OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
CALCULATION COVER SHEET

1. QA: QA

2. Calculation Title
Horizontal Drop of the Naval SNF Long Waste Package on Unyielding Surface

3. Document Identifier (including Revision Number)
CAL-VDC-ME-000003 REV 00

4. Total Attachments
3

5. Attachment Numbers - Number of pages in each
I-2, II-1, III-10

	Print Name	Signature	Date
6. Originator	Timothy Schmitt	Tim Schmitt	5/19/00
7. Checker	Zekai Ceylan	Zekai Ceylan	5/19/00
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9. Remarks

Revision History

10. Revision No.	11. Description of Revision
00	Initial Issue

CONTENTS

1. PURPOSE

The objective of this calculation is to determine the structural response of a Naval Spent Nuclear Fuel (SNF) Long Waste Package (WP) subjected to a 2.4-*m* horizontal drop on an unyielding surface (US). The scope of this document is limited to reporting the calculation results in terms of maximum stress intensities. This calculation is associated with the waste package design and was performed by the Waste Package Design section in accordance with the development plan for *Horizontal Drop of the Naval SNF Long Waste Package on Unyielding Surface* (See Ref. 15). AP-3.12Q, Revision 0, ICN 1, *Calculations*, was used to perform the calculation and develop the document.

2. METHOD

The finite element calculation was performed by using the commercially available ANSYS Version (V) 5.4 and LS-DYNA finite element code. The result of this calculation is provided in terms of maximum stress intensities. The control of the electronic management of data was accomplished in accordance with AP-SV.1Q, Revision 0, ICN 1.

3. ASSUMPTIONS

In the course of developing this document, the following assumptions were made regarding the WP structural calculations.

3.1 Some of the temperature-dependent material properties are not available for SB-575 N06022 (Alloy 22) and SA-240 S31600 (316NG [nuclear grade] stainless steel [SS]). Therefore, room-temperature (20 °*C*) material properties were assumed for all materials. The impact of using room-temperature material properties was anticipated to be small. The rationale for this assumption is that the mechanical properties of these materials do not change significantly at the temperatures experienced during handling and lifting operations. This assumption was used in Section 5.1.

3.2 Some of the rate-dependent material properties are not available for the materials used. Therefore, the material properties obtained under the static loading conditions were assumed for all materials. In general, this is a conservative assumption. In this case, the impact of using material properties obtained under static loading conditions was anticipated to be small. The rationale for this assumption is that the mechanical properties of subject materials do not significantly change at the peak strain rates in the course of the 2.4-*m* horizontal drop. This assumption was used in Section 5.1.

3.3 The Poisson's ratio of Alloy 22 is not available in literature. Therefore, the Poisson's ratio of Alloy 625 (SB-443 N06625) was assumed for Alloy 22. The impact of this assumption was anticipated to be negligible. The rationale for this assumption is that the chemical compositions of Alloy 22 and Alloy 625 are similar (see Ref. 4 and Ref. 1, respectively). This assumption was used in Section 5.1.

3.4 The target surface was conservatively assumed to be essentially unyielding with a large elastic modulus for the target surface compared to the waste package. The rationale for this assumption is that a bounding set of results is required in terms of stresses, and it is known that the use of an essentially unyielding surface with high stiffness ensures slightly higher stresses in the WP. This assumption was used in Section 5.5.

3.5 The exact geometry of the Naval SNF canister is simplified for the purpose of this calculation in such a way that its total mass, 44452 kg (see Section 5.3), is assumed to be distributed within a cylinder with uniform mass density. This assumption slightly increases the bending moment acting on the weld joining the lower inner shell lid and the inner shell. The rationale for this conservative assumption is to provide the set of bounding results, while simplifying the finite element representation (FER). This assumption is used in Section 5.5.

4. USE OF COMPUTER SOFTWARE AND MODELS

4.1 SOFTWARE

One of the finite element analysis (FEA) computer codes used for this calculation is ANSYS V5.4, which was obtained from Software Configuration Management in accordance with appropriate procedures, and is identified by the Computer Software Configuration Item (CSCI) 30040 V5.4. ANSYS V5.4 is a commercially available finite element analysis code and is appropriate for structural calculations of waste packages as performed in this calculation. The calculation using the ANSYS V5.4 software was executed on the Hewlett-Packard (HP) workstation identified with CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor) tag number 111504. The software qualification of the ANSYS V5.4 software was summarized in the Software Qualification Report for ANSYS V5.4 (Ref. 6). Qualification of ANSYS V5.4 on the Waste Package Operations (WPO) HP UNIX workstations was documented in Reference 8. The ANSYS evaluation performed for this calculation is fully within the range of the validation performed for the ANSYS V5.4 code. Access to the code was granted by the Software Configuration Secretariat in accordance with the appropriate procedures.

The input files and output files for ANSYS V5.4 (included in Nahzdp_b.old) are provided in Reference 13.

The second FEA computer code, used for this calculation is Livermore Software Technology Corporation (LSTC) LS-DYNA Version 940, which is unqualified software (see Ref. 14). The interim use of LS-DYNA Version 940 (SAN: LV-2000-095, STN: 10291-940-00) in support of the site recommendation is delineated in *Software Management*, AP-SI.1Q, Revision 2, ICN 4, Section 5.11. LS-DYNA Version 940 qualification is being performed as part of the qualification of ANSYS V5.6 since LS-DYNA Version 940 is available both as a component (module) of ANSYS and as a separate finite element code. Currently, Waste Package Department licensed LS-DYNA version 940 directly from LSTC. Software Activity Plan (SAP) for ANSYS V5.6, SDN: 10145-SAP-5.6-00, SAN: LV-1999-124, identifies the intended use of LS-DYNA Version 940 prior to qualification. LS-DYNA Version 940 was obtained from the Configuration Management. LS-DYNA Version 940 is appropriate for its intended use. LS-DYNA Version 940 validation is planned to be performed in accordance with AP-SI.1Q, Revision 2, ICN 4, Section 5.11. The calculations were executed on a Hewlett-Packard (HP) 9000 series workstation (CRWMS M&O tag number 115288).

The input files (identified by .k and .inc extensions) and output files (Dropout and d3hsp) for LS-DYNA Version 940 are provided in Reference 13.

4.2 SOFTWARE ROUTINES

None used.

4.3 MODELS

None used.

5. CALCULATION

5.1 MATERIAL PROPERTIES

Material properties used in this calculation are listed in this section. Some of the temperature-dependent and rate-dependent material properties were not available for Alloy 22 and 316NG SS. Therefore, room-temperature material properties obtained under the static loading conditions were used in this calculation (Assumptions 3.1 and 3.2).

SB-575 N06022 (ASTM B 575) (Alloy 22) (Outer shell, outer shell lids, extended outer shell lid base, outer shell lifting features, upper and lower trunnion collar sleeves, and inner shell support ring):

- Density = 8690 kg/m^3 (0.314 lb/in^3) (Ref. 4, p. 2)
- Yield strength = 310 *MPa* (45 *ksi*) (Ref. 4, Table 4)
- Tensile strength = 690 *MPa* (100 *ksi*) (Ref. 4, Table 4)
- Elongation = 0.45 (Ref. 4, Table 4)
- Poisson's ratio = 0.278 (Ref. 1, p. 143; see Assumption 3.3)
- Modulus of elasticity = 206 *GPa* ($29.9 \cdot 10^6$ *psi*) (Ref. 9, p. 14)

SA-240 S31600 (316NG SS, which is 316 SS with tightened control on carbon and nitrogen content and has the same material properties as 316 SS [see Ref. 11]) (Inner shell, inner shell lids, and inner shell lifting feature):

- Density = 7980 kg/m^3 (Ref. 5, p. 7)
- Yield strength = 205 *MPa* (30 *ksi*) (Ref. 3, Table 2)
- Tensile strength = 515 *MPa* (75 *ksi*) (Ref. 3, Table 2)
- Elongation = 0.40 (Ref. 3, Table 2)

- Poisson's ratio = 0.3 (Ref. 1, Figure 15, p. 755)
- Modulus of elasticity = 195 GPa ($28.3 \cdot 10^6$ psi) (Ref. 2, Table TM-1)

5.2 CALCULATIONS FOR TANGENT MODULI

The results of this simulation are required to include elastic and plastic deformations for Alloy 22 and 316NG SS. When the materials are driven into the plastic range, the slope of stress-strain curve continuously changes. Thus, a simplification for this curve is needed to incorporate plasticity into the FER. A standard approximation commonly used in engineering is to use a straight line that connects the yield point and the ultimate tensile strength point of the material. The following parameters were used in the subsequent calculations:

S_y = yield strength
S_u = ultimate tensile strength
e_y = strain corresponding to yield strength
e_u = ultimate elongation (strain corresponding to ultimate tensile strength)
E = modulus of elasticity
E_1 = tangent modulus (slope of the stress-strain curve in the plastic region)

In the case of 316NG SS, the strain corresponding to the yield strength is:

$e_y = S_y / E = 205 \cdot 10^6 / 195 \cdot 10^9 = 1.051 \cdot 10^{-3}$ (see Section 5.1)

Hence, the tangent modulus is:

$E_1 = (S_u - S_y)/(e_u - e_y) = (0.515 - 0.205)/(0.40 - 1.051 \cdot 10^{-3}) = 0.777\,GPa$ (see Section 5.1)

Similarly, for Alloy 22:

$E_1 = (S_u - S_y)/(e_u - e_y) = (0.690 - 0.310)/(0.45 - 0.310/206) = 0.847\,GPa$ (see Section 5.1)

5.3 MASS AND GEOMETRIC DIMENSIONS OF NAVAL SNF CANISTER

This calculation was performed by using the following mass and geometric dimensions of the Naval SNF canister:

Bounding total mass $= 44452\,kg$ (49 *tons*) (Ref. 10, Enclosure 3, p. 2)
Bounding outside diameter $= 1.689\,m\ (66.5\,in)$ (Ref. 10, Enclosure 3, p. 2)
Bounding overall length $= 5.385\,m\ (212\,in)$ (Ref. 10, Enclosure 3, p. 2)

5.4 INITIAL VELOCITY OF WASTE PACKAGE

To reduce the computer execution time while preserving all features of the problem relevant to the structural calculation, the WP is given an initial velocity and set in a position just before impact. Using Newton's law:

Gravity (g) $= 9.815\frac{m}{s^2}$
Drop Height (h) $= 2.4\,m$ (Ref. 12, Section 1.2.2.1.4)
Kinetic Energy (K.E.) $= \frac{1}{2}\cdot m\cdot v^2$
Potential Energy (P.E.) $= m\cdot g\cdot h$
By conservation of energy: K.E. = P.E.

$$\frac{1}{2}\cdot m\cdot v^2 = m\cdot g\cdot h$$

$$v=\sqrt{2\cdot g\cdot h}=\sqrt{2\cdot 9.815\cdot 2.4}=6.864\ \frac{m}{s}$$

5.5 FINITE ELEMENT REPRESENTATION

A full three-dimensional (3-D) FER was developed in ANSYS V5.4 for the WP by using the dimensions provided in Attachment I. No symmetry was used to create the FER. The FER was created with the largest possible gap between the inner and outer shells, having a 4-*mm* radial gap (Ref. 7). This gap results in a slightly lower total mass of the WP than that listed in Attachment I, which shows a 0-*mm* radial gap between the inner and outer shells, but the difference is small and the impact was anticipated to be negligible. Since the WP is dropped in a horizontal orientation, the inner shell and Naval SNF canister were placed lying flat against the bottom, such that a 0-*mm* gap is at the bottom and an 8-*mm* gap is at the top (see Figure III-1). The internal structure of the WP was simplified by reducing the structure of the Naval SNF canister to a cylinder with uniform mass density (Assumption 3.5). The total mass and geometric dimensions of the canister (see Section 5.3) define the density. The benefit of using this approach was to reduce the computer execution time while preserving all features of the problem relevant to the structural calculation.

The target surface was conservatively assumed to be essentially unyielding (Assumption 3.4).

The mesh of the FER is appropriately generated and refined in the contact region according to standard engineering practice. Thus, the accuracy and representativeness of the results of this linear calculation are deemed acceptable.

The initial drop height was reduced from 2.4 *m* to 0.1 *mm*, and the WP was given an initial velocity (see Section 5.4). The benefit of using this approach was a reduction in the computer execution time while preserving all features of the problem relevant to the structural calculation.

The FER was then used in LS-DYNA Version 940 to perform the transient dynamic analysis for the Naval SNF WP horizontal drop design basis event.

6. RESULTS

This document may be affected by technical product input information that requires confirmation. Any changes to the document that may occur as a result of completing the confirmation activities will be reflected in subsequent revisions. The status of the input information quality may be confirmed by review of the Document Input Reference System database.

The results obtained from LS-DYNA are reported in terms of maximum shear stress. Since the maximum stress intensities are desired, the results must be translated. The maximum shear stress is defined as one-half the difference between principal stresses one and three. Maximum stress intensity is defined as simply the difference between principal stresses one and three. Therefore, the results obtained from LS-DYNA will be multiplied by two, to obtain the final stress intensities.

The maximum stresses were found by carefully examining each time step taken by LS-DYNA, which outputs the element with the highest magnitude of stress, at each step, for each defined part. The results show that the maximum stress intensities occur in the lower trunnion collar with a magnitude of 798 *MPa* (see Figure III-2), which exceeds the tensile strength of Alloy 22. However, the lower trunnion collar sleeve is not part of the containment barrier. It acts as an impact limiter for the containment barrier in this case. The maximum stress intensity in the outer shell has a magnitude of 694 *MPa* (see Figure III-3 and Figure III-4), which exceeds the tensile strength of Alloy 22. However, closer examination of the region in which this level of intensity occurs shows that the stresses decrease significantly along the thickness of the shell (see Figure III-5). A time history of element #3039, the element on the outer surface where the maximum stress occurs, and element #3040, the element on the inner surface immediately underneath element #3039, is given in Figure III-9. This figure shows that element #3040 has a maximum level of 580 *MPa*. This is less than the tensile strength of Alloy 22 (see Section 5.1).

The maximum stress intensity in the inner shell is 484 *MPa* (see Figure III-6 and Figure III-7). Again, closer examination of the region in which this magnitude of intensity occurs shows that the stresses decrease significantly along the thickness of the shell (see Figure III-8). A time history of the element with the highest stress and the element inside shows that the stresses are much lower (see Figure III-10). Element #6449 on the inner surface of the inner shell has a maximum stress of 430 *MPa*. This is less than the tensile strength of 316 NG SS (see Section 5.1).

7. REFERENCES

1. American Society for Metals 1980. *Properties and Selection: Stainless Steels, Tool Materials and Special-Purpose Metals.* Volume 3 of *Metals Handbook.* 9th Edition. Metals Park, Ohio: American Society for Metals. TIC: 209801.

2. ASME (American Society of Mechanical Engineers) 1995. "Materials." Section II of *1995 ASME Boiler and Pressure Vessel Code.* New York, New York: American Society of Mechanical Engineers. TIC: 245287.

3. ASTM A 240/A 240M-99. 1999. *Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 246994.

4. ASTM B 575-99a. 1999. *Standard Specification for Low-Carbon Nickel-Molybdenum-Chromium, Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Chromium-Molybdenum-Copper, Low-Carbon Nickel-Chromium-Molybdenum-Tantalum, and Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy Plate, Sheet, and Strip.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 247534.

5. ASTM G 1-90 (Reapproved 1999). 1990. *Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 238771.

6. CRWMS M&O 1998. *Software Qualification Report for ANSYS V5.4, A Finite Element Code.* CSCI: 30040 V5.4. DI: 30040-2003, Rev. 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980609.0847.

7. CRWMS M&O 2000. *Waste Package Operations Fabrication Process Report.* TDR-EBS-ND-000003 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000217.0244.

8. Doering, T.W. 1998. "Qualification of ANSYS V5.4 on the WPO HP UNIX Workstations." Interoffice correspondence from T.W. Doering (CRWMS M&O) to G. Carlisle, May 22, 1998, LV.WP.SMB.05/98-100..ACC: MOL.19980730.0147.

9. Haynes International 1997. *Hastelloy C-22 Alloy.* Kokomo, Indiana: Haynes International. TIC: 238121.

10. Naples, E.M. 1999. Thermal, Shielding, and Structural Information on the Naval Spent Nuclear Fuel (SNF) Canister. Letter from E.M. Naples (Department of the Navy) to D.C. Haught (DOE/YMSCO), August 6, 1999, with enclosures. ACC: MOL.19991001.0133.

11. Pasupathi, V. 1999. "Waste Package Structural Material." Interoffice correspondence from V. Pasupathi (CRWMS M&O) to T.W. Doering, May 7, 1999, LV.WP.VP.05/99-073. ACC: MOL.19990518.0316.

12. CRWMS M&O 1999. *Uncanistered Spent Nuclear Fuel Disposal Container System Description Document.* SDD-UDC-SE-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991217.0512.

13. CRWMS M&O 2000. *Electronic Files for Horizontal Drop of the Naval SNF Long Waste Package on Unyielding Surface.* CAL-VDC-ME-000003 REV 00. Las Vegas, NV: CRWMS M&O. ACC: MOL.20000428.0104.

14. CRWMS M&O 2000. *Software Code: LSTC LS-DYNA V940.* V940. HP 9000. 10291-940-00.

15. CRWMS M&O 2000. *Horizontal Drop of the Naval SNF Long Waste Package on Unyielding Surface.* Development Plan TDP-VDC-ME-000004 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000320.0181.

16. Guida, R.A. 1997. Size and Weight Limits for Canisters Used for Disposal of Naval Spent Nuclear Fuel. Letter from R.A. Guida (DON) to Dr. R. Dyer (DOE), October 29, 1997. ACC: MOL.19980121.0011.

8. ATTACHMENTS

Attachment I (2 pages): Design sketches (*Naval SNF Long Waste Package Configuration for Site Recommendation* [SK-0194 REV 01]; two sheets) (This attachment uses Reference 16 and Attachment II)

Attachment II (1 pages): Weld configuration sketches (*Naval SNF Long Waste Package Weld Configuration* [SK-0195 REV 00]; one sheet)

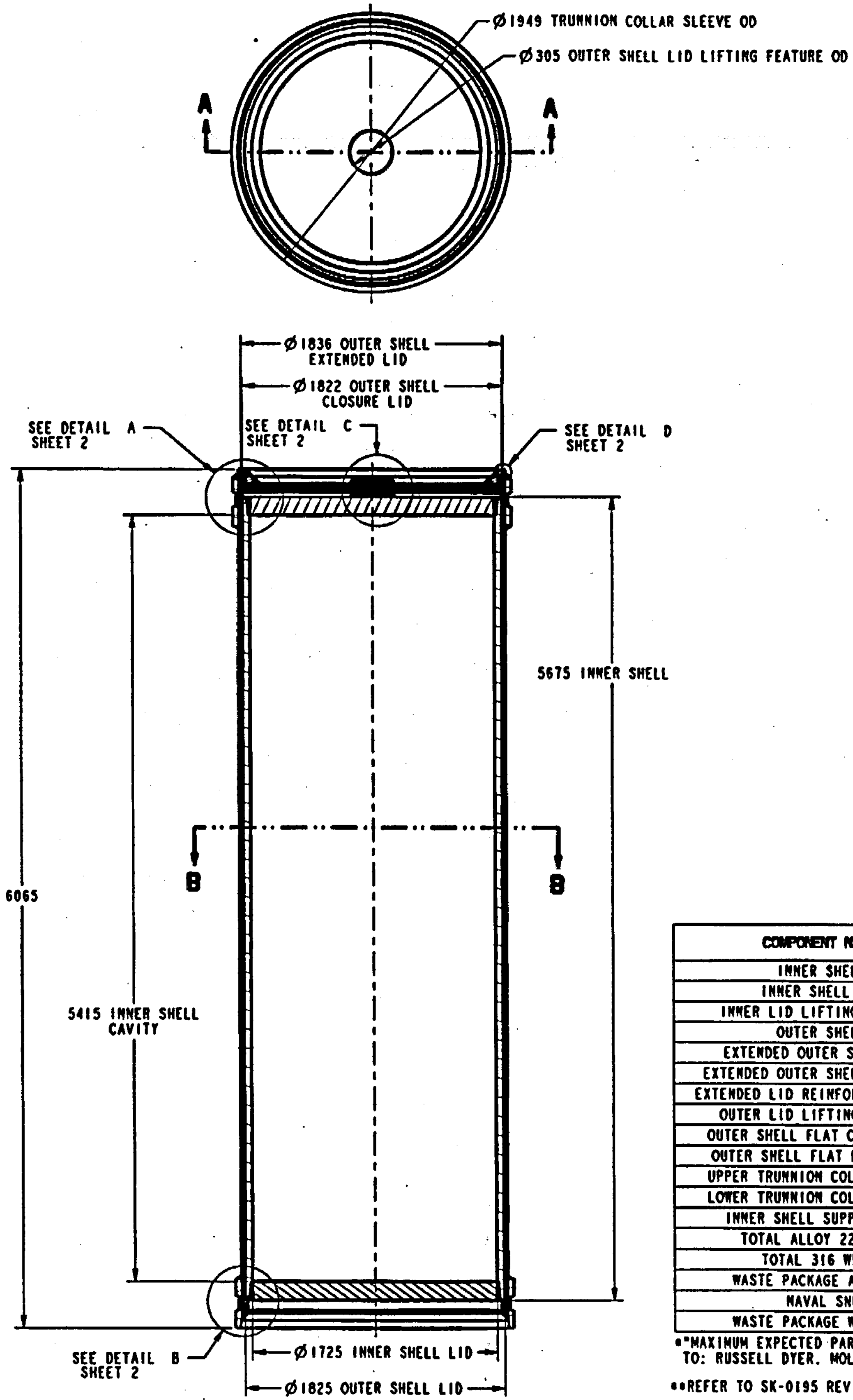
Attachment III (10 pages): Figures obtained from LS-DYNA

Table 7-1 includes the name, date, time, and size for each electronic file in Reference 13.

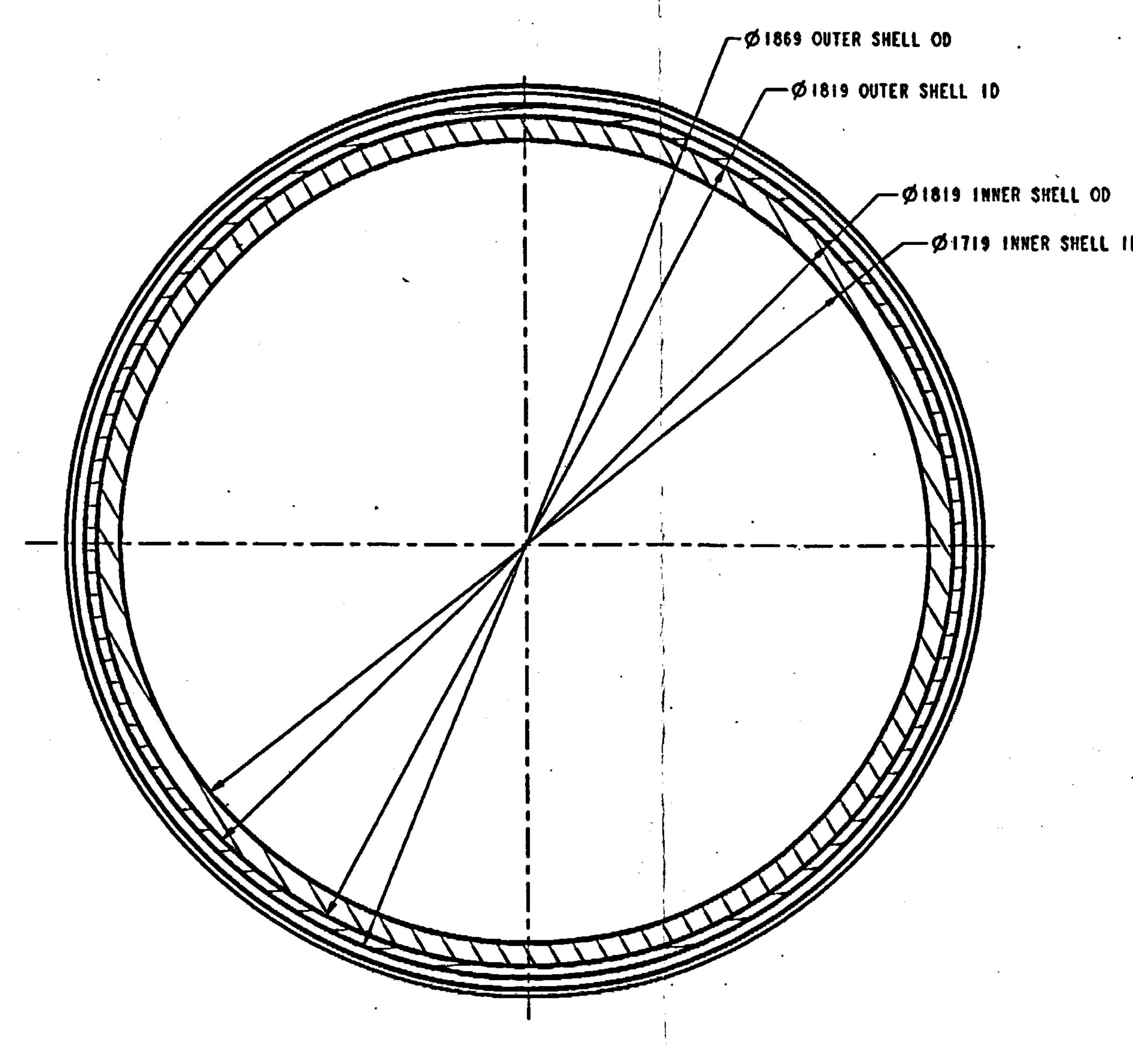
Table 7-1. File Names, Dates, Times, and Sizes

Name	Date	Time	Size
Nahzdp_b.old	04/06/2000	1:43 pm	359 KB
main.k	04/10/2000	10:45 am	2 KB
Element.inc	04/10/2000	10:49 am	1.42 MB
Nodes.inc	04/10/2000	10:49 am	1.41 MB
Nodesset1.inc	04/10/2000	10:49 am	245 KB
Nodesset2.inc	04/10/2000	10:50 am	2 KB
Dropout	04/10/2000	10:59 am	5 KB
d3hsp	04/10/2000	10:48 am	4.98 MB

NOTE: The file sizes may vary with operating system.



SECTION A-A



SECTION B-B

COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG)	QTY RQD
INNER SHELL	SA-240 S31600	50	12372	1
INNER SHELL LID	SA-240 S31600	130	2390	2
INNER LID LIFTING FEATURE	SA-240 S31600	27	12	1
OUTER SHELL	SB-575 N06022	25	7430	1
EXTENDED OUTER SHELL LID	SB-575 N06022	25	158	1
EXTENDED OUTER SHELL LID BASE	SB-575 N06022	25	528	1
EXTENDED LID REINFORCEMENT RING	SB-575 N06022	50	118	1
OUTER LID LIFTING FEATURE	SB-575 N06022	27	13	2
OUTER SHELL FLAT CLOSURE LID	SB-575 N06022	10	227	1
OUTER SHELL FLAT BOTTOM LID	SB-575 N06022	25	564	1
UPPER TRUNNION COLLAR SLEEVE	SB-575 N06022	40	604	1
LOWER TRUNNION COLLAR SLEEVE	SB-575 N06022	40	592	1
INNER SHELL SUPPORT RING	SB-575 N06022	20	49	1
TOTAL ALLOY 22 WELDS	SFA-5.14 N06022	-	298	**
TOTAL 316 WELDS	SFA-5.9 S31680	-	243	**
WASTE PACKAGE ASSEMBLY	-	-	28005	1
NAVAL SNF	-	-	44452*	1
WASTE PACKAGE WITH SNF	-	-	72457	1

*"MAXIMUM EXPECTED PARAMETERS FOR NAVAL REACTORS CANISTERS" 10/29/97 FROM: RICHARD GUIDA TO: RUSSELL DYER. MOL.19980121.0011

**REFER TO SK-0195 REV 00 "NAVAL SNF LONG WASTE PACKAGE WELD CONFIGURATION"

UNITS: mm

DO NOT SCALE FROM SKETCH

"FOR INFORMATION ONLY"

NAVAL SNF LONG WASTE PACKAGE CONFIGURATION FOR SITE RECOMMENDATION	
SKETCH NUMBER: SK-0194 REV 01	SHEET 1 OF 2
SKETCHED BY: GENE CONNELL	EGC 01/26/00 SMB 01/26/00 JAC 1/26/00
DATE: 01/11/00	
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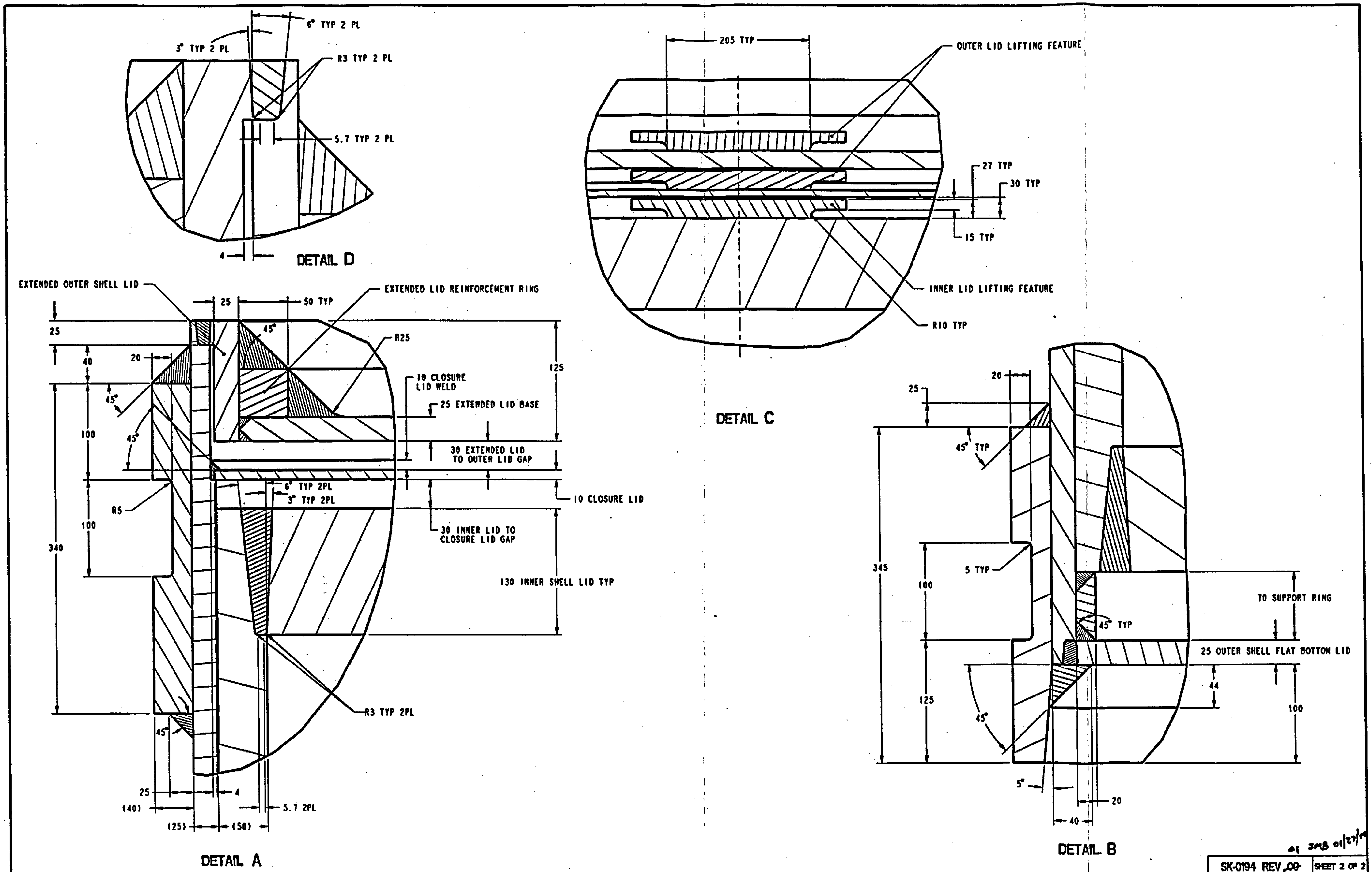
6° TYP 2 PL
3° TYP 2 PL
R3 TYP 2 PL
5.7 TYP 2 PL
4
DETAIL D
205 TYP
OUTER LID LIFTING FEATURE
27 TYP
30 TYP
15 TYP
INNER LID LIFTING FEATURE
R10 TYP
DETAIL C
EXTENDED OUTER SHELL LID
EXTENDED LID REINFORCEMENT RING
25
50 TYP
45°
R25
10 CLOSURE LID WELD
25 EXTENDED LID BASE
30 EXTENDED LID TO OUTER LID GAP
10 CLOSURE LID
6° TYP 2PL
3° TYP 2PL
30 INNER LID TO CLOSURE LID GAP
130 INNER SHELL LID TYP
R3 TYP 2PL
20
40
100
100
340
R5
125
25
(40)
(25)
(50)
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45° TYP
5 TYP
345
100
125
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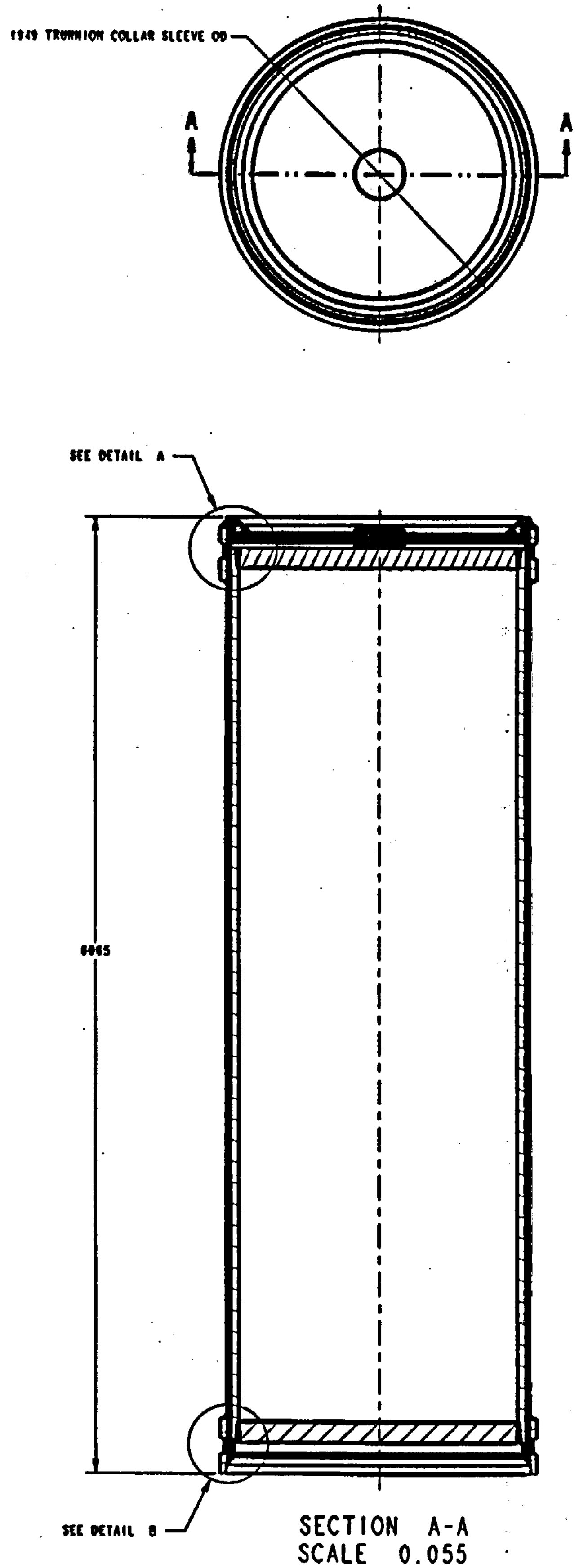
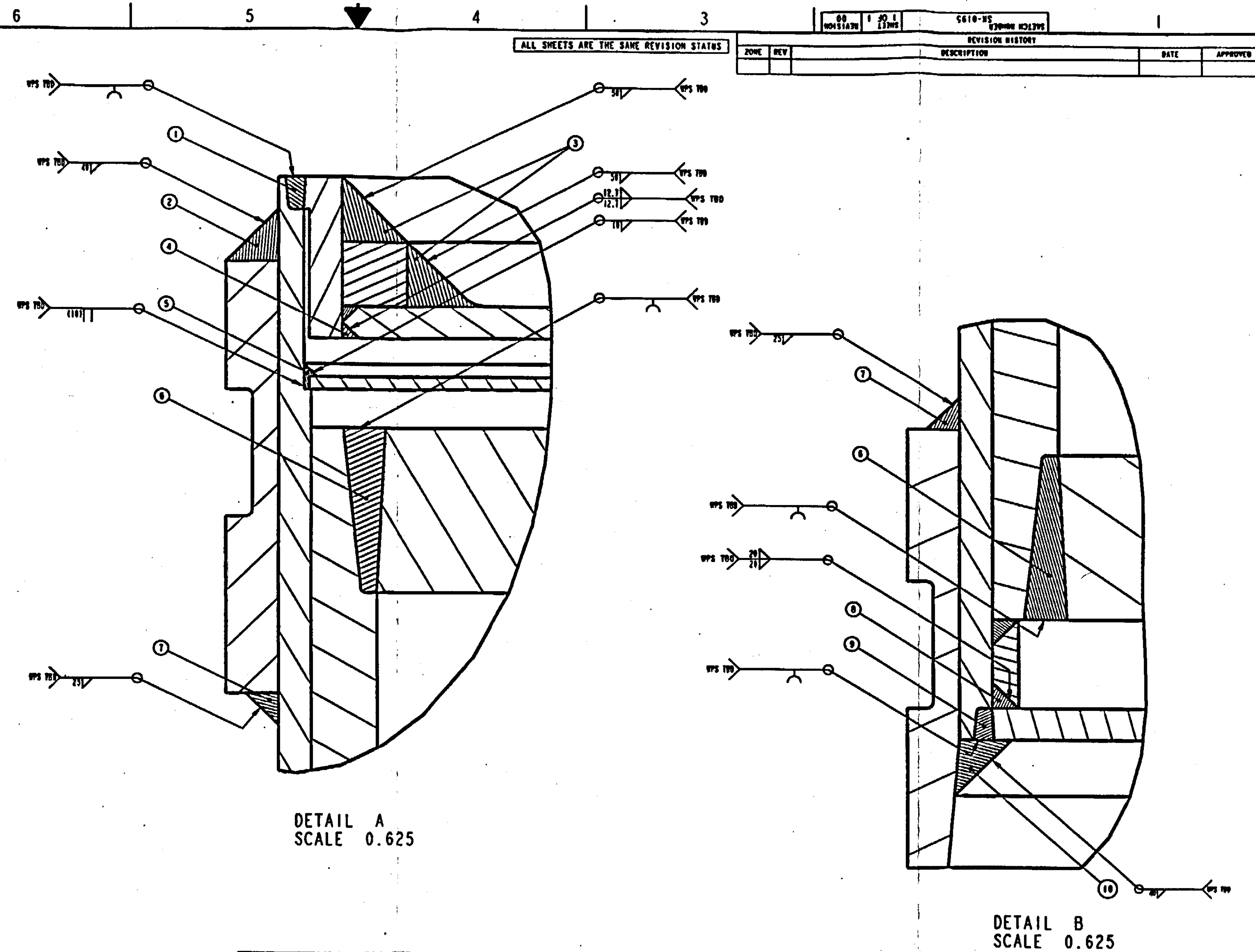
SK-0194 REV 00
SHEET 2 OF 2





WELDS	MATERIAL	MASS (KG)	QTY ROD
WELD 1	SFA-5.14 N06022	16	1
WELD 2	SFA-5.14 N06022	41	1
WELD 3	SFA-5.14 N06022	116	1
WELD 4	SFA-5.14 N06022	3.8	2
WELD 5	SFA-5.14 N06022	4.5	1
WELD 6	SFA-5.9 S31680	123	2
WELD 7	SFA-5.14 N06022	16	2
WELD 8	SFA-5.14 N06022	9.9	2
WELD 9	SFA-5.14 N06022	16	1
WELD 10	SFA-5.14 N06022	44	1
TOTAL ALLOY 22 WELDS	SFA-5.14 N06022	298	-
TOTAL 316 WELDS	SFA-5.9 S31680	246	-

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THIRD ANGLE PROJECTION

DIMENSIONS ARE IN MILLIMETERS AND DEGREES UNLESS OTHERWISE NOTED

DO NOT SCALE FROM SKETCH

APPROVALS	INITIAL/DATE
SKETCHED BY BRYAN HARKINS	BH 28March00
STRUCTURAL LEAD SCOTT BENNETT	SMB 05/09/00
MANUFACTURING MGR JERRY COGAR	JC 05/10/00
DESIGN GROUP MGR ~~THOMAS DOERING~~ MICHAEL ANDERSON	MA 5/10/00

WASTE PACKAGE DEPARTMENT

M&O Civilian Radioactive Waste Management System MANAGEMENT & OPERATING CONTRACTOR

TITLE

NAVAL SNF LONG WASTE PACKAGE WELD CONFIGURATION

SKETCH NUMBER SK-0195

REVISION 00

SCALE .055

SHEET 1 OF 1

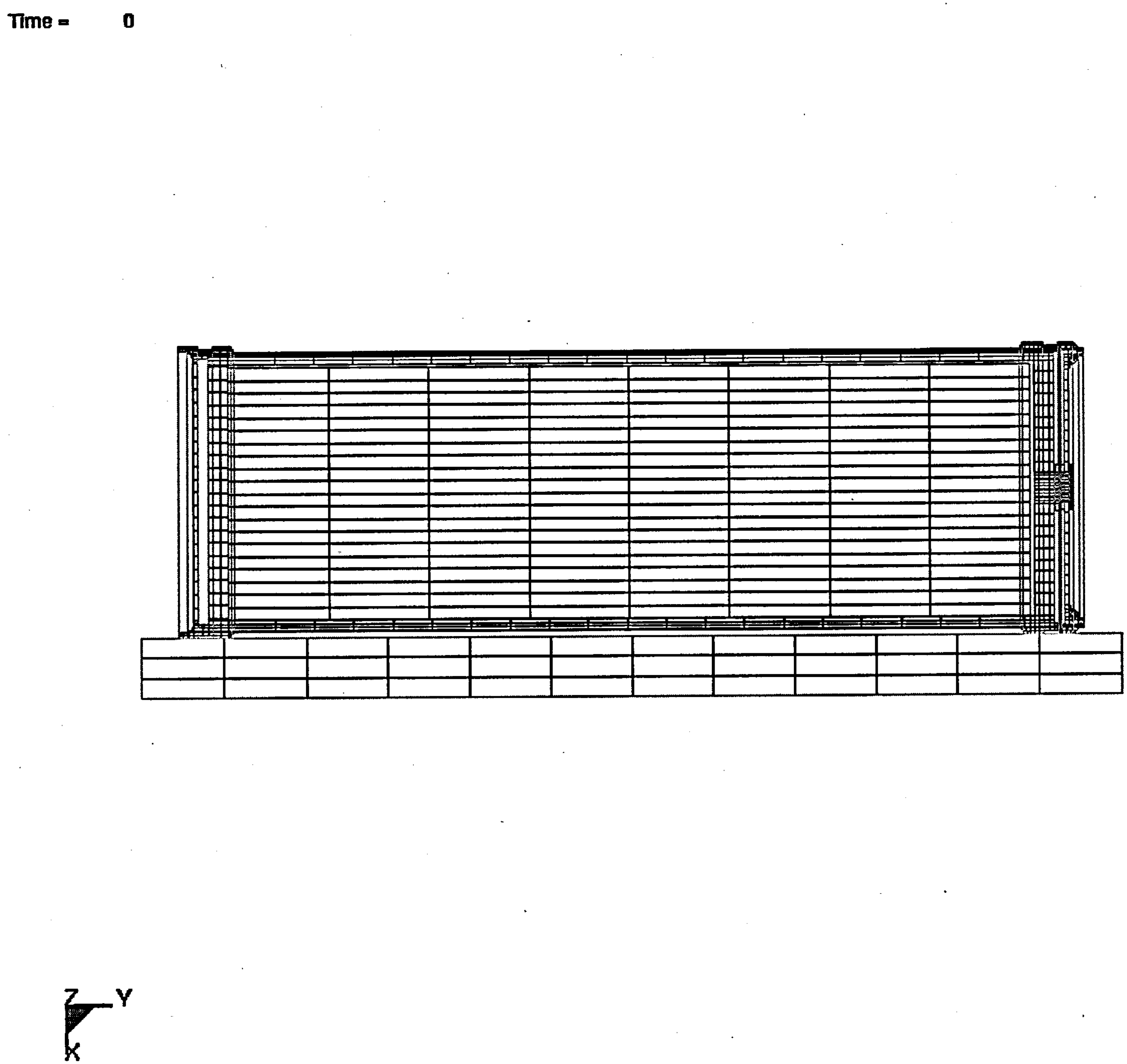

Figure III-1. Cross-Sectional View of Finite Element Representation of the Naval Waste Package and Unyielding Surface

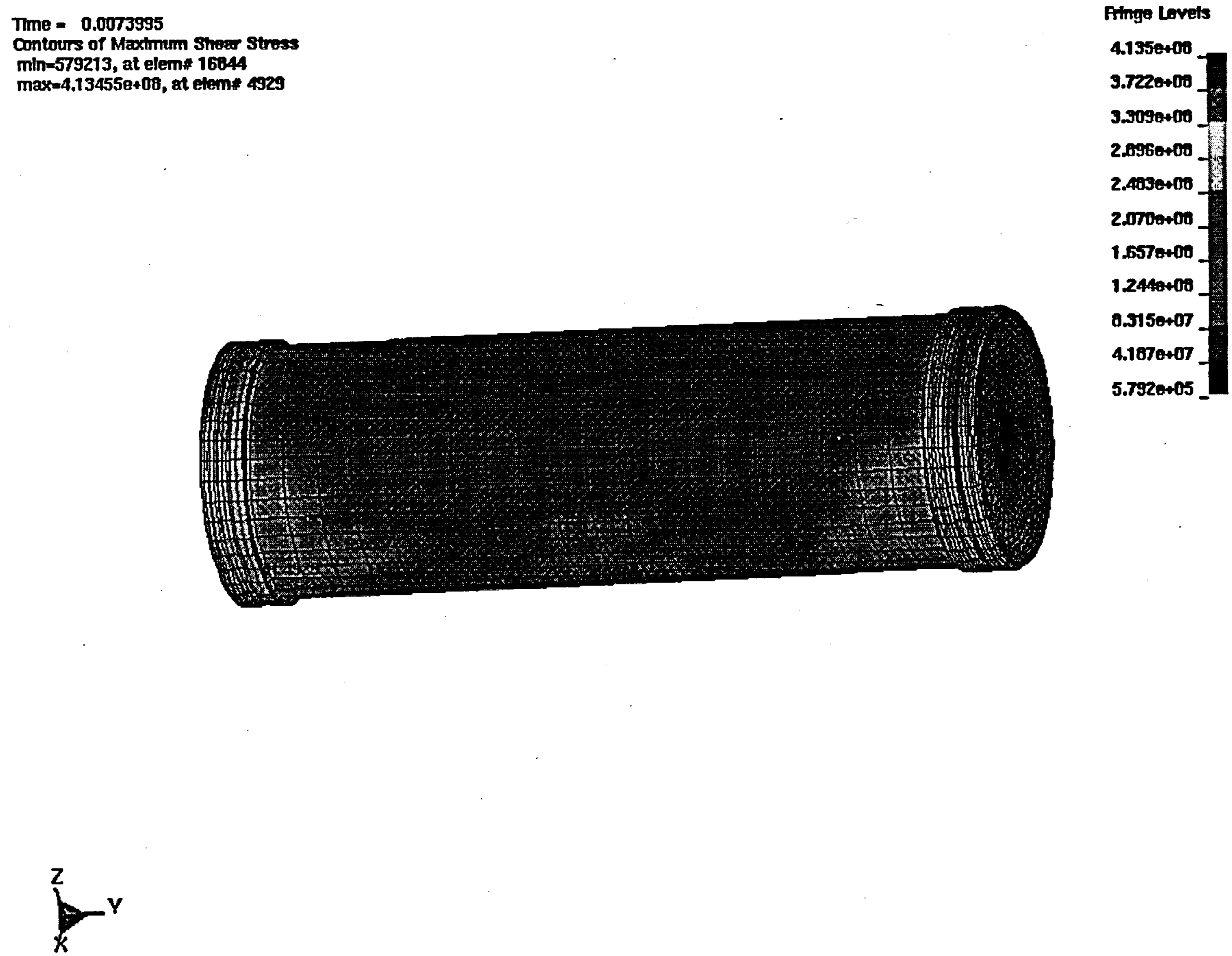

Figure III-2. Stress Intensity Plot for Complete Waste Package

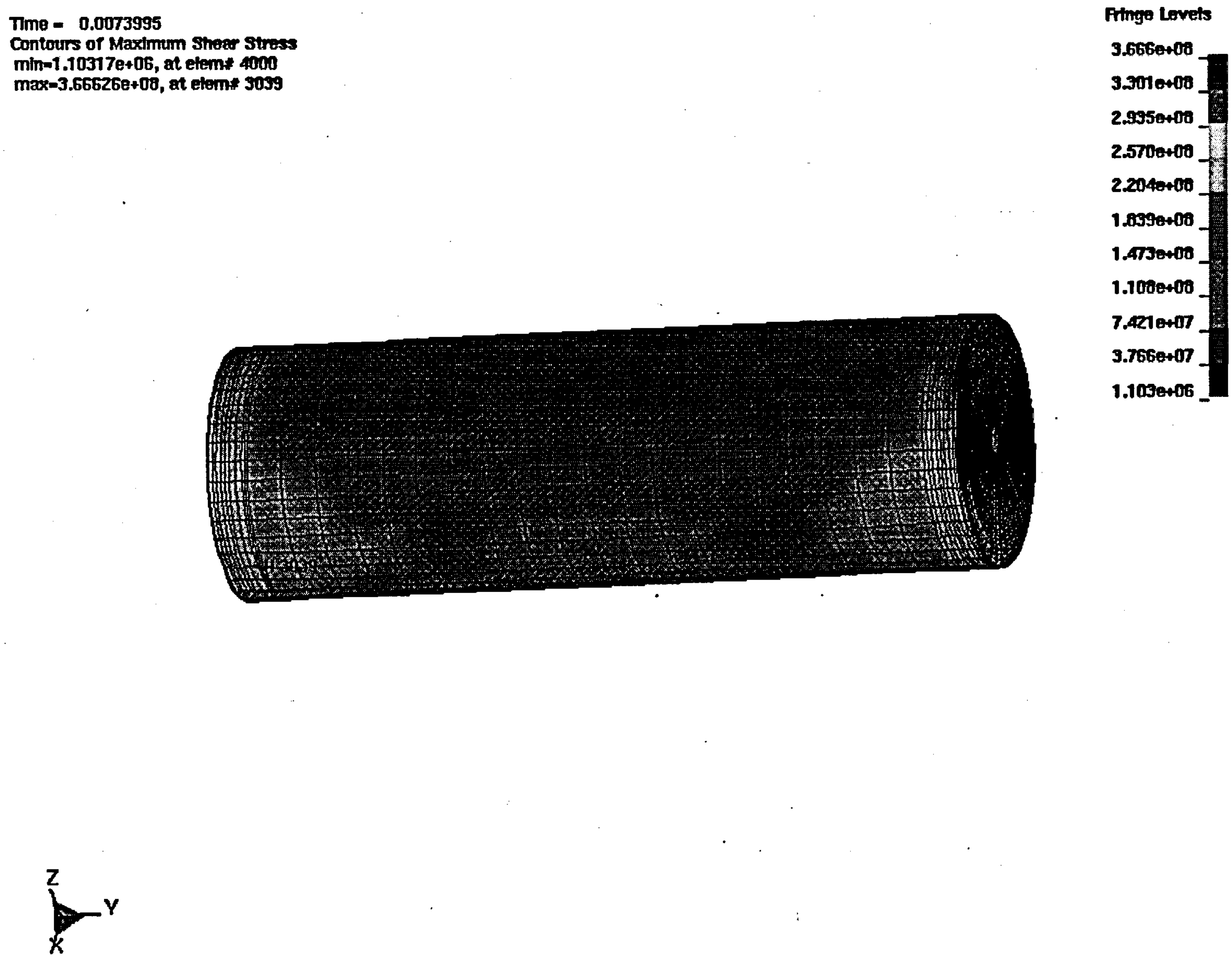

Figure III-3. Stress Intensity Plot of Outer Shell and Closure Lid

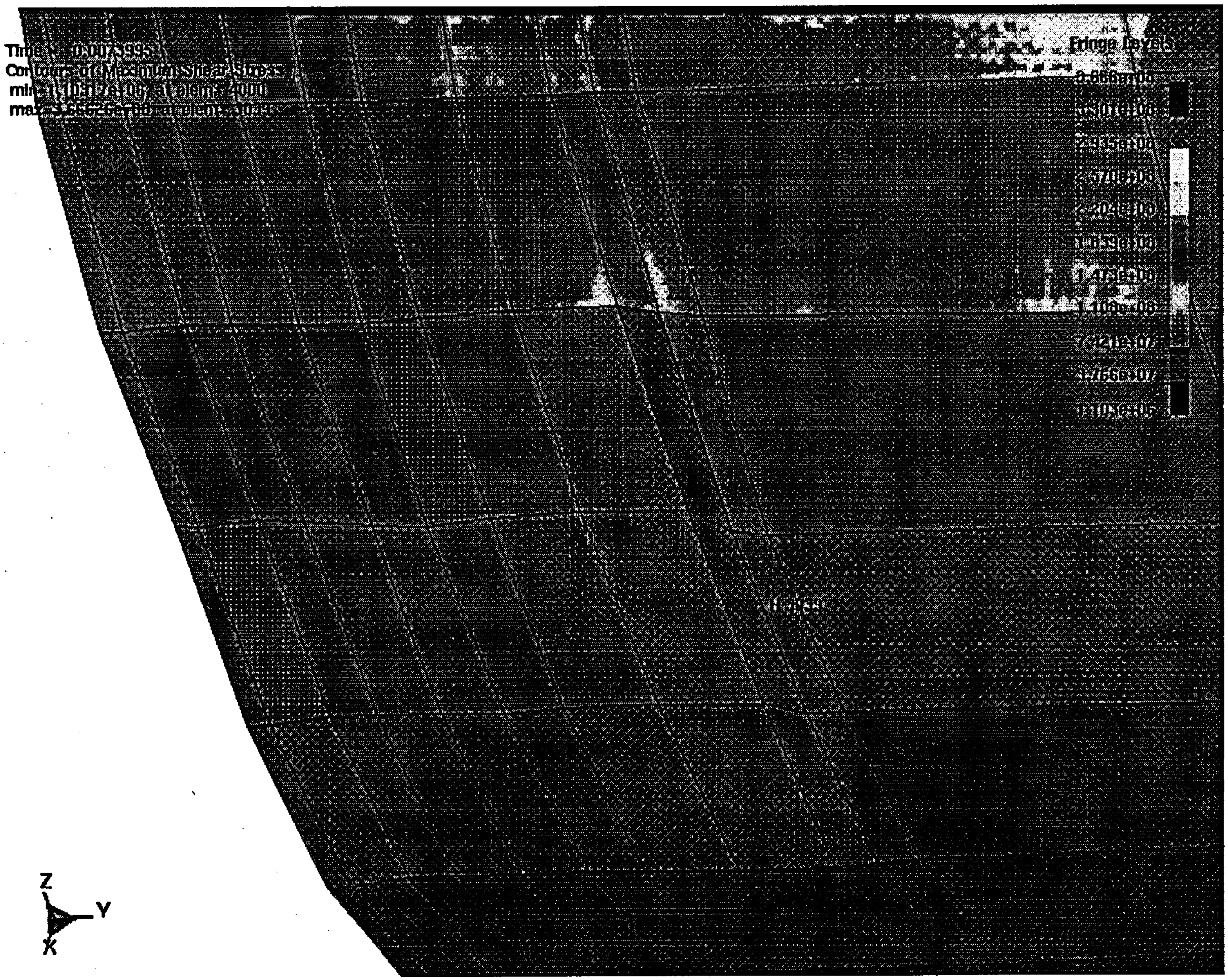

Figure III-4. Detail of Location of Highest Stress Intensity of Outer Shell

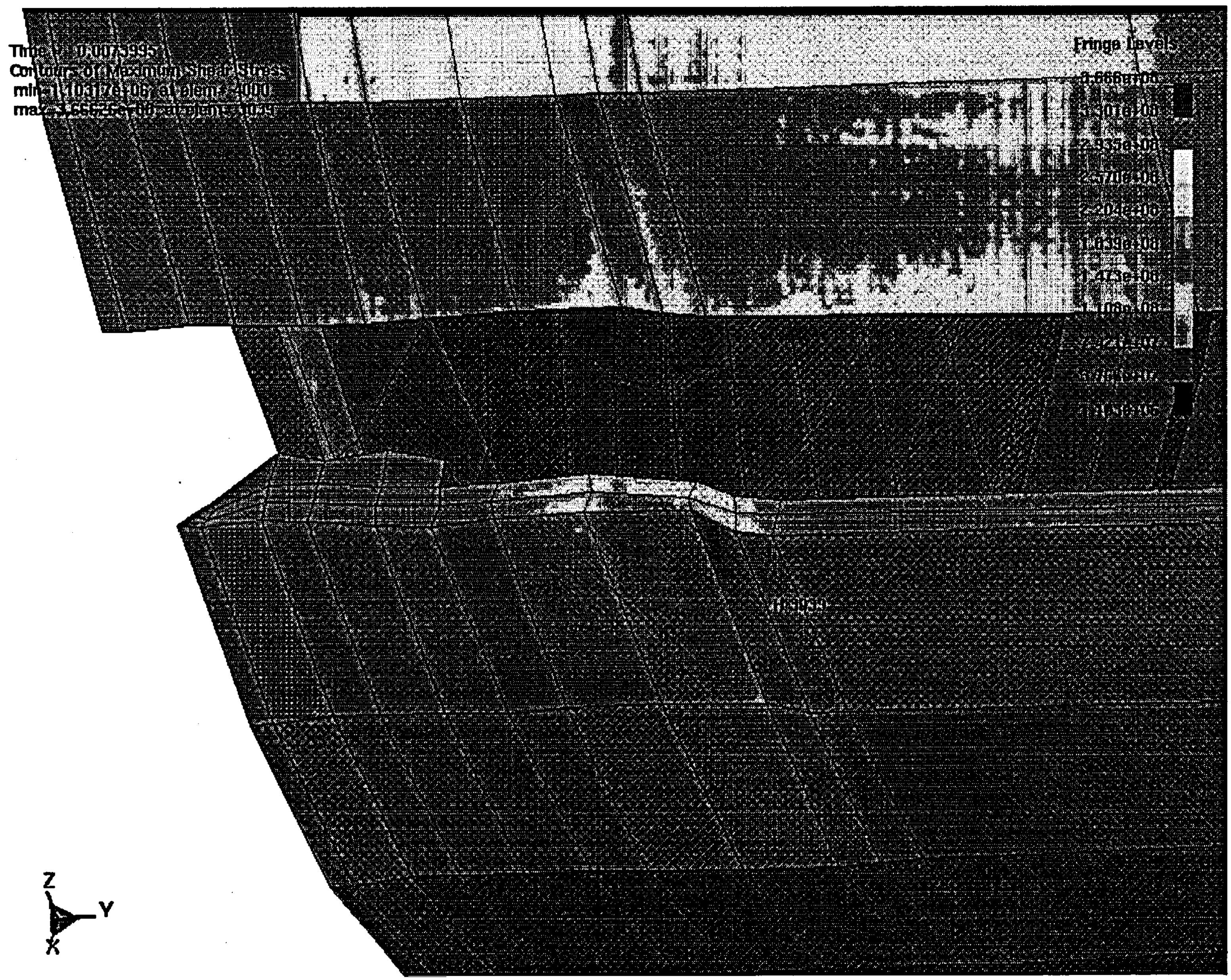

Figure III-5. Detail of Location of Highest Stress Intensity Showing Stress Penetration of Outer Shell

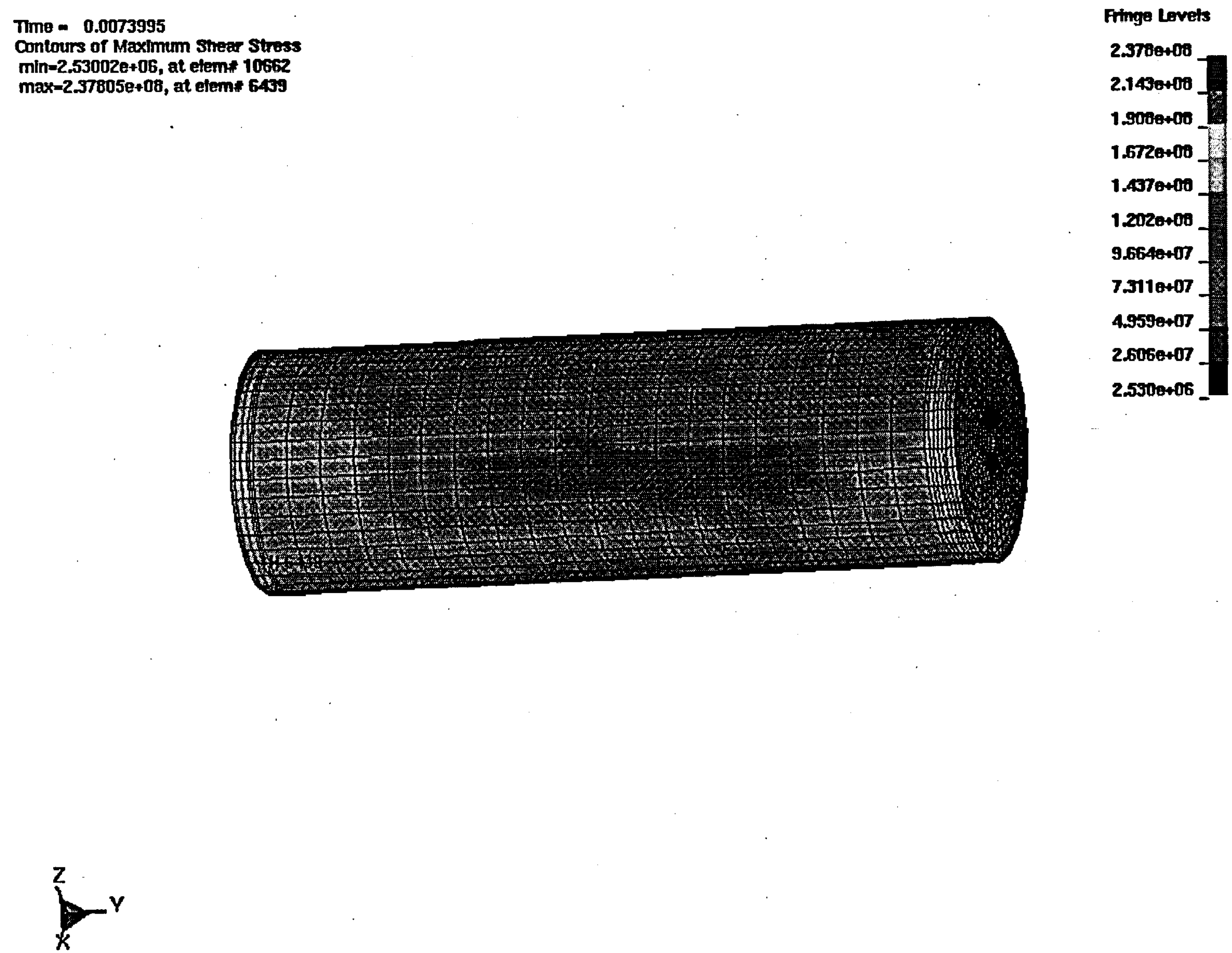

Figure III-6. Stress Intensity Plot of Inner Shell and Inner Lid

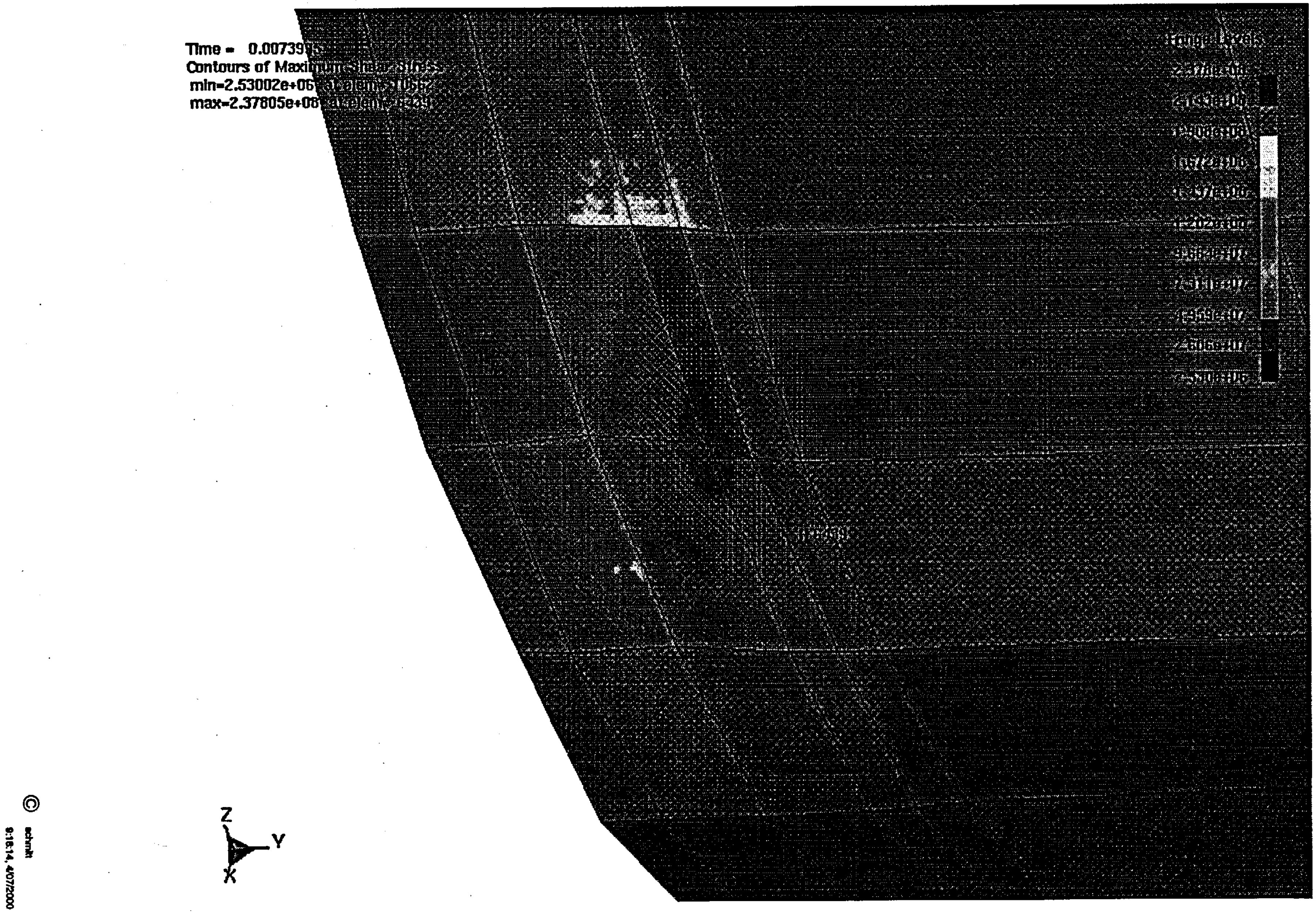

Figure III-7. Detail of Location of Highest Stress Intensity of Inner Shell

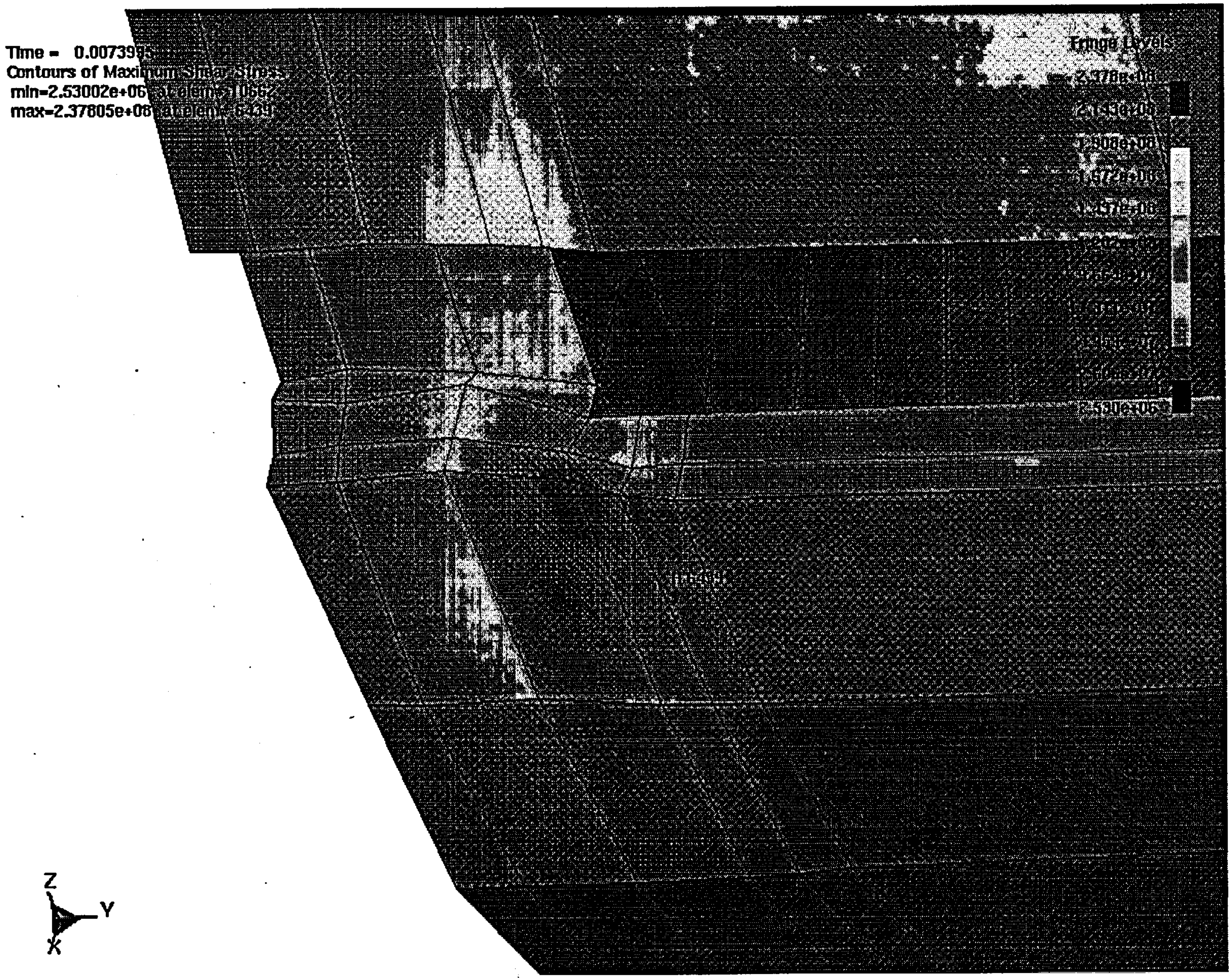

Figure III-8. Detail of Location of Highest Stress Intensity Showing Stress Penetration of Inner Shell

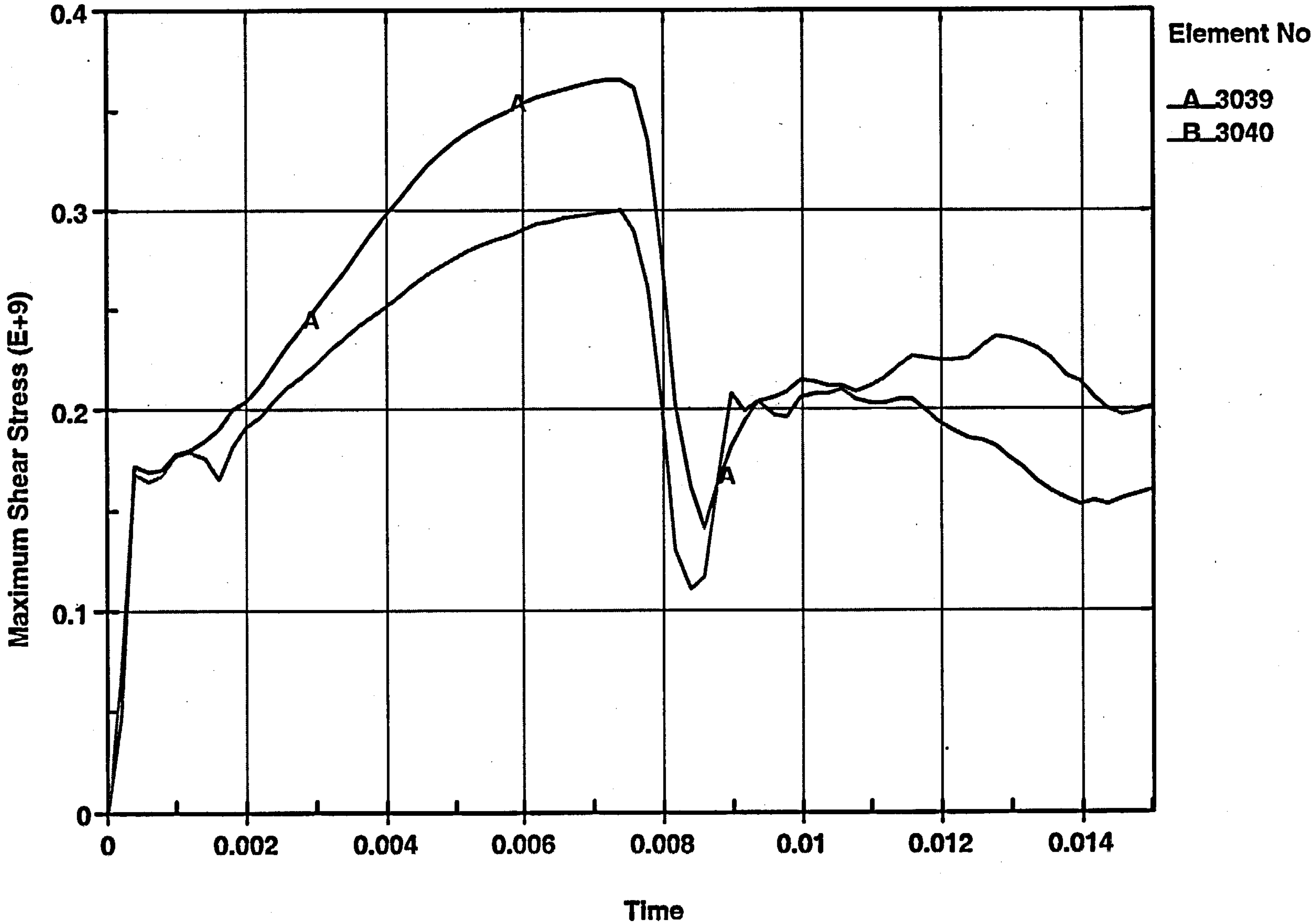

Figure III-9. Time History Plot of External and Internal Elements at the Highest Stress Location of the Outer Shell

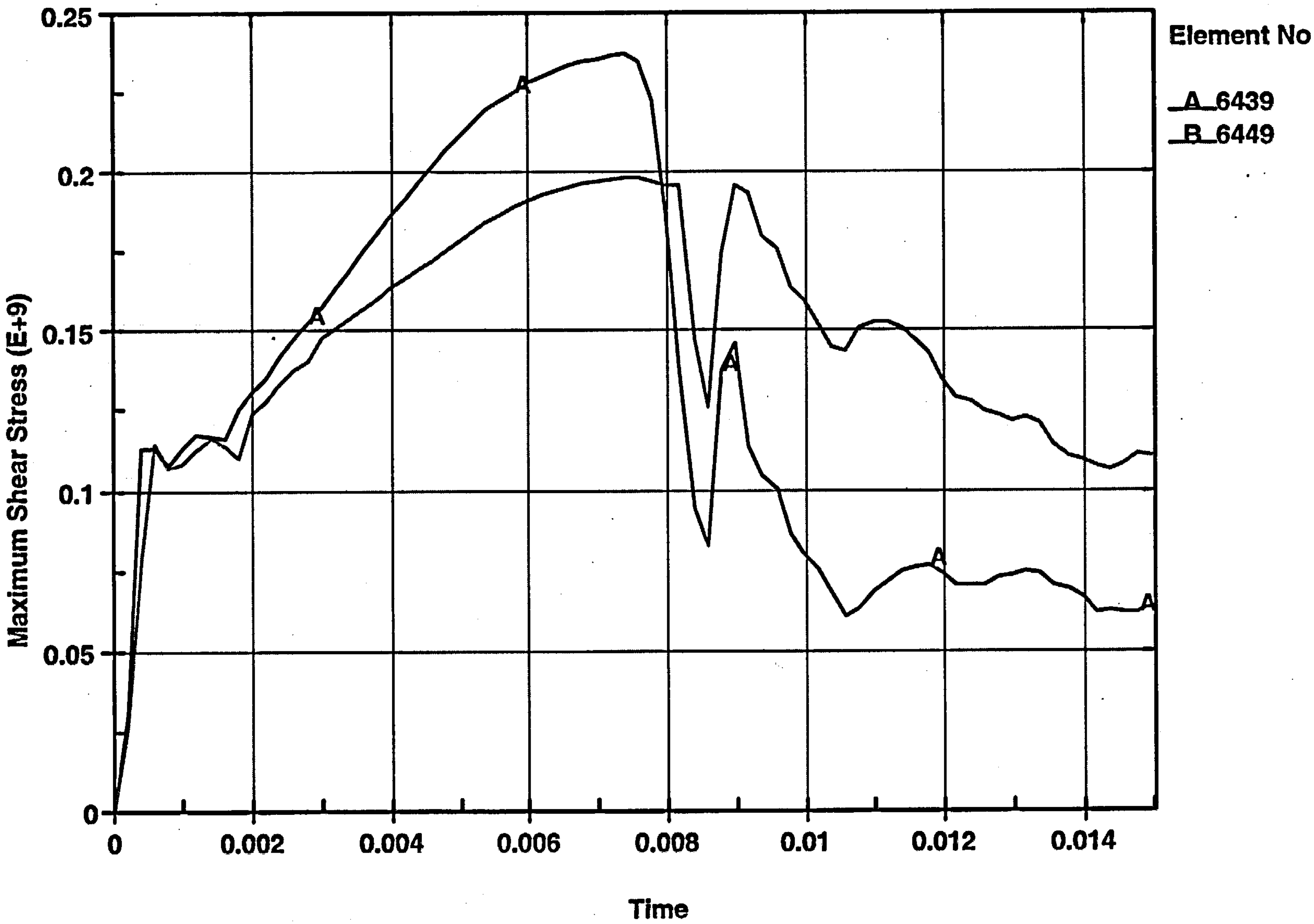

Figure III-10. Time History Plot of External and Internal Elements at the Highest Stress Location of the Inner Shell