	1.000	384.	384.	5663.	6048.
ELBOW	6360	2.267	384.	384.	12836.	13221.
	6361	2.267	384.	384.	9094.	9478.
RUN	6361	1.000	384.	384.	4012.	4396.
	6365	1.000	384.	384.	6239.	6624.
RUN	5090	2.806	384.	384.	10232.	10616.
	6410	1.000	384.	384.	1942.	2327.
ELBOW	6410	2.267	384.	384.	4402.	4787.
	6411	2.267	384.	384.	8086.	8471.
RUN	6411	1.000	384.	384.	3568.	3952.
	6430	1.000	384.	384.	10329.	10714.

079T1000008
230

FOR D NEW 7-82

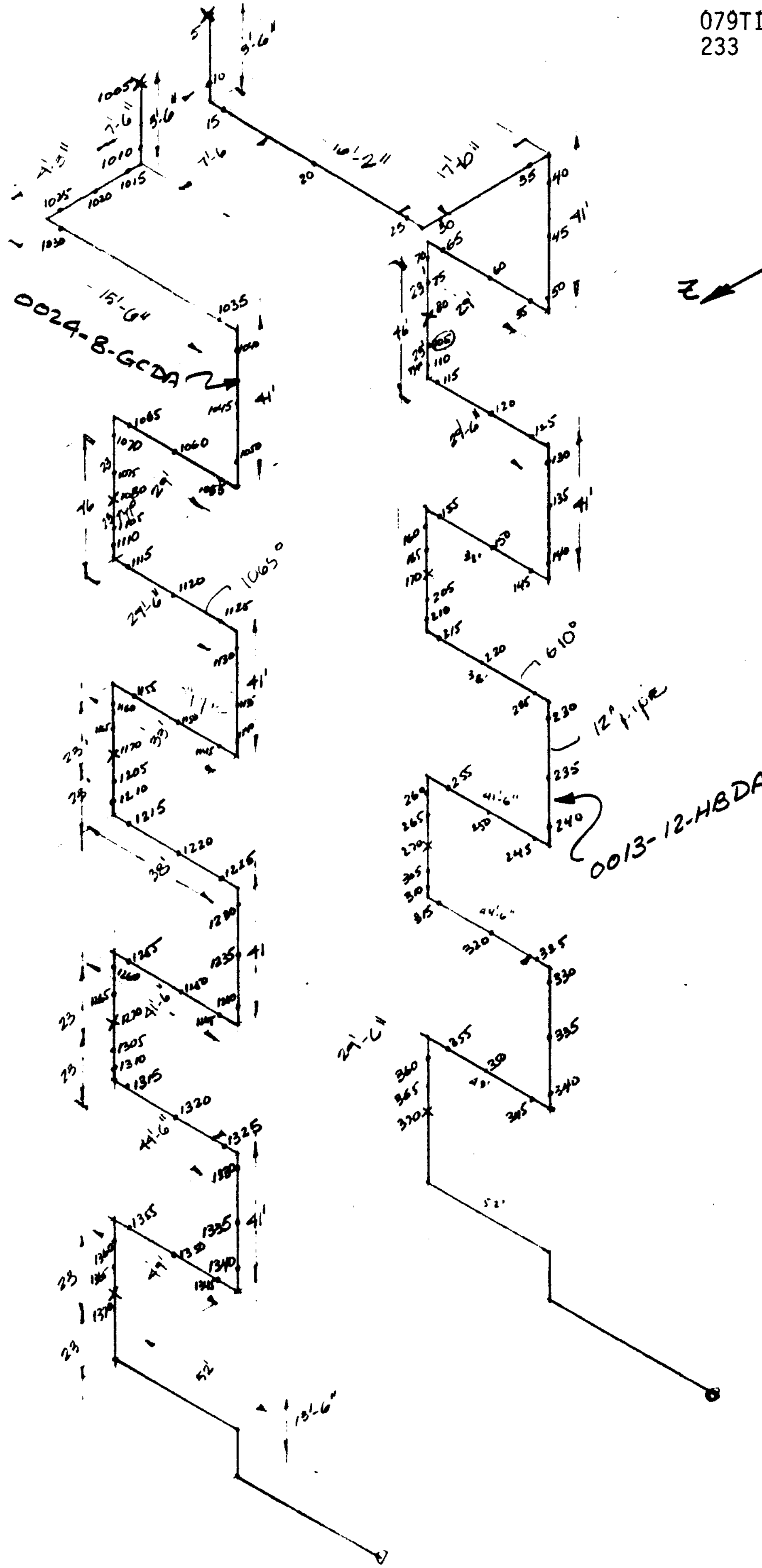
ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

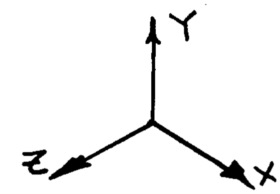
MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
ELBOW	6430	2.267	384.	384.	23412.	23797.
	6431	2.267	384.	384.	20390.	20774.
RUN	6431	1.000	384.	384.	8996.	9380.
	6450	1.000	384.	384.	8201.	8585.
ELBOW	6450	2.267	384.	384.	18588.	18972.
	6451	2.267	384.	384.	21655.	22039.
RUN	6451	1.000	384.	384.	9554.	9938.
	6460	1.000	384.	384.	7308.	7693.
ELBOW	6460	2.267	384.	384.	16565.	16950.
	6461	2.267	384.	384.	13990.	14375.
RUN	6461	1.000	384.	384.	6172.	6557.
	6465	1.000	384.	384.	7885.	8269.

079TI000008
231

APPENDIX 6.6
INPUT AND OUTPUT DATA FOR SODIUM PIPING IN TOWER

079TI000008
233





PREPARED BY: KCS	Rockwell International Energy Systems Group	234 PAGE NO. OF
CHECKED BY:		079TI000008 REPORT NO.
DATE: 4-18-83		MODEL NO.

TABLE B-1

INPUT DATA

SYSTEM	Tower Piping	REFERENCE		
		NO.	REV.	PAGE
Line Number	0013-12-HBDA			
Design Temperature	610° F			
Design Pressure	65 psi			
Normal Operating Temperature	610° F			
Normal operating Pressure	65 psi			
Pipe O.D. ×/schedule	12.75"/Sch 40			
Pipe Thickness ×	.375"			
Pipe Material	CS			
Insulation Type	-			
Weight of Pipe Lbs/Ft	49.56			
weight of contents Lbs/ft	$.9 \times 49 = 44.1$			
Weight of Insulation Lbs/ft	$\frac{\pi}{4}(24.75^2 - 12.75^2)\ 14/144 = 34.4$			
Total Weight × Lbs/ft	128.5			
E_c ×	27.9×10^6 psi			
Seismic Category	I			

TABLE B-1
INPUT DATA

SYSTEM	Tower Piping	REFERENCE		
		NO.	REV.	PAGE
Line Number	0024-8-GCDA			
Design Temperature	1100°F			
Design Pressure	65 psi			
Normal operating Temperature	1055°F			
Normal operating Pressure	65 psi			
Pipe O.D.×/schedule	8.625"/sch. 40			
Pipe Thickness ×	.322"			
Pipe Material	SS 304			
Insulation Type	–			
Weight of Pipe LBS/Ft	28.55			
Weight of contents Lbs/ft	.9 × 21.69 = 19.5			
Weight of Insulation Lbs/ft	–			
Total Weight × Lbs/ft	48.1			
E_e ×	28.3			
Seismic Category	I			

```
IAT6140 JOB ORIGIN FROM GROUP=RM206    , DSP=IJP, DEVICE=INTRDR   , 000
09:49:15 IAT4401  LOCATE FOR STEP=A         DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
09:49:15 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
09:49:15 IAT4401  LOCATE FOR STEP=G         DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
09:49:15 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
09:49:15 IAT4401  LOCATE FOR STEP=G         DD=FT15F001 DSN=$WW232.CARRIZO.RISER.CS610.DATA
09:49:15 IAT4402 UNIT=3350     ,VOL(S)=AVTSOA
09:49:15 IAT4401  LOCATE FOR STEP=G         DD=FT69F001 DSN=$WW049.ROCKPIPE.USERS
09:49:15 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
09:49:15 IAT4401  LOCATE FOR STEP=ELTEMP    DD=STEPLIB  DSN=$WW049.ELTEMP.LOAD
09:49:15 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
09:49:16 USES :     CVTSOK  01 043546 D $WW049.NUPIPE.LOAD
09:49:16 USES       AVTSOA  01 043546 D $WW232.CARRIZO.RISER.CS610.DATA
09:49:38 IAT5200 JOB 0890 ($WW232A2) IN SETUP ON MAIN=I        P=03 LOCAL
09:49:38 IAT5210 J=0890 STEPLIB  USING D CVTSOK ON 528   $WW049.NUPIPE.LOAD
09:49:38 IAT5210 J=0890 FT15F001 USING D AVTSOA ON 520   $WW232.CARRIZO.RISER.CS610.DATA
09:51:07 IAT2000 JOB 0890 $WW232A2 SELECTED I        GRP=BIG
09:51:09 I R= $WW232A2 NEF995I $WW232A2 STARTED, 4/18/83,09.51.29 ASID=00017
09:51:09 I R= $WW232A2 IEF403I $WW232A2 - STARTED - TIME=09.51.29
09:51:39 I R= $WW232A2 +IH0002I STOP      1
09:51:40 I R= $WW232A2 IEF404I $WW232A2 - ENDED - TIME=09.52.00
09:51:40 I R= $WW232A2 NEF996I $WW232A2 ENDED,  4/18/83,B.U.=      .7241 *0716935   ,3081-I3,JOB CC= 001
09:51:41 IAT5400 JOB 0890 ($WW232A2) IN BREAKDOWN
/$WW232A2 JOB 'GURSAHANI LB30130340*0716935        005  5001003037', *
/ REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
/*MAIN ORG=RM005,SYSTEM=/C                                         00000300
/ EXEC ROCKPIPE,PROG=SMALL
/G.SYSIN DD DSN=$WW232.CARRIZO.RISER.CS610.DATA,DISP=SHR
```

O R I G I N A L   I N P U T   B Y   GURSAHANI   O N   04/18/83   A T   09:51:37   W I T H   P R I O R I T Y   3

CARRIZO 12" CS DOWNCOMER								1
CONTROL			2.0					2
FLEXAN	1	1	2.0					3
THERMAL AT DESIGN TEMPERATURE								4
XSECTN		1	12.75	0.375	128.5	27.9	65.	5
OPVAL 610	1	1	25.61	.04702			65.	6
ANCHOR		5						7
RUN	5	10		-3.5		1.0	1.0	8
ELBOW	- 10	15						9
RUN	15	20	8.0					10
RUN	20	25	8.167					11
ELBOW	- 25	30						12
RUN	30	35			-17.833			13
ELBOW	- 35	40						14
RUN	40	45		-20.5				15
RUN	45	50		-20.5				16
ELBOW	- 50	55						17
RUN	55	60	-14.5					18
RUN	60	65	-14.5					19
ELBOW	- 65	70						20
RUN	70	75		-11.5				21
RUN	75	80		-11.5				22
ANCHOR		80	-12.833	-67.5	-17.833			23
RUN	80	105		-11.5				24
RUN	105	110		-11.5				25
ELBOW	- 110	115						26
RUN	115	120	14.75					27
RUN	120	125	14.75					28
ELBOW	- 125	130						29
RUN	130	135		-20.5				30
RUN	135	140		-20.5				31
ELBOW	- 140	145						32
RUN	145	150	-16.5					33
RUN	150	155	-16.5					34
ELBOW	- 155	160						35
RUN	160	165		-11.5				36
RUN	165	170		-11.5				37
ANCHOR		170	-16.333	-154.5	-17.833			38
RUN	170	205		-11.5				39
RUN	205	210		-11.5				40
ELBOW	- 210	215						41
RUN	215	220	19.0					42
RUN	220	225	19.0					43
ELBOW	- 225	230						44
RUN	230	235		-20.5				45
RUN	235	240		-20.5				46
ELBOW	- 240	245						47
RUN	245	250	-20.75					48
RUN	250	255	-20.75					49
ELBOW	- 255	260						50
RUN	260	265		-11.5				51
RUN	265	270		-11.5				52
ANCHOR		270	-19.833	-241.5	-17.833			53
RUN	270	305		-11.5				54
RUN	305	310		-11.5				55
ELBOW	- 310	315						56
RUN	315	320	22.25					57
RUN	320	325	22.25					58
ELBOW	- 325	330						59

RUN	330	335		-20.5		60
RUN	335	340		-20.5		61
ELBOW	- 340	345				62
RUN	345	350	-24.5			63
RUN	350	355	-24.5			64
ELBOW	- 355	360				65
RUN	360	365		-11.5		66
RUN	365	370		-11.5		67
ANCHOR		370	-24.333	-328.5	-17.833	68
STRESS7						69
10CASES	1					70
ALLDONE						71

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	5	1.000	553.	553.	2554.	3107.
	10	1.000	553.	553.	2511.	3063.
ELBOW	10	2.864	553.	553.	7191.	7744.
	15	2.864	553.	553.	6557.	7109.
RUN	15	1.000	553.	553.	2289.	2842.
	20	1.000	553.	553.	1582.	2134.
RUN	20	1.000	553.	553.	1582.	2134.
	25	1.000	553.	553.	1335.	1888.
ELBOW	25	2.864	553.	553.	3825.	4377.
	30	2.864	553.	553.	3338.	3890.
RUN	30	1.000	553.	553.	1165.	1718.
	35	1.000	553.	553.	1363.	1916.
ELBOW	35	2.864	553.	553.	3905.	4457.
	40	2.864	553.	553.	4474.	5026.
RUN	40	1.000	553.	553.	1562.	2115.
	45	1.000	553.	553.	1676.	2228.
RUN	45	1.000	553.	553.	1676.	2228.
	50	1.000	553.	553.	2374.	2926.
ELBOW	50	2.864	553.	553.	6799.	7351.
	55	2.864	553.	553.	6331.	6884.
RUN	55	1.000	553.	553.	2211.	2763.
	60	1.000	553.	553.	212.	764.
RUN	60	1.000	553.	553.	212.	764.
	65	1.000	553.	553.	1803.	2355.
ELBOW	65	2.864	553.	553.	5163.	5716.
	70	2.864	553.	553.	5637.	6189.
RUN	70	1.000	553.	553.	1968.	2521.
	75	1.000	553.	553.	1582.	2135.

0791I000008
239

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	75	1.000	553.	553.	1582.	2135.
	80	1.000	553.	553.	1330.	1882.
RUN	80	1.000	553.	553.	1816.	2368.
	105	1.000	553.	553.	1738.	2290.
RUN	105	1.000	553.	553.	1738.	2290.
	110	1.000	553.	553.	1670.	2223.
ELBOW	110	2.864	553.	553.	4783.	5336.
	115	2.864	553.	553.	4271.	4824.
RUN	115	1.000	553.	553.	1491.	2044.
	120	1.000	553.	553.	2.	555.
RUN	120	1.000	553.	553.	2.	555.
	125	1.000	553.	553.	1487.	2039.
ELBOW	125	2.864	553.	553.	4258.	4810.
	130	2.864	553.	553.	4769.	5322.
RUN	130	1.000	553.	553.	1665.	2218.
	135	1.000	553.	553.	1794.	2347.
RUN	135	1.000	553.	553.	1794.	2347.
	140	1.000	553.	553.	1923.	2475.
ELBOW	140	2.864	553.	553.	5507.	6060.
	145	2.864	553.	553.	5054.	5606.
RUN	145	1.000	553.	553.	1765.	2317.
	150	1.000	553.	553.	79.	631.
RUN	150	1.000	553.	553.	79.	631.
	155	1.000	553.	553.	1607.	2159.
ELBOW	155	2.864	553.	553.	4602.	5154.
	160	2.864	553.	553.	5055.	5608.
RUN	160	1.000	553.	553.	1765.	2318.
	165	1.000	553.	553.	1697.	2250.

079T000008
240

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	165	1.000	553.	553.	1697.	2250.
	170	1.000	553.	553.	1619.	2172.
RUN	170	1.000	553.	553.	1389.	1941.
	205	1.000	553.	553.	1336.	1888.
RUN	205	1.000	553.	553.	1336.	1888.
	210	1.000	553.	553.	1289.	1842.
ELBOW	210	2.864	553.	553.	3692.	4245.
	215	2.864	553.	553.	3385.	3937.
RUN	215	1.000	553.	553.	1182.	1734.
	220	1.000	553.	553.	9.	562.
RUN	220	1.000	553.	553.	9.	562.
	225	1.000	553.	553.	1163.	1715.
ELBOW	225	2.864	553.	553.	3331.	3883.
	230	2.864	553.	553.	3638.	4191.
RUN	230	1.000	553.	553.	1270.	1823.
	235	1.000	553.	553.	1358.	1911.
RUN	235	1.000	553.	553.	1358.	1911.
	240	1.000	553.	553.	1446.	1999.
ELBOW	240	2.864	553.	553.	4142.	4695.
	245	2.864	553.	553.	3874.	4427.
RUN	245	1.000	553.	553.	1353.	1905.
	250	1.000	553.	553.	63.	616.
RUN	250	1.000	553.	553.	63.	616.
	255	1.000	553.	553.	1226.	1779.
ELBOW	255	2.864	553.	553.	3512.	4065.
	260	2.864	553.	553.	3780.	4333.
RUN	260	1.000	553.	553.	1320.	1872.
	265	1.000	553.	553.	1274.	1826.

079TI000008
241

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	265	1.000	553.	553.	1274.	1826.
	270	1.000	553.	553.	1220.	1773.
RUN	270	1.000	553.	553.	1180.	1732.
	305	1.000	553.	553.	1126.	1678.
RUN	305	1.000	553.	553.	1126.	1678.
	310	1.000	553.	553.	1078.	1631.
ELBOW	310	2.864	553.	553.	3089.	3641.
	315	2.864	553.	553.	2866.	3418.
RUN	315	1.000	553.	553.	1001.	1553.
	320	1.000	553.	553.	23.	575.
RUN	320	1.000	553.	553.	23.	575.
	325	1.000	553.	553.	955.	1508.
ELBOW	325	2.864	553.	553.	2735.	3288.
	330	2.864	553.	553.	2958.	3510.
RUN	330	1.000	553.	553.	1033.	1585.
	335	1.000	553.	553.	1122.	1675.
RUN	335	1.000	553.	553.	1122.	1675.
	340	1.000	553.	553.	1212.	1764.
ELBOW	340	2.864	553.	553.	3470.	4023.
	345	2.864	553.	553.	3288.	3841.
RUN	345	1.000	553.	553.	1148.	1701.
	350	1.000	553.	553.	64.	617.
RUN	350	1.000	553.	553.	64.	617.
	355	1.000	553.	553.	1020.	1572.
ELBOW	355	2.864	553.	553.	2920.	3473.
	360	2.864	553.	553.	3103.	3655.
RUN	360	1.000	553.	553.	1083.	1636.
	365	1.000	553.	553.	1036.	1589.

FORM 1 EW 7-82

This page left intentionally blank

This page left intentionally blank

This page left intentionally blank

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	365	1.000	553.	553.	1036.	1589.
	370	1.000	553.	553.	982.	1535.

079TI00008
246

```
SUMMARY OF ERRORS FOR THIS JOB   ERROR NUMBER   NUMBER OF ERRORS

                                         208              22
IAT6140 JOB ORIGIN FROM GROUP=RM206    , DSP=IJP, DEVICE=INTRDR  , 000
10:50:07 IAT4401  LOCATE FOR STEP=A        DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
10:50:07 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
10:50:07 IAT4401  LOCATE FOR STEP=G        DD=STEPLIB  DSN=$WW049.NUPIPE.LOAD
10:50:07 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
10:50:07 IAT4401  LOCATE FOR STEP=G        DD=FT15F001 DSN=$WW232.CARRIZO.RISER.SS1100.DATA
10:50:07 IAT4402 UNIT=3350     ,VOL(S)=AVTSOA
10:50:07 IAT4401  LOCATE FOR STEP=G        DD=FT69F001 DSN=$WW049.ROCKPIPE.USERS
10:50:07 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
10:50:07 IAT4401  LOCATE FOR STEP=ELTEMP   DD=STEPLIB  DSN=$WW049.ELTEMP.LOAD
10:50:07 IAT4402 UNIT=3350     ,VOL(S)=CVTSOK
10:50:07 USES     CVTSOK             D $WW049.NUPIPE.LOAD
10:50:07 USES     AVTSOA             D $WW232.CARRIZO.RISER.SS1100.DATA
10:50:07 IAT5200 JOB 2315 ($WW232C1) IN SETUP ON MAIN=I        P=03 LOCAL
10:50:07 IAT5210 J=2315 STEPLIB  USING D CVTSOK ON 528   $WW049.NUPIPE.LOAD
10:50:07 IAT5210 J=2315 FT15F001 USING D AVTSOA ON 520   $WW232.CARRIZO.RISER.SS1100.DATA
10:50:10 IAT2000 JOB 2315 $WW232C1 SELECTED I        GRP=BIG
10:50:11 I R= $WW232C1 NEF995I $WW232C1 STARTED, 4/18/83,10.50.31 ASID=00007
10:50:11 I R= $WW232C1 IEF403I $WW232C1 - STARTED - TIME=10.50.31
10:50:49 I R= $WW232C1 +IH0002I STOP      1
10:50:50 I R= $WW232C1 IEF404I $WW232C1 - ENDED - TIME=10.51.10
10:50:50 I R= $WW232C1 NEF996I $WW232C1 ENDED,  4/18/83,B.U.=     .7319 *07,16935   ,3081-I3,JOB CC= 001
10:50:50 IAT5400 JOB 2315 ($WW232C1) IN BREAKDOWN
/$WW232C1 JOB 'GURSAHANI LB30130340*0716935        005  5001003037', *
/ REGION=4500K,TIME=4,MSGCLASS=T,MSGLEVEL=1,NOTIFY=$WW232
/*MAIN ORG=RM005,SYSTEM=/C                                          00000300
/ EXEC ROCKPIPE,PROG=SMALL
/G.SYSIN DD DSN=$WW232.CARRIZO.RISER.SS1100.DATA,DISP=SHR
```

FORM 126-P-130 NEW 7-82

079TI000008
247

```
O R I G I N A L   I N P U T   B Y   GURSAHANI   O N  04/18/83  A T   10:50:48  W I T H  P R I O R I T Y  3
CARRIZO  8" SS DOWNCOMER
CONTROL                   2.0
FLEXAN         1    1      2.0
 THERMAL AT DESIGN TEMPERATURE
XSECTN              1  8.625     0.322      48.1       28.3        65.
OPVAL1100      1    1  21.8      .1284                             65.
ANCHOR              1005
RUN          1005 1010            -3.5                 1.0      1.0
ELBOW       -1010 1015
RUN          1015 1020                      2.0
RUN          1020 1025                      2.25
ELBOW       -1025 1030
RUN          1030 1035  15.5
ELBOW       -1035 1040
RUN          1040 1045           -20.5
RUN          1045 1050           -20.5
ELBOW       -1050 1055
RUN          1055 1060 -14.5
RUN          1060 1065 -14.5
ELBOW       -1065 1070
RUN          1070 1075           -11.5
RUN          1075 1080           -11.5
ANCHOR            1080
RUN          1080 1105           -11.5
RUN          1105 1110           -11.5
ELBOW       -1110 1115
RUN          1115 1120  14.75
RUN          1120 1125  14.75
ELBOW       -1125 1130
RUN          1130 1135           -20.5
RUN          1135 1140           -20.5
ELBOW       -1140 1145
RUN          1145 1150 -16.5
RUN          1150 1155 -16.5
ELBOW       -1155 1160
RUN          1160 1165           -11.5
RUN          1165 1170           -11.5
ANCHOR            1170
RUN          1170 1205           -11.5
RUN          1205 1210           -11.5
ELBOW       -1210 1215
RUN          1215 1220   19.0
RUN          1220 1225   19.0
ELBOW       -1225 1230
RUN          1230 1235           -20.5
RUN          1235 1240           -20.5
ELBOW       -1240 1245
RUN          1245 1250 -20.75
RUN          1250 1255 -20.75
ELBOW       -1255 1260
RUN          1260 1265           -11.5
RUN          1265 1270           -11.5
ANCHOR            1270
RUN          1270 1305           -11.5
RUN          1305 1310           -11.5
ELBOW       -1310 1315
RUN          1315 1320  22.25
RUN          1320 1325  22.25
ELBOW       -1325 1330
```

FORM 121 V 7-82

RUN	1330	1335		-20.5	60
RUN	1335	1340		-20.5	61
ELBOW	-1340	1345			62
RUN	1345	1350	-24.5		63
RUN	1350	1355	-24.5		64
ELBOW	-1355	1360			65
RUN	1360	1365		-11.5	66
RUN	1365	1370		-11.5	67
ANCHOR		1370			68
STRESS7					69
10CASES	1				70
ALLDONE					71

079TI000008
249

FORM 126-P-130 NEW 7-82

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	1005	1.000	435.	435.	6509.	6945.
	1010	1.000	435.	435.	6148.	6583.
ELBOW	1010	2.440	435.	435.	15000.	15436.
	1015	2.440	435.	435.	14429.	14865.
RUN	1015	1.000	435.	435.	5914.	6349.
	1020	1.000	435.	435.	5864.	6299.
RUN	1020	1.000	435.	435.	5864.	6299.
	1025	1.000	435.	435.	5859.	6294.
ELBOW	1025	2.440	435.	435.	14296.	14731.
	1030	2.440	435.	435.	13267.	13702.
RUN	1030	1.000	435.	435.	5438.	5873.
	1035	1.000	435.	435.	1273.	1708.
ELBOW	1035	2.440	435.	435.	3106.	3541.
	1040	2.440	435.	435.	4345.	4780.
RUN	1040	1.000	435.	435.	1781.	2216.
	1045	1.000	435.	435.	4553.	4988.
RUN	1045	1.000	435.	435.	4553.	4988.
	1050	1.000	435.	435.	7479.	7914.
ELBOW	1050	2.440	435.	435.	18249.	18684.
	1055	2.440	435.	435.	17472.	17907.
RUN	1055	1.000	435.	435.	7161.	7596.
	1060	1.000	435.	435.	826.	1261.
RUN	1060	1.000	435.	435.	826.	1261.
	1065	1.000	435.	435.	5517.	5952.
ELBOW	1065	2.440	435.	435.	13461.	13896.
	1070	2.440	435.	435.	14238.	14673.
RUN	1070	1.000	435.	435.	5835.	6271.
	1075	1.000	435.	435.	4253.	4688.

0791I000008
250

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	1075	1.000	435.	435.	4253.	4688.
	1080	1.000	435.	435.	2544.	2979.
RUN	1080	1.000	435.	435.	4159.	4594.
	1105	1.000	435.	435.	3981.	4417.
RUN	1105	1.000	435.	435.	3981.	4417.
	1110	1.000	435.	435.	3820.	4255.
ELBOW	1110	2.440	435.	435.	9319.	9755.
	1115	2.440	435.	435.	8650.	9085.
RUN	1115	1.000	435.	435.	3545.	3980.
	1120	1.000	435.	435.	17.	452.
RUN	1120	1.000	435.	435.	17.	452.
	1125	1.000	435.	435.	3579.	4014.
ELBOW	1125	2.440	435.	435.	8733.	9168.
	1130	2.440	435.	435.	9402.	9837.
RUN	1130	1.000	435.	435.	3854.	4289.
	1135	1.000	435.	435.	4154.	4589.
RUN	1135	1.000	435.	435.	4154.	4589.
	1140	1.000	435.	435.	4454.	4890.
ELBOW	1140	2.440	435.	435.	10868.	11304.
	1145	2.440	435.	435.	10274.	10709.
RUN	1145	1.000	435.	435.	4211.	4646.
	1150	1.000	435.	435.	195.	631.
RUN	1150	1.000	435.	435.	195.	631.
	1155	1.000	435.	435.	3820.	4255.
ELBOW	1155	2.440	435.	435.	9321.	9756.
	1160	2.440	435.	435.	9915.	10350.
RUN	1160	1.000	435.	435.	4064.	4499.
	1165	1.000	435.	435.	3902.	4337.

0791000008
251

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	1165	1.000	435.	435.	3902.	4337.
	1170	1.000	435.	435.	3725.	4160.
RUN	1170	1.000	435.	435.	3167.	3602.
	1205	1.000	435.	435.	3047.	3482.
RUN	1205	1.000	435.	435.	3047.	3482.
	1210	1.000	435.	435.	2938.	3373.
ELBOW	1210	2.440	435.	435.	7168.	7603.
	1215	2.440	435.	435.	6768.	7203.
RUN	1215	1.000	435.	435.	2774.	3209.
	1220	1.000	435.	435.	5.	440.
RUN	1220	1.000	435.	435.	5.	440.
	1225	1.000	435.	435.	2763.	3199.
ELBOW	1225	2.440	435.	435.	6742.	7178.
	1230	2.440	435.	435.	7143.	7578.
RUN	1230	1.000	435.	435.	2928.	3363.
	1235	1.000	435.	435.	3130.	3566.
RUN	1235	1.000	435.	435.	3130.	3566.
	1240	1.000	435.	435.	3333.	3768.
ELBOW	1240	2.440	435.	435.	8132.	8567.
	1245	2.440	435.	435.	7782.	8217.
RUN	1245	1.000	435.	435.	3189.	3625.
	1250	1.000	435.	435.	152.	587.
RUN	1250	1.000	435.	435.	152.	587.
	1255	1.000	435.	435.	2886.	3321.
ELBOW	1255	2.440	435.	435.	7041.	7477.
	1260	2.440	435.	435.	7391.	7827.
RUN	1260	1.000	435.	435.	3029.	3465.
	1265	1.000	435.	435.	2920.	3355.

079TI000008
252

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	1265	1.000	435.	435.	2920.	3355.
	1270	1.000	435.	435.	2801.	3236.
RUN	1270	1.000	435.	435.	2676.	3111.
	1305	1.000	435.	435.	2556.	2991.
RUN	1305	1.000	435.	435.	2556.	2991.
	1310	1.000	435.	435.	2446.	2881.
ELBOW	1310	2.440	435.	435.	5968.	6403.
	1315	2.440	435.	435.	5679.	6114.
RUN	1315	1.000	485.	435.	2328.	2763.
	1320	1.000	435.	435.	37.	473.
RUN	1320	1.000	435.	435.	37.	473.
	1325	1.000	435.	435.	2253.	2688.
ELBOW	1325	2.440	435.	435.	5496.	5932.
	1330	2.440	435.	435.	5785.	6220.
RUN	1330	1.000	435.	435.	2371.	2806.
	1335	1.000	435.	435.	2575.	3010.
RUN	1335	1.000	435.	435.	2575.	3010.
	1340	1.000	435.	435.	2779.	3214.
ELBOW	1340	2.440	435.	435.	6780.	7215.
	1345	2.440	435.	435.	6542.	6978.
RUN	1345	1.000	435.	435.	2681.	3117.
	1350	1.000	435.	435.	149.	584.
RUN	1350	1.000	435.	435.	149.	584.
	1355	1.000	435.	435.	2384.	2819.
ELBOW	1355	2.440	435.	435.	5816.	6252.
	1360	2.440	435.	435.	6054.	6489.
RUN	1360	1.000	435.	435.	2481.	2916.
	1365	1.000	435.	435.	2371.	2807.

079T100008
253

ASME SECTION III CLASS 2 OR ANSI B31.1.B STRESS SUMMARY

MEMBER	NODE	STRESS INTENSIF FACTOR	SUSTAINED STRESS EQ.8 PSI	OCCASIONAL STRESS EQ.9 PSI	EXPANSION STRESS EQ.10 PSI	SUSTAINED PLUS EXPANSION STRESS EQ.11 PSI
RUN	1365	1.000	435.	435.	2371.	2807.
	1370	1.000	435.	435.	2251.	2686.

079TI000008
254

TABLE OF CONTENTS

BY: GURSAHANI CPU SECONDS USED: 1.713 PRIORITY: 3

ON MAIN: 04/18/83 AT 10:50:48 OFF MAIN: 04/18/83 AT 10:51:01

079TI000008
255