OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
CALCULATION COVER SHEET

1. QA: QA

2. Calculation Title
Structural Calculations for the Lifting in Vertical Orientation of 5-DHLW/DOE SNF Single CRM Waste Packages

3. Document Identifier (including Revision Number)
CAL-DDC-ME-000001 REV 00

MOL.19991029.0157

4. Total Attachments	5. Attachment Numbers - Number of pages in each
5	I-3, II-4, III-3, IV-10, V-10

	Print Name	Signature	Date
6. Originator	Sreten Mastilovic		10/18/99
7. Checker	Michael J. Plinski		10/18/1999
8. Lead	Scott M. Bennett		10/22/99

9. Remarks

Revision History

10. Revision No.	11. Description of Revision
REV 00	initial issue

CONTENTS

Page

1. PURPOSE

The purpose of this activity is to determine the structural response of the extension of outer shell (which is referred to as skirt throughout this document) designs of both long and short design concepts of 5-Defense High-Level Waste (DHLW)/Department of Energy (DOE) spent nuclear fuel (SNF) single corrosion resistant material (CRM) waste packages (WP) (see p. II-1 and p. II-3), subjected to a gravitational load in the course of lifting in vertical orientation. The scope of this document is limited to reporting the calculation results in terms of stress intensity magnitudes. This activity is associated with the WP design; calculations are performed by the Waste Package Design group. AP-3.12Q, Revision 0, ICN 0, *Calculations*, is used to perform the calculation and develop the document.

2. METHOD

The finite element solutions are performed by making use of the commercially available ANSYS Version (V) 5.4 finite element code. The mass calculations are performed by using an industry standard Pro/Engineer Version 20.0 software. The results of these calculations are provided in terms of maximum stress intensity magnitudes for two different WP design variations.

3. ASSUMPTIONS

In the course of developing this document, the following assumptions are made regarding the 5-DHLW/DOE SNF single CRM WP structural calculations.

3.1 Some of the temperature-dependent material properties were not available for SB-575 N06022 (Alloy 22) and SA-579 K92820 (18Ni [250] maraging steel [MS]). Therefore, room-temperature (20 °C) material properties are assumed for both materials. The impact of using room-temperature material properties is anticipated to be small. The basis for this assumption is that the mechanical properties of said materials do not change significantly at the WP temperatures experienced during handling and lifting operations. This assumption is used in Section 5.1.2.

3.2 Lifting pin is assumed to be made of 18Ni (250) MS. The basis for this assumption is that this steel is extensively used when the excellent mechanical properties combined with superior fabricability (in particular, the lack of distortion during age hardening) are required. No additional basis for this assumption is deemed to be necessary in this document, since future analyses will be performed to determine the adequacy of the current design including the materials selection. This assumption is used in Section 5.1.2 and Section 5.2.

3.3 The magnitudes of the contact stiffness between the skirt and the lifting pin is assumed to be $1 \cdot 10^8\ N/m$. The basis for this assumption is explained below:

The magnitude of the contact stiffness between surfaces is one of the parameters that affects the results. If the contact stiffness value is very large, stiffness matrix ill-conditioning and divergence occur. On the other hand an extremely small contact stiffness value results in compatibility violations. Therefore, an optimum value for the contact stiffness is one that is between and is arrived at iteratively. This assumption is used in Section 5.2.

3.4 The finite element representations include only the WP skirt and the lifting pin. Consequently the distributed load resulting from the WP mass (excepting one skirt mass) is applied uniformly on the skirt cut-plane cross-sectional area where the skirt joins the WP. The basis for this assumption is that the unavoidable, slight deviation from uniform load distribution, caused by the WP geometry, does not significantly influence the calculation results. This assumption is used in Section 5.2 and Section 5.3.

3.5 The boundary conditions in the finite element representations include fixed nodes at the bottom surface of the lifting pin (supressed both translations and rotations). The basis for this assumption is that the details of the lifting device are unknown at the present, and that, since the lifting pins have large cross sectional dimensions compared to their lengths (see p. II-2 and p. II-4), the small deflection of the pin fixed in cantilever-beam configuration, although it changes the stress distribution along the skirt thickness (e.g., lifting pin length) in the contact region, nonetheless does not have significant effect on maximum stress intensity. This assumption is used in Section 5.2.

4. USE OF COMPUTER SOFTWARE AND MODELS

The finite element analysis computer code used for this calculation is ANSYS V5.4 which is identified with the Computer Software Configuration Item (CSCI) 30040 V5.4 and was obtained from Software Configuration Management in accordance with appropriate procedures. 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 calculations using the ANSYS V5.4 software were executed on the Hewlett-Packard (HP) workstation identified with Civilian Radioactive Waste Management System (CRWMS) and Operating Contractor (M&O) tag number 700887. The software qualification of the ANSYS V5.4 software is summarized in the Software Qualification Report for ANSYS V5.4 (Ref. 2). Qualification of ANSYS V5.4 on the Waste Package Operations (WPO) HP UNIX workstations is documented in Reference 5. The ANSYS evaluations performed for this design are fully within the range of the validation performed for the ANSYS V5.4 code. Access to the code was granted by the Software Configuration Secretary in accordance with the appropriate procedures.

Industry standard software used in this calculation is Pro/Engineer Version 20.0. This software is executed on the HP workstation. Pro/Engineer Version 20.0 is not controlled computer software, and it has not been qualified under the Office of Civilian Radioactive Waste Management (OCRWM) procedures.

Attachments IV and V contain the input/output data obtained from Pro/Engineer Version 20.0. The mass densities given in Section 5.1.2 are used as inputs to Pro/Engineer Version 20.0 and corresponding masses of WP components are obtained for the use in structural evaluations. There are no user-operated equations of mathematical models, algorithms, or numerical solution techniques applicable to the software routine since Pro/Engineer Version 20.0 is an engineering drawing software package and the subject mass calculations are performed by the source code, based on the dimensions of structural components and the mass density of materials. Verification of this software is accomplished by two test cases, one for each waste package, as described in Section 5.1.1. The range of input parameter values is limited to the dimensions of the structural components used in those cases; all mass calculations depend on specific geometry of the subject components. No limitations are identified on software routine applications or validity.

5. CALCULATION

5.1 CALCULATION DATA

5.1.1 Mass of Waste Packages

Total mass of 5-DHLW/DOE SNF-long single CRM WP loaded with HLW canisters and DOE SNF = 56263 *kg* (see p. II-1)
Total mass of 5-DHLW/DOE SNF-short single CRM WP loaded with HLW canisters and DOE SNF = 37710 *kg* (see p. II-3)

One of the 5-DHLW/DOE SNF-long single CRM WP structural components, the outer shell lid, is selected for verification of the mass obtained from Pro/Engineer Version 20.0. The mass of this component is determined as product of the mass density (see Section 5.1.2) and the volume, using the dimensions provided on page II-1:

$$\text{Mass} = 8690 \cdot 0.025 \cdot 1.983^2 \pi / 4 = 670.95763\, kg$$

The mass obtained by preceding calculation is identical to the mass provided on page IV-4.

Preceding verification procedure is valid for the outer shell lid of the 5-DHLW/DOE SNF-short single CRM WP as well, since the geometric dimensions, and the material are the same. Consequently, it can be verified that the mass obtained in previous calculation is identical to the mass presented on page V-5.

5.1.2 Material Properties

Waste package skirt and lifting pin material properties used in the calculations are listed in this section. Some of the temperature-dependent material properties were not available for Alloy 22 and 18Ni (250) MS; therefore, room-temperature material properties were used in calculations (Assumption 3.1).

SB-575 N06022 (ASTM B 575) (Alloy 22. Waste package skirt, Ref. 4, Table 5-4):

- Density = 8690 kg/m^3 (0.314 lb/in^3) (Ref. 7, p. 2)
- Yield strength = 310 *MPa* (45 *ksi*) (Ref. 7, Table 3)
- Tensile strength = 690 *MPa* (100 *ksi*) (Ref. 7, Table 3)
- Poisson's ratio was not available for Alloy 22. Since the chemical compositions of Alloy 22 and Alloy 625 are similar (see Ref. 7, Table 1 and Ref. 6, p. 143), Poisson's ratio of Alloy

625 is used for Alloy 22: Poisson's ratio = 0.278 (Ref. 6, p. 143)

- Modulus of elasticity = 206 GPa ($29.9 \cdot 10^6$ psi) (Ref. 3, p. 14)

SA 579 K92820 (ASTM A 579) (18Ni [250] Grade 72 MS. Lifting pin, see Assumption 3.2):

- Density = 8000 kg/m^3 (Ref. 1, p. 451)
- Poisson's ratio = 0.3 (Ref. 1, p. 451)
- Modulus of elasticity = 186 GPa (Ref. 1, p. 451)

5.2 FINITE ELEMENT REPRESENTATION

Two different three-dimensional finite element representations are developed using the dimensions provided in Attachment II, corresponding to the two WP skirt design variations being investigated for the 5-DHLW long and short waste packages. The finite element representations include only the WP skirt and the lifting pin (see Figure III-1); consequently, the distributed load resulting from the WP mass (excepting the skirt mass) is applied uniformly on the skirt cut-plane cross-sectional area where the skirt joins the WP (see Assumption 3.4). These finite element representations make use of one-third circumferential symmetry. This modeling approach to the WP lifting in vertical orientation has the benefit of reducing the computer execution time while preserving all features relevant for the structural calculation.

Contact elements are used to represent contact between the lifting hole and the lifting pin. The magnitude of the contact stiffness is one of the parameters that affects the results. If the stiffness value is very large, stiffness matrix ill-conditioning and divergence occur. On the other hand an extremely small stiffness value results in compatibility violations. Having that in mind, an optimum value for the contact stiffness that works best, $1 \cdot 10^8$ N/m, is determined as the results of succesive iterations (see Assumption 3.3).

5.3 DISTRIBUTED LOAD CALCULATION

5.3.1 Distributed Load Calculations for the 5-DHLW/DOE SNF-Long Single CRM WP

In order to simplify the finite element representation, the extension of the outer shell (skirt) is isolated from the WP and the effect of the WP is taken into account by a uniformly distributed load applied on the cut-plane of the skirt (see Assumption 3.4). The following parameters are defined which will be used in the calculations of the magnitude of distributed load:

m = total mass of loaded WP
m_p = total mass of loaded WP excluding one skirt
m_s = skirt mass
V_s = skirt volume
A_s = area of skirt cross section
L_s = skirt length
T_s = skirt thickness
D_o = skirt outer diameter
D_i = skirt inner diameter
D_h = lifting hole diameter
ρ_s = mass density of skirt material (Alloy 22)
g = gravitational acceleration

The thickness, area of cross section, and volume of the skirt are, respectively:

$$T_s = (D_o - D_i)/2 = (2.130 - 2.030)/2 = 0.05000\,m \quad \text{(p. II-1)}$$

$$A_s = (D_o^2 - D_i^2)\pi/4 = (2.130^2 - 2.030^2)\pi/4 = 0.3267\,m^2$$

$$V_s = A_s L_s - 3 D_h^2 T_s \pi/4 = 0.3267 \cdot 0.350 - 3 \cdot 0.210^2 \cdot 0.05\pi/4 = 0.1091\,m^3 \quad \text{(p. II-1)}$$

Therefore, the total mass of the WP excluding one skirt is:

$$m_p = m - m_s = m - \rho_s V_s = 56263 - 8690 \cdot 0.1091 = 55{,}310\,kg \quad \text{(see Section 5.1.1)}$$

Finally, the distributed load is:

$$p = m_p\, g / A_s = 55310 \cdot 9.81/0.3267 = 1.66\,MPa$$

5.3.2 Distributed Load Calculations for the 5-DHLW/DOE SNF-Short Single CRM WP

A calculation similar to the one presented in the preceding section is performed in order to determine magnitude of the distributed load on the skirt of 5-DHLW/DOE SNF-short single CRM WP. The parameters used in the following calculations are previously defined in Section 5.3.1.

The thickness, $T_s = 0.05000\,m$, and the area of cross section, $A_s = 0.3267\,m^2$, are the same as for the long WP design. The volume of the skirt is:

$$V_s = A_s L_s - 3 D_h^2 T_s \pi/4 = 0.3267 \cdot 0.280 - 3 \cdot 0.130^2 \cdot 0.05\pi/4 = 0.08949\,m^3 \quad \text{(p. II-3)}$$

Therefore, the total mass of the WP excluding one skirt is:

$$m_p = m - m_s = m - \rho_s V_s = 37710 - 8690 \cdot 0.08949 = 36{,}930\ kg \quad \text{(see Section 5.1.1)}$$

Finally, the distributed load is:

$$p = m_p\, g / A_s = 36930 \cdot 9.81/0.3267 = 1.11\,MPa$$

6. RESULTS

Unqualified data were used in the development of the results in this document. If the results from this document are used as input into documents directly relied upon for radiological safety or waste isolation issues, than unqualified inputs are required to be identified and tracked as TBV (to be verified) in accordance with appropriate procedures (see *AP-3.15Q, Revision 0, ICN 1, Managing Technical Product Inputs, Attachment 3*).

The design inputs (hole diameters and skirt lengths) for the structural calculations for the lifting in vertical orientation of both, long and short, design concepts of 5-DHLW/DOE SNF single CRM WP are summarized in Table 6-1.

Table 6-1. Design Inputs for the Lifting in Vertical Orientation of 5-DHLW/DOE SNF Single CRM Waste Packages

	Hole diameter (mm)	Skirt length (mm)
Long	210 (Reference 8, Attachment VI, line # 118)	350 (Reference 8, Attachment VI, line # 117)
Short	130 (Reference 8, Attachment VIII, line # 118)	280 (Reference 8, Attachment VIII, line # 117)

The results corresponding to these two (long and short) design concepts show that the maximum stress intensities in their skirts are: 99 *MPa* (Reference 8, Attachment VII, line # 357), and 97 *MPa* (see Reference 8, Attachment IX, line # 356), respectively. These stress intensity magnitudes are less than one third of the yield strength (310 *MPa*) and one fifth of the tensile strength (690 *MPa*) of Alloy 22 (see Section 5.1.2).

7. ATTACHMENTS

Attachment I (3 pages): Document Input Reference Sheets

Attachment II (4 pages): Design sketches

Attachment III (3 pages): Figures obtained from ANSYS

Attachment IV (10 pages): 5-DHLW/DOE SNF-long single CRM WP structural component masses

Attachment V (10 pages): 5-DHLW/DOE SNF-short single CRM WP structural component masses

Attachments VI through IX have been moved to Reference 8. The following is the list of electronic files including names, dates, times and sizes available in that reference. Note that these are no longer attachments to this document; they are listed for information only.

Description	Date	Time	Size
Attachment VI: lift1.at6	08/11/99	2:37 pm	141 KB
Attachment VII: lift1.at7	08/23/99	10:56 am	15 KB
Attachment VIII: lift1.at8	09/20/99	10:16 am	141 KB
Attachment IX: lift1.at9	09/20/99	10:19 am	15 KB

8. REFERENCES

1. American Society for Metals (ASM) 1978. *Metals Handbook Ninth Edition, Volume 1, Properties and Selection: Irons and Steels.* Metals Park, Ohio: ASM. TIC: 209799.

2. Civilian Radioactive Waste Management System (CRWMS) Management and Operating Contractor (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.

3. Haynes International, Inc. 1997. *Hastelloy C-22 Alloy.* Haynes International Product Brochure. Kokomo, Indiana: Haynes International, Inc. TIC: 238121.

4. CRWMS M&O 1999. *Licence Application Design Selection Report.* B00000000-01717-4600-00123 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990528.0303.

5. 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 (CRWMS M&O), May 22, 1998, LV.WP.SMB.05/98-100. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980730.0147.

6. ASM 1980. *Metals Handbook, Ninth Edition, Volume 3, Properties and Selection: Stainless Steels, Tool Materials and Special-Purpose Metals.* Metals Park, Ohio: ASM. TIC: 209801.

7. American Society for Testing and Materials (ASTM) 1998. *Standard Specification for Low-Carbon Nickel-Molybdenum-Chromium, Low Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Chromium-Molybdenum-Copper and Low-Carbon Nickel Chromium-Molybdenum-Tungsten Alloy Plate, Sheet, and Strip.* ASTM B 575-97. West Conshohocken, Pennsylvania: ASTM. TIC: 241816.

8. CRWMS M&O 1999. *Electronic Files for Structural Calculations for the Lifting in Vertical Orientation of 5-DHLW/DOE SNF Single CRM Waste Packages, CAL-DDC-ME-000001 REV 00.* Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990922.0377.

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
DOCUMENT INPUT REFERENCE SHEET

1. Document Identifier No./Rev.:	Change:	Title:
CAL-DDC-ME-000001 REV 00	N/A	Structural Calculations for the Lifting in Vertical Orientation of 5-DHLW/DOE SNF Single CRM Waste Packages

Input Document			4. Input Status	5. Section Used in	6. Input Description	7. TBV/TBD Priority	8. TBV Due To		
	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-confirmed
2a 1	American Society for Metals (ASM) 1978. Metals Handbook Ninth Edition, Volume I, Properties and Selection: Irons and Steels. Metals Park, Ohio: ASM. TIC: 209799.	Page 451	N/A	5.1	(1) Poisson's ratio of SA 579 K92820	N/A	N/A	N/A	N/A
		Page 451	N/A	5.1	(2) Modulus of elasticity of SA 579 K92820	N/A	N/A	N/A	N/A
		Page 451	N/A	5.1	(3) Density of SA 579 K92820	N/A	N/A	N/A	N/A
2	Civilian Radioactive Waste Management System (CRWMS) Management and Operating Contractor (M&O) 1998. Software Qualification Report for ANSYS V5.4, A Finite Element Code (CSCI: 30040 V5.4). 30040-2003 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980609.0847	Entire docu-ment	N/A	4	(1) Qualification report for ANSYS V5.4	N/A	N/A	N/A	N/A
3	HAYNES International, Inc. 1997. Hastelloy Alloy C-22. Kokomo, Indiana: Haynes International, Inc. TIC: 238121.	Page 14	N/A	5.1	(1) Modulus of elasticity of SB-575 N06022 This reference is pending for acceptance from DOE AMOPE. See Section 6 for justification on input status	N/A	✓	N/A	N/A

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	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-confirmed
2a 4	CRWMS M&O 1999. License Application Design Selection Report. B00000000-01717-4600-00123 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990528.0303.	Table 5-4	N/A	5.1	(1) Waste package outer shell material specification	N/A	N/A	N/A	N/A
5	Doering, T.W. 1998. "Qualification of ANSYS V5.4 on the WPO HP UNIX Workstations". Interoffice correspondence, T. W. Doering (CRWMS M&O) to Gregory Carlisle (CRWMS M&O), May 22, 1998, LV.WP.SMB.05/99-100. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980730.0147.	Entire docu-ment	N/A	4	(1) Qualification of ANSYS V5.4 on HP UNIX workstations	N/A	N/A	N/A	N/A
6	ASM 1980. Metals Handbook Ninth Edition, Volume 3, Properties and Selection: Stainless Steels, Tool Materials and Special-Purpose Metals. Metals Park, Ohio: ASM. TIC: 209801.	Page 143 Page 143	N/A N/A	5.1 5.1	(1) Chemical composition of Alloy 625 (2) Poisson's ratio of Alloy 625 to be used for SB-575 N06022	N/A N/A	N/A N/A	N/A N/A	N/A N/A

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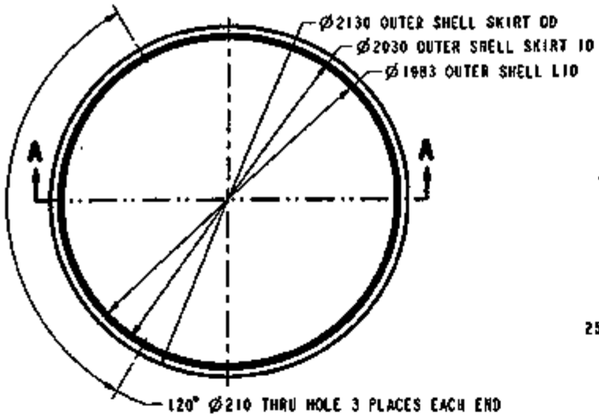
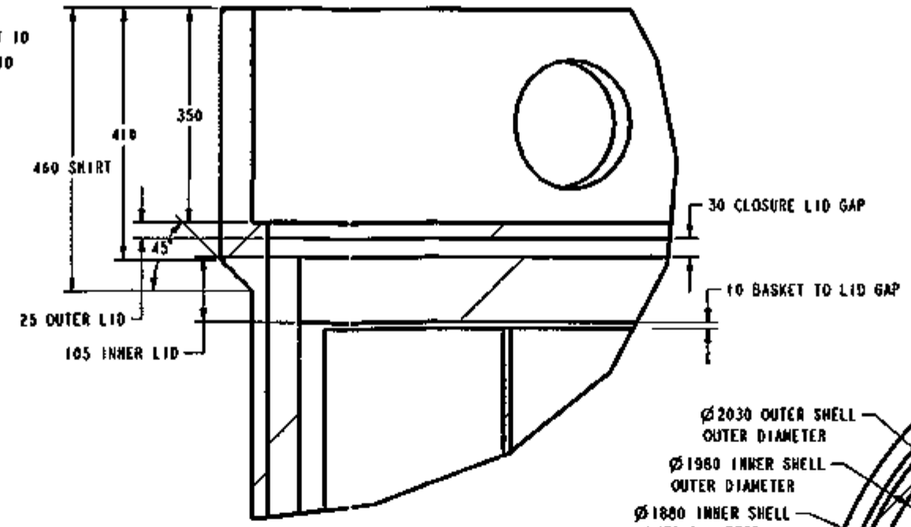
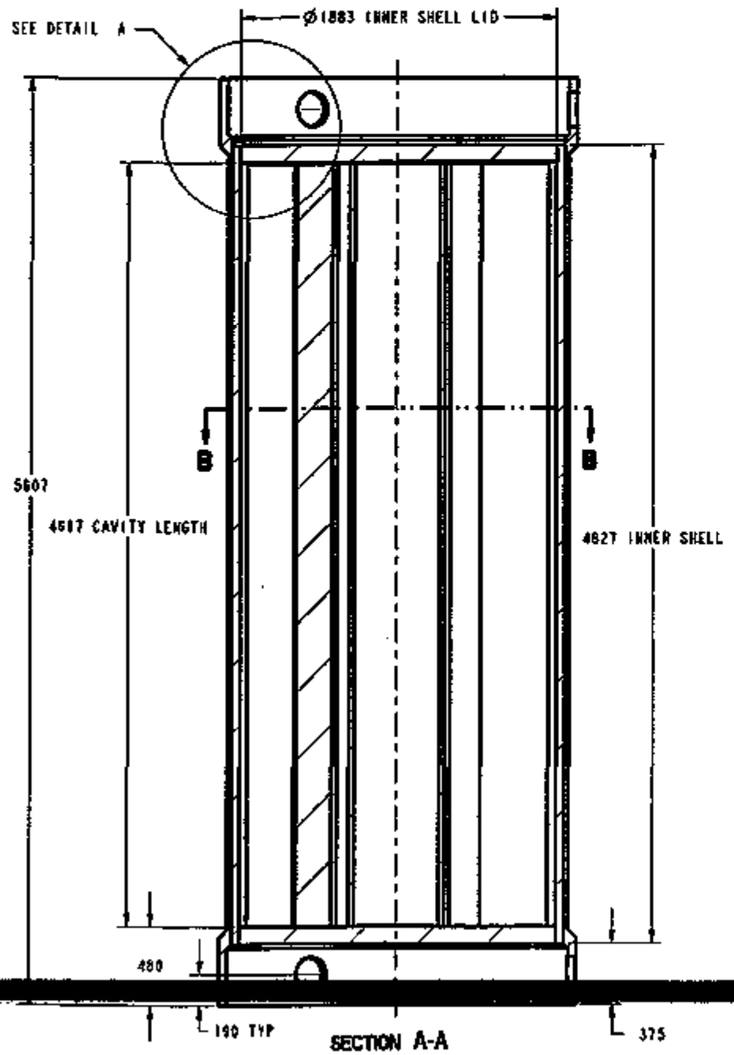
Input Document			4. Input Status	5. Section Used in	6. Input Description	7. TBV/TBD Priority	8. TBV Due To		
	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-confirmed
2a	ASTM 1998. Standard Specification for Low-Carbon Nickel-Molybdenum-Chromium, Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Chromium-Molybdenum-Copper and Low-Carbon Nickel-Chromium-Molybdenum-Tungsten	Page 2	N/A	5.1	(1) Density of SB-575 N06022	N/A	N/A	N/A	N/A
7		Table 1	N/A	5.1	(2) Chemical composition of SB-575 N06022	N/A	N/A	N/A	N/A
		Table 3	N/A	5.1	(3) Yield strength of SB-575 N06022	N/A	N/A	N/A	N/A
7 (con t'd)	Alloy Plate, Sheet, and Strip. ASTM Designation: B 575-97. West Conshohocken, Pennsylvania: ASTM. TIC: 241816.	Table 3	N/A	5.1	(4) Tensile strength of SB-575 N06022	N/A	N/A	N/A	N/A
8	CRWMS M&O 1999. Electronic Files for Structural Calculations for the Lifting in Vertical Orientation of 5-DHLW/DOE SNF Single CRM Waste Packages, CAL-DDC-ME-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990922.0377.	Entire Docu-ment	N/A	6	(1) Design inputs: hole diameters and skirth lengths	N/A	N/A	N/A	N/A
			N/A	6	(2) Stress Intensity Magnitudes	N/A	N/A	N/A	N/A

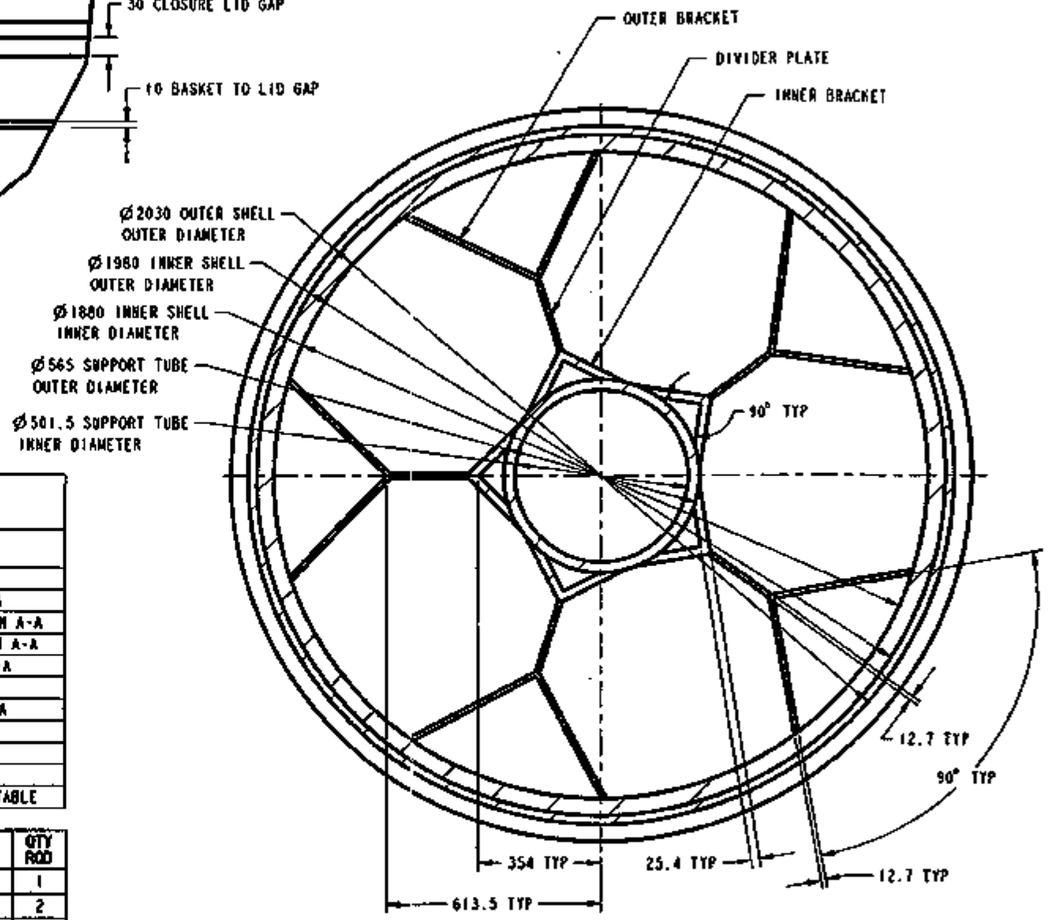




DETAIL A



SECTION A-A



SECTION B-B

REVISION 01

ITEM NUMBER	ITEM
1	Ø210 LIFTING FEATURE WAS Ø70 ON TOP VIEW
2	5607 WP ASSEMBLY LENGTH WAS 5357 ON SECTION A-A
3	480 SKIRT END TO INNER LID LENGTH WAS 355 ON SECTION A-A
4	190 SKIRT END TO LIFTING FEATURE WAS 115 ON SECTION A-A
5	375 SKIRT END TO OUTER LID WAS 250 ON SECTION A-A
6	460 FLARED SKIRT LENGTH WAS 335 ON DETAIL A
7	410 FLARED SKIRT EDGE LENGTH WAS 285 ON DETAIL A
8	350 SKIRT LENGTH WAS 225 ON DETAIL A
9	9089 OUTER SHELL MASS WAS 8460 ON DATA TABLE
10	32542 WP ASSEMBLY MASS WAS 31913 ON DATA TABLE
11	56263 WP ASSEMBLY WITH SIF MASS WAS 55634 ON DATA TABLE

COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG)	QTY ROD
OUTER SHELL	SB-575 N06022	25	9089	1
OUTER SHELL LID	SB-575 N06022	25	871	2
INNER SHELL	SA-240 (316 NG)	50	11663	1
INNER SHELL LID	SA-240 (316 NG)	105	2333	2
DIVIDER PLATE	SA-516 K02700	12.7	100	5
INNER BRACKET	SA-516 K02700	25.4	296	5
OUTER BRACKET	SA-516 K02700	12.7	375	5
SUPPORT TUBE	SA-516 K02700	31.75	1924	1
WASTE PACKAGE ASSEMBLY	-	-	32542	1
HLW GLASS ASSEMBLY	-	-	4200*	5
18" DOE CANISTER LONG	-	-	2721**	1
WP ASSEMBLY WITH SNF	-	-	56263	1

* CRWMS M&O INTEROFFICE CORRESPONDENCE, C. HEATH TO D. FOUST, DC.WKI.CAH. 5/97.02.

** UNITED STATES DEPARTMENT OF ENERGY 1998. DESIGN SPECIFICATION FOR DEPARTMENT OF ENERGY STANDARDIZED SPENT NUCLEAR FUEL CANISTERS, VOLUME I, DESIGN SPECIFICATION, REV 1. WASHINGTON D.C.: UNITED STATES DEPARTMENT OF ENERGY. TIC: 241528.

UNITS: mm

DO NOT SCALE FROM SKETCH

"FOR INFORMATION ONLY"

5-DHLW/DOE SNF-LONG SINGLE CRM DISPOSAL CONTAINER

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DATE: 08/05/99

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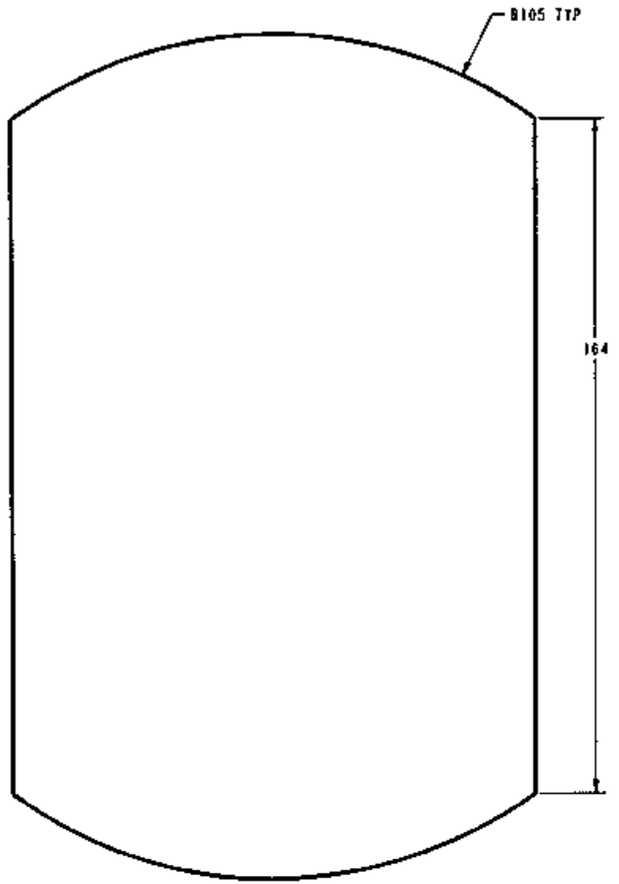
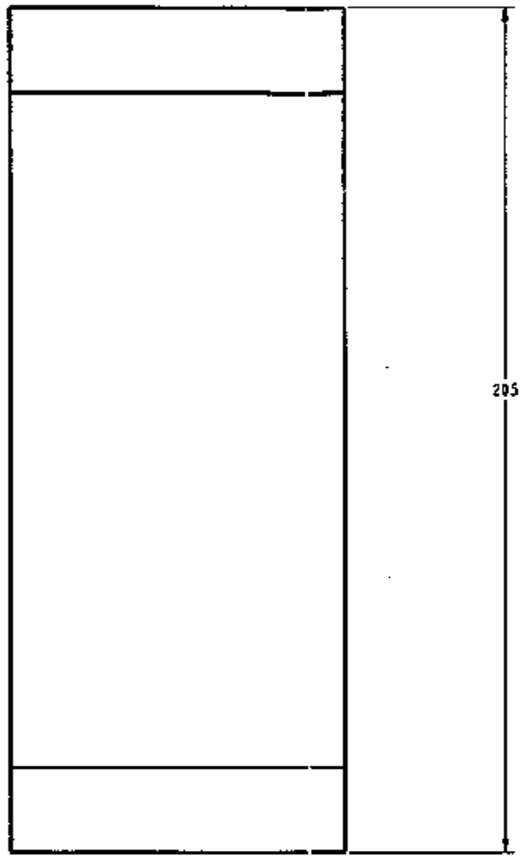
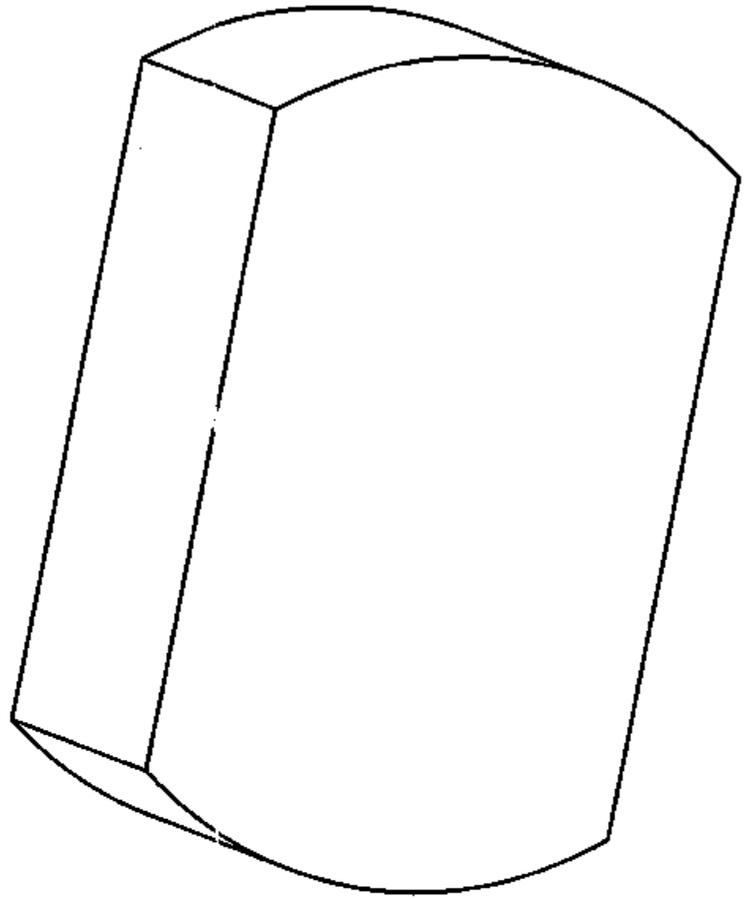
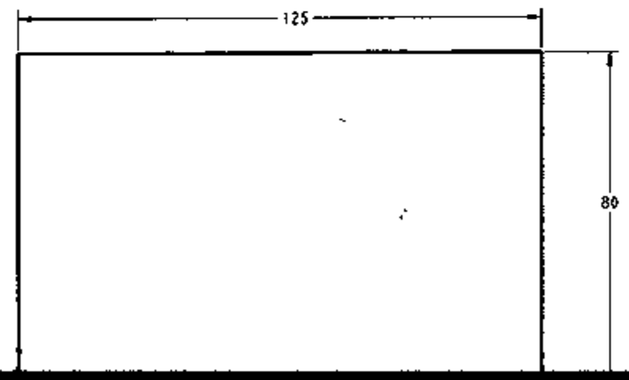








COMPONENT NAME	MATERIAL	THICKNESS	MASS (kg)	QTY REQ
LIFTING PIN	SA-579 X92820	80	15.3	1

"FOR INFORMATION ONLY"

DO NOT SCALE FROM SKETCH

UNITS: mm

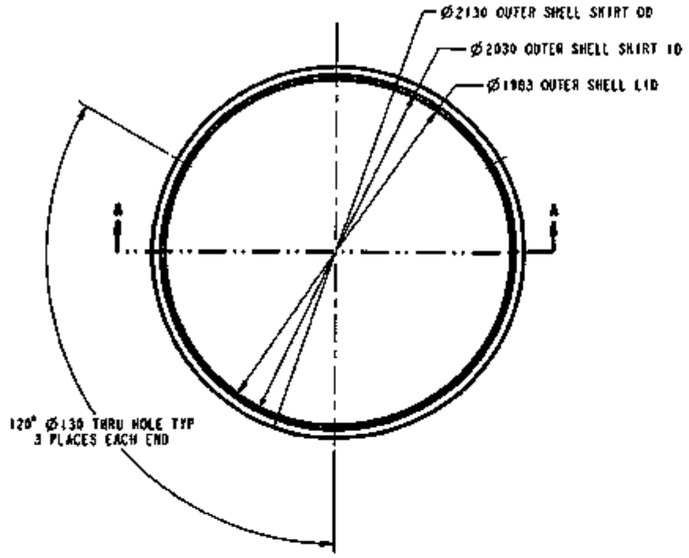
LIFTING PIN FOR 5-DHLW/DOE SNF-LONG AND NAVAL SNF-LONG SINGLE CRM WASTE PACKAGES

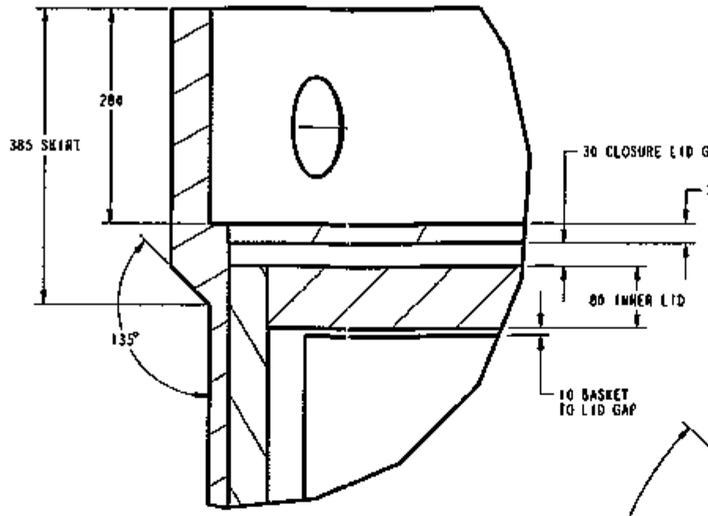
SKETCH NUMBER: SK-0151 REV 00

ORIGINATOR: ANDREW AILES AA SMB 8.12.99

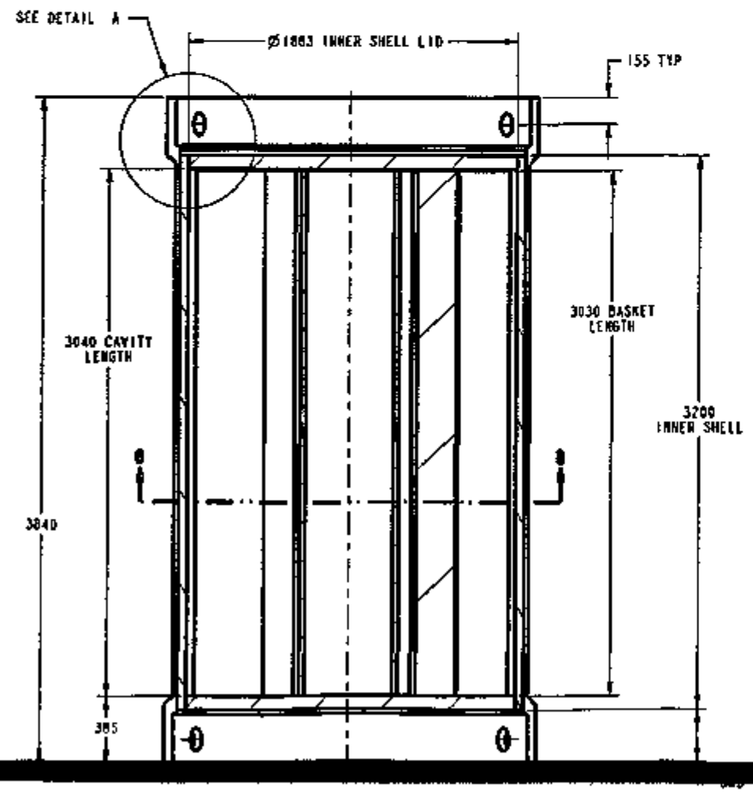
DATE: 08-12-99 8-12-99 8.13.99 8.12.99

FILE: /home/ailes/proe/0151/0151rev00.dwg

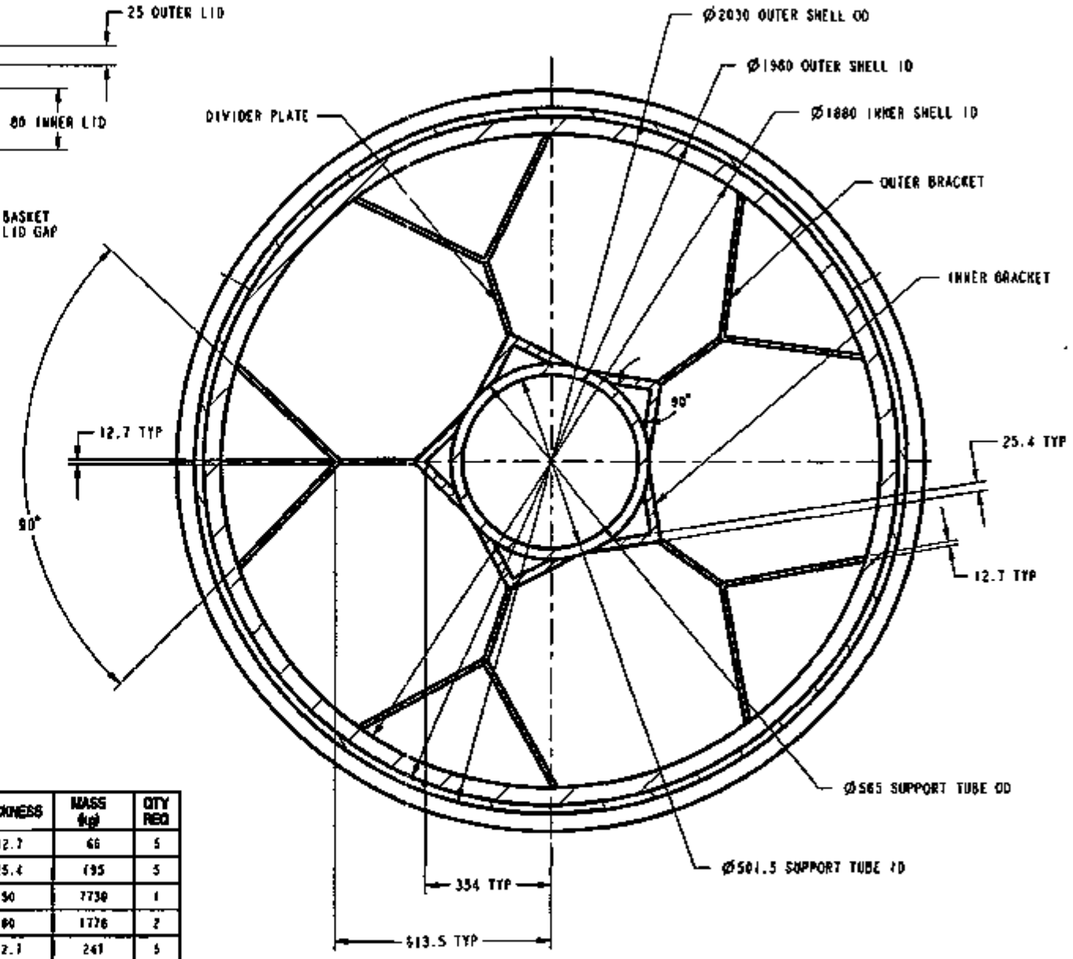




DETAIL A



SECTION A-A



SECTION B-B

COMPONENT NAME	MATERIAL	THICKNESS	MASS (kg)	QTY REQ
DIVIDER PLATE	SA-516 K02700	12.7	66	5
INNER BRACKET	SA-516 K02700	25.4	195	5
INNER SHELL	SA-240 (316KG)	50	7730	1
INNER SHELL LID	SA-240 (316KG)	80	1776	2
OUTER BRACKET	SA-516 K02700	12.7	261	5
OUTER SHELL	SB-575 N06022	25	6516	1
OUTER SHELL LID	SB-575 N06022	25	671	2
SUPPORT TUBE	SA-516 K02700	31.75	1265	1
WASTE PACKAGE ASSEMBLY	-	-	22940	1
HLW GLASS ASSEMBLY	-	-	25001	5
18" DOE CANISTER SHORT	-	-	2270**	1
WP ASSEMBLY WITH SNF	-	-	37716	1

"FOR INFORMATION ONLY"

5-DHLW/DOE SNF SHORT SINGLE CRM WASTE PACKAGE

SKETCH NUMBER: SK-0143 REV 01

SKETCHED BY: BRYAN HARKINS 09/20/99

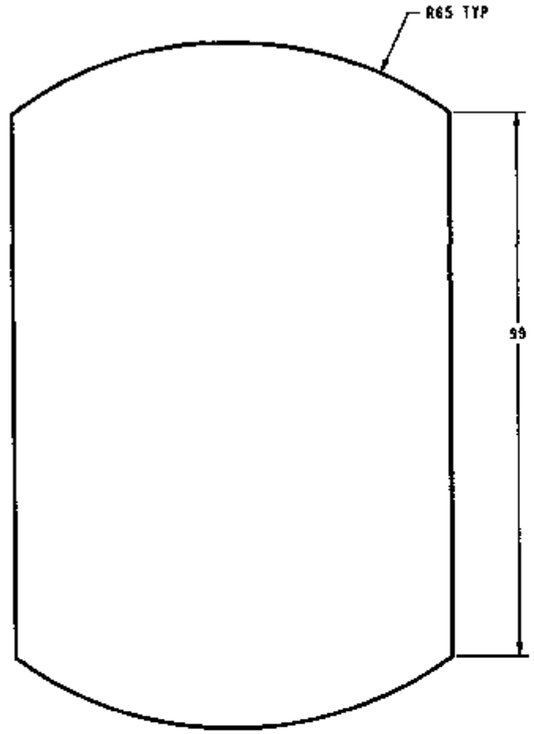
DATE: 09/20/99

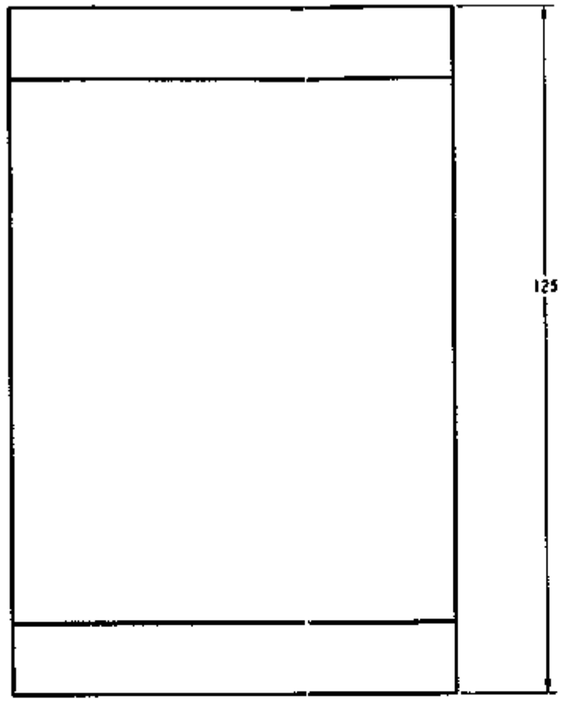
FILE: /home/pro_library/checkout/sketches/Sdhlw_home/Sdhlw_short/sk-0143.dwg

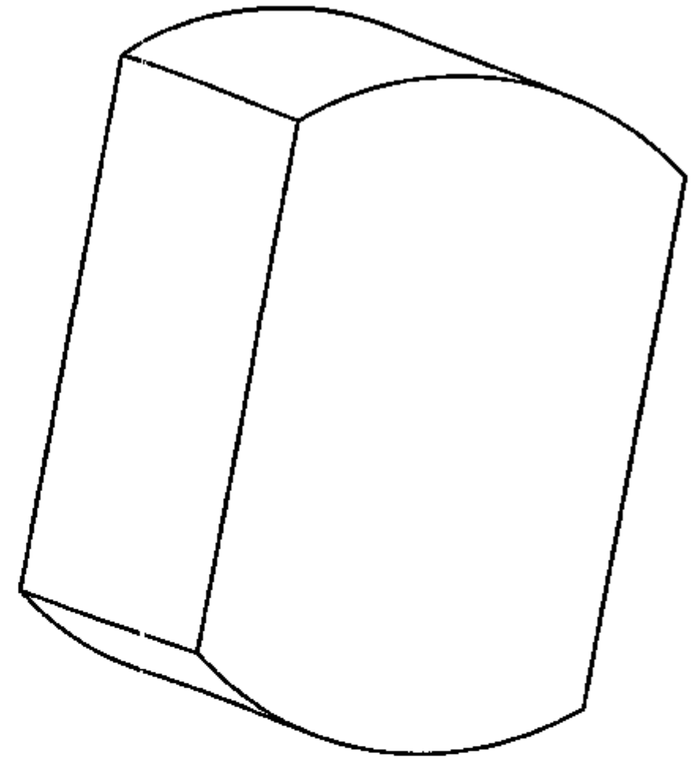
MAY 13, 1997, VIENNA, VA: CRWMS M&O. ACC: MOV.19970513.0118

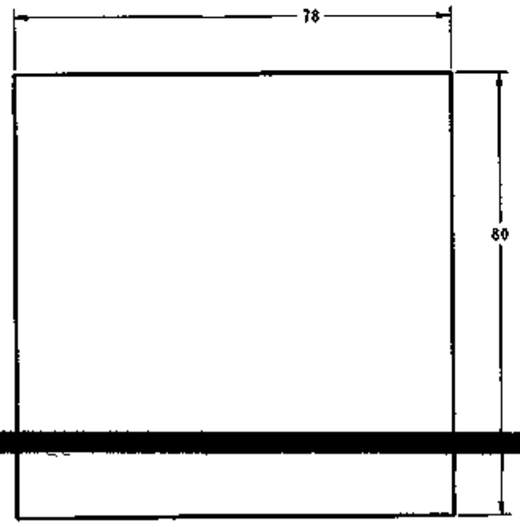
**DOE1998. DESIGN SPECIFICATION FOR DEPARTMENT OF ENERGY STANDARDIZED SPENT NUCLEAR FUEL CANISTERS, VOLUME I. DESIGN SPECIFICATION, REV 1. WASHINGTON D.C.: UNITED STATES DEPARTMENT OF ENERGY. TIC: 241528.

UNITS: mm
DO NOT SCALE









COMPONENT NAME	MATERIAL	THICKNESS	MASS (kg)	QTY REQ
LIFTING PIN	SA-579 K92820	60	5.83	1

"FOR INFORMATION ONLY"

DO NOT SCALE FROM SKETCH

UNITS: mm

LIFTING PIN FOR 21-PWR, 44-BWR, AND 5-DHLW/DOE SNF-SHORT SINGLE CRM WASTE PACKAGES

SKETCH NUMBER: SK-0152 REV 00

ORIGINATOR: ANDREW AILES AA 5-26 2-26 8.12.99

DATE: 08-12-99 8-12-99 02/12/99

FILE: /home/ailes/proe/0152/0152rev00.dwg

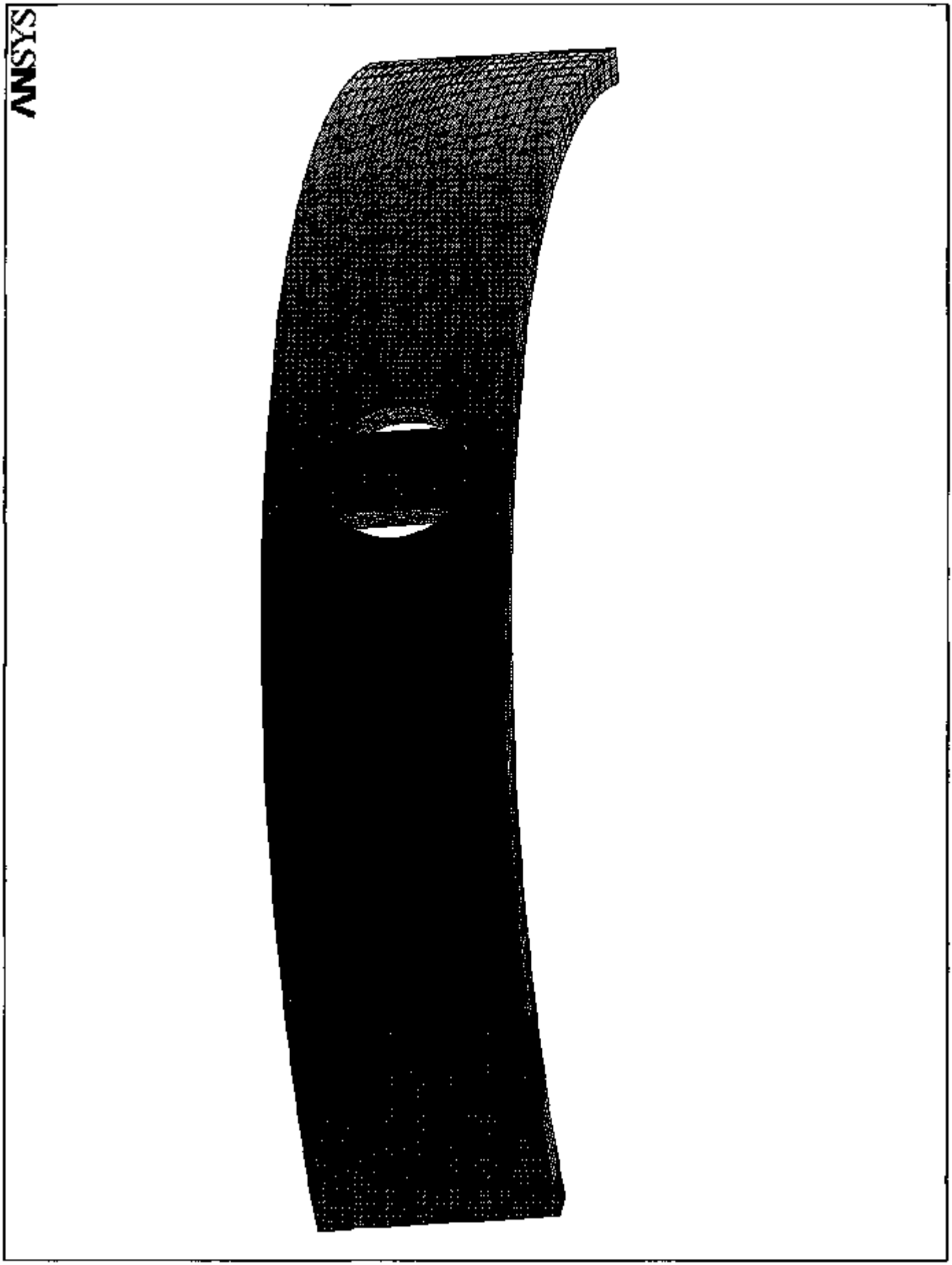


Figure III-1. Finite Element Representation of the 5-DHLW/DOE SNF Single CRM WP Skirt and Locking Pin

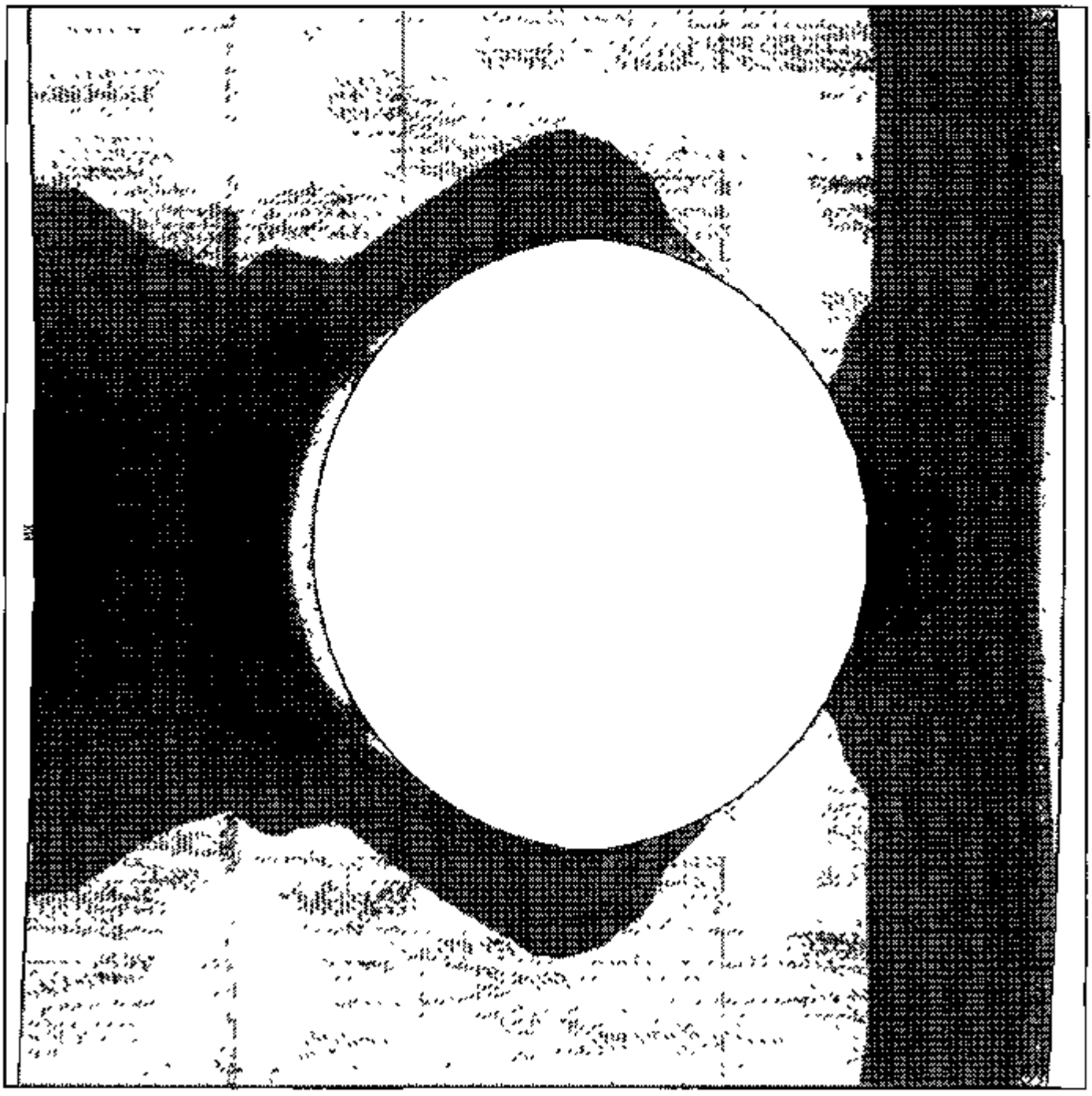


Figure III-2. Stress Intensity Plot for the skirt of the 5-DHLW/DOE SNF-Long Single CRM WP

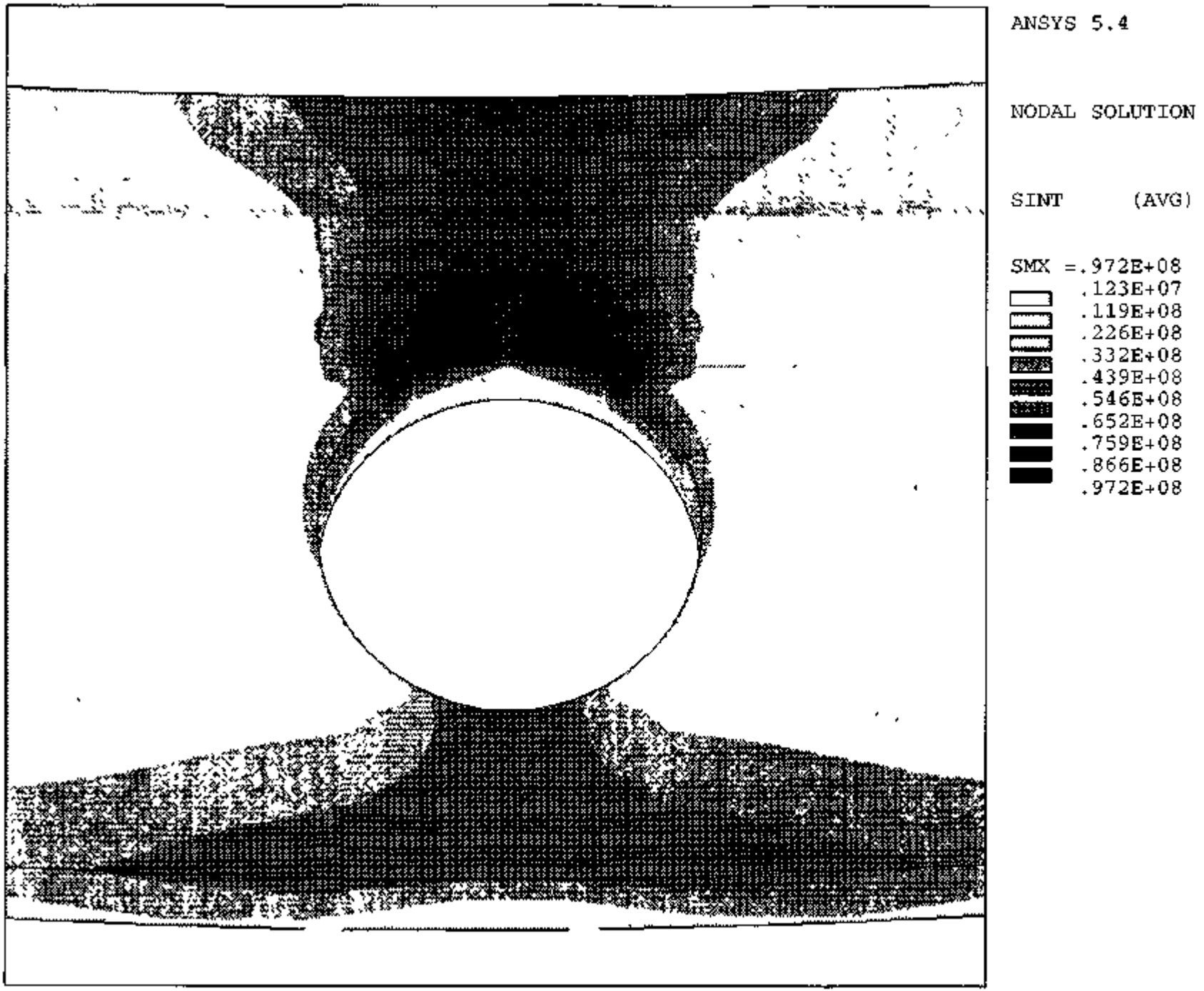


Figure III-3. Stress Intensity Plot for the Skirt of the 5-DHLW/DOE SNF-Short Single CRM WP

Mass Properties of 5-DHLW/DOE SNF-Long Single CRM Waste Package

MASS PROPERTIES OF THE PART 5DHLW_GUIDETUBE_LONG-SCRM

VOLUME =	2.4504321e+08	MM^3
SURFACE AREA =	1.5542172e+07	MM^2
DENSITY =	7.8500000e-06	KILOGRAM / MM^3
MASS =	1.9235892e+03	KILOGRAM

CENTER OF GRAVITY with respect to _5DHLW_GUIDETUBE_ coordinate frame:

X Y Z	0.0000000e+00	2.3035000e+03	0.0000000e+00	MM

INERTIA with respect to _5DHLW_GUIDETUBE_ coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	1.3677643e+10	0.0000000e+00	-3.8353318e+04
Iyx Iyy Iyz	0.0000000e+00	1.3723063e+08	0.0000000e+00
Izx Izy Izz	-3.8353318e+04	0.0000000e+00	1.3677668e+10

INERTIA at CENTER OF GRAVITY with respect to _5DHLW_GUIDETUBE_ coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	3.4708630e+09	0.0000000e+00	-3.8353318e+04
Iyx Iyy Iyz	0.0000000e+00	1.3723063e+08	0.0000000e+00
Izx Izy Izz	-3.8353318e+04	0.0000000e+00	3.4708879e+09

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM * MM^2)

I1 I2 I3	1.3723063e+08	3.4708351e+09	3.4709158e+09	

ROTATION MATRIX from _5DHLW_GUIDETUBE_ orientation to PRINCIPAL AXES:

0.00000	-0.80883	-0.58805
1.00000	0.00000	0.00000
0.00000	-0.58805	0.80883

ROTATION ANGLES from _5DHLW_GUIDETUBE_ orientation to PRINCIPAL AXES (degrees):

angles about x y z	0.000	-36.019	90.000	

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3	2.6709721e+02	1.3432623e+03	1.3432779e+03	MM

Mass Properties of 5-DHLW/DOE SNF-Long Single CRM Waste Package

MASS PROPERTIES OF THE PART 5DHLW_INNERBARRIER_LONG-SCRM

VOLUME =	1.4615092e+09	MM^3
SURFACE AREA =	5.9143152e+07	MM^2
DENSITY =	7.9800000e-06	KILOGRAM / MM^3
MASS =	1.1662843e+04	KILOGRAM

CENTER OF GRAVITY with respect to _5DHLW_INNERBARRI coordinate frame:

X Y Z	0.0000000e+00	2.4135000e+03	0.0000000e+00	MM

INERTIA with respect to _5DHLW_INNERBARRI coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	9.5960524e+10	0.0000000e+00	-3.0375976e+06
Iyx Iyy Iyz	0.0000000e+00	1.0868717e+10	0.0000000e+00
Izx Izy Izz	-3.0375976e+06	0.0000000e+00	9.5962498e+10

INERTIA at CENTER OF GRAVITY with respect to _5DHLW_INNERBARRI coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	2.8024668e+10	0.0000000e+00	-3.0375976e+06
Iyx Iyy Iyz	0.0000000e+00	1.0868717e+10	0.0000000e+00
Izx Izy Izz	-3.0375976e+06	0.0000000e+00	2.8026642e+10

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM * MM^2)

I1 I2 I3	1.0868717e+10	2.8022461e+10	2.8028849e+10	

ROTATION MATRIX from _5DHLW_INNERBARRI orientation to PRINCIPAL AXES:

0.00000	-0.80902	-0.58779
1.00000	0.00000	0.00000
0.00000	-0.58779	0.80902

ROTATION ANGLES from _5DHLW_INNERBARRI orientation to PRINCIPAL AXES (degrees):

angles about x y z	0.000	-36.000	90.000

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3	9.6535469e+02	1.5500686e+03	1.5502452e+03	MM

Mass Properties of 5-DHLW/DOE SNF-Long Single CRM Waste Package

MASS PROPERTIES OF THE PART 5DHLW_INNERLID_LONG-SCRM

VOLUME =	2.9240165e+08	MM^3
SURFACE AREA =	6.1906952e+06	MM^2
DENSITY =	7.9800000e-06	KILOGRAM / MM^3
MASS =	2.3333652e+03	KILOGRAM

CENTER OF GRAVITY with respect to _5DHLW_INNERLID_L coordinate frame:

X Y Z	0.0000000e+00	0.0000000e+00	5.2500000e+01 MM

INERTIA with respect to _5DHLW_INNERLID_L coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	5.2566868e+08	-2.1103890e+04	0.0000000e+00
Iyx Iyy Iyz	-2.1103890e+04	5.2565496e+08	0.0000000e+00
Izx Izy Izz	0.0000000e+00	0.0000000e+00	1.0341734e+09

INERTIA at CENTER OF GRAVITY with respect to _5DHLW_INNERLID_L coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	5.1923734e+08	-2.1103890e+04	0.0000000e+00
Iyx Iyy Iyz	-2.1103890e+04	5.1922362e+08	0.0000000e+00
Izx Izy Izz	0.0000000e+00	0.0000000e+00	1.0341734e+09

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM * MM^2)

I1 I2 I3	5.1920829e+08	5.1925267e+08	1.0341734e+09

ROTATION MATRIX from _5DHLW_INNERLID_L orientation to PRINCIPAL AXES:

0.58778	-0.80902	0.00000
0.80902	0.58778	0.00000
0.00000	0.00000	1.00000

ROTATION ANGLES from _5DHLW_INNERLID_L orientation to PRINCIPAL AXES (degrees):

angles about x y z	0.000	0.000	54.000

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3	4.7171475e+02	4.7173491e+02	6.6574103e+02 MM

Mass Properties of 5-DHLW/DOE SNF-Long Single CRM Waste Package

MASS PROPERTIES OF THE PART 5DHLW_OUTERLID_LONG-SCRM

VOLUME = 7.7210314e+07 MM^3
SURFACE AREA = 6.3325696e+06 MM^2
DENSITY = 8.6900000e-06 KILOGRAM / MM^3
MASS = 6.7095763e+02 KILOGRAM

CENTER OF GRAVITY with respect to _5DHLW_OUTERLID_L coordinate frame:
X Y Z 0.0000000e+00 0.0000000e+00 1.2500000e+01 MM

INERTIA with respect to _5DHLW_OUTERLID_L coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:
Ixx Ixy Ixz 1.6503991e+08 -5.3637528e+02 0.0000000e+00
Iyx Iyy Iyz -5.3637528e+02 1.6503956e+08 0.0000000e+00
Izx Izy Izz 0.0000000e+00 0.0000000e+00 3.2979991e+08

INERTIA at CENTER OF GRAVITY with respect to _5DHLW_OUTERLID_L coordinate frame:
(KILOGRAM * MM^2)
INERTIA TENSOR:
Ixx Ixy Ixz 1.6493508e+08 -5.3637528e+02 0.0000000e+00
Iyx Iyy Iyz -5.3637528e+02 1.6493473e+08 0.0000000e+00
Izx Izy Izz 0.0000000e+00 0.0000000e+00 3.2979991e+08

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM * MM^2)
I1 I2 I3 1.6493434e+08 1.6493547e+08 3.2979991e+08

ROTATION MATRIX from _5DHLW_OUTERLID_L orientation to PRINCIPAL AXES:
1.00000 0.00000 0.00000
0.00000 1.00000 0.00000
0.00000 0.00000 1.00000

ROTATION ANGLES from _5DHLW_OUTERLID_L orientation to PRINCIPAL AXES (degrees):
angles about x y z 0.000 0.000 0.000

RADII OF GYRATION with respect to PRINCIPAL AXES:
R1 R2 R3 4.9580168e+02 4.9580337e+02 7.0109637e+02 MM

Mass Properties of 5-DHLW/DOE SNF-Long Single CRM Waste Package

MASS PROPERTIES OF THE PART DIVIDER_PLATE-SCRM

VOLUME = 1.2773663e+07 MM^3
SURFACE AREA = 2.1341636e+06 MM^2
DENSITY = 7.8500000e-06 KILOGRAM / MM^3
MASS = 1.0027325e+02 KILOGRAM

CENTER OF GRAVITY with respect to _DIVIDER_PLATE-SC coordinate frame:

X Y Z	6.3500000e+00	2.3035000e+03	1.0916000e+02 MM

INERTIA with respect to _DIVIDER_PLATE-SC coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	7.1100799e+08	-1.4667195e+06	-6.9506011e+04
Iyx Iyy Iyz	-1.4667195e+06	1.5985199e+06	-2.5213716e+07
Izx Izy Izz	-6.9506011e+04	-2.5213716e+07	7.0942025e+08

INERTIA at CENTER OF GRAVITY with respect to _DIVIDER_PLATE-SC coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	1.7775200e+08	0.0000000e+00	0.0000000e+00
Iyx Iyy Iyz	0.0000000e+00	3.9962997e+05	0.0000000e+00
Izx Izy Izz	0.0000000e+00	0.0000000e+00	1.7735506e+08

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM * MM^2)

I1 I2 I3	3.9962997e+05	1.7735506e+08	1.7775200e+08

ROTATION MATRIX from _DIVIDER_PLATE-SC orientation to PRINCIPAL AXES:

0.00000	0.00000	1.00000
1.00000	0.00000	0.00000
0.00000	1.00000	0.00000

ROTATION ANGLES from _DIVIDER_PLATE-SC orientation to PRINCIPAL AXES (degrees):

angles about x y z	0.000	90.000	90.000

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3	6.3130099e+01	1.3299314e+03	1.3314188e+03 MM

Mass Properties of 5-DHLW/DOE SNF-Long Single CRM Waste Package

MASS PROPERTIES OF THE PART INNERBRACKET-SCRM

VOLUME = 3.7741264e+07 MM^3
SURFACE AREA = 3.7483969e+06 MM^2
DENSITY = 7.8500000e-06 KILOGRAM / MM^3
MASS = 2.9626892e+02 KILOGRAM

CENTER OF GRAVITY with respect to _INNERBRACKET-SCR coordinate frame:
X Y Z -5.3362187e+01 -5.3362530e+01 2.3035000e+03 MM

INERTIA with respect to _INNERBRACKET-SCR coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:
Ixx Ixy Ixz 2.0977707e+09 -3.1062160e+05 3.6417316e+07
Iyx Iyy Iyz -3.1062160e+05 2.0977708e+09 3.6417550e+07
Izx Izy Izz 3.6417316e+07 3.6417550e+07 3.4450413e+06

INERTIA at CENTER OF GRAVITY with respect to _INNERBRACKET-SCR coordinate frame:
(KILOGRAM * MM^2)

INERTIA TENSOR:
Ixx Ixy Ixz 5.2489086e+08 5.3301639e+05 0.0000000e+00
Iyx Iyy Iyz 5.3301639e+05 5.2489105e+08 0.0000000e+00
Izx Izy Izz 0.0000000e+00 0.0000000e+00 1.7577653e+06

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM * MM^2)
I1 I2 I3 1.7577653e+06 5.2435794e+08 5.2542397e+08

ROTATION MATRIX from _INNERBRACKET-SCR orientation to PRINCIPAL AXES:
0.00000 0.70717 0.70704
0.00000 -0.70704 0.70717
1.00000 0.00000 0.00000

ROTATION ANGLES from _INNERBRACKET-SCR orientation to PRINCIPAL AXES (degrees):
angles about x y z -90.000 44.995 -90.000

RADII OF GYRATION with respect to PRINCIPAL AXES:
R1 R2 R3 7.7026010e+01 1.3303652e+03 1.3317168e+03 MM

Mass Properties of 5-DHLW/DOE SNF-Long Single CRM Waste Package

MASS PROPERTIES OF THE PART OUTER_BRACKET-SCRM

VOLUME = 4.7771456e+07 MM^3
SURFACE AREA = 7.6798380e+06 MM^2
DENSITY = 7.8500000e-06 KILOGRAM / MM^3
MASS = 3.7500593e+02 KILOGRAM

CENTER OF GRAVITY with respect to _OUTER_BRACKET-SC coordinate frame:

X Y Z	-7.0509743e+00	1.4795702e+02	2.3035000e+03	MM

INERTIA with respect to _OUTER_BRACKET-SC coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	2.6639122e+09	3.9659737e+05	6.0908161e+06
Iyx Iyy Iyz	3.9659737e+05	2.6636658e+09	-1.2780915e+08
Izx Izy Izz	6.0908161e+06	-1.2780915e+08	2.1381807e+07

INERTIA at CENTER OF GRAVITY with respect to _OUTER_BRACKET-SC coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	6.6587923e+08	5.3757525e+03	0.0000000e+00
Iyx Iyy Iyz	5.3757525e+03	6.7382362e+08	0.0000000e+00
Izx Izy Izz	0.0000000e+00	0.0000000e+00	1.3153803e+07

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM * MM^2)

I1 I2 I3	1.3153803e+07	6.6587923e+08	6.7382362e+08

ROTATION MATRIX from _OUTER_BRACKET-SC orientation to PRINCIPAL AXES:

0.00000	1.00000	0.00068
0.00000	-0.00068	1.00000
1.00000	0.00000	0.00000

ROTATION ANGLES from _OUTER_BRACKET-SC orientation to PRINCIPAL AXES (degrees):

angles about x y z	-90.000	0.000	-90.000

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3	1.8728655e+02	1.3325351e+03	1.3404606e+03	MM

Mass Properties of 5-DHLW/DOE SNF-Long Single CRM Waste Package

MASS PROPERTIES OF THE PART OUTERBARRIER_A22

VOLUME =	1.0459619e+09	MM^3
SURFACE AREA =	7.2040902e+07	MM^2
DENSITY =	8.6900000e-06	KILOGRAM / MM^3
MASS =	9.0894093e+03	KILOGRAM

CENTER OF GRAVITY with respect to _OUTERBARRIER_A22 coordinate frame:

X Y Z	0.0000000e+00	-2.8035000e+03	0.0000000e+00	MM

INERTIA with respect to OUTERBARRIER_A22 coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	1.0547773e+11	0.0000000e+00	-1.6038572e+06
Iyx Iyy Iyz	0.0000000e+00	9.3173227e+09	0.0000000e+00
Izx Izy Izz	-1.6038572e+06	0.0000000e+00	1.0547876e+11

INERTIA at CENTER OF GRAVITY with respect to _OUTERBARRIER_A22 coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	3.4038497e+10	0.0000000e+00	-1.6038572e+06
Iyx Iyy Iyz	0.0000000e+00	9.3173227e+09	0.0000000e+00
Izx Izy Izz	-1.6038572e+06	0.0000000e+00	3.4039530e+10

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM * MM^2)

I1 I2 I3	9.3173227e+09	3.4037329e+10	3.4040698e+10

ROTATION MATRIX from _OUTERBARRIER_A22 orientation to PRINCIPAL AXES:

0.00000	-0.80821	-0.58890
1.00000	0.00000	0.00000
0.00000	-0.58890	0.80821

ROTATION ANGLES from _OUTERBARRIER_A22 orientation to PRINCIPAL AXES (degrees):

angles about x y z	0.000	-36.079	90.000

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3	1.0124597e+03	1.9351289e+03	1.9352247e+03	MM

Mass Properties of 5-DHLW/DOE SNF-Long Single CRM Waste Package

MASS PROPERTIES OF THE ASSEMBLY TOP_ASSEMBLY_REVISION

```
                    VOLUME =  3.9831702e+09 MM^3
                SURFACE AREA =  2.3958475e+08 MM^2
             AVERAGE DENSITY =  8.1699316e-06 KILOGRAM / MM^3
                        MASS =  3.2542228e+04 KILOGRAM

      CENTER OF GRAVITY with respect to _TOP_ASSEMBLY_REV coordinate frame:
X   Y   Z          0.0000000e+00  2.8145801e+03  0.0000000e+00  MM

 INERTIA with respect to _TOP_ASSEMBLY_REV coordinate frame:  (KILOGRAM * MM^2)

INERTIA TENSOR:
Ixx Ixy Ixz        3.6623177e+11  0.0000000e+00  1.3953871e+06
Iyx Iyy Iyz        0.0000000e+00  2.4450348e+10  0.0000000e+00
Izx Izy Izz        1.3953871e+06  0.0000000e+00  3.6623477e+11

INERTIA at CENTER OF GRAVITY with respect to _TOP_ASSEMBLY_REV coordinate frame:
                                                          (KILOGRAM * MM^2)
INERTIA TENSOR:
Ixx Ixy Ixz        1.0843676e+11  0.0000000e+00  1.3953871e+06
Iyx Iyy Iyz        0.0000000e+00  2.4450348e+10  0.0000000e+00
Izx Izy Izz        1.3953871e+06  0.0000000e+00  1.0843976e+11

                PRINCIPAL MOMENTS OF INERTIA:  (KILOGRAM * MM^2)
I1  I2  I3         2.4450348e+10  1.0843621e+11  1.0844031e+11

      ROTATION MATRIX from _TOP_ASSEMBLY_REV orientation to PRINCIPAL AXES:
                      0.00000       -0.93074        0.36569
                      1.00000        0.00000        0.00000
                      0.00000        0.36569        0.93074

 ROTATION ANGLES from _TOP_ASSEMBLY_REV orientation to PRINCIPAL AXES (degrees):
angles about x  y  z   0.000          21.450         90.000

                RADII OF GYRATION with respect to PRINCIPAL AXES:
R1  R2  R3         8.6679996e+02  1.8254230e+03  1.8254576e+03  MM
```

MASS PROPERTIES OF COMPONENTS OF THE ASSEMBLY
(in assembly units and the _TOP_ASSEMBLY_REV coordinate frame)

	DENSITY	MASS	MATERIAL C.G.: X	Y	Z
OUTERBARRIER_A22			UNKNOWN		
	8.69000e-06	9.08941e+03	-4.85654e-05	2.80350e+03	-1.83059e-04
5DHLW_OUTERLID_LONG-SCRM			UNKNOWN		
	8.69000e-06	6.70958e+02	-1.32100e-13	5.24450e+03	-8.54152e-14
5DHLW_INNERBARRIER_LONG-SCRM			UNKNOWN		
	7.94560e-06	2.21109e+04	2.41349e-13	2.81981e+03	-7.60846e-15

Mass Properties of 5-DHLW/DOE SNF-Long Single CRM Waste Package

```
5DHLW_OUTERLID_LONG-SCRM          UNKNOWN
     8.69000e-06  6.70958e+02  1.32100e-13  3.62500e+02 -8.54152e-14
```

Mass Properties of 5-DHLW/DOE SNF-Short Single CRM Waste Package

```
                MASS PROPERTIES OF THE PART 5DHLW_GUIDETUBE_SHORT

                        VOLUME =  1.6116365e+08 MM^3
                  SURFACE AREA =  1.0258420e+07 MM^2
                       DENSITY =  7.8500000e-06 KILOGRAM / MM^3
                          MASS =  1.2651347e+03 KILOGRAM

      CENTER OF GRAVITY with respect to _5DHLW_GUIDETUBE_ coordinate frame:
X   Y   Z           0.0000000e+00  1.5150000e+03  0.0000000e+00  MM

 INERTIA with respect to _5DHLW_GUIDETUBE_ coordinate frame:  (KILOGRAM * MM^2)

INERTIA TENSOR:
Ixx Ixy Ixz         3.9168113e+09  0.0000000e+00 -2.5224778e+04
Iyx Iyy Iyz         0.0000000e+00  9.0255853e+07  0.0000000e+00
Izx Izy Izz        -2.5224778e+04  0.0000000e+00  3.9168277e+09

INERTIA at CENTER OF GRAVITY with respect to _5DHLW_GUIDETUBE_ coordinate frame:
                                                          (KILOGRAM * MM^2)
INERTIA TENSOR:
Ixx Ixy Ixz         1.0130426e+09  0.0000000e+00 -2.5224778e+04
Iyx Iyy Iyz         0.0000000e+00  9.0255853e+07  0.0000000e+00
Izx Izy Izz        -2.5224778e+04  0.0000000e+00  1.0130590e+09

                PRINCIPAL MOMENTS OF INERTIA:  (KILOGRAM * MM^2)
I1  I2  I3          9.0255853e+07  1.0130243e+09  1.0130773e+09

      ROTATION MATRIX from _5DHLW_GUIDETUBE_ orientation to PRINCIPAL AXES:
                        0.00000       -0.80902       -0.58779
                        1.00000        0.00000        0.00000
                        0.00000       -0.58779        0.80902

 ROTATION ANGLES from _5DHLW_GUIDETUBE_ orientation to PRINCIPAL AXES (degrees):
angles about x  y  z    0.000         -36.000         90.000

                RADII OF GYRATION with respect to PRINCIPAL AXES:
R1  R2  R3          2.6709719e+02  8.9483210e+02  8.9485553e+02  MM
```

Mass Properties of 5-DHLW/DOE SNF-Short Single CRM Waste Package

```
              MASS PROPERTIES OF THE PART 5DHLW_INNERBARRIER_SHORT

                        VOLUME =  9.6870519e+08 MM^3
                  SURFACE AREA =  3.9412788e+07 MM^2
                       DENSITY =  7.9800000e-06 KILOGRAM / MM^3
                          MASS =  7.7302674e+03 KILOGRAM

      CENTER OF GRAVITY with respect to _5DHLW_INNERBARRI coordinate frame:
X   Y   Z           0.0000000e+00  1.6000000e+03  0.0000000e+00  MM

 INERTIA with respect to _5DHLW_INNERBARRI coordinate frame:  (KILOGRAM * MM^2)

INERTIA TENSOR:
Ixx Ixy Ixz         2.9969420e+10  0.0000000e+00 -2.0133741e+06
Iyx Iyy Iyz         0.0000000e+00  7.2039800e+09  0.0000000e+00
Izx Izy Izz        -2.0133741e+06  0.0000000e+00  2.9970728e+10

INERTIA at CENTER OF GRAVITY with respect to _5DHLW_INNERBARRI coordinate frame:
                                                        (KILOGRAM * MM^2)
INERTIA TENSOR:
Ixx Ixy Ixz         1.0179935e+10  0.0000000e+00 -2.0133741e+06
Iyx Iyy Iyz         0.0000000e+00  7.2039800e+09  0.0000000e+00
Izx Izy Izz        -2.0133741e+06  0.0000000e+00  1.0181243e+10

               PRINCIPAL MOMENTS OF INERTIA:  (KILOGRAM * MM^2)
I1  I2  I3          7.2039800e+09  1.0178472e+10  1.0182706e+10

      ROTATION MATRIX from _5DHLW_INNERBARRI orientation to PRINCIPAL AXES:
                      0.00000       -0.80902       -0.58779
                      1.00000        0.00000        0.00000
                      0.00000       -0.58779        0.80902

 ROTATION ANGLES from _5DHLW_INNERBARRI orientation to PRINCIPAL AXES (degrees):
angles about x  y  z    0.000         -36.000         90.000

               RADII OF GYRATION with respect to PRINCIPAL AXES:
R1  R2  R3          9.6535931e+02  1.1474771e+03  1.1477158e+03  MM
```

Mass Properties of 5-DHLW/DOE SNF-Short Single CRM Waste Package

MASS PROPERTIES OF THE PART 5DHLW_INNERLID_SHORT

VOLUME = 2.2278221e+08 MM^3
SURFACE AREA = 6.0428048e+06 MM^2
DENSITY = 7.9800000e-06 KILOGRAM / MM^3
MASS = 1.7778020e+03 KILOGRAM

CENTER OF GRAVITY with respect to _5DHLW_INNERLID_S coordinate frame:

X	Y	Z	0.0000000e+00	0.0000000e+00	4.0000000e+01	MM

INERTIA with respect to _5DHLW_INNERLID_S coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx	Ixy	Ixz	3.9776869e+08	-1.6079155e+04	0.0000000e+00
Iyx	Iyy	Iyz	-1.6079155e+04	3.9775824e+08	0.0000000e+00
Izx	Izy	Izz	0.0000000e+00	0.0000000e+00	7.8794164e+08

INERTIA at CENTER OF GRAVITY with respect to _5DHLW_INNERLID_S coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx	Ixy	Ixz	3.9492421e+08	-1.6079155e+04	0.0000000e+00
Iyx	Iyy	Iyz	-1.6079155e+04	3.9491376e+08	0.0000000e+00
Izx	Izy	Izz	0.0000000e+00	0.0000000e+00	7.8794164e+08

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM * MM^2)

I1	I2	I3	3.9490208e+08	3.9493589e+08	7.8794164e+08

ROTATION MATRIX from _5DHLW_INNERLID_S orientation to PRINCIPAL AXES:

0.58778	-0.80902	0.00000
0.80902	0.58778	0.00000
0.00000	0.00000	1.00000

ROTATION ANGLES from _5DHLW_INNERLID_S orientation to PRINCIPAL AXES (degrees):

angles about	x	y	z	0.000	0.000	54.000

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1	R2	R3	4.7130604e+02	4.7132622e+02	6.6574103e+02	MM

Mass Properties of 5-DHLW/DOE SNF-Short Single CRM Waste Package

```
                MASS PROPERTIES OF THE PART 5DHLW_OUTERBARRIER_SHORT

                          VOLUME =  7.4913838e+08 MM^3
                      SURFACE AREA =  4.9912127e+07 MM^2
                           DENSITY =  8.6900000e-06 KILOGRAM / MM^3
                              MASS =  6.5100125e+03 KILOGRAM

       CENTER OF GRAVITY with respect to _5DHLW_OUTERBARRI coordinate frame:
X   Y   Z              0.0000000e+00  1.9246735e+03  0.0000000e+00  MM

 INERTIA with respect to  5DHLW_OUTERBARRI coordinate frame:  (KILOGRAM * MM^2)

INERTIA TENSOR:
Ixx Ixy Ixz            3.7628220e+10  0.0000000e+00 -1.2180377e+06
Iyx Iyy Iyz            0.0000000e+00  6.6973820e+09  1.1791867e+05
Izx Izy Izz           -1.2180377e+06  1.1791867e+05  3.7629021e+10

INERTIA at CENTER OF GRAVITY with respect to _5DHLW_OUTERBARRI coordinate frame:
                                                              (KILOGRAM * MM^2)
INERTIA TENSOR:
Ixx Ixy Ixz            1.3512736e+10  0.0000000e+00 -1.2180377e+06
Iyx Iyy Iyz            0.0000000e+00  6.6973820e+09  1.1899333e+05
Izx Izy Izz           -1.2180377e+06  1.1899333e+05  1.3513538e+10

                 PRINCIPAL MOMENTS OF INERTIA:  (KILOGRAM * MM^2)
I1  I2  I3             6.6973820e+09  1.3511855e+10  1.3514419e+10

       ROTATION MATRIX from _5DHLW_OUTERBARRI orientation to PRINCIPAL AXES:
                          0.00000       -0.81008       -0.58632
                          1.00000       -0.00001        0.00001
                         -0.00002       -0.58632        0.81008

 ROTATION ANGLES from _5DHLW_OUTERBARRI orientation to PRINCIPAL AXES (degrees):
angles about X  y  z      0.000         -35.896          90.000

                 RADII OF GYRATION with respect to PRINCIPAL AXES:
R1  R2  R3             1.0142888e+03  1.4406768e+03  1.4408135e+03  MM
```

Mass Properties of 5-DHLW/DOE SNF-Short Single CRM Waste Package

```
                MASS PROPERTIES OF THE PART 5DHLW_OUTERLID_SHORT

                        VOLUME =  7.7210314e+07 MM^3
                  SURFACE AREA =  6.3325696e+06 MM^2
                       DENSITY =  8.6900000e-06 KILOGRAM / MM^3
                          MASS =  6.7095763e+02 KILOGRAM

      CENTER OF GRAVITY with respect to _5DHLW_OUTERLID_S coordinate frame:
X   Y   Z           0.0000000e+00  0.0000000e+00  1.2500000e+01  MM

 INERTIA with respect to _5DHLW_OUTERLID_S coordinate frame:  (KILOGRAM * MM^2)

INERTIA TENSOR:
Ixx Ixy Ixz         1.6503991e+08 -5.3637528e+02  0.0000000e+00
Iyx Iyy Iyz        -5.3637528e+02  1.6503956e+08  0.0000000e+00
Izx Izy Izz         0.0000000e+00  0.0000000e+00  3.2979991e+08

INERTIA at CENTER OF GRAVITY with respect to _5DHLW_OUTERLID_S coordinate frame:
                                                        (KILOGRAM * MM^2)
INERTIA TENSOR:
Ixx Ixy Ixz         1.6493508e+08 -5.3637528e+02  0.0000000e+00
Iyx Iyy Iyz        -5.3637528e+02  1.6493473e+08  0.0000000e+00
Izx Izy Izz         0.0000000e+00  0.0000000e+00  3.2979991e+08

               PRINCIPAL MOMENTS OF INERTIA:  (KILOGRAM * MM^2)
I1  I2  I3          1.6493434e+08  1.6493547e+08  3.2979991e+08

      ROTATION MATRIX from _5DHLW_OUTERLID_S orientation to PRINCIPAL AXES:
                      1.00000        0.00000        0.00000
                      0.00000        1.00000        0.00000
                      0.00000        0.00000        1.00000

 ROTATION ANGLES from _5DHLW_OUTERLID_S orientation to PRINCIPAL AXES (degrees):
angles about x  y  z    0.000          0.000          0.000

               RADII OF GYRATION with respect to PRINCIPAL AXES:
R1  R2  R3          4.9580168e+02  4.9580337e+02  7.0109637e+02  MM
```

Mass Properties of 5-DHLW/DOE SNF-Short Single CRM Waste Package

MASS PROPERTIES OF THE ASSEMBLY 5DHLW_SHORT_TOP

VOLUME =	2.8022045e+09	MM^3
SURFACE AREA =	1.6900671e+08	MM^2
AVERAGE DENSITY =	8.1864653e-06	KILOGRAM / MM^3
MASS =	2.2940150e+04	KILOGRAM

CENTER OF GRAVITY with respect to _5DHLW_SHORT_TOP coordinate frame:

X Y Z	0.0000000e+00	1.6056317e+03	0.0000000e+00	MM

INERTIA with respect to _5DHLW_SHORT_TOP coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	9.9577133e+10	0.0000000e+00	-3.2061871e+06
Iyx Iyy Iyz	0.0000000e+00	1.7147303e+10	0.0000000e+00
Izx Izy Izz	-3.2061871e+06	0.0000000e+00	9.9579237e+10

INERTIA at CENTER OF GRAVITY with respect to _5DHLW_SHORT_TOP coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	4.0436208e+10	0.0000000e+00	-3.2061871e+06
Iyx Iyy Iyz	0.0000000e+00	1.7147303e+10	0.0000000e+00
Izx Izy Izz	-3.2061871e+06	0.0000000e+00	4.0438312e+10

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM * MM^2)

I1 I2 I3	1.7147303e+10	4.0433885e+10	4.0440634e+10	

ROTATION MATRIX from _5DHLW_SHORT_TOP orientation to PRINCIPAL AXES:

0.00000	-0.80988	-0.58659
1.00000	0.00000	0.00000
-0.00001	-0.58659	0.80988

ROTATION ANGLES from _5DHLW_SHORT_TOP orientation to PRINCIPAL AXES (degrees):

angles about x y z	0.000	-35.916	90.000

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3	8.6456924e+02	1.3276225e+03	1.3277333e+03	MM

MASS PROPERTIES OF COMPONENTS OF THE ASSEMBLY
(in assembly units and the _5DHLW_SHORT_TOP coordinate frame)

DENSITY	MASS	MATERIAL C.G.: X	Y	Z
5DHLW_BARRIERS_SHORT		UNKNOWN		
8.25678e-06	1.91378e+04	-1.30476e-05	1.60774e+03	2.91756e-05
5DHLW_GUIDETUBE_SHORT		UNKNOWN		
7.85000e-06	1.26513e+03	-4.53230e-14	1.59500e+03	-9.46788e-14
GUIDE_SHORT		UNKNOWN		
7.85000e-06	5.07443e+02	5.49244e+02	1.59500e+03	3.48981e+00
GUIDE_SHORT		UNKNOWN		

Mass Properties of 5-DHLW/DOE SNF-Short Single CRM Waste Package

```
     7.85000e-06  5.07443e+02  1.66407e+02  1.59500e+03  5.23441e+02
GUIDE_SHORT                    UNKNOWN
     7.85000e-06  5.07443e+02 -4.46399e+02  1.59500e+03  3.20014e+02
GUIDE_SHORT                    UNKNOWN
     7.85000e-06  5.07443e+02 -4.42297e+02  1.59500e+03 -3.25661e+02
GUIDE_SHORT                    UNKNOWN
     7.85000e-06  5.07443e+02  1.73045e+02  1.59500e+03 -5.21284e+02
```

Mass Properties of 5-DHLW/DOE SNF-Short Single CRM Waste Package

MASS PROPERTIES OF THE PART DIVIDER_PLATE_SHORT

VOLUME = 8.4011719e+06 MM^3
SURFACE AREA = 1.4055265e+06 MM^2
DENSITY = 7.8500000e-06 KILOGRAM / MM^3
MASS = 6.5949200e+01 KILOGRAM

CENTER OF GRAVITY with respect to _DIVIDER_PLATE_SH coordinate frame:

X	Y	Z	6.3500000e+00	1.5150000e+03 1.0916000e+02 MM

INERTIA with respect to _DIVIDER_PLATE_SH coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx	Ixy	Ixz	2.0287213e+08	-6.3444779e+05	-4.5713743e+04
Iyx	Iyy	Iyz	-6.3444779e+05	1.0513382e+06	-1.0906507e+07
Izx	Izy	Izz	-4.5713743e+04	-1.0906507e+07	2.0182788e+08

INERTIA at CENTER OF GRAVITY with respect to _DIVIDER_PLATE_SH coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx	Ixy	Ixz	5.0718032e+07	0.0000000e+00	0.0000000e+00
Iyx	Iyy	Iyz	0.0000000e+00	2.6283456e+05	0.0000000e+00
Izx	Izy	Izz	0.0000000e+00	0.0000000e+00	5.0456970e+07

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM * MM^2)

I1	I2	I3	2.6283456e+05	5.0456970e+07	5.0718032e+07

ROTATION MATRIX from _DIVIDER_PLATE_SH orientation to PRINCIPAL AXES:

0.00000	0.00000	1.00000
1.00000	0.00000	0.00000
0.00000	1.00000	0.00000

ROTATION ANGLES from _DIVIDER_PLATE_SH orientation to PRINCIPAL AXES (degrees):

angles about	x	y	z	0.000	90.000 90.000

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1	R2	R3	6.3130099e+01	8.7469334e+02	8.7695323e+02 MM

Mass Properties of 5-DHLW/DOE SNF-Short Single CRM Waste Package

MASS PROPERTIES OF THE PART INNERBRACKET_SHORT

VOLUME =	2.4822233e+07	MM^3
SURFACE AREA =	2.4709096e+06	MM^2
DENSITY =	7.8500000e-06	KILOGRAM / MM^3
MASS =	1.9485453e+02	KILOGRAM

CENTER OF GRAVITY with respect to _INNERBRACKET_SHO coordinate frame:

X Y Z	-5.3362187e+01	-5.3362530e+01	1.5150000e+03	MM

INERTIA with respect to _INNERBRACKET_SHO coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	5.9744617e+08	-2.0429422e+05	1.5752764e+07
Iyx Iyy Iyz	-2.0429422e+05	5.9744628e+08	1.5752865e+07
Izx Izy Izz	1.5752764e+07	1.5752865e+07	2.2657858e+06

INERTIA at CENTER OF GRAVITY with respect to _INNERBRACKET_SHO coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	1.4965631e+08	3.5056211e+05	0.0000000e+00
Iyx Iyy Iyz	3.5056211e+05	1.4965644e+08	0.0000000e+00
Izx Izy Izz	0.0000000e+00	0.0000000e+00	1.1560732e+06

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM * MM^2)

I1 I2 I3	1.1560732e+06	1.4930581e+08	1.5000694e+08

ROTATION MATRIX from _INNERBRACKET_SHO orientation to PRINCIPAL AXES:

0.00000	0.70717	0.70704
0.00000	-0.70704	0.70717
1.00000	0.00000	0.00000

ROTATION ANGLES from _INNERBRACKET_SHO orientation to PRINCIPAL AXES (degrees):

angles about x y z	-90.000	44.995	-90.000

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3	7.7026010e+01	8.7535275e+02	8.7740562e+02	MM

Mass Properties of 5-DHLW/DOE SNF-Short Single CRM Waste Package

MASS PROPERTIES OF THE PART OUTER_BRACKET_SHORT

VOLUME =	3.1419039e+07	MM^3
SURFACE AREA =	5.0580886e+06	MM^2
DENSITY =	7.8500000e-06	KILOGRAM / MM^3
MASS =	2.4663946e+02	KILOGRAM

CENTER OF GRAVITY with respect to _OUTER_BRACKET_SH coordinate frame:

X Y Z	-7.0509743e+00	1.4795702e+02	1.5150000e+03	MM

INERTIA with respect to _OUTER_BRACKET_SH coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	7.6190308e+08	2.6084004e+05	2.6346584e+06
Iyx Iyy Iyz	2.6084004e+05	7.6174107e+08	-5.5285439e+07
Izx Izy Izz	2.6346584e+06	-5.5285439e+07	1.4062703e+07

INERTIA at CENTER OF GRAVITY with respect to _OUTER_BRACKET_SH coordinate frame: (KILOGRAM * MM^2)

INERTIA TENSOR:

Ixx Ixy Ixz	1.9041078e+08	3.5356045e+03	0.0000000e+00
Iyx Iyy Iyz	3.5356045e+03	1.9563577e+08	0.0000000e+00
Izx Izy Izz	0.0000000e+00	0.0000000e+00	8.6511880e+06

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM * MM^2)

I1 I2 I3	8.6511880e+06	1.9041078e+08	1.9563577e+08

ROTATION MATRIX from _OUTER_BRACKET_SH orientation to PRINCIPAL AXES:

0.00000	1.00000	0.00068
0.00000	-0.00068	1.00000
1.00000	0.00000	0.00000

ROTATION ANGLES from _OUTER_BRACKET_SH orientation to PRINCIPAL AXES (degrees):

angles about x y z	-90.000	0.000	-90.000

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3	1.8728655e+02	8.7864712e+02	8.9062084e+02	MM