OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
CALCULATION COVER SHEET

1. QA: QA

2. Calculation Title Waste Package Lifting Calculation			
3. Document Identifier (including Revision Number) CAL-EBS-ME-000007 REV 01			
4. Total Attachments 16	5. Attachment Numbers - Number of pages in each see Remarks		
	Print Name	Signature	Date
6. Originator	Hongyan Marr	Hongyan Marr	5/10/00
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9. Remarks
Attachment Numbers - Number of pages in each
I-6, II-3, III-3, IV-1, V-2, VI-2, VII-2, VIII-2, IX-1, X-1, XI-3, XII-3, XIII-2, XIV-2, XV-2 and XVI-2.

Revision History

10. Revision No.	11. Description of Revision
00	Initial Issue.
01	Complete Revision. Update the 21 PWR and naval waste package lifting calculations and also include lifting calculations for the 44 BWR and 5 DHLW/DOE spent nuclear fuel waste packages.

CONTENTS

1. PURPOSE

The objective of this calculation is to evaluate the structural response of the waste package during the horizontal and vertical lifting operations in order to support the waste package lifting feature design. The scope of this calculation includes the evaluation of the 21 PWR UCF (pressurized water reactor uncanistered fuel) waste package, naval waste package, 5 DHLW/DOE SNF (defense high-level waste / Department of Energy spent nuclear fuel) - short waste package, and 44 BWR (boiling water reactor) UCF waste package. Procedure AP-3.12Q, Revision 0, ICN 0, *Calculations*, is used to develop and document this calculation.

Referencing in this calculation refers to the input document numbers appearing in column 2a of the Document Input Reference System sheets, Attachment I hereto.

2. METHOD

Finite element solution is performed using the commercially available ANSYS Version (V) 5.4 finite element code. Finite element representations of the waste package lifted in the horizontal and vertical orientation are developed and analyzed using the static ANSYS V5.4 solver. The results of this calculation are provided in terms of stresses.

3. ASSUMPTIONS

3.1 It is assumed that the waste package shells and internal components have solid connections at the adjacent surfaces in the case of horizontal lifting. The basis for this assumption is that the connection between the inner and outer shell, outer shell and trunnion lifting feature, and inner shell and fuel basket are achieved either by welding or by shrink fit (Attachments II and III, and Reference 20). Reference 21, which supersedes Reference 20, specifies loose fit between the inner and outer shell. However, since the structural performance of the lifting feature is the main objective of this calculation and total force acting on the lifting feature remains unchanged, this will have no impact to the lifting calculation. This assumption is used in Section 5.2.

3.2 Some of the temperature-dependent material properties are not available for the waste package materials. Therefore, properties at room temperature (20°C) are assumed in the absence of more appropriate data. Otherwise, the material properties evaluated at 93°C (200°F) are used when available since the average waste package surface temperature is around 100°C several days after it is loaded with SNF in the assembly transfer system (Ref. 9). The basis for this assumption is that the mechanical properties of subject materials do not change significantly at the temperatures the waste package experiences during the handling operation. This assumption is used in Section 5.1.

3.3 The Poisson's ratio for Alloy 22 (SB-575 N06022) is not available in the literature. The Poisson's ratio of Alloy 625 (SB-443 N06625) is assumed for Alloy 22. The basis for this assumption is the similar chemical compositions of Alloy 22 and Alloy 625 (Ref. 2, and Ref. 3, respectively). This assumption is used in Section 5.1.

3.4 The Poisson's ratio of A 516 carbon steel (SA-516 K02700) is not available in the literature. The Poisson's ratio of cast carbon steel is assumed for A 516 carbon steel. The basis for this assumption is that the elastic constants of cast carbon steels are only slightly affected by the changes in composition and structure (Ref. 6). This assumption is used in Section 5.1.

3.5 The material properties of Neutronit A 978 are not available in the literature. The material properties of Neutronit A 976 are assumed for Neutronit A 978. The basis for this assumption is that these two materials have close similarity in chemical composition (Ref. 12). This assumption is used in Section 5.1.

3.6 The Poisson's ratio is not available either for Neutronit A 978 or for Neutronit A 976. The Poisson's ratio of 316 stainless steel (SS) (SA-240 S31600) is assumed for Neutronit A 978. The basis for this assumption is that the chemical compositions of Neutronit A 978 and 316 SS are similar (Ref. 19 and Ref. 6, respectively). This assumption is used in Section 5.1.

4. USE OF COMPUTER SOFTWARE AND MODELS

4.1 SOFTWARE APPROVED FOR QUALITY ASSURANCE (QA) WORK

The finite element computer code used for this calculation is ANSYS V5.4, which is identified by the Computer System Configuration Item (CSCI) identifier 30040 V5.4. ANSYS V5.4 is a commercially available finite element code and is appropriate for the structural analysis of the waste package as performed in this calculation. Calculations using the ANSYS V5.4 software were executed on a Hewlett-Packard (HP) 9000 Series (Computer Processing Unit Name: "Bloom" and Civilian Radioactive Waste Management System - Management and Operating Contractor [CRWMS-M&O] Tag Number: 700887). The software qualification of ANSYS V5.4, including problems of the type analyzed in this report, is summarized in the Software Qualification Report for ANSYS Version 5.4 (Ref. 13). Qualification of ANSYS V5.4 on the Waste Package Operations HP UNIX workstations is documented in References 14 through 16. The ANSYS V5.4 evaluations performed in this calculation are fully within the range of the validation performed for the ANSYS V5.4. Access to, and use of, the code for this calculation was granted by Software Configuration Secretariat in accordance with the appropriate procedures.

4.2 SOFTWARE ROUTINES

The commercially available software used in this calculation is Pro/Engineer Release 2000i. This software is executed on a HP workstation. Pro/Engineer Release 2000i is not controlled computer software and is not required to be qualified under Section 2.1 of AP-SI.1Q, *Software Management*.

Attachment IX, files #9, #10, #19, and #20 contain the input/output mass property information obtained from Pro/Engineer Release 2000i. The mass densities given in Section 5.1 are used as inputs to Pro/Engineer Release 2000i and corresponding masses of waste package 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 Release 2000i 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 a test case, as described in Attachment X. 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.

4.3 MODELS

None used.

5. CALCULATION

5.1 MATERIAL PROPERTIES

The number of digits in the values cited herein may be the result of a calculation or may reflect the input from another source; consequently, it should not be interpreted as an indication of accuracy.

Temperature-dependent material properties are not available for most of the materials used in this calculation; therefore, room-temperature material properties are used whenever the more appropriate mechanical properties at elevated temperature are not available (Assumption 3.2).

Alloy 22 (SB-575 N06022) (waste package outer shell and trunnion collar sleeves, see Attachments II, III, XI, and XII):

> Density = 8690 kg/m^3 (0.314 lb/in^3) (Ref. 2)
> Poisson's ratio = 0.278 (at 20°C) (Ref. 3 and Assumption 3.3)
> Modulus of elasticity = 203 GPa (29.4 * 10^6 psi, at 93°C) (Ref. 4)
> Yield strength = 310 MPa (45 ksi, at 20°C) (Ref. 2)
> Tensile strength = 690 MPa (100 ksi, at 20°C) (Ref. 2)
> % elongation = 45 (at 20°C) (Ref. 2)

316NG (nuclear grade) (SA-240 S31600) (waste package inner shell, see Attachnments II, III, XI, and XII) (316NG SS, which is 316 SS with tightened control on carbon and nitrogen content, has the same mechanical and physical properties as 316 SS. [See Ref. 1]):

> Density = 7980 kg/m^3 (Ref. 5)
> Poisson's ratio = 0.298 (at 20°C) (Ref. 3)
> Modulus of elasticity = 195 GPa (28.3 * 10^6 psi, at 20°C) (Ref. 10)
> Yield strength = 207 MPa (30 ksi, at 20°C) (Ref. 10)
> Tensile strength = 517 MPa (75 ksi, at 20°C) (Ref. 10)
> % elongation = 40 (at 20°C) (Ref. 7)

A 516 Grade 70 (SA-516 K02700) (waste package tubes and basket guides, see Attachments II, III, XI, and XII):

> Density = 7850 kg/m^3 (Ref. 16. Material supplied to ASTM A 516/A 516M-90 specification A 20/A 20 M-97a (Ref. 17))
> Poisson's ratio = 0.3 (Ref. 6 and Assumption 3.4)
> Modulus of elasticity = 197 GPa (28.6 * 10^6 psi, at 93°C) (Ref. 10. The carbon content of A516 Grade 70 can be up to 0.31% (Ref. 17) and difference between the elastic moduli for steels with carbon content less than or greater than 0.30% specified at the temperature of interest is negligibly small (Ref. 10, Table TM-1))

Yield strength = 239 MPa (34.6 ksi, at 93°C) (Ref. 10)
Tensile strength = 483 MPa (70 ksi, at 93°C) (Ref. 10)
% elongation = 21 (Ref. 18)

Neutronit A 978 (waste package criticality control plates, see Attachments II, III, XI, and XII; see Assumption 3.5):

Density = 7760 kg/m^3 (Ref. 19)
Poisson's ratio = 0.3 (at 20°C) (Ref. 3 and Assumption 3.6)
Modulus of elasticity = 200 GPa (at 20°C) (Ref. 19)
Yield strength = 250 MPa (at 20°C) (Ref. 19)
Tensile strength = 550 MPa (at 20°C) (Ref. 19)
% elongation = 6 (Ref. 19)

The results of lifting simulations may require including elastic and plastic deformations for the materials. When the materials are driven into the plastic range, the slope of the stress-strain curve continuously changes. Thus, a simplification for this curve is needed to incorporate plasticity into the finite element representation. A standard approximation is commonly used in engineering by assuming a straight line that connects the yield point to the ultimate tensile strength point of the material (see Figure 5-1).

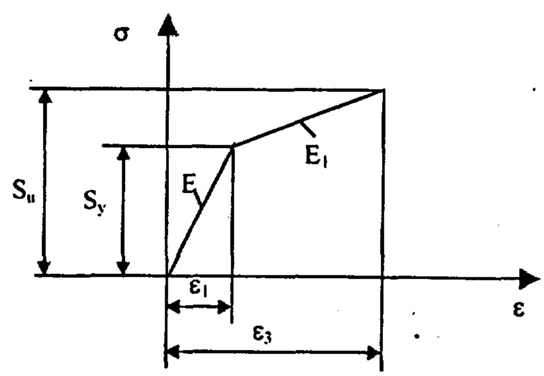


Figure 5-1. Stress-Strain Curve

where:

S_y = Yield strength
S_u = Ultimate tensile strength
ε_1, ε_3 = Strain magnitudes (corresponding to yield strength and elongation, respectively)
E = Elastic modulus (slope of the stress-strain line in the elastic region)
E_t = Tangent modulus (slope of the stress-strain line in the plastic region)

The slope, E_t, is determined by: $E_t = \frac{S_u - S_y}{\varepsilon_3 - \varepsilon_1}$

where: $\varepsilon_1 = S_y / E$

For Alloy 22:

$E_t = (0.690 - 0.310) / (0.45 - (0.310 / 203)) = 0.847$ GPa

For 316NG:

E1=(0.517-0.207)/(0.4-(0.207/195))=0.777 GPa

For A 516:

E1=(0.483-0.239)/(0.21-(0.239/197))=1.169 GPa

For Neutronit 978:

E1=(0.550-0.250)/(0.06-(0.250/200))=5.106 GPa

5.2 DESCRIPTION OF FINITE ELEMENT REPRESENTATIONS

5.2.1 Horizontal Lifting

To calculate the structural response of the waste package to horizontal lifting operation, three-dimensional (3-D) half-symmetry finite element representations are developed to take advantage of the symmetric geometry of the waste package. For the 21 PWR waste package, the 3-D representation includes most of the waste package components. Components, like lid lifting features, inner shell support ring, and basket guide stiffeners are not included in the finite element representation. Aluminum thermal shunts, which are not used as structural members, are also excluded from the representation. Spent nuclear fuel assemblies are not included in the representation due to their unknown material and physical properties. To keep the overall dimension and mass of the waste package unchanged, the tube size is adjusted to make up for the removal of the thermal shunts, and all component densities are adjusted to match the total waste package mass. Similarly, for the naval waste package, 5 DHLW/DOE – short waste package, and 44 BWR waste package, the 3-D representation does not include the lid lifting features, inner shell support ring, canisters, or SNF basket inside the inner shell. The masses of the naval canister, 5 DHLW/DOE - canisters, and 44 BWR SNF basket are added to the finite element representations by modifying the density of the inner shells to match the masses of the waste packages. For the 21 PWR waste package, naval waste package, 5 DHLW/DOE – short waste package, and 44 BWR waste package, the waste package shells and internal components are assumed to have solid connections at the adjacent surfaces in the case of the horizontal lifting (see Assumption 3.1). The simplification of the representations for all of the waste packages has negligible effect on the lifting results. Attachments II, III, XI, and XII show the design details for the waste packages. The finite element representations are displayed on page V-1, page VI-1, page XIII-1, and page XIV-1.

The lifting mechanism is designed in such a way that the trunnion collars will be placed around both trunnion collar sleeves in order to lift the waste package horizontally (p. IV-1). Therefore, the boundary condition is specified in such a way to have the bottom half of the trunnion collar sleeve surfaces constrained. Gravitational acceleration is applied in the representation.

5.2.2 Vertical Lifting

To calculate the structural response of the waste package to vertical lifting operation, 3-D half-symmetry finite element representations are developed to take advantage of the symmetric geometry of the waste package. Only inner and outer shells and lifting collar sleeves are included in the finite element representations for all of the waste packages. The masses of the components internal to the inner shell are added to the inner shell to match the total waste package masses. Since the critical parts of the waste package for vertical lifting are lifting sleeve welds, the lifting sleeves are modified to leave 3-mm gaps between the outer shell and sleeves. Mesh refinement is performed around the weld regions. Since the trunnion rings may not be fully engaged into the trunnion collar lifting mechanism during the handling operation, to be conservative, the boundary conditions are specified to constrain partial upper surface (outer half) of the upper lifting sleeve. Gravitational acceleration is applied in the representation. The finite element representations for vertical lifting are displayed on page VII-1, page VIII-1, page XV-1, and page XVI-1.

Tables 5-1 through 5-4 show the material masses and their grouping used in finite element representations for the 21 PWR waste package, naval waste package, 44 BWR waste package, and 5 DHLW/DOE SNF – short waste package, respectively:

Table 5-1. 21 PWR Waste Package Structural Component Masses

Component Name	Total Mass (kg) (p. II-2)	Mass Calculated in ANSYS V5.4 (Table IX-1, File #1 & #5)			
		Material Number	Component Represented in ANSYS V5.4	Mass (kg)	
				Horizontal Lifting	Vertical Lifting
Fuel Basket Tubes	3444	1	Tube	19685.4	N/A
PWR Fuel Assemblies	16241.4				
Fuel Basket A-plate	680	2	Neutron Absorber Plates	2400	N/A
Fuel Basket B-plate	680				
Fuel Basket C-plate	704				
Fuel Basket D-Plate	168				
Fuel Basket E-Plate	168				
Basket A-Side Guide	864	3	Side Guide	1534.08	N/A
Basket A-Stiffener	46.08				

Basket B-Side Guide	576				
Basket B-Stiffener	48				
Basket C-Stiffener	73.6	4	Corner Guide	745.6	N/A
Basket Corner Guide	672				
Inner Shell	8709	5	Inner Shell & Inner Lid	11249	35614.1 (mass of the components internal to the inner shell are added)
Inner Shell Lid	2400				
316 Welds	128				
Inner Lid Lifting Feature	12				
Outer Shell	4193	6	Outer Shell & Outer Lid	5064	5064
Outer Shell Flat Closure Lid	159				
Outer Shell Flat Bottom Lid	396				
Outer Lid Lifting Feature	26				
Alloy 22 Welds	249				
Inner Shell Support Ring	41				
Extended Outer Shell Lid	132	9	Outer Shell & Outer Lid	595	595
Extended Outer Shell Lid Base	366				
Extended Lid Reinforcement Ring	97				
Upper Trunnion Collar Sleeve	507	10	Upper Trunnion Collar Sleeve	507	507
Lower Trunnion Collar Sleeve	497	11	Lower Trunnion Collar Sleeve	497	497
Waste Package Total Mass	42277			42278	42278

Table 5-2. Naval Waste Package Structural Component Masses

Component Name	Total Mass (kg) (p. III-1)	Mass Calculated in ANSYS V5.4 (Table IX-1, File #3 & #7)			
		Material Number	Component Represented in ANSYS V5.4	Mass (kg)	
				Horizontal Lifting	Vertical Lifting
Naval SNF Canister	44452	5	Inner Shell & Inner Lid	61859	61859
Inner Shell	12372				
Inner Shell Lid	4780				
316 Welds	243				
Inner Lid Lifting Feature	12				
Outer Shell	7430	6	Outer Shell & Outer Lid	8594	8594
Outer Shell Flat Closure Lid	227				
Outer Shell Flat Bottom Lid	564				
Outer Lid Lifting Feature	26				
Alloy 22 Welds	298				
Inner Shell Support Ring	49				
Extended Outer Shell Lid	158	9	Outer Shell & Outer Lid	804	804
Extended Outer Shell Lid Base	528				
Extended Lid Reinforcement Ring	118				
Upper Trunnion Collar Sleeve	604	10	Upper Trunnion Collar Sleeve	604	604

Lower Trunnion Collar Sleeve	592	11	Lower Trunnion Collar Sleeve	592	592
Waste Package Total Mass	72457			72453	72453

Table 5-3. 44 BWR Waste Package Structural Component Masses

Component Name	**Total Mass (kg) (Table IX, File #19)**	**Mass Calculated in ANSYS V5.4 (Table IX, File #11 & #15)**			
		Material Number	**Component Represented in ANSYS V5.4**	**Mass (kg)**	
				Horizontal Lifting	**Vertical Lifting**
Basket B-Sideguide	608	5	Inner Shell & Inner Lid	35705	35705
Basket B-Stiffener	20				
Basket Cornerguide	1476				
Basket Stiffener	174				
Fuel Basket A-Plate	250				
Fuel Basket B-Plate	250				
Fuel Basket C-Plate	232				
Fuel Basket D-Plate	704				
Fuel Basket E-Plate	704				
Fuel Basket F-Plate	170				
Fuel Basket G-Plate	170				
Fuel Basket Tube	4965				
Inner Shell	8886				
Inner Shell Lid	2503				
316 Welds	131				
Inner Lid Lifting Feature	12				
Spent Nuclear Fuel	14450				
Outer Shell	4275	6	Outer Shell & Outer Lid	5173	5173
Outer Shell Flat Closure Lid	165				
Outer Shell Flat Bottom Lid	412				
Outer Lid Lifting Feature	26				
Alloy 22 Welds	253				
Inner Shell Support Ring	42				
Extended Outer Shell Lid	135	9	Outer Shell & Outer Lid	615	615
Extended Outer Shell Lid Base	381				
Extended Lid Reinforcement Ring	99				
Upper Trunnion Collar Sleeve	517	10	Upper Trunnion Collar Sleeve	517	517
Lower Trunnion Collar Sleeve	507	11	Lower Trunnion Collar Sleeve	507	507
Waste Package Total Mass	42517			42517	42517

Table 5-4. 5 DHLW/DOE -Short Waste Package Structural Component Masses

Component Name	Total Mass (kg) (Table IX, File #20)	Mass Calculated In ANSYS V5.4 (Table IX, File #13 & #17)			
		Material Number	Component Represented in ANSYS V5.4	Mass (kg)	
				Horizontal Lifting	Vertical Lifting
Divider Plate	330	5	Inner Shell & Inner Lid	29870	29870
Inner Bracket	974				
Outer Bracket	1233				
Support Tube	1265				
Inner Shell	7621				
Inner Shell Lid	3531				
316 Welds	133				
Inner Lid Lifting Feature	12				
18" Canister Short	2270				
HLW Glass Assembly	12500				
Outer Shell	4692	6	Outer Shell & Outer Lid	6033	6033
Outer Shell Flat Closure Lid	268				
Outer Shell Flat Bottom Lid	669				
Outer Lid Lifting Feature	26				
Alloy 22 Welds	325				
Inner Shell Support Ring	53				
Extended Outer Shell Lid	172	9	Outer Shell & Outer Lid	930	930
Extended Outer Shell Lid Base	629				
Extended Outer Lid Reinforcing Ring	129				
Upper Trunnion Collar Sleeve	655	10	Upper Trunnion Collar Sleeve	655	655
Lower Trunnion Collar Sleeve	642	11	Lower Trunnion Collar Sleeve	642	642
Waste Package Total Mass	38130			38130	38130

NOTE: The difference between the total mass from page II-2 and page III-1 and the mass calculated in ANSYS V5.4 is due to the round-off error.

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

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 structural response of the waste packages to lifting is reported using maximum stress intensity or absolute value of first principal stress obtained from the finite element solution to the problem. Between the stress intensity (S_{int}) and first principal stress (S_1), the greater value is reported for each component of the waste package. The calculation results are summarized in Tables 6-1 through 6-8. Stress intensity contours are displayed on pages V-2, VI-2, VII-2, VIII-2, XIII-2, XIV-2, XV-2, and XVI-2.

Table 6-1. Calculation Results for Horizontal Lifting of 21 PWR Waste Package (Table IX-1, File #2)

Waste Package Component	Maximum Stress (MPa)
Upper Lifting Collar Sleeves	S_{int} = 15.5
Lower Lifting Collar Sleeves	S_{int} = 14.8
Tubes	S_{int} = 3.7
Side Guides	S_{int} = 7.9
Corner Guides	S_{int} = 4.9
Criticality Control Plates	S_{int} = 5.6
Extended Outer Shell Lid	S_{int} = 2.8
Outer Shell and Lids	S_{int} = 7.5
Inner Shell and Lids	S_{int} = 5.5

Table 6-2. Calculation Results for Horizontal Lifting of Naval Waste Package (Table IX-1, File #4)

Waste Package Component	Maximum Stress (MPa)
Upper Lifting Collar Sleeves	S_{int} = 12.6
Lower Lifting Collar Sleeves	S_{int} = 14.5
Outer Shell and Lids	S_{int} = 7.5
Inner Shell and Lids	S_{int} = 4.3

Table 6-3. Calculation Results for Horizontal Lifting of 44 BWR Waste Package (Table IX-1, File #12)

Waste Package Component	Maximum Stress (MPa)
Upper lifting collar sleeves	S_{int} = 11.1
Lower Lifting collar sleeves	S_{int} = 11.0
Outer shell and lids	S_{int} = 5.3
Inner shell and lids	S_{int} = 3.2

Table 6-4. Calculation Results for Horizontal Lifting of 5 DHLW/DOE -Short Waste Package (Table IX-1, File #14)

Waste Package Component	Maximum Stress (MPa)
Upper lifting collar sleeves	$S_{int} = 5.2$
Lower Lifting collar sleeves	$S_{int} = 4.1$
Outer shell and lids	$S_{int} = 3.0$
Inner shell and lids	$S_{int} = 1.9$

Table 6-5. Calculation Results for Vertical Lifting of 21 PWR Waste Package (Table IX-1, File #6)

Waste Package Component	Maximum Stress (MPa)
Upper Lifting Collar Sleeves	$S_1 = 12.4$
Outer Shell and Lids	$S_{int} = 6.2$
Inner Shell and Lids	$S_{int} = 1.3$

Table 6-6. Calculation Results for Vertical Lifting of Naval Waste Package (Table IX-1, File #8)

Waste Package Component	Maximum Stress (MPa)
Upper Lifting Collar Sleeves	$S_{int} = 18.0$
Outer Shell and Lids	$S_{int} = 9.8$
Inner Shell and Lids	$S_1 = 2.1$

Table 6-7. Calculation Results for Vertical Lifting of 44 BWR Waste Package (Table IX-1, File #16)

Waste Package Component	Maximum Stress (MPa)
Upper lifting collar sleeves	$S_{int} = 12.2$
Outer shell and lids	$S_{int} = 6.2$
Inner shell and lids	$S_{int} = 1.3$

Table 6-8. Calculation Results for Vertical Lifting of 5 DHLW/DOE -Short Waste Package (Table IX-1, File #18)

Waste Package Component	Maximum Stress (MPa)
Upper lifting collar sleeves	$S_{int} = 9.1$
Outer shell and lids	$S_{int} = 5.9$
Inner shell and lids	$S_{int} = 1.9$

7. ATTACHMENTS

The attachments to this calculation are summarized in Table 7-1.

Table 7-1. Attachments Summary

Attachment Number	Description	Pages
I	Document Input Reference System Sheets	6
II	Sketch of 21PWR Waste Package (SK-0175 REV 02 and SK-0191 REV 00)	3
III	Sketch of Naval Waste Package (SK-0194 REV 01 and SK-0195 REV 00)	3
IV	Waste Package Lifting Mechanism	1
V	21 PWR Waste Package Horizontal Lifting Mesh and Stress Contours	2
VI	Naval Horizontal Lifting Mesh and Stress Contours	2
VII	21 PWR Waste Package Vertical Lifting Mesh and Stress Contours	2
VIII	Naval Waste Package Vertical Lifting Mesh and Stress Contours	2
IX	List of ANSYS V5.4 Output Files and Pro/Engineer Release 2000i Mass Property Files	1
X	Verification of Mass Calculation in Pro/Engineer Release 2000i	1
XI	Sketch of 44 BWR Waste Package (SK-0192 REV 00 and SK-0193 REV 00)	3
XII	Sketch of 5 DHLW/DOE SNF Waste Package (SK-0196 REV 02 and SK-0197 REV 00)	3
XIII	44 BWR Waste Package Horizontal Lifting Mesh and Stress Contours	2
XIV	5 DHLW/DOE SNF – Short Waste Package Horizontal Lifting Mesh and Stress Contours	2
XV	44 BWR Waste Package Vertical Lifting Mesh and Stress Contours	2
XVI	5 DHLW/DOE SNF – Short Waste Package Vertical Lifting Mesh and Stress Contours	2

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
DOCUMENT INPUT REFERENCE SHEET

1. Document Identifier No./Rev.:	Change:	Title:
CAL-EBS-ME-000007 Rev. 01 (as of 10-may-2000 09:23:13)	N/A	WASTE PACKAGE LIFTING CALCULATION

Input Document			4. Input Status	5. Section Used in	6. Input Description	7. TBV/TBD Priority	8. TBVDue To		
2a.	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-Confirmed
1	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.	Entire	N/A - Reference Only	5.1	Mechanical Properties are the same for both 316NG and 316 SS	N/A	N/A	N/A	N/A
2	ASTM B 575-97. 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.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 241816.	Table 3	N/A - Accepted Data (Fact)	5.1	Alloy 22 tensile strength	N/A	N/A	N/A	N/A
		Section 7.1	N/A - Accepted Data (Fact)	5.1	Alloy 22 density	N/A	N/A	N/A	N/A
		Table 3	N/A - Accepted Data (Fact)	5.1	Alloy 22 yield strength	N/A	N/A	N/A	N/A
		Table 1	N/A - Accepted Data (Fact)	3.3	Alloy 22 chemical composition	N/A	N/A	N/A	N/A
		Table 3	N/A - Accepted Data (Fact)	5.1	Alloy 22 elongation	N/A	N/A	N/A	N/A

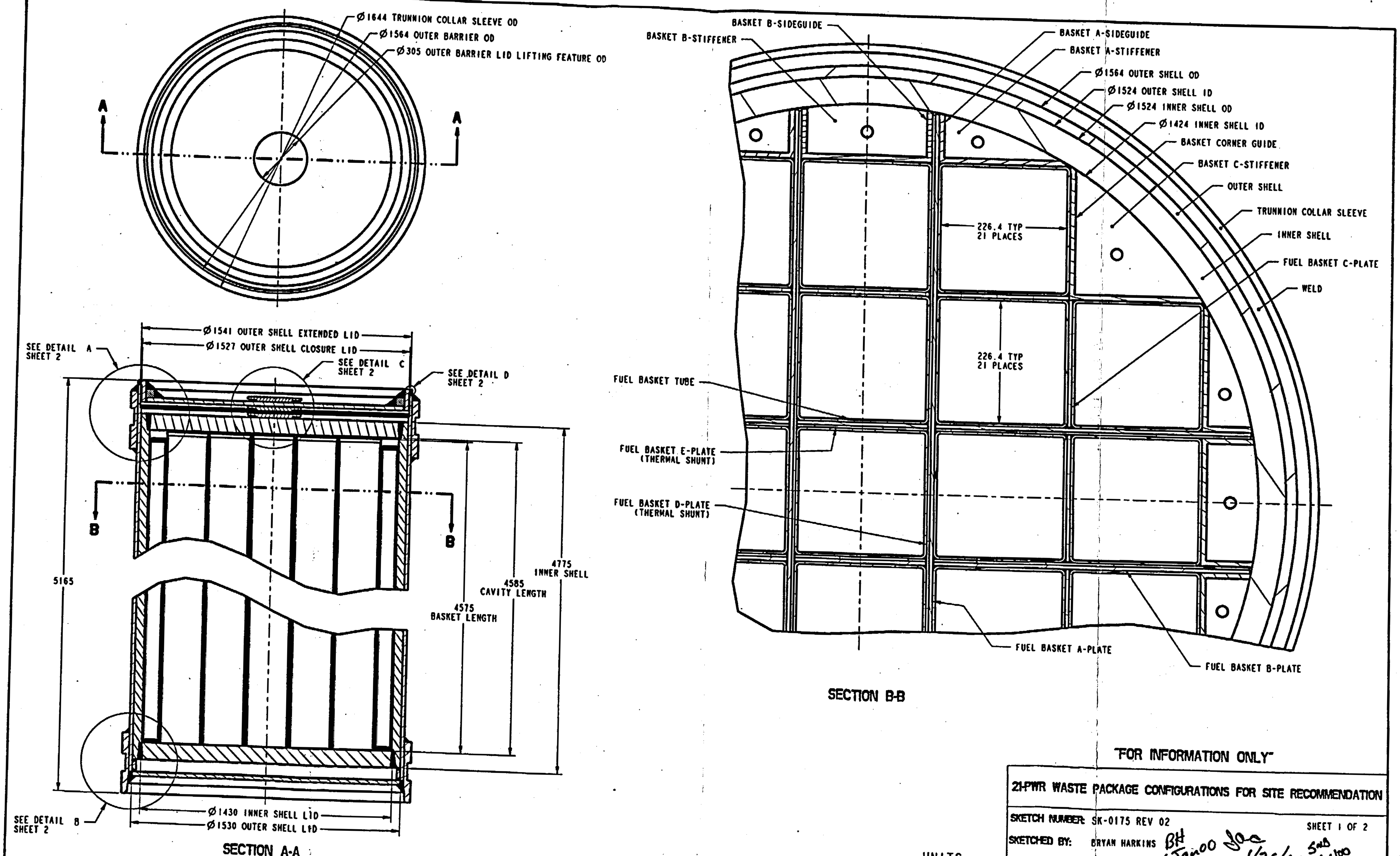
3	American Society for Metals 1980. *Properties and Selection: Stainless Steels, Tool Materials and Special-Purpose Metals.* Volume 3 of *Metals Handbook.* 9th Edition. Metals Park, Ohio: American Society for Metals. TIC: 209801.	Page 755, Figure 15	N/A - Accepted Data (Fact)	5.1	316 SS Poisson's ratio	N/A	N/A	N/A	N/A
		Page 143	N/A - Accepted Data (Fact)	3.3 & 5.1	Alloy 625 chemical composition and Poisson's ratio	N/A	N/A	N/A	N/A
4	Haynes International. 1988. Hastelloy Alloy C-22. Kokomo, Indiana: Haynes International. TIC: 239938.	Page 14	TBV-3990	5.1	Alloy 22 yield and tensile strength at 760 degrees C; Alloy 22 percent elongation, coefficient of thermal expansion, thermal conductivity, specific heat, and modulus elasticity as a function of temperature; Alloy 22 melting temperature.	1	X	N/A	N/A
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.	Table X1	N/A - Accepted Data (Fact)	5.1	316 SS density	N/A	N/A	N/A	N/A
6	ASM International 1990. *Properties and Selection: Irons, Steels, and High-Performance Alloys.* Volume 1 of *Metals Handbook.* 10th Edition. Materials Park, Ohio: ASM International. TIC: 245666.	Page 374	N/A - Accepted Data (Fact)	5.1	A 516 Poisson's ratio	N/A	N/A	N/A	N/A
		Page 843	N/A - Accepted Data (Fact)	3.5	316 SS chemical composition	N/A	N/A	N/A	N/A
		Page 374	N/A - Accepted Data (Fact)	3.4	The elastic constants of cast carbon steels are only slightly affected by the changes in composition and structure.	N/A	N/A	N/A	N/A
7	ASTM A 240/A 240M-97a. 1997. *Standard Specification for Heat-Resisting Chromium*	Table 2	N/A - Accepted	5.1	316 SS elongation	N/A	N/A	N/A	N/A

	and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels. West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 239431.		Data (Fact)						
8	CRWMS M&O 1998. *Thermal Evaluation of a 21 PWR Waste Package in the Assembly Transfer System.* BBA000000-01717-0210-00013 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981012.0493.	Figure 6-4	N/A - Reference Only	3.2	Waste package surface temperature	N/A	N/A	N/A	N/A
9	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.	Table Y-1	N/A - Accepted Data (Fact)	5.1	A 516 yield strength	N/A	N/A	N/A	N/A
		Table U	N/A - Accepted Data (Fact)	5.1	A 516 tensile strength	N/A	N/A	N/A	N/A
		Table TM-1	N/A - Accepted Data (Fact)	5.1	316 SS modulus of elasticity	N/A	N/A	N/A	N/A
		Table Y-1	N/A - Accepted Data (Fact)	5.1	316 SS yield strength	N/A	N/A	N/A	N/A
		Table U	N/A - Accepted Data (Fact)	5.1	316 SS tensile strength	N/A	N/A	N/A	N/A
		Table TM-1	N/A - Accepted Data (Fact)	5.1	A 516 modulus of elasticity	N/A	N/A	N/A	N/A

		Table TM-1	N/A - Accepted Data (Fact)	5.1	Difference between the elastic moduli for steels with carbon content less than or greater than 0.30% specified at the temperature of interest is neglegibley small.	N/A	N/A	N/A	N/A
10	McCoy, J.K. 1997. "Modulus of Elasticity for Neutronit." Interoffice correspondence from J.K. McCoy (CRWMS M&O) to S.M. Bennett, January 16, 1997, LV.WP.JKM.01/97-010 ACC: MOL.19970625.0427; MOL.19970625.0428.	Entire	N/A - Reference Only	3.6	Neutronit A 976 and Neutronit A 978 have close similarity in composition.	N/A	N/A	N/A	N/A
11	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.	Entire	N/A - Reference Only	4.1	Qualification report for ANSYS 5.4	N/A	N/A	N/A	N/A
12	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.	Entire	N/A - Reference Only	4.1	Qualification of ANSYS 5.4 on UNIX workstations	N/A	N/A	N/A	N/A
13	Doering, T.W. 1998. "Qualification of ANSYS V5.4 on New WPO HP UNIX Workstation." Interoffice correspondence from T.W. Doering (CRWMS M&O) to G. Carlisle, November 11, 1998, LV.WP.MML.11/98-220. ACC: MOL.19981217.0106.	Entire	N/A - Reference Only	4.1	ANSYS 5.4 qualification on UNIX workstations	N/A	N/A	N/A	N/A
14	Doering, T.W. 1999. "Qualification of ANSYS V5.4 on Three New WPO HP UNIX Workstations." Interoffice correspondence from T.W. Doering (CRWMS M&O) to G.P. Carlisle, May 3,	Entire	N/A - Reference Only	4.1	ANSYS 5.4 qualification on UNIX workstations	N/A	N/A	N/A	N/A

	1999, LV.WP.SMB.05/99-071 ACC: MOL.19990518.0322.								
15	ASTM A 516/A 516M - 90. 1991. *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service.* Philadelphia, Pennsylvania: American Society for Testing and Materials. TIC: 240032.	Section 3.1	N/A - Accepted Data (Fact)	5.1	Material supplied to ASTM A 516/ A 516M-90 specification conforms to specification A 20/A 20M-95a	N/A	N/A	N/A	N/A
		Table 1	N/A - Accepted Data (Fact)	5.1	A 516 chemical composition	N/A	N/A	N/A	N/A
		Table 2	N/A - Accepted Data (Fact)	5.1	A 516 elongation	N/A	N/A	N/A	N/A
16	ASTM A 20/A 20M-97a. 1997. *Standard Specification for General Requirements for Steel Plates for Pressure Vessels.* West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 242529.	Section 14.1	N/A - Accepted Data (Fact)	5.1	A 516 density	N/A	N/A	N/A	N/A
17	Kugler, A. 1997. Sheet and Plate for Nuclear Engineering, Bohler Neutronit A976. Houston, Texas: Bohler Bleche GmbH. TIC: 246410.	Entire	TBV-4112	5.1	NEUTRONIT A 978 YIELD STRENGTH, TENSILE STRENGTH, DENSITY, CHEMICAL COMPOSITION, ELONGATION AND MODULUS OF ELASTICITY	1	X	N/A	N/A
18	CRWMS M&O 1999. *Waste Package Fabrication Process Report.* BBA000000-01717-2500-00010 REV 03. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990617.0237.	Page 21	N/A - Reference Only	3.1	Shrink fit of waste package inner and outer barriers	N/A	N/A	N/A	N/A
19	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.	8.1.8	N/A - Reference Only	3.1	Loose fit between inner and outer shell	N/A	N/A	N/A	N/A
20	CRWMS M&O 2000. *Electronic Files for*	Entire	N/A -	Attachment	ANSYS V5.4 and	N/A	N/A	N/A	N/A

	Waste Package Lifting Calculation. CAL-EBS-ME-000007 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000504.0302.		Reference Only	IX	Pro/Engineer Release 2000i files				
21	CRWMS M&O 1997. *Waste Container Cavity Size Determination.* BBAA00000-01717-0200-00026 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980106.0061.	Entire	N/A - Reference Only	Attachments II and XI	PWR and BWR fuel assembly mass	N/A	N/A	N/A	N/A
22	DOE (U.S. Department of Energy) 1999. *Waste Acceptance System Requirements Document.* DOE/RW-0351, Rev. 03. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: HQO.19990226.0001.	4.2.3.1.A.4	N/A - Reference Only	Attachment XII	Mass of HLW glass assembly	N/A	N/A	N/A	N/A
23	DOE (U.S. Department of Energy) 1998. "Design Specification." Volume 1 of *Preliminary Design Specification for Department of Energy Standardized Spent Nuclear Fuel Canisters.* DOE/SNF/REP-011, Rev. 1. Washington , D.C.: U.S. Department of Energy, Office of Spent Fuel Management and Special Projects. TIC: 241528.	Entire	N/A - Reference Only	Attachment XII	Mass of 18" canister short	N/A	N/A	N/A	N/A
24	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.	Entire	N/A - Reference Only	Attachment III	Mass of naval SNF	N/A	N/A	N/A	N/A



"FOR INFORMATION ONLY"

21-PWR WASTE PACKAGE CONFIGURATIONS FOR SITE RECOMMENDATION	
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SKETCHED BY: BRYAN HARKINS BH 26Jan00	
DATE: 01/26/00	
FILE: /home/pro_library/checkout/sketches/21pwr/sk-0175.dwg	

UNITS: mm

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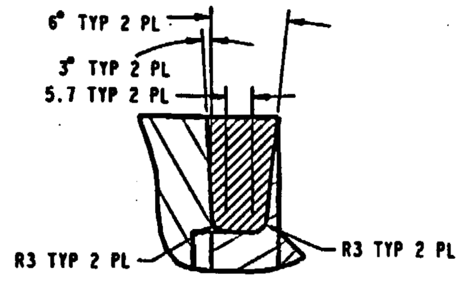
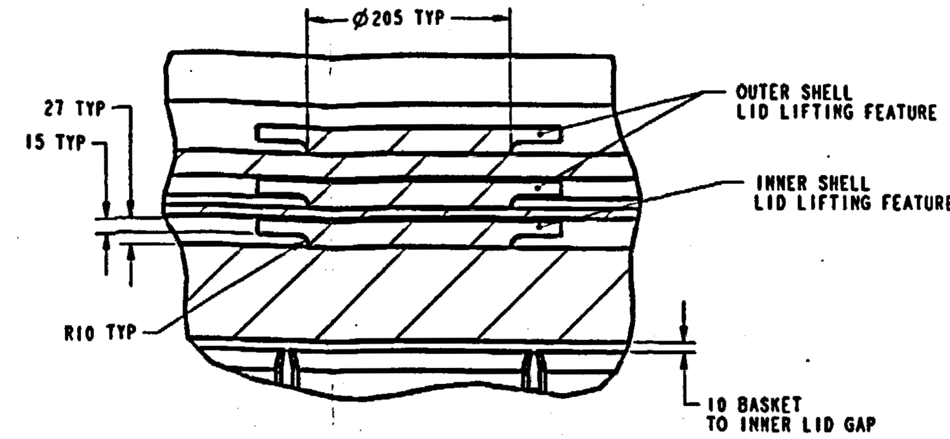


DETAIL D



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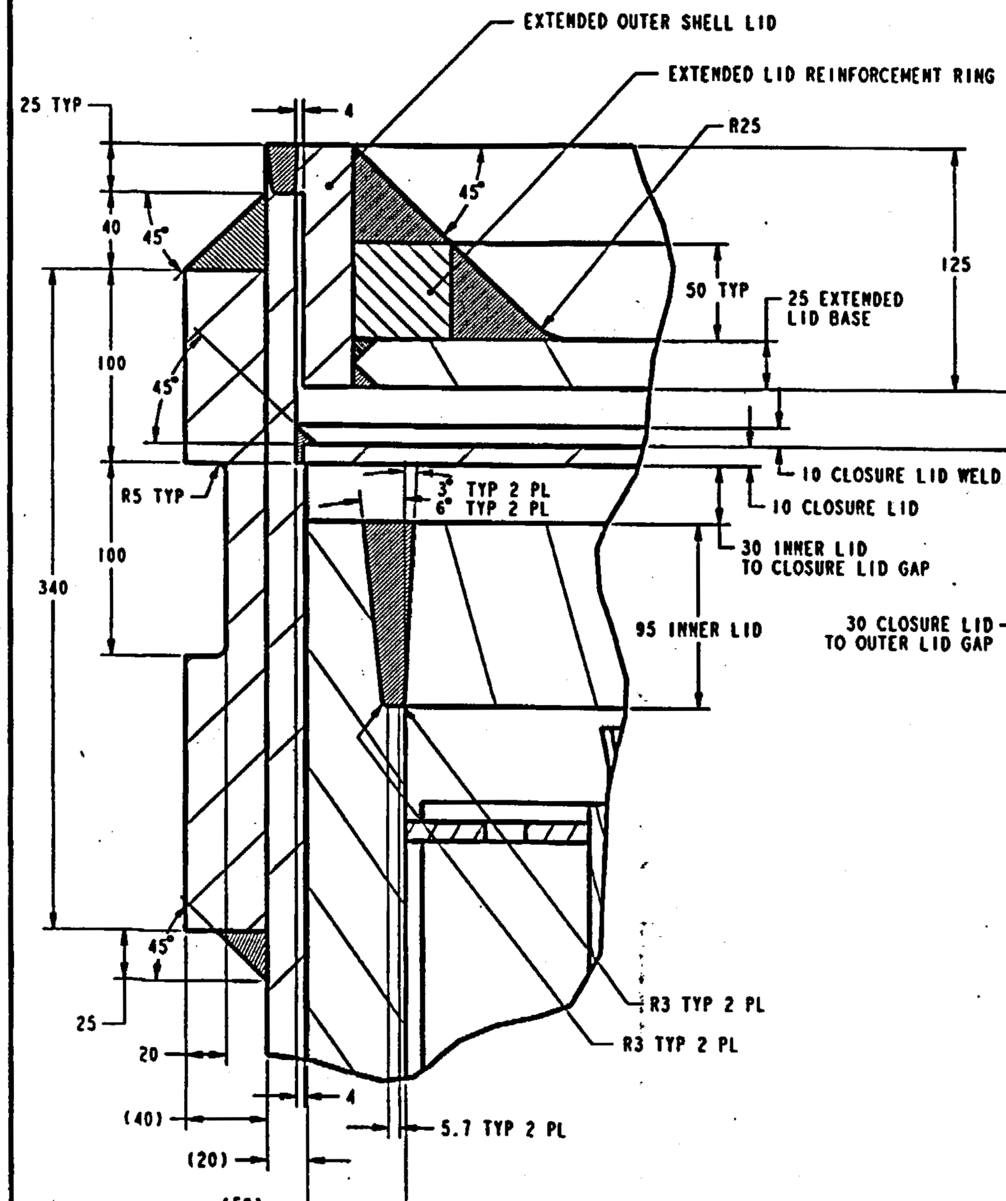
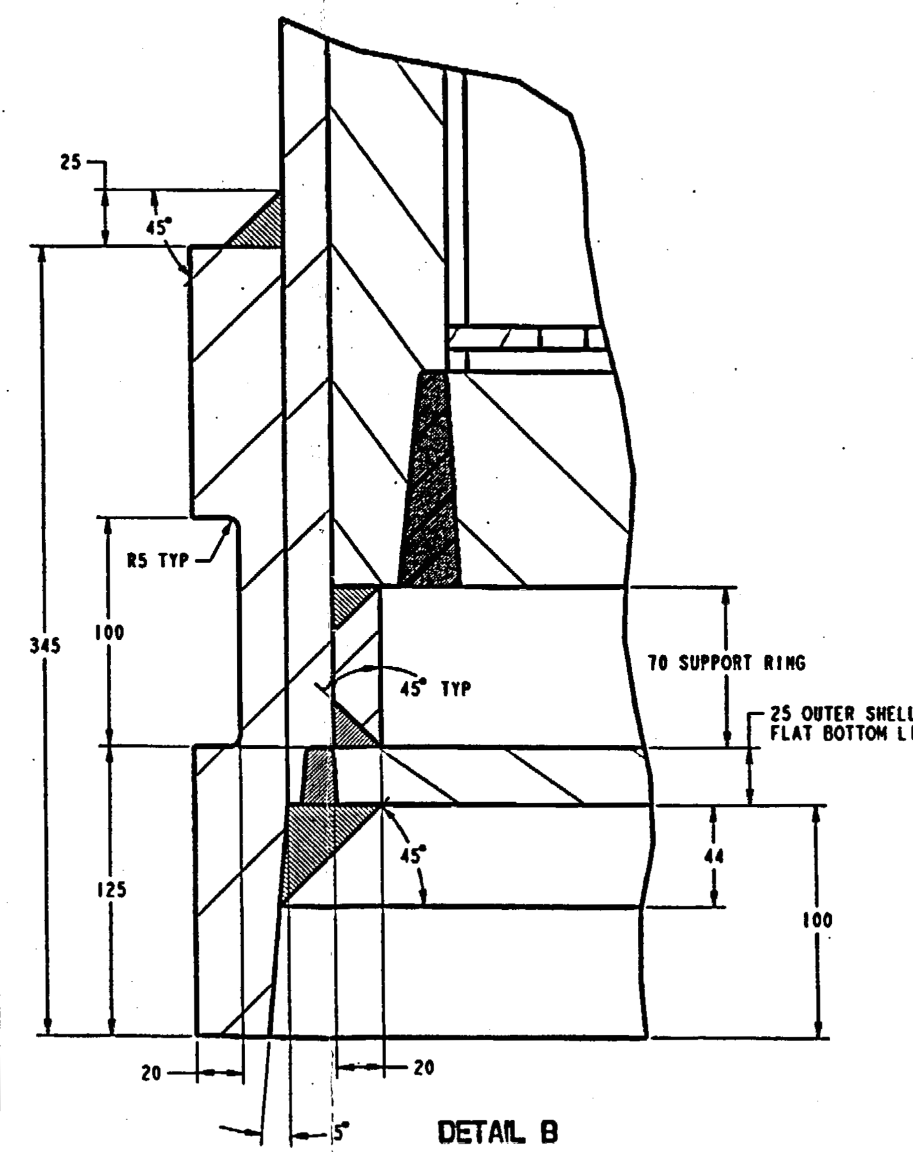


DETAIL A

21-PWR WASTE PACKAGE ASSEMBLY WITH STAINLESS STEEL/BORON PLATES

21-PWR CONTROL ROD WASTE PACKAGE ASSEMBLY WITH CARBON STEEL PLATES

COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG)	QTY ROD
BASKET A-SIDEGUIDE	SA-516 K02700	10	27	32
BASKET A-STIFFENER	SA-516 K02700	10	0.72	64
BASKET B-SIDEGUIDE	SA-516 K02700	10	36	16
BASKET B-STIFFENER	SA-516 K02700	10	1.5	32
BASKET C-STIFFENER	SA-516 K02700	10	2.3	32
BASKET CORNERGUIDE	SA-516 K02700	10	42	16
FUEL BASKET A-PLATE	NEUTRONIT A 978	7	85	8
	#SA-516 K02700	#7	#86	#8
FUEL BASKET B-PLATE	NEUTRONIT A 978	7	85	8
	#SA-516 K02700	#7	#86	#8
FUEL BASKET C-PLATE	NEUTRONIT A 978	7	44	16
	#SA-516 K02700	#7	#45	#16
FUEL BASKET D-PLATE	SB-209 A96061 T4	5	21	8
FUEL BASKET E-PLATE	SB-209 A96061 T4	5	21	8
FUEL BASKET TUBE	SA-516 K02700	5	164	21
INNER SHELL	SA-240 S31600	50	8709	1
INNER SHELL LID	SA-240 S31600	95	1200	2
INNER LID LIFTING FEATURE	SA-240 S31600	27	12	1
OUTER SHELL	SB-575 N06022	20	4193	1
EXTENDED OUTER SHELL LID	SB-575 N06022	25	132	1
EXTENDED OUTER SHELL LID BASE	SB-575 N06022	25	366	1
OUTER LID LIFTING FEATURE	SB-575 N06022	27	13	2
EXTENDED LID REINFORCEMENT RING	SB-575 N06022	50	97	1
OUTER SHELL FLAT CLOSURE LID	SB-575 N06022	10	159	1
OUTER SHELL FLAT BOTTOM LID	SB-575 N0-6022	25	396	1
UPPER TRUNNION COLLAR SLEEVE	SB-575 N06022	40	507	1
LOWER TRUNNION COLLAR SLEEVE	SB-575 N06022	40	497	1
INNER SHELL SUPPORT RING	SB-575 N06022	20	41	1
TOTAL ALLOY 22 WELDS	SFA-5.14 N06022	-	249	**
TOTAL 316 WELDS	SFA-5.9 S31680	-	128	**
WASTE PACKAGE ASSEMBLY	-	-	26035	1
	-	-	#26059	#1
PWR FUEL ASSEMBLY	-	-	773.4*	21
WP ASSEMBLY WITH SNF	-	-	42277	1
	-	-	#42301	#1



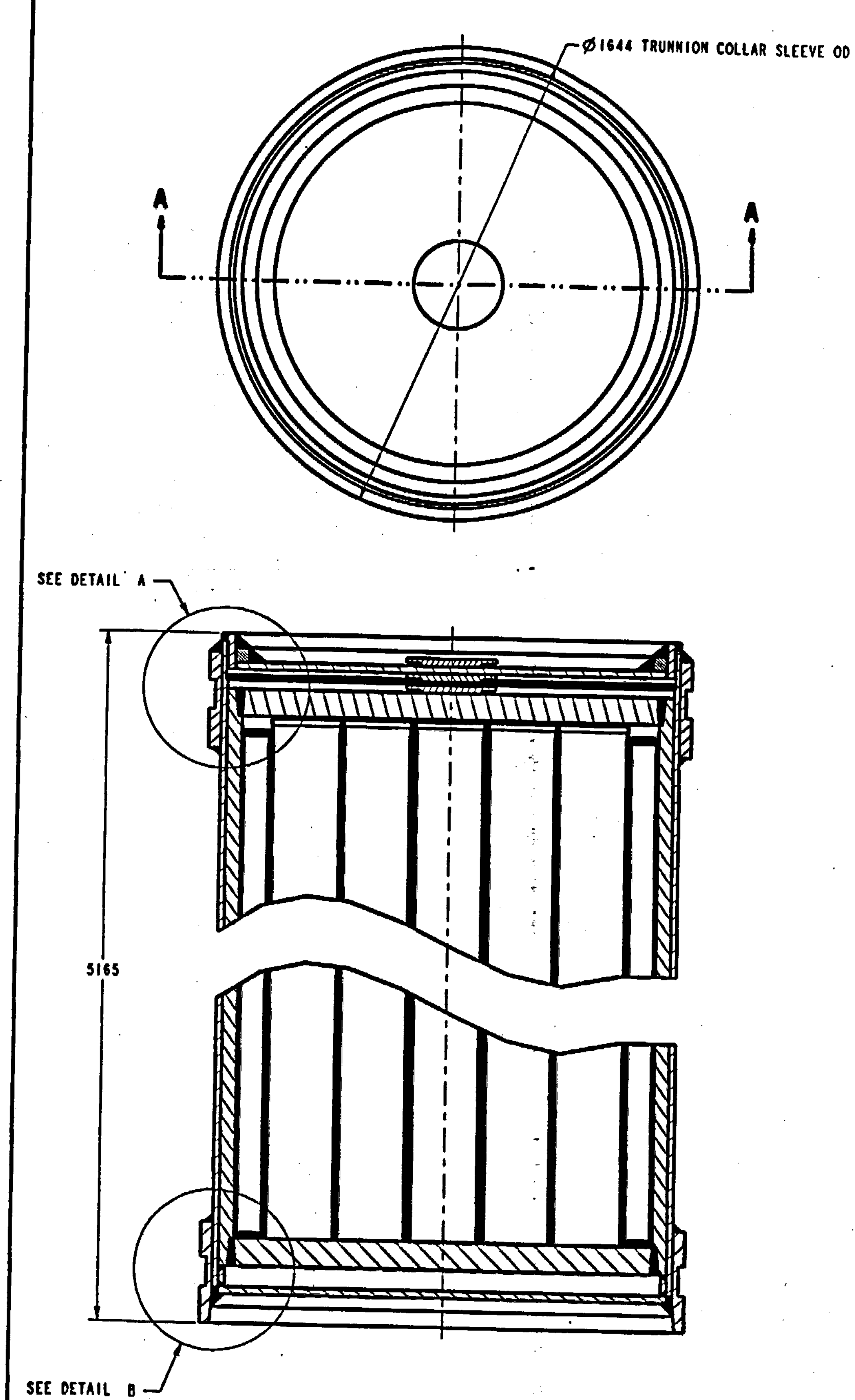
DETAIL B

* CRWMS M&O 1997. WASTE CONTAINER CAVITY SIZE DETERMINATION. BBAA00000-01717-0200-00026 REV 00. LAS VEGAS, NV: CRWMS M&O. ACC: MOL.19980106.0061 (Ref. 21)

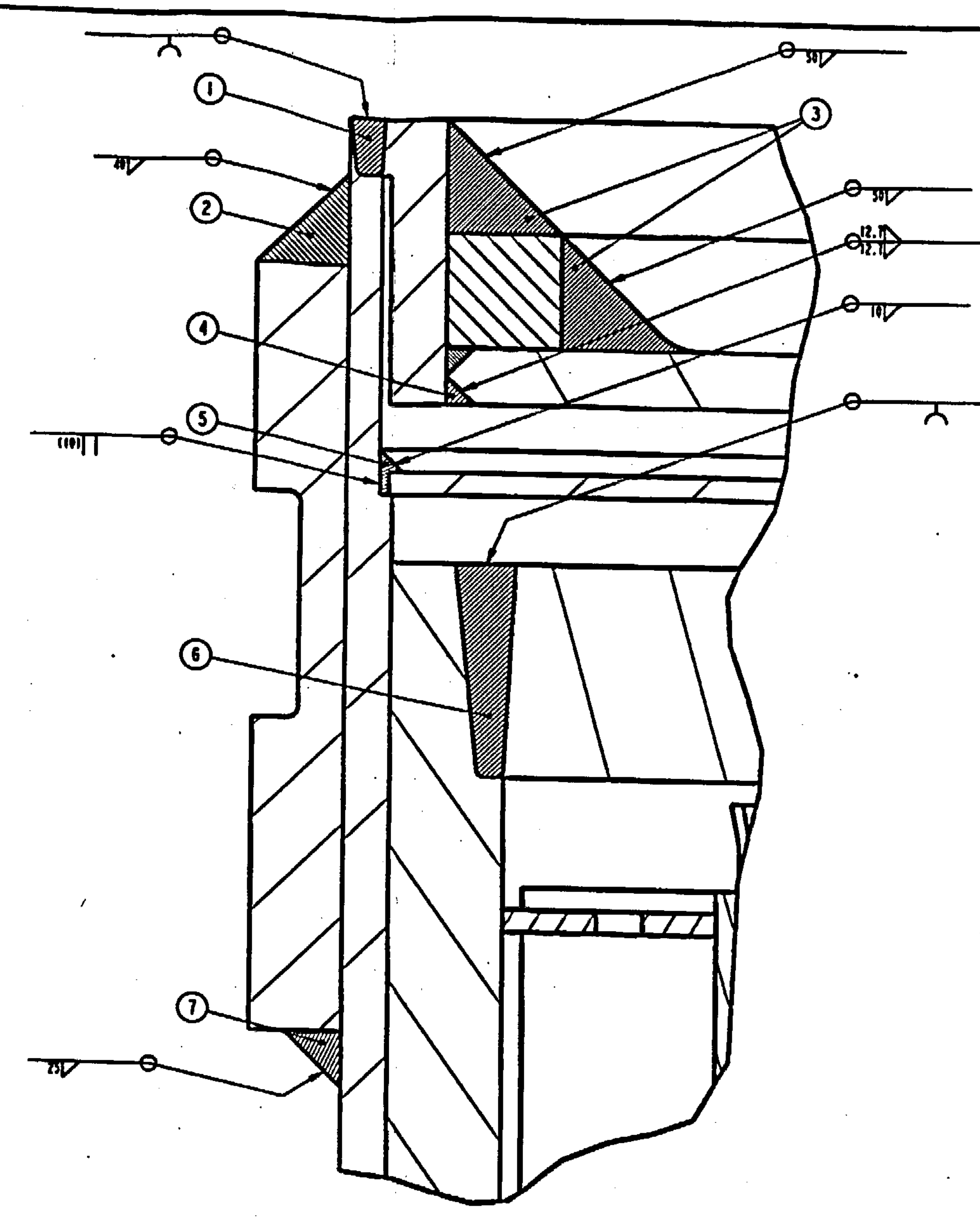
** REFER TO SK-0191 REV 00 "21-PWR WASTE PACKAGE WELD CONFIGURATION"

02 SMB 01/27/00

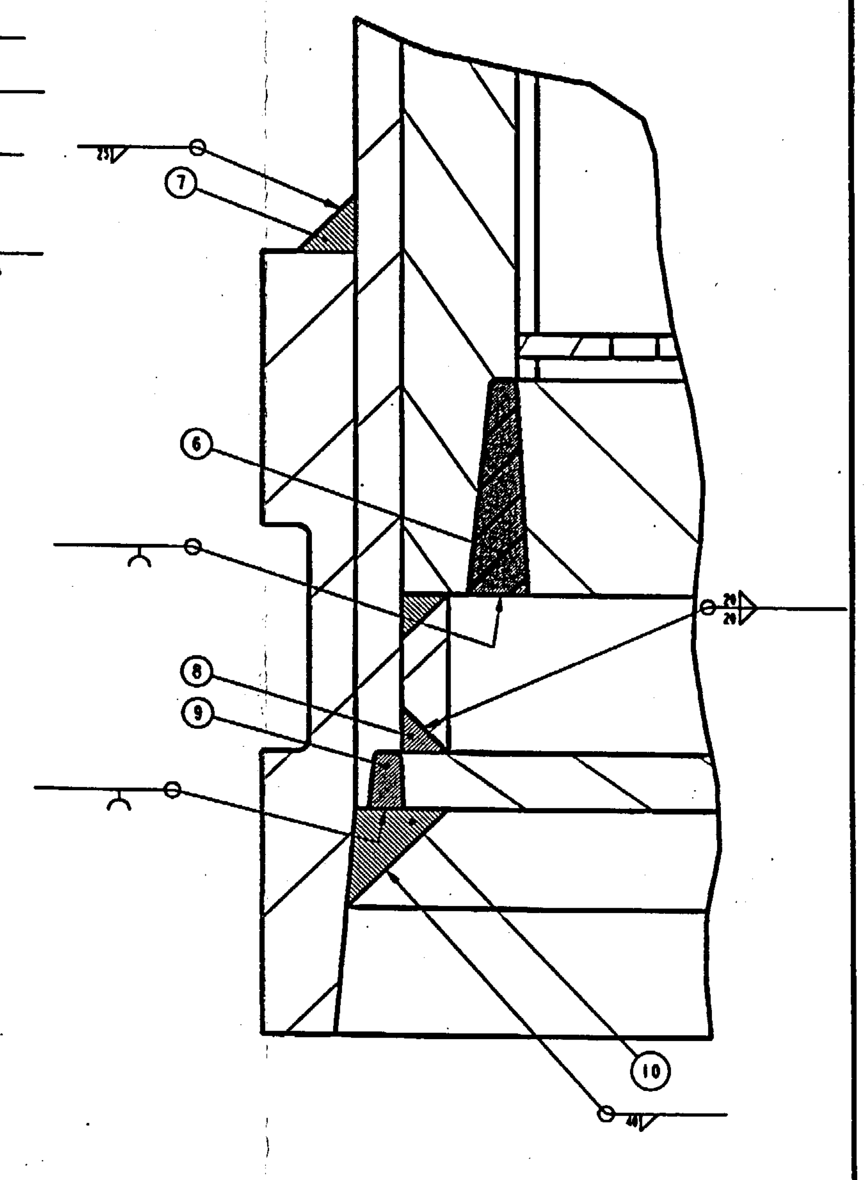
SK-0175 REV ~~01~~ | SHEET 2 OF 2



SECTION A-A



DETAIL A



DETAIL B

WELD	MATERIAL	MASS (KG)	QTY ROD
1	SFA-5.14 N06022	14	1
2	SFA-5.14 N06022	35	1
3	SFA-5.14 N06022	96	1
4	SFA-5.14 N06022	3.1	2
5	SFA-5.14 N06022	3.8	1
6	SFA-5.9 S31680	64	2
7	SFA-5.14 N06022	13	2
8	SFA-5.14 N06022	8.2	2
9	SFA-5.14 N06022	14	1
10	SFA-5.14 N06022	37	1
TOTAL ALLOY 22 WELDS	SFA-5.14 N06022	249	-
TOTAL 316 WELDS	SFA-5.9 S31680	128	-

UNITS: mm

DO NOT SCALE FROM SKETCH

REVISIONS

REV	DESCRIPTION	CHK BY	DATE
00	ISSUED APPROVED	BH	03/09/00

"FOR INFORMATION ONLY"

21-PWR WASTE PACKAGE WELD CONFIGURATION

SKETCH NUMBER: SK-0191 REV 00

SKETCHED BY: BRYAN HARKINS BH 13March00 SMB 03/13/00 JAC 3/13/00

DATE: 03/09/00

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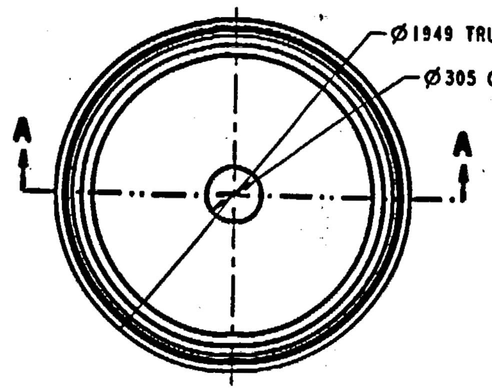
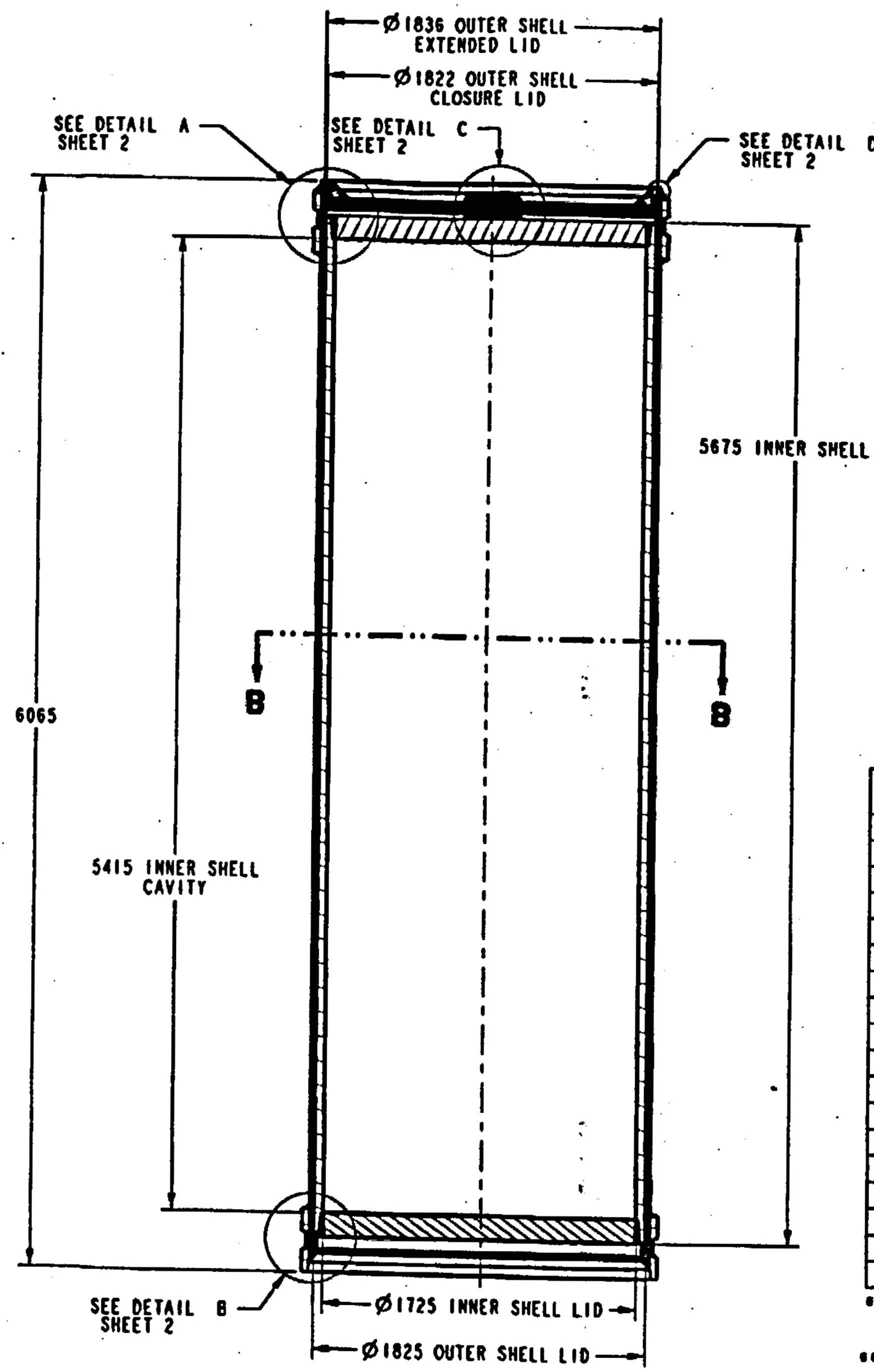
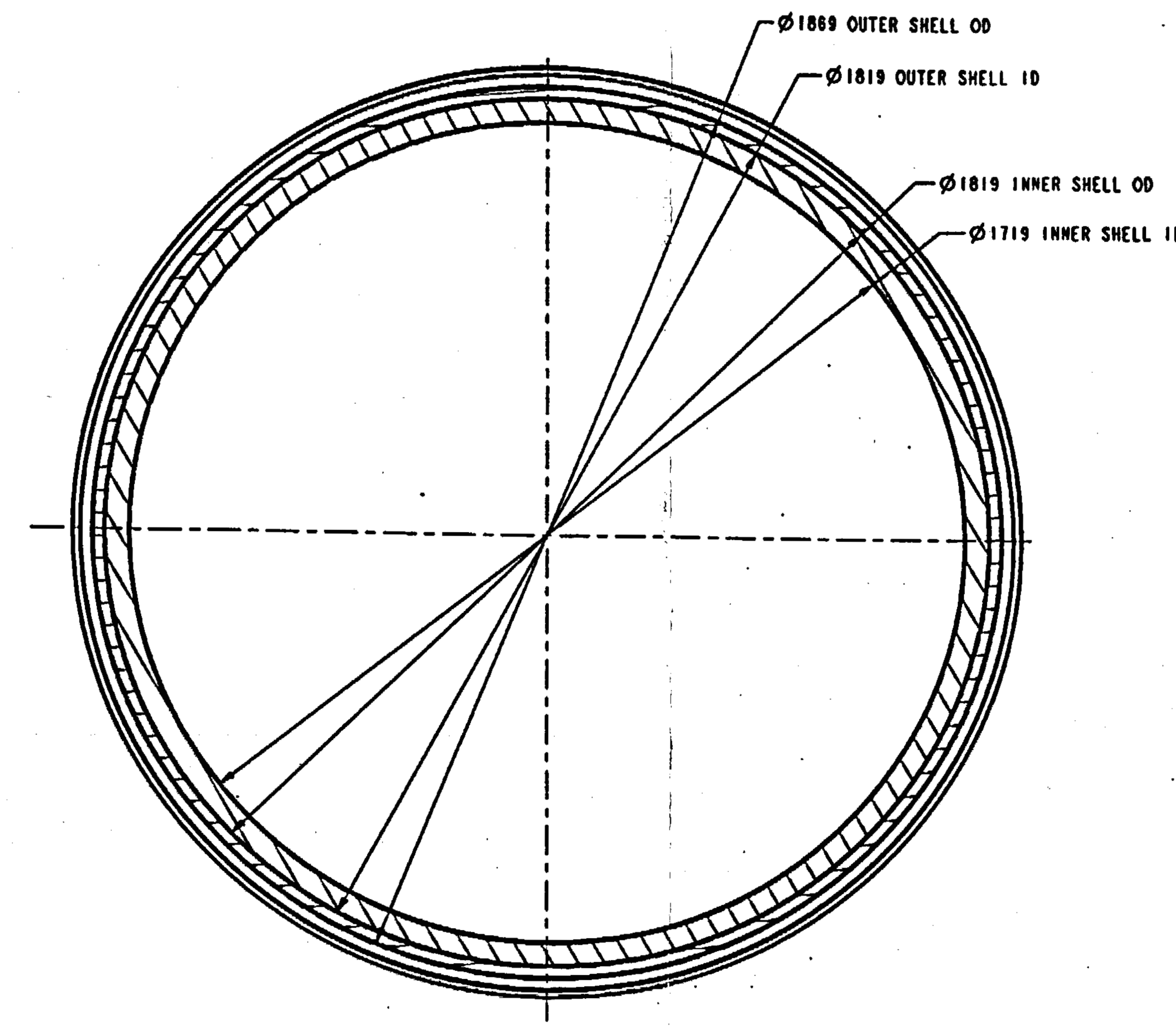




SECTION A-A



SECTION B-B

COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG)	QTY ROD
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 (Ref. 24)

**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	
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SKETCHED BY: GENE CONNELL EGC 01/26/00	SMB 01/26/00 JAE 1/26/00
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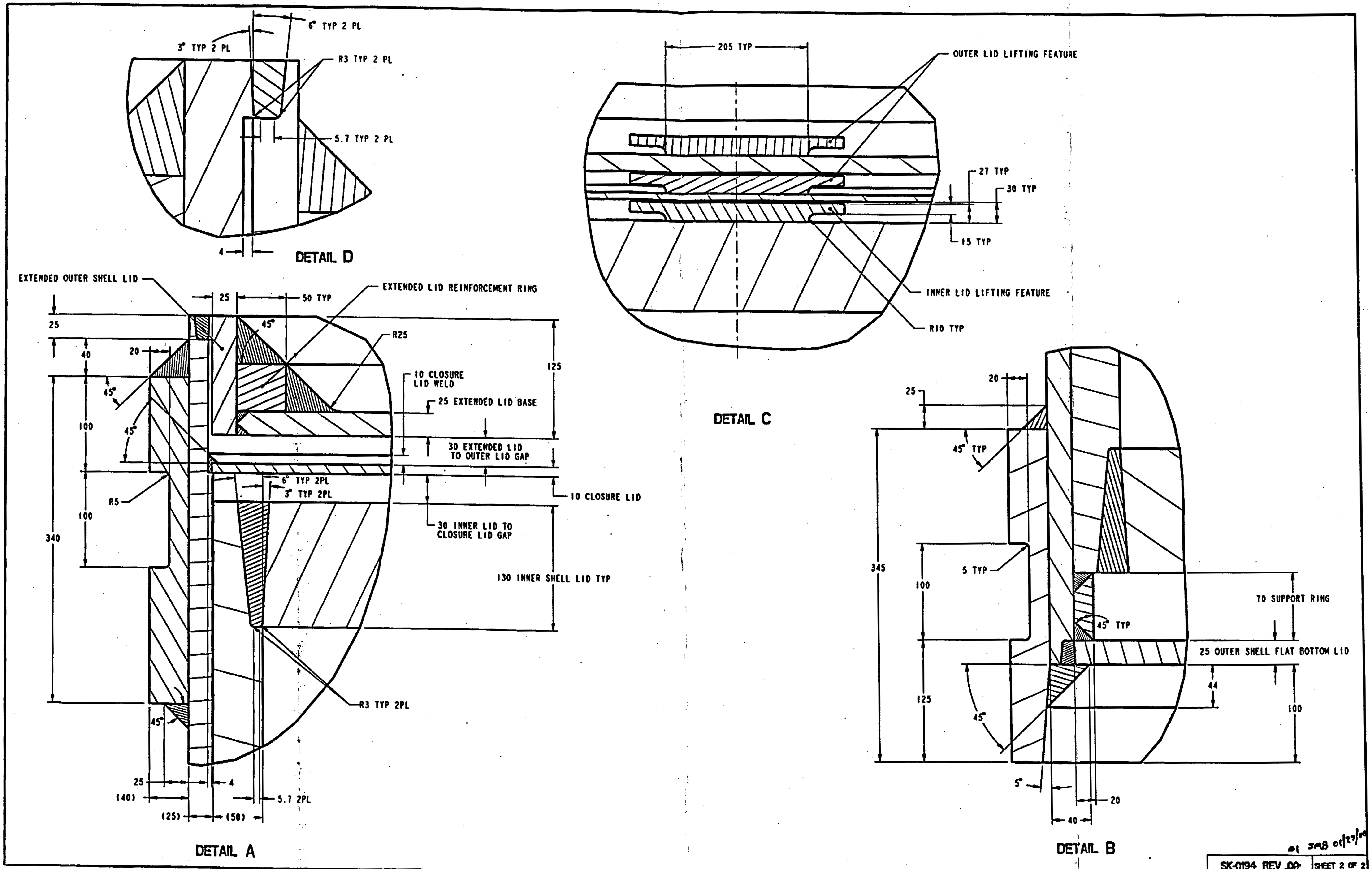


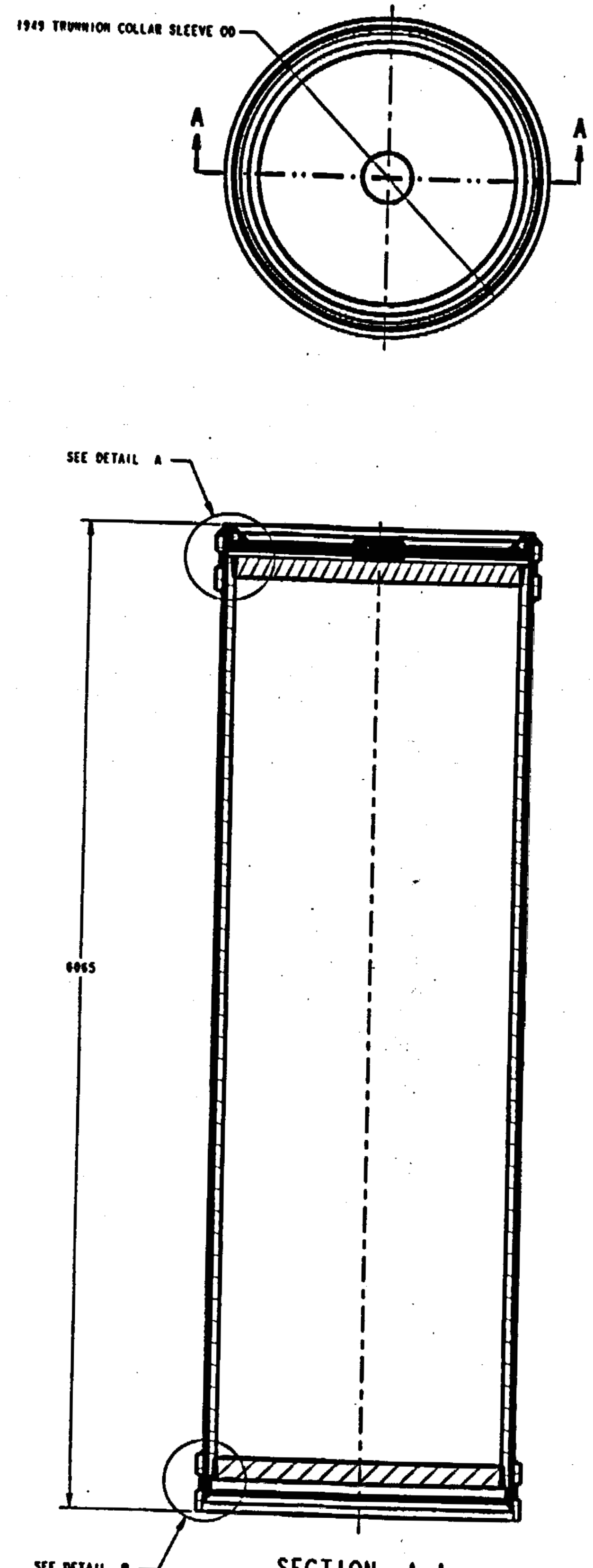
6° TYP 2 PL
3° TYP 2 PL
R3 TYP 2 PL
5.7 TYP 2 PL
4
DETAIL D
205 TYP
OUTER LID LIFTING FEATURE
27 TYP
30 TYP
15 TYP
INNER LID LIFTING FEATURE
R10 TYP
DETAIL C
EXTENDED OUTER SHELL LID
25
50 TYP
EXTENDED LID REINFORCEMENT RING
45°
R25
40
20
125
10 CLOSURE LID WELD
25 EXTENDED LID BASE
30 EXTENDED LID TO OUTER LID GAP
6° TYP 2PL
3° TYP 2PL
10 CLOSURE LID
R5
100
340
30 INNER LID TO CLOSURE LID GAP
130 INNER SHELL LID TYP
R3 TYP 2PL
(40)
(25)
(50)
5.7 2PL
DETAIL A
45° TYP
345
5 TYP
70 SUPPORT RING
25 OUTER SHELL FLAT BOTTOM LID
44
5°
DETAIL B
SK-0194 REV 00
SHEET 2 OF 2

ALL SHEETS ARE THE SAME REVISION STATUS

SKETCH NUMBER	SHEET	REVISION
SK-0195	1 OF 1	00

REVISION HISTORY

ZONE	REV	DESCRIPTION	DATE	APPROVED



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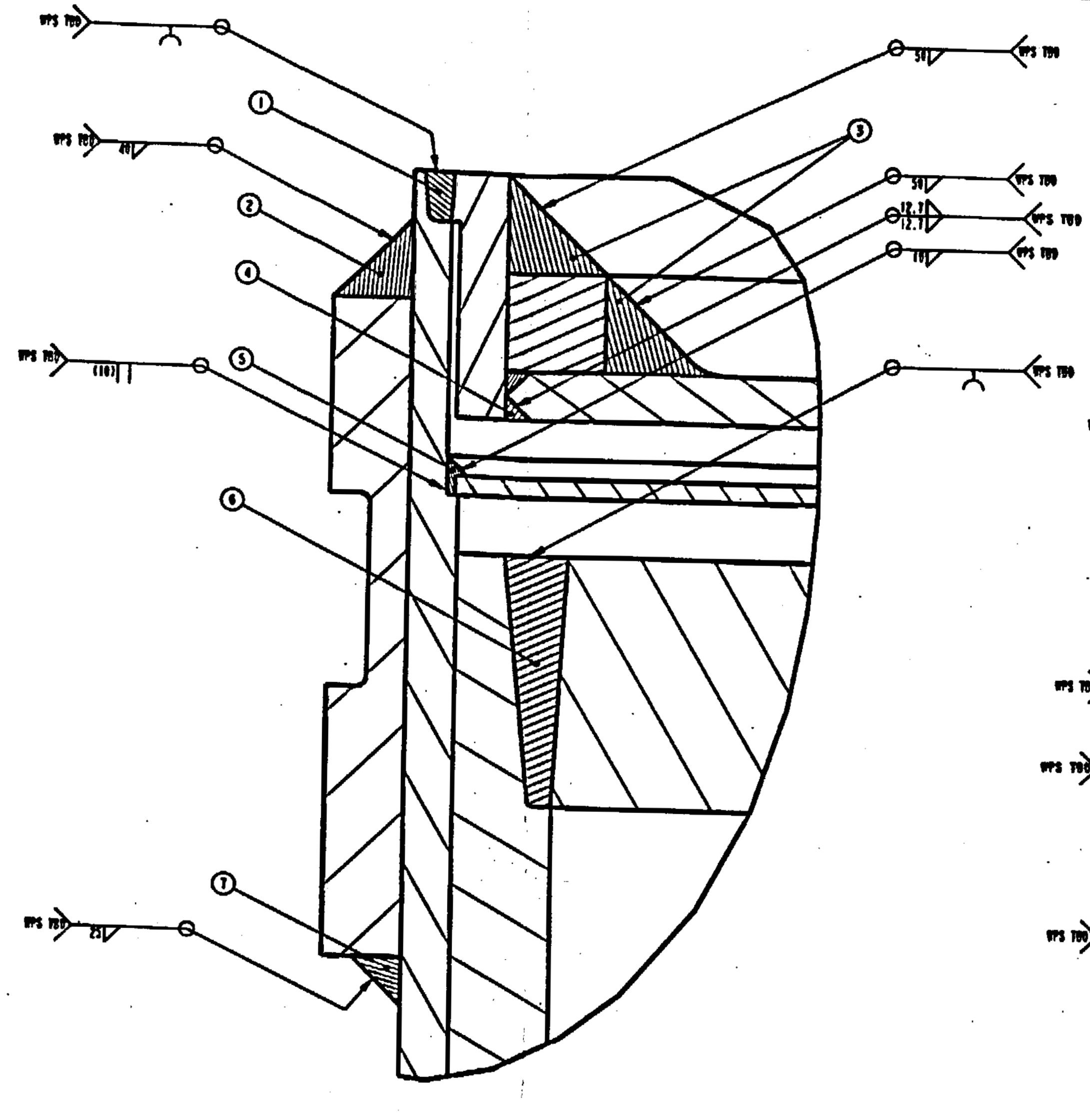

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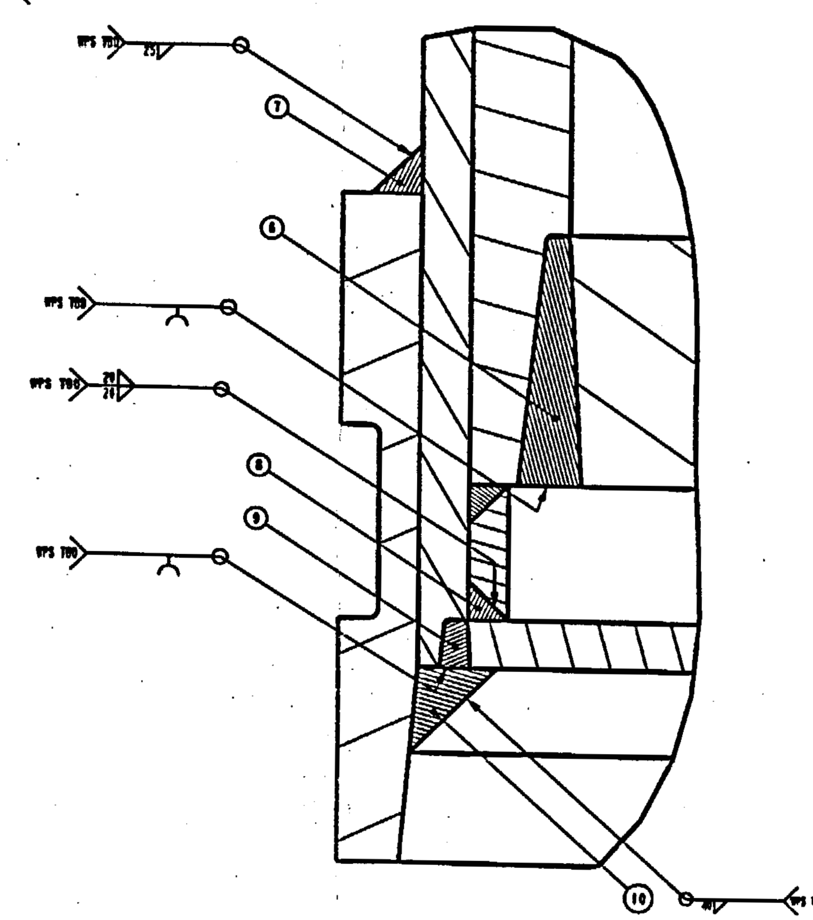


DETAIL B
SCALE 0.625

WELDS	MATERIAL	MASS (KG)	QTY REQ
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	-

"FOR INFORMATION ONLY"
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	JGC 05/10/00
DESIGN GROUP MGR ~~THOMAS DOERING~~ MICHAEL ANDERSON	MA 5/9/00

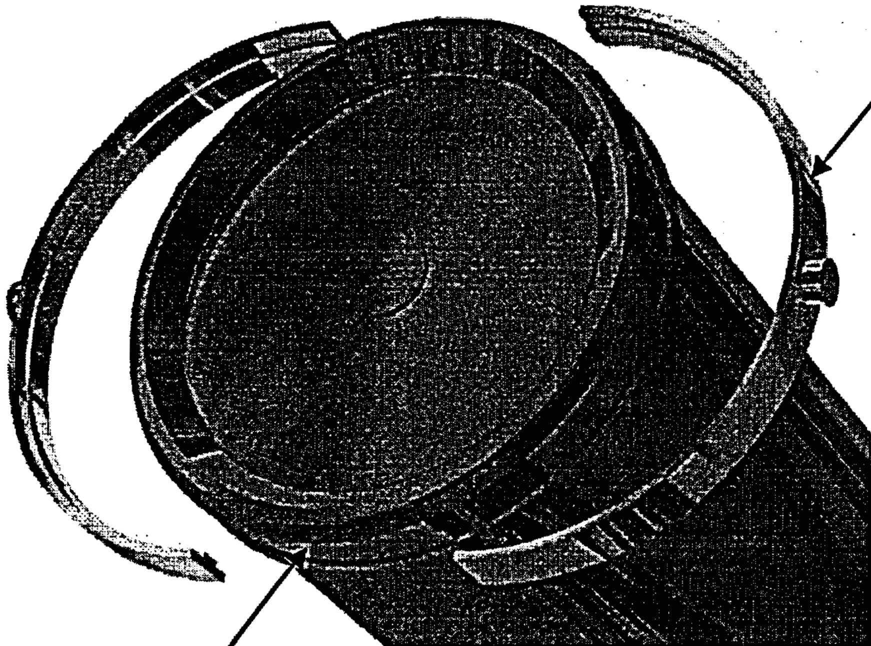
WASTE PACKAGE DEPARTMENT
M&O Civilian Radioactive Waste Management System MANAGEMENT & OPERATING CONTRACTOR

TITLE
NAVAL SNF LONG WASTE PACKAGE WELD CONFIGURATION

SKETCH NUMBER SK-0195
REVISION 00
SCALE .055
SHEET 1 OF 1

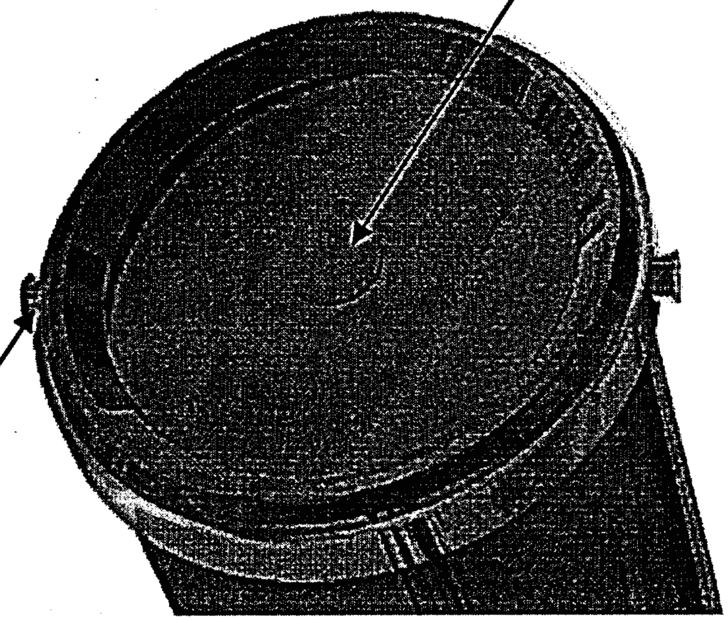
Waste Package Configuration Before Trunnion Collar Emplacement

Unnasembled Trunnion Collar



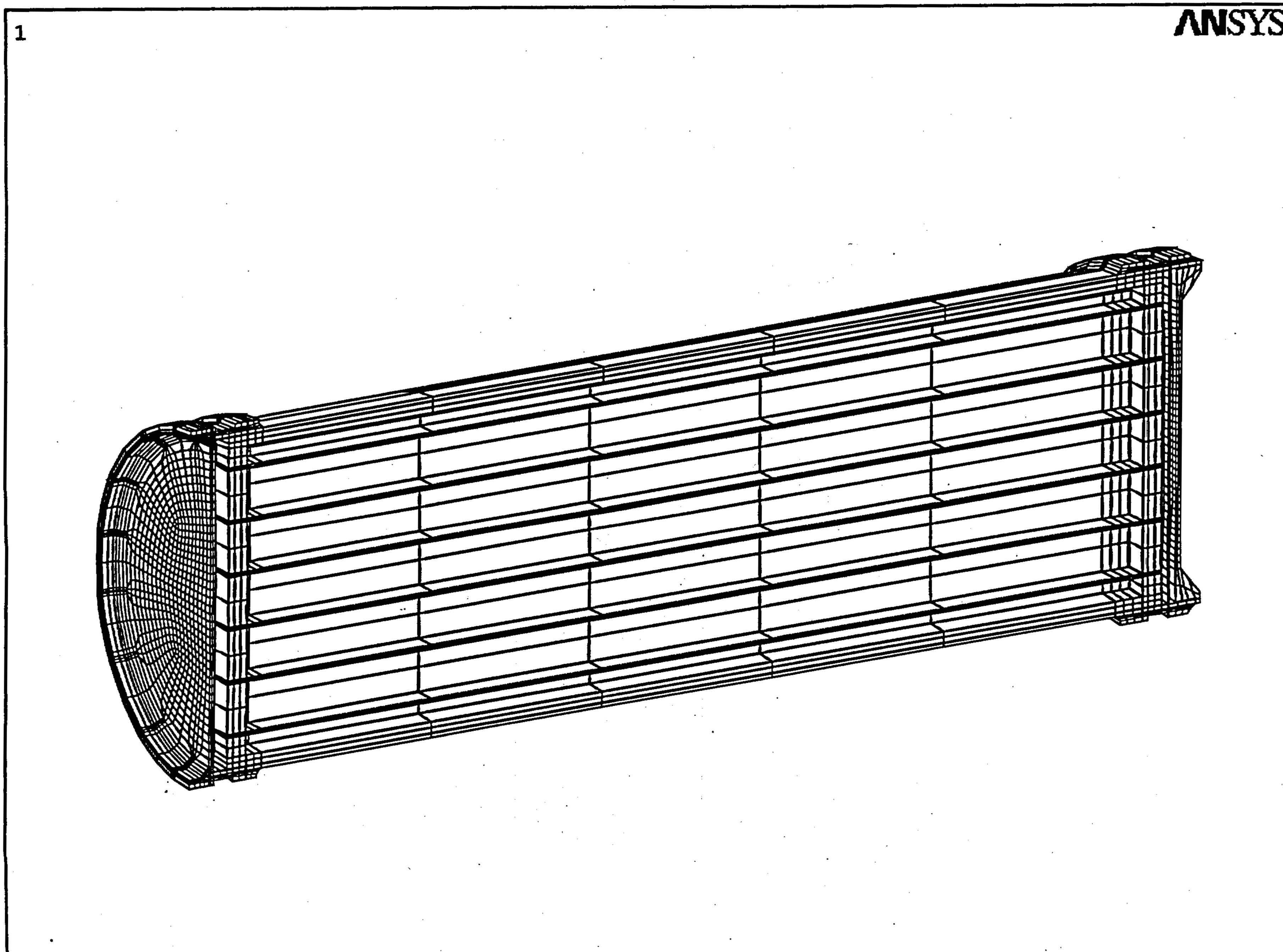
Trunnion Collar Sleeve

Outer Lid
Lifting Feature

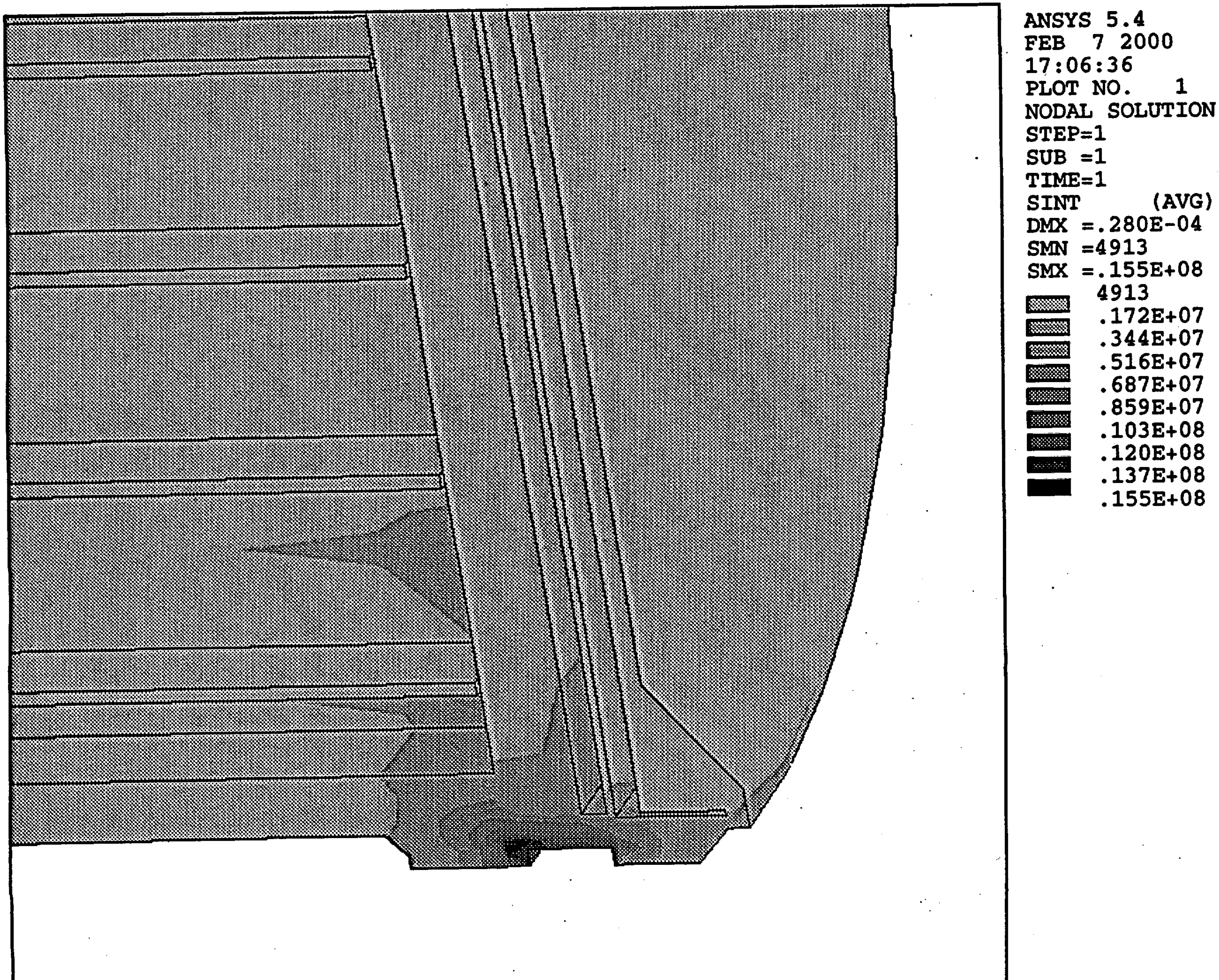


Assembled Trunnion Collar

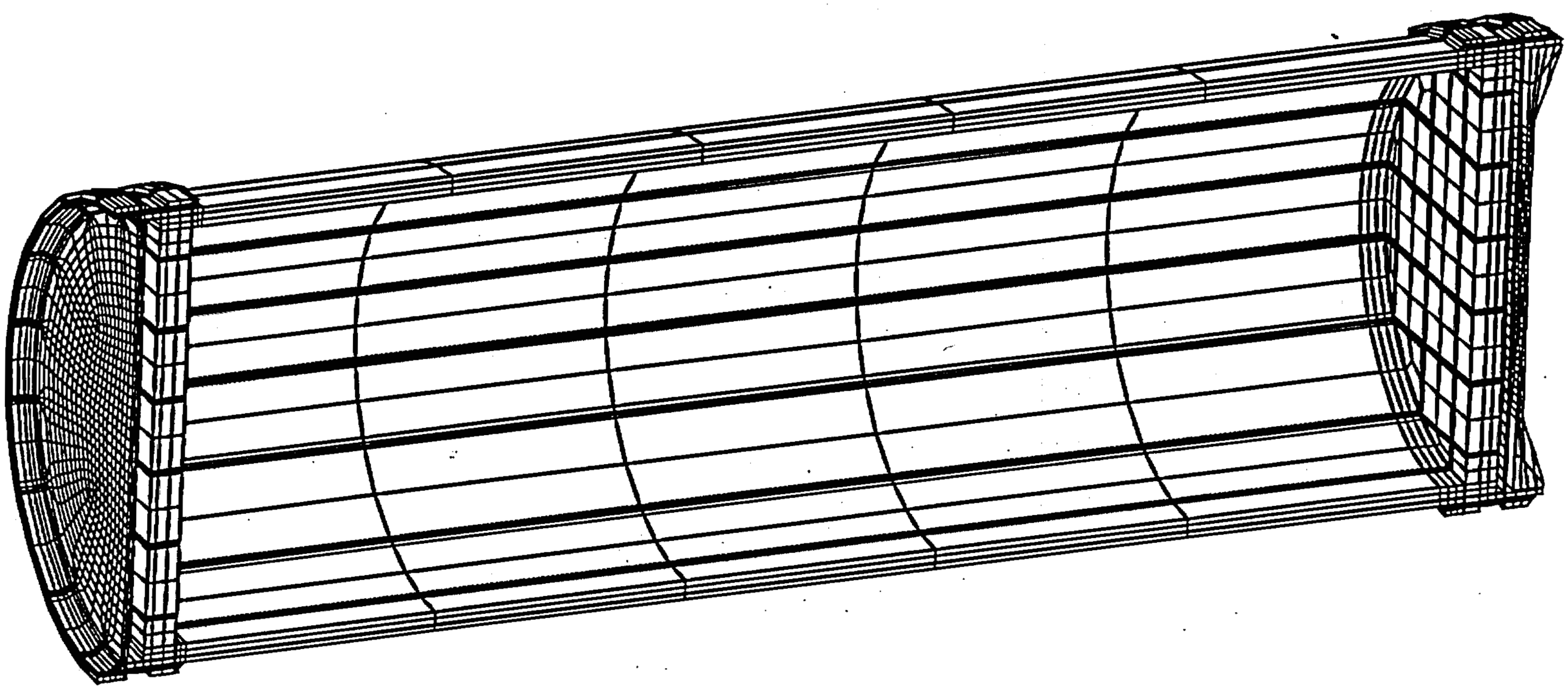
Waste Package Configuration After Trunnion Collar Emplacement



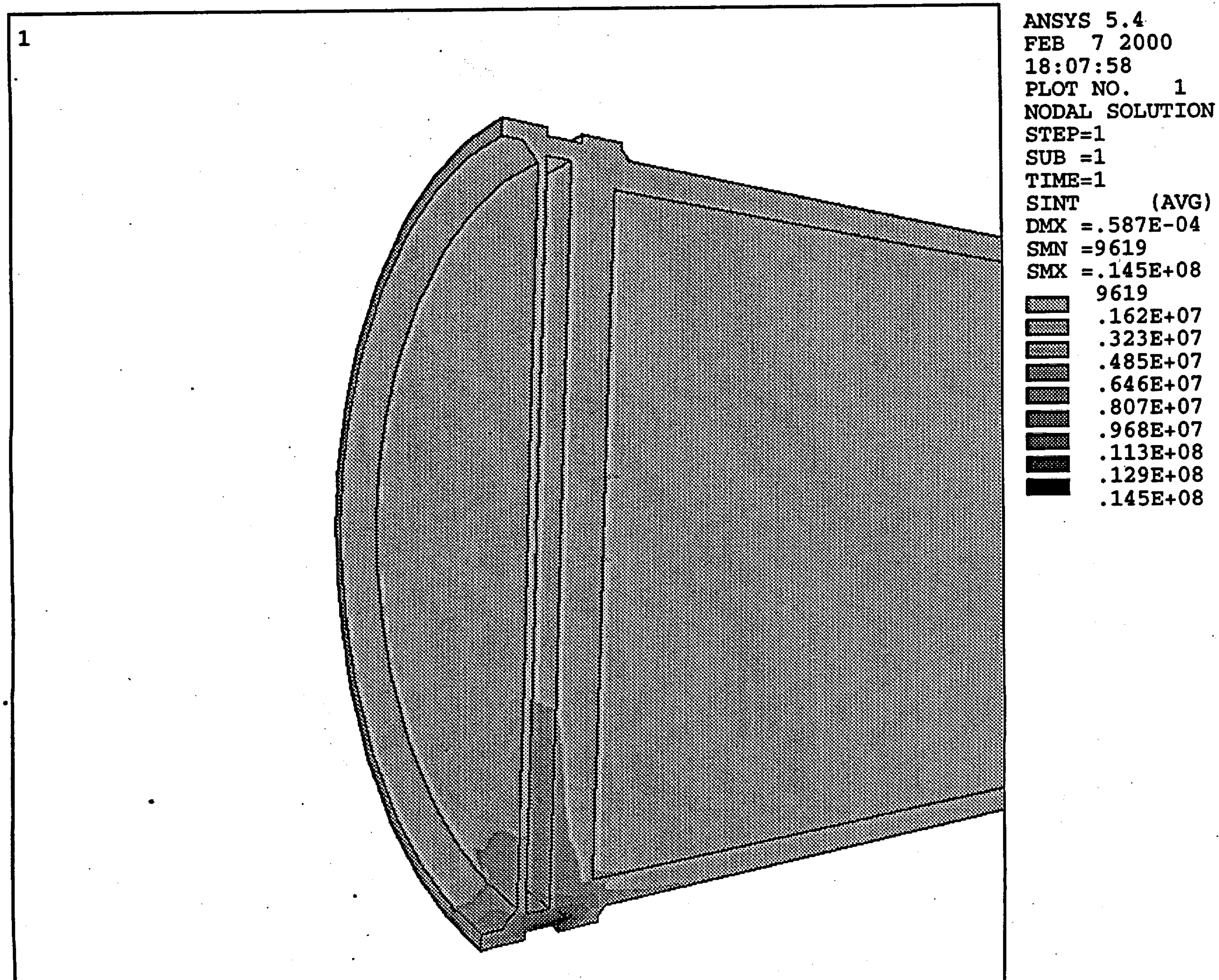
21 PWR Waste Package Horizontal Lifting - Mesh



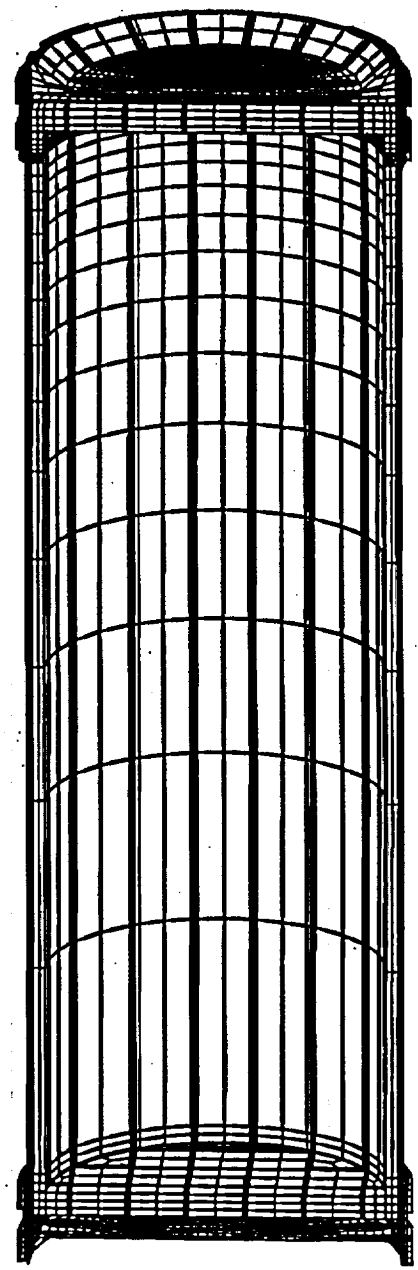
21 PWR Waste Package Horizontal Lifting - Stress Intensity



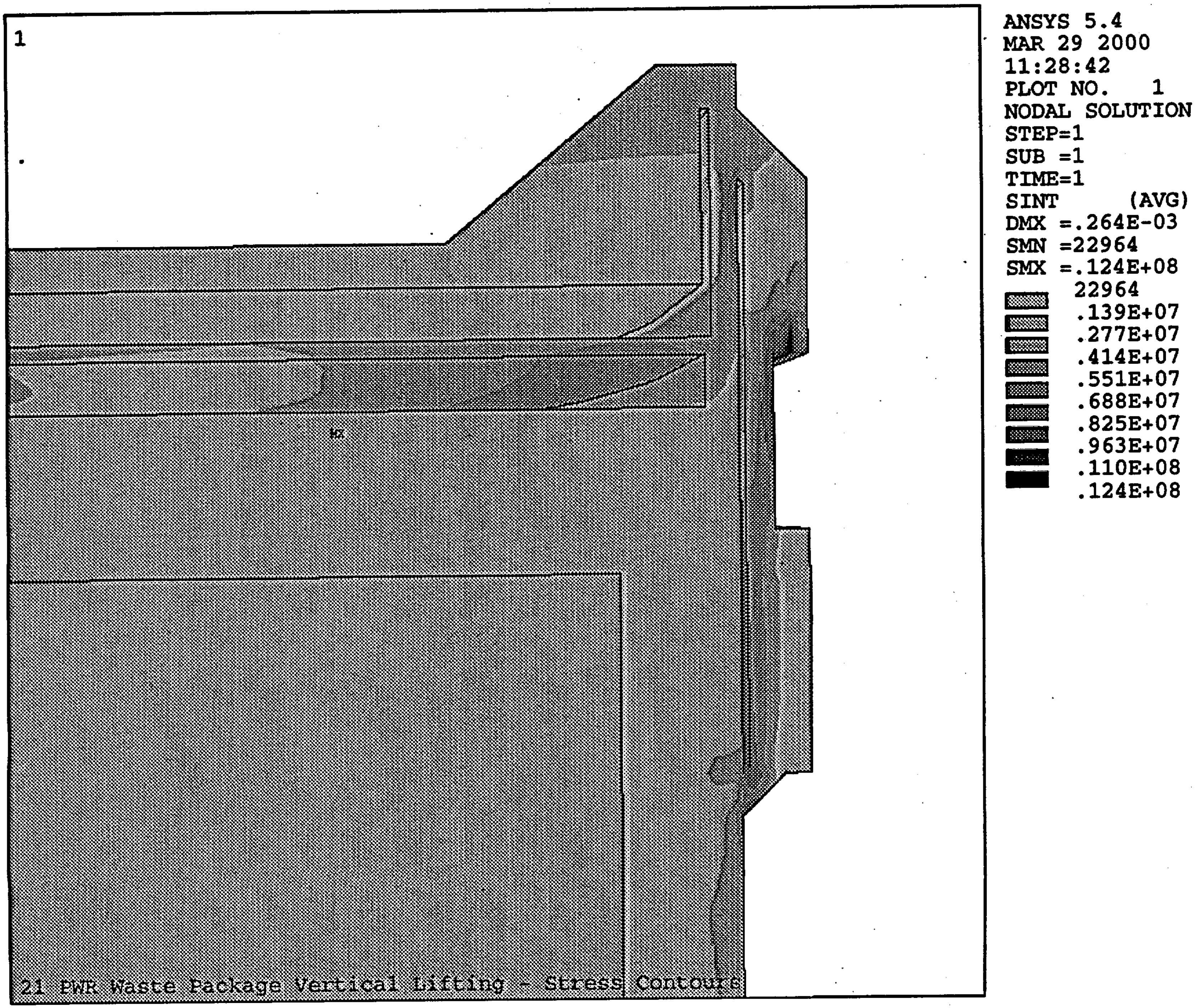
Naval Waste Package Horizontal Lifting - Mesh

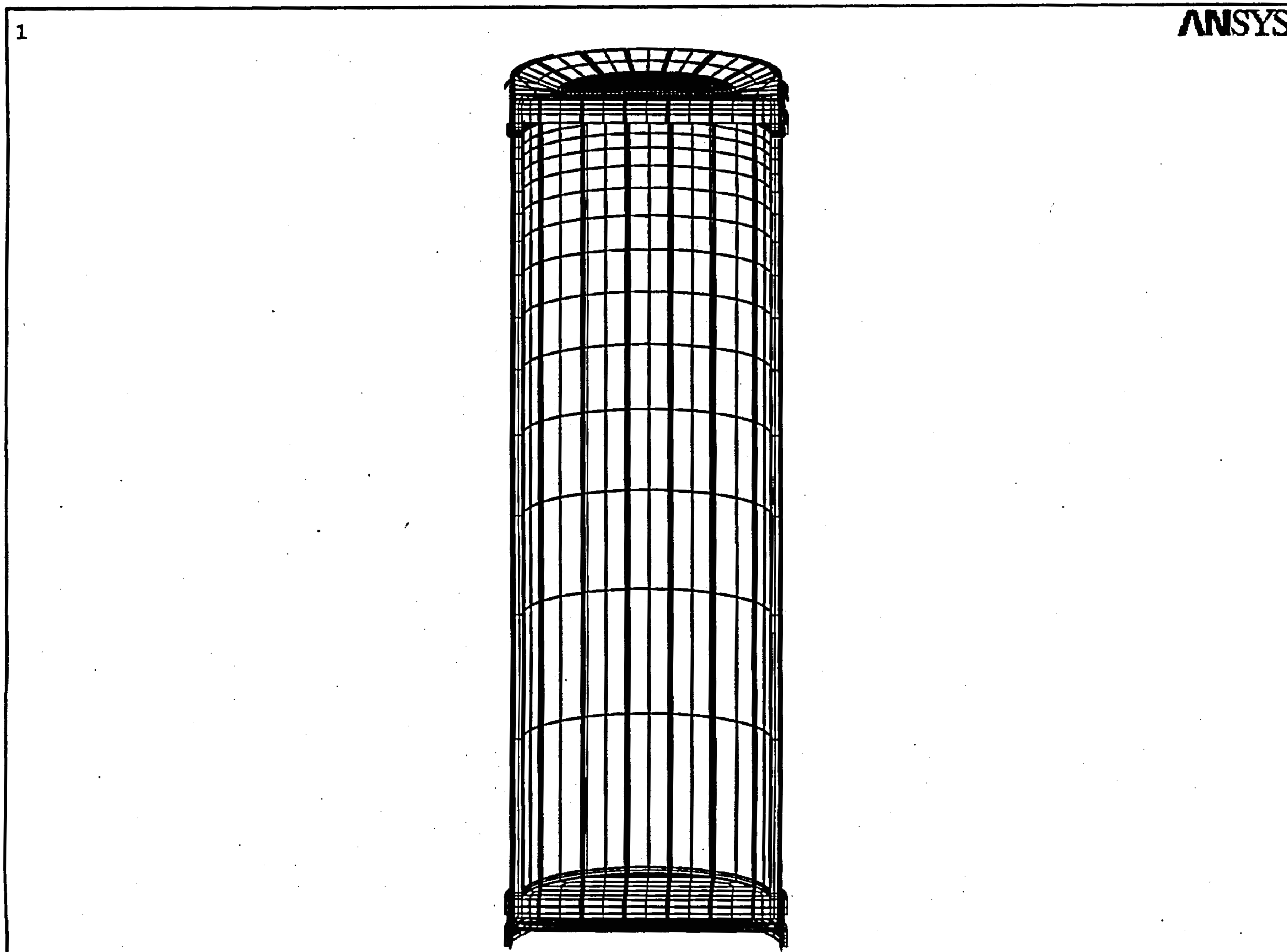


Naval Waste Package Horizontal Lifting - Stress Intensity

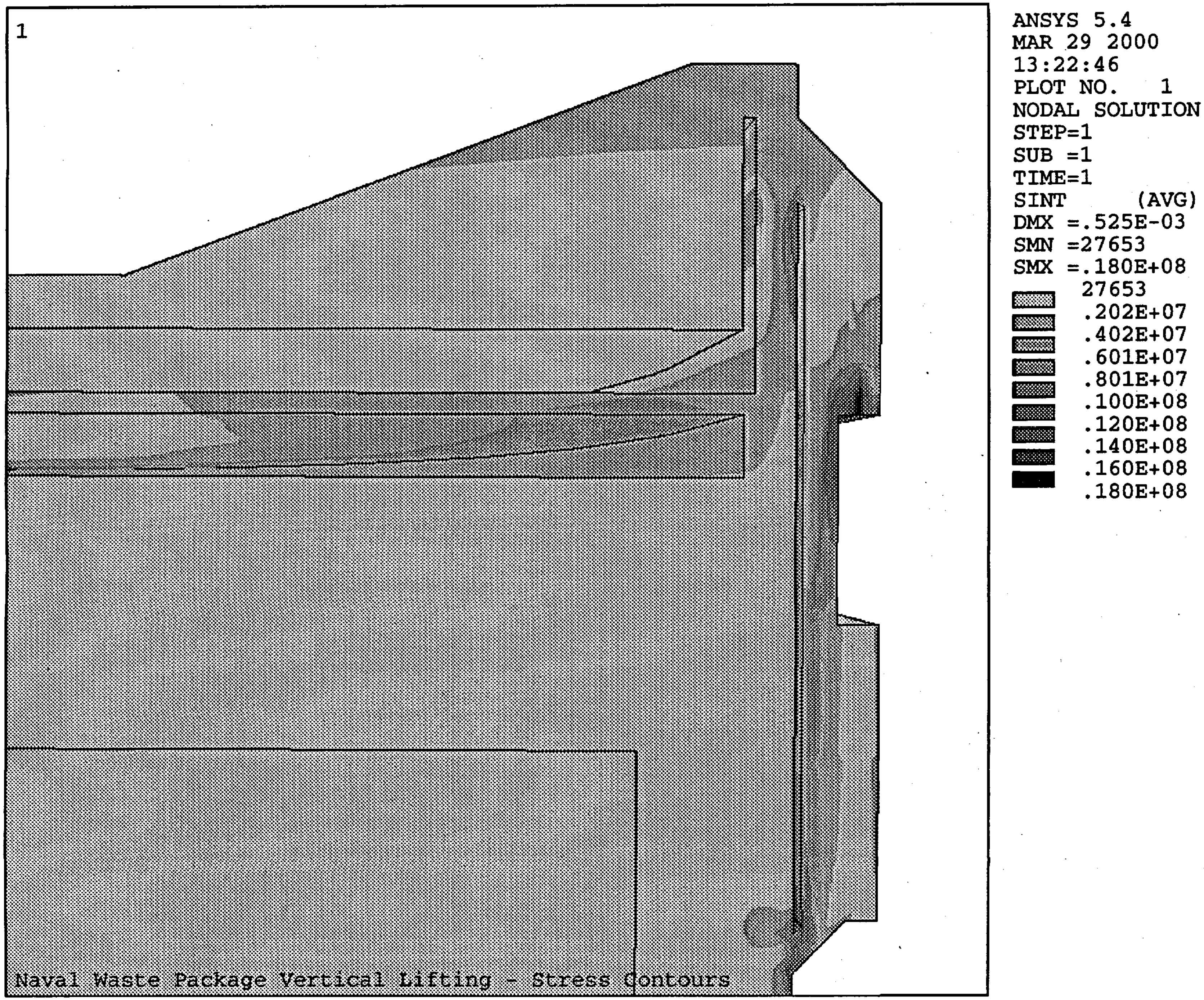


21 PWR Waste Package Vertical lifting - Mesh


1
MX
21 PWR Waste Package Vertical Lifting - Stress Contours
ANSYS 5.4
MAR 29 2000
11:28:42
PLOT NO. 1
NODAL SOLUTION
STEP=1
SUB =1
TIME=1
SINT (AVG)
DMX =.264E-03
SMN =22964
SMX =.124E+08
22964
.139E+07
.277E+07
.414E+07
.551E+07
.688E+07
.825E+07
.963E+07
.110E+08
.124E+08



Naval Waste Package Vertical Lifting - Mesh


1
ANSYS 5.4
MAR 29 2000
13:22:46
PLOT NO. 1
NODAL SOLUTION
STEP=1
SUB =1
TIME=1
SINT (AVG)
DMX =.525E-03
SMN =27653
SMX =.180E+08
27653
.202E+07
.402E+07
.601E+07
.801E+07
.100E+08
.120E+08
.140E+08
.160E+08
.180E+08
Naval Waste Package Vertical Lifting - Stress Contours

FILES SUMMARY

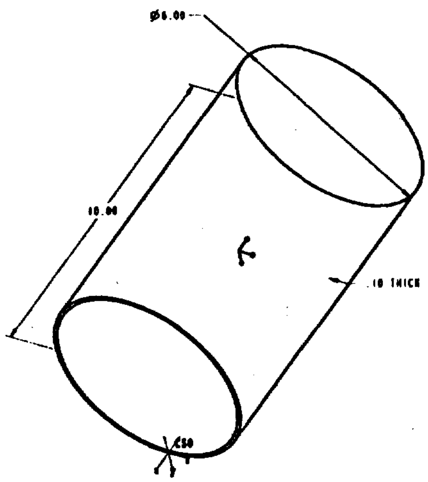
The ANSYS V5.4 files listed in Table IX-1 include the output files, which record the input commands and solution process, and post-processing files used to extract the results for each case analyzed. Mass property files generated by Pro/Engineer Release 2000i are also listed. All files are stored on a compact disk (CD) (Ref. 20).

Table IX-1. File Summary

File #	File Name	Description	Size (kb)	Date	Time
1	/lift21_h/lift21_h.out	21 PWR waste package horizontal lifting	2411	2/8/2000	11:31 AM
2	/lift21_h/post.out		53	2/15/2000	1:25 PM
3	/liftnv_h/liftnv_h.out	Naval waste package horizontal lifting	2570	2/8/2000	11:32 AM
4	/liftnv_h/post.out		35	2/15/2000	1:24 PM
5	/lift21_v/lift21_v.out	21 PWR waste package vertical lifting	3002	3/31/2000	1:18 PM
6	/lift21_v/post.out		35	3/31/2000	1:19 PM
7	/liftnv_v/liftnv_v.out	Naval waste package vertical lifting	3109	3/31/2000	1:19 PM
8	/liftnv_v/post.out		35	3/31/2000	1:19 PM
9	m21_proe.prn	21 PWR waste package mass property	69	2/22/2000	1:49 PM
10	mnv_proe.prn	Naval waste package mass property	46	2/23/2000	10:40 AM
11	/lift44_h/lift44_h.out	44 BWR waste package horizontal lifting	2441	3/31/2000	1:17 PM
12	/lift44_h/post.out		35	3/31/2000	1:19 PM
13	/lift5_h/lift5d_h.out	5 DHLW/DOE SNF – Short waste package horizontal lifting	2578	3/31/2000	1:17 PM
14	/lift5_h/post.out		35	3/31/2000	1:19 PM
15	/lift44_v/lift44_v.out	44 BWR waste package vertical lifting	3003	3/31/2000	1:19 PM
16	/lift44_v/post.out		35	3/31/2000	1:19 PM
17	/lift5d_v/lift5d_v.out	5 DHLW/DOE SNF – Short waste package vertical lifting	3046	3/31/2000	1:18 PM
18	/lift5d_v/post.out		35	3/31/2000	1:19 PM
19	m44_proe.prn	44 BWR waste package mass property	56	3/27/2000	4:47 PM
20	m5_proe.prn	5 DHLW/DOE SNF – Short waste package mass property	53	3/27/2000	4:47 PM

Verification of Mass Calculation in Pro/Engineer Release 2000i

To verify the values of mass calculated by Pro/Engineer 2000i, a simple cylindrical shell is created in Pro/Engineer 2000i. The values calculated from Pro/Engineer (Pro/E) 2000i are shown in the following mass property printout. Thus, the mass obtained from Pro/E 2000i is 18.535397 kg.




```
                         MASS PROPERTIES OF THE PART SHELL

                       VOLUME =  1.8535397e+01 M^3
                 SURFACE AREA =  3.7441501e+02 M^2
                      DENSITY =  1.0000000e+00 KILOGRAM / M^3
                         MASS =  1.8535397e+01 KILOGRAM

               CENTER OF GRAVITY with respect to CSO coordinate frame:
X  Y  Z             -5.0000000e+00 -3.0000000e+00  0.0000000e+00  M

           INERTIA with respect to CSO coordinate frame:  (KILOGRAM * M^2)

INERTIA TENSOR:
Ixx Ixy Ixz          3.2816920e+02 -2.7803095e+02  0.0000000e+00
Iyx Iyy Iyz         -2.7803095e+02  6.9852187e+02  0.0000000e+00
Izx Izy Izz          0.0000000e+00  0.0000000e+00  8.6534044e+02

     INERTIA at CENTER OF GRAVITY with respect to CSO coordinate frame:
                                                        (KILOGRAM * M^2)
INERTIA TENSOR:
Ixx Ixy Ixz          1.6135063e+02  0.0000000e+00  0.0000000e+00
Iyx Iyy Iyz          0.0000000e+00  2.3513696e+02  0.0000000e+00
Izx Izy Izz          0.0000000e+00  0.0000000e+00  2.3513695e+02

                PRINCIPAL MOMENTS OF INERTIA:  (KILOGRAM * M^2)
I1  I2  I3           1.6135063e+02  2.3513694e+02  2.3513696e+02

             ROTATION MATRIX from CSO 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 CSO 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           2.9504237e+00  3.5617177e+00  3.5617178e+00  M
```

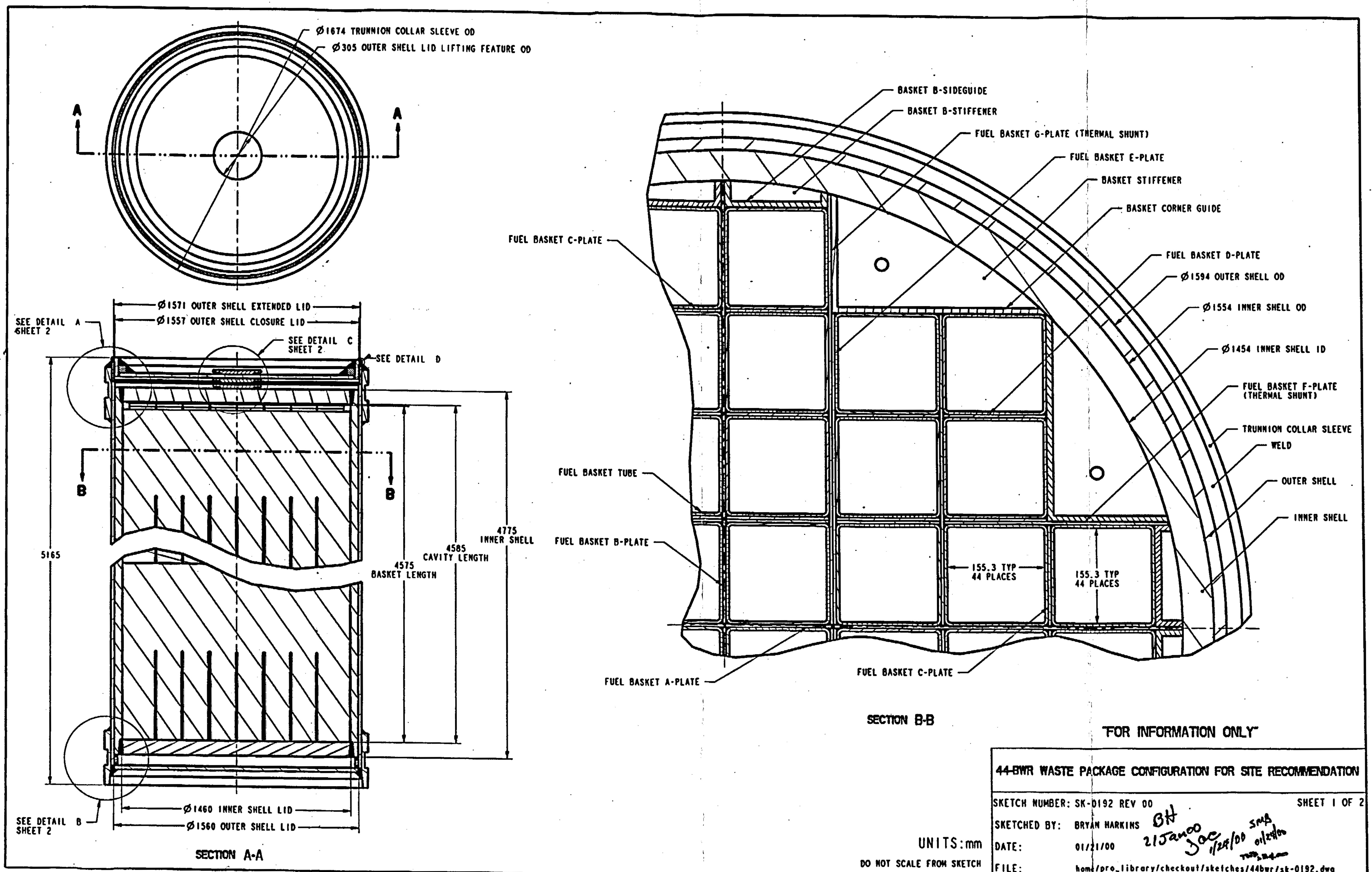
Based on the dimensions given above, the mass of the shell can be verified as the following:

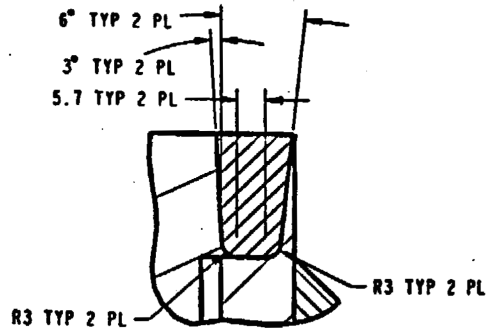
$M = (r_2^2 - r_1^2) \cdot \pi \cdot L \cdot \rho = 18.535397$ kg

where: M = shell mass

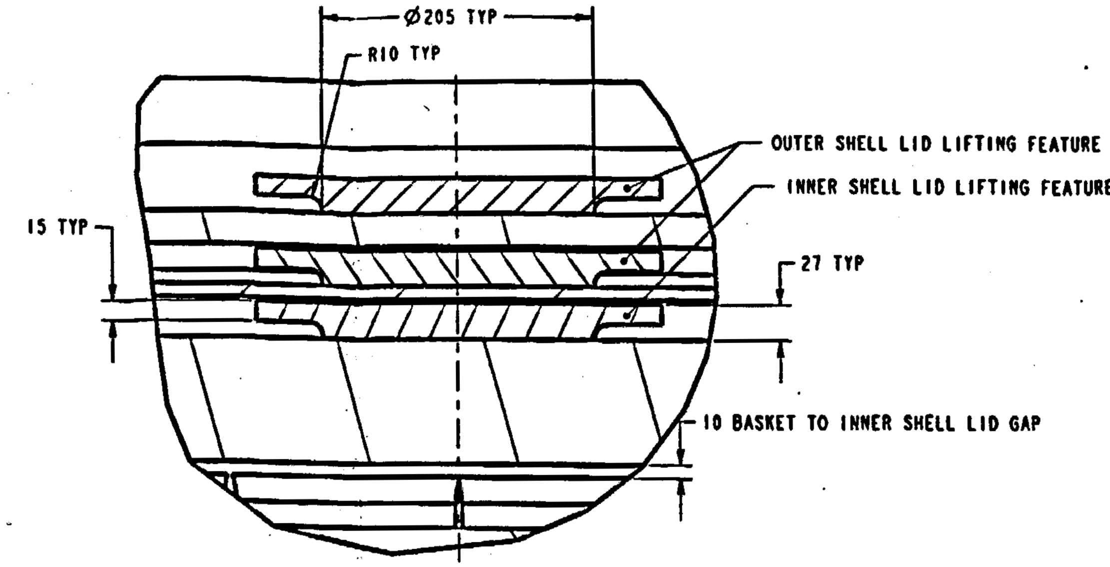
- r_1 = shell inner radius =2.9 m
- r_2 = shell outer radius = 3 m
- L = shell length = 10 m
- ρ = density = 1 kg/m^3

Thus, the mass obtained from Pro/E 2000i is identical with the mass calculated here.

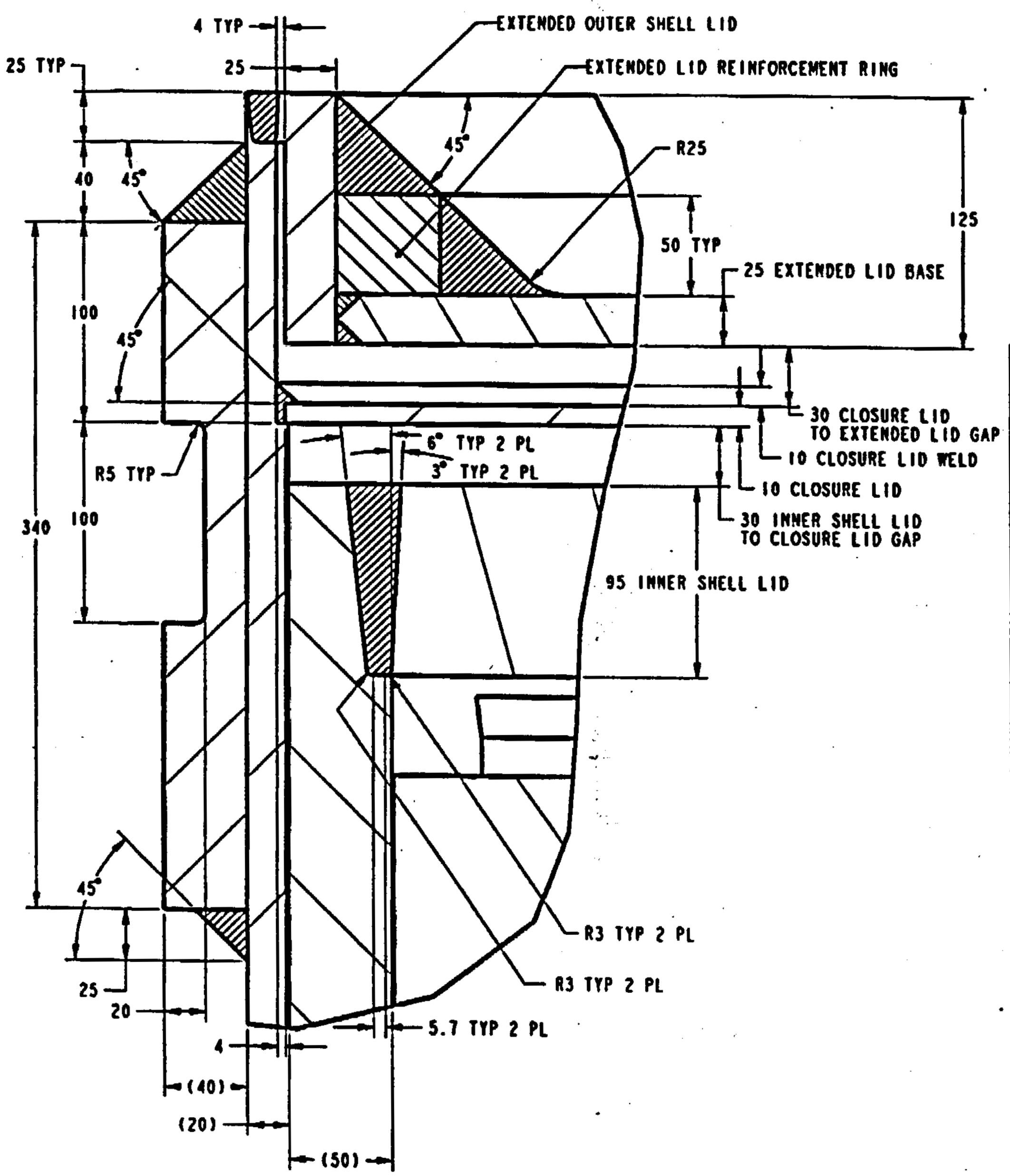

Ø1674 TRUNNION COLLAR SLEEVE OD
Ø305 OUTER SHELL LID LIFTING FEATURE OD
A
A
Ø1571 OUTER SHELL EXTENDED LID
Ø1557 OUTER SHELL CLOSURE LID
SEE DETAIL A SHEET 2
SEE DETAIL C SHEET 2
SEE DETAIL D
B
B
5165
4775 INNER SHELL
4585 CAVITY LENGTH
4575 BASKET LENGTH
SEE DETAIL B SHEET 2
Ø1460 INNER SHELL LID
Ø1560 OUTER SHELL LID
SECTION A-A
BASKET B-SIDEGUIDE
BASKET B-STIFFENER
FUEL BASKET G-PLATE (THERMAL SHUNT)
FUEL BASKET E-PLATE
BASKET STIFFENER
BASKET CORNER GUIDE
FUEL BASKET C-PLATE
FUEL BASKET D-PLATE
Ø1594 OUTER SHELL OD
Ø1554 INNER SHELL OD
Ø1454 INNER SHELL ID
FUEL BASKET F-PLATE (THERMAL SHUNT)
TRUNNION COLLAR SLEEVE
WELD
OUTER SHELL
INNER SHELL
FUEL BASKET TUBE
FUEL BASKET B-PLATE
155.3 TYP 44 PLACES
155.3 TYP 44 PLACES
FUEL BASKET A-PLATE
FUEL BASKET C-PLATE
SECTION B-B
"FOR INFORMATION ONLY"
44-BWR WASTE PACKAGE CONFIGURATION FOR SITE RECOMMENDATION
SKETCH NUMBER: SK-0192 REV 00
SHEET 1 OF 2
SKETCHED BY: BRYAN HARKINS
DATE: 01/21/00
FILE: home/pro_library/checkout/sketches/44bwr/sk-0192.dwg
UNITS: mm
DO NOT SCALE FROM SKETCH



DETAIL D



DETAIL C



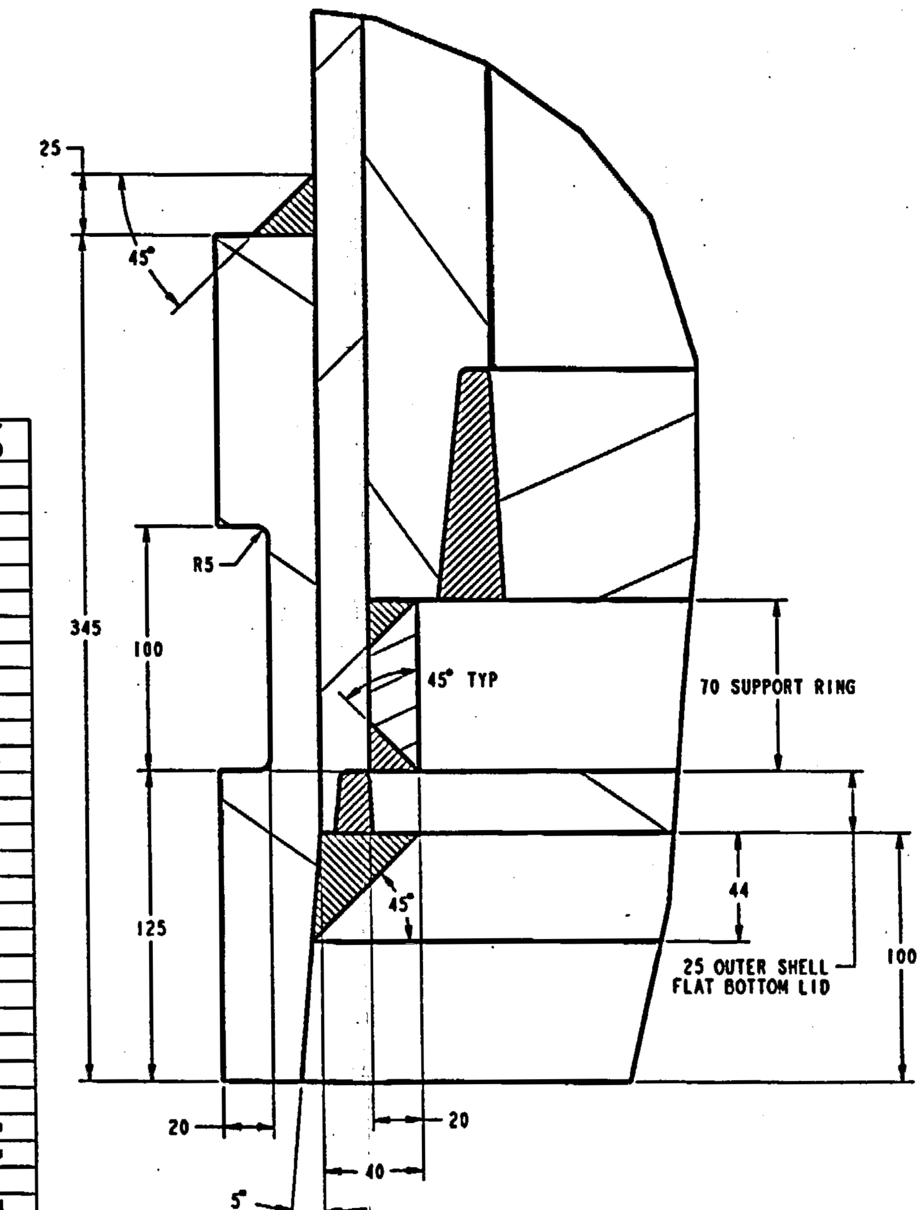
DETAIL A

COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG)	QTY ROD
BASKET B-SIDEGUIDE	SA-516 K02700	10	19	32
BASKET B-STIFFENER	SA-516 K02700	10	0.31	64
BASKET CORNERGUIDE	SA-516 K02700	10	46	32
BASKET STIFFENER	SA-516 K02700	10	2.7	64
FUEL BASKET A-PLATE	NEUTRONIT A 978	5	63	4
FUEL BASKET B-PLATE	NEUTRONIT A 978	5	63	4
FUEL BASKET C-PLATE	NEUTRONIT A 978	5	15	16
FUEL BASKET D-PLATE	NEUTRONIT A 978	5	44	16
FUEL BASKET E-PLATE	NEUTRONIT A 978	5	44	16
FUEL BASKET F-PLATE	SB-209 A96061 T4	5	21	8
FUEL BASKET G-PLATE	SB-209 A96061 T4	5	21	8
FUEL BASKET TUBE	SA-516 K02700	5	113	44
INNER SHELL	SA-240 S31600	50	8886	1
INNER SHELL LID	SA-240 S31600	95	1251	2
INNER SHELL LID LIFTING FEATURE	SA-240 S31600	27	12	1
OUTER SHELL	SB-575 N06022	20	4275	1
EXTENDED OUTER SHELL LID	SB-575 N06022	25	135	1
EXTENDED OUTER SHELL LID BASE	SB-575 N06022	25	381	1
OUTER SHELL LID LIFTING FEATURE	SB-575 N06022	27	13	2
EXTENDED LID REINFORCEMENT RING	SB-575 N06022	50	99	1
OUTER SHELL FLAT CLOSURE LID	SB-575 N06022	10	165	1
OUTER SHELL FLAT BOTTOM LID	SB-575 N06022	25	412	1
UPPER TRUNNION COLLAR SLEEVE	SB-575 N06022	40	517	1
LOWER TRUNNION COLLAR SLEEVE	SB-575 N06022	40	507	1
INNER SHELL SUPPORT RING	SB-575 N06022	20	42	1
TOTAL ALLOY 22 WELDS	SFA-5.14 N06022	-	253	**
TOTAL 316 WELDS	SFA-5.9 S31680	-	131	**
WASTE PACKAGE ASSEMBLY	-	-	28068	1
BWR FUEL ASSEMBLY	-	-	328.4*	44
WASTE PACKAGE ASSEMBLY WITH SNF	-	-	42517	1

* CRWMS M&O 1997. WASTE CONTAINER CAVITY SIZE DETERMINATION. BBAA00000-01717-0200-00026 REV 00 LAS VEGAS, NV: CRWMS M&O. ACC: MOL.19980106.0061 (Ref. 21)

** REFER TO SK-0193 REV 00 "~~SINGLE CRM~~ 44-BWR WASTE PACKAGE ASSEMBLY WELD CONFIGURATION"

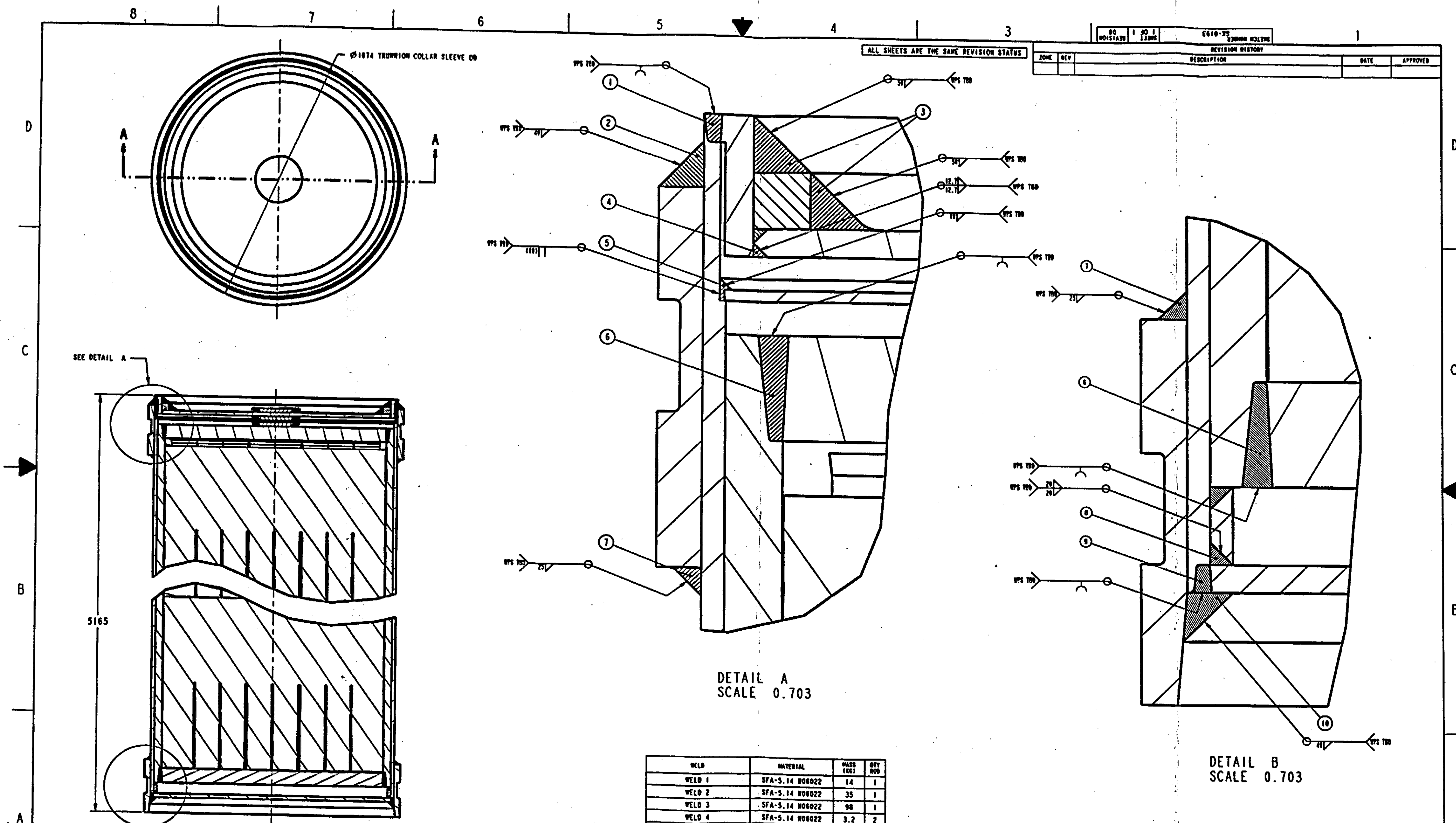
HM 5/10/00



DETAIL B

SK-0192 REV 00	SHEET 2 OF 2

ALL SHEETS ARE THE SAME REVISION STATUS



WELD	MATERIAL	MASS (KG)	QTY REQ
WELD 1	SFA-5.14 N06022	14	1
WELD 2	SFA-5.14 N06022	35	1
WELD 3	SFA-5.14 N06022	98	1
WELD 4	SFA-5.14 N06022	3.2	2
WELD 5	SFA-5.14 N06022	3.8	1
WELD 6	SFA-5.9 S31600	65	2
WELD 7	SFA-5.14 N06022	14	2
WELD 8	SFA-5.14 N06022	8.4	2
WELD 9	SFA-5.14 N06022	14	1
WELD 10	SFA-5.14 N06022	38	1
TOTAL ALLOY 22 WELDS	SFA-5.14 N06022	253	-
TOTAL 316 WELDS	SFA-5.9 S31600	131	-

"FOR INFORMATION ONLY"

THIRD ANGLE PROJECTION

DIMENSIONS ARE IN MILLIMETERS AND DEGREES UNLESS OTHERWISE NOTED

DO NOT SCALE FROM SKETCH

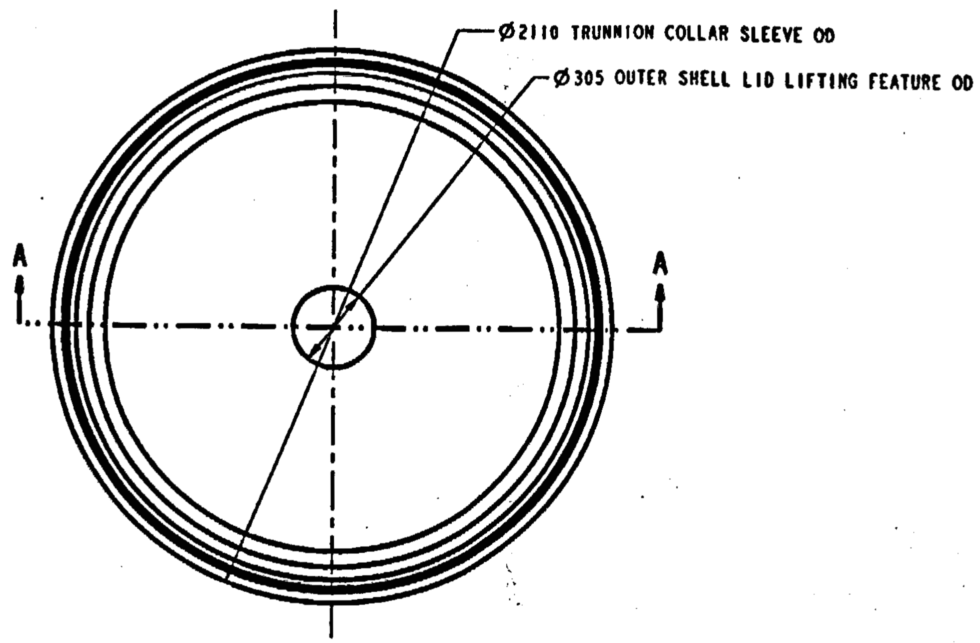
APPROVALS	INITIAL/DATE
SKETCHED BY BRYAN HARKINS	BH 28 March 00
STRUCTURAL LEAD SCOTT BENNETT	SMB 05/09/00
MANUFACTURING MGR JERRY COGAR	JC 05/10/00
DESIGN GROUP MGR ~~THOMAS DOERING~~ MICHAEL ANDERSON	5/10/00

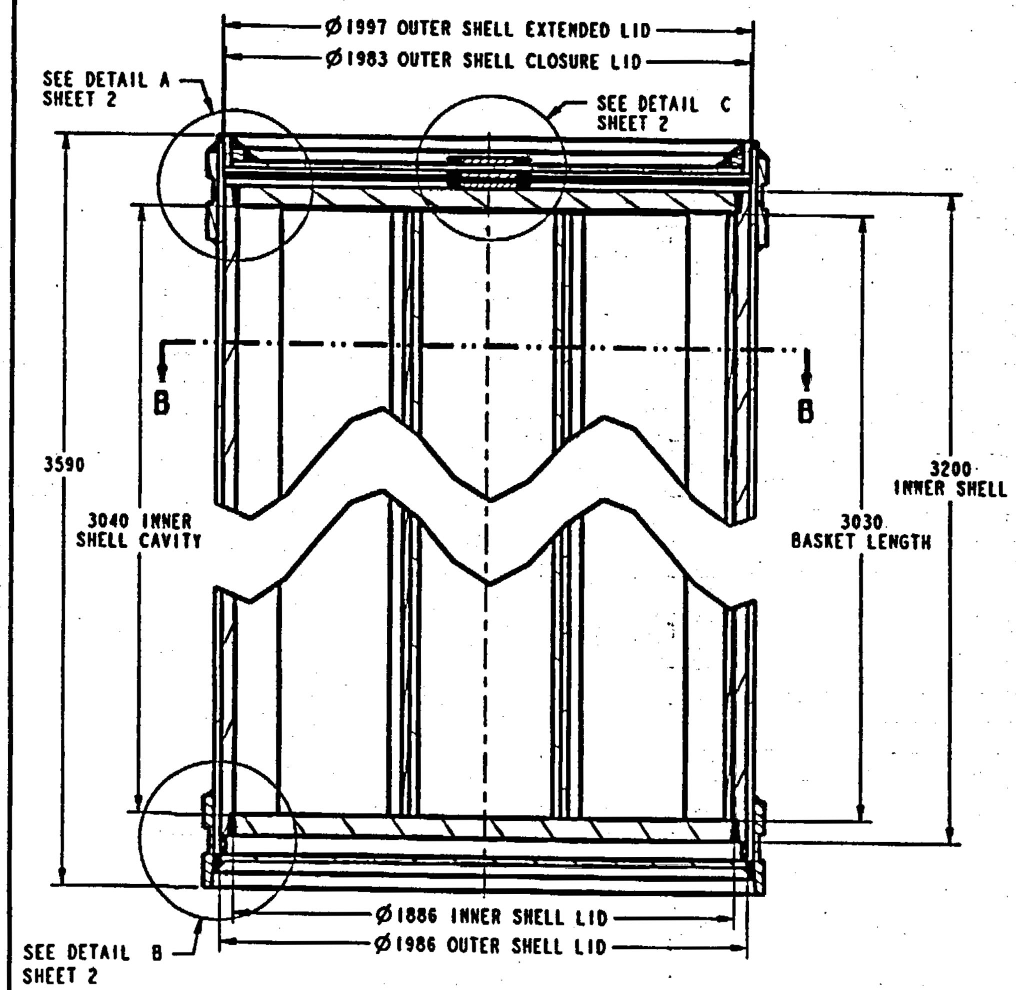
WASTE PACKAGE DEPARTMENT

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

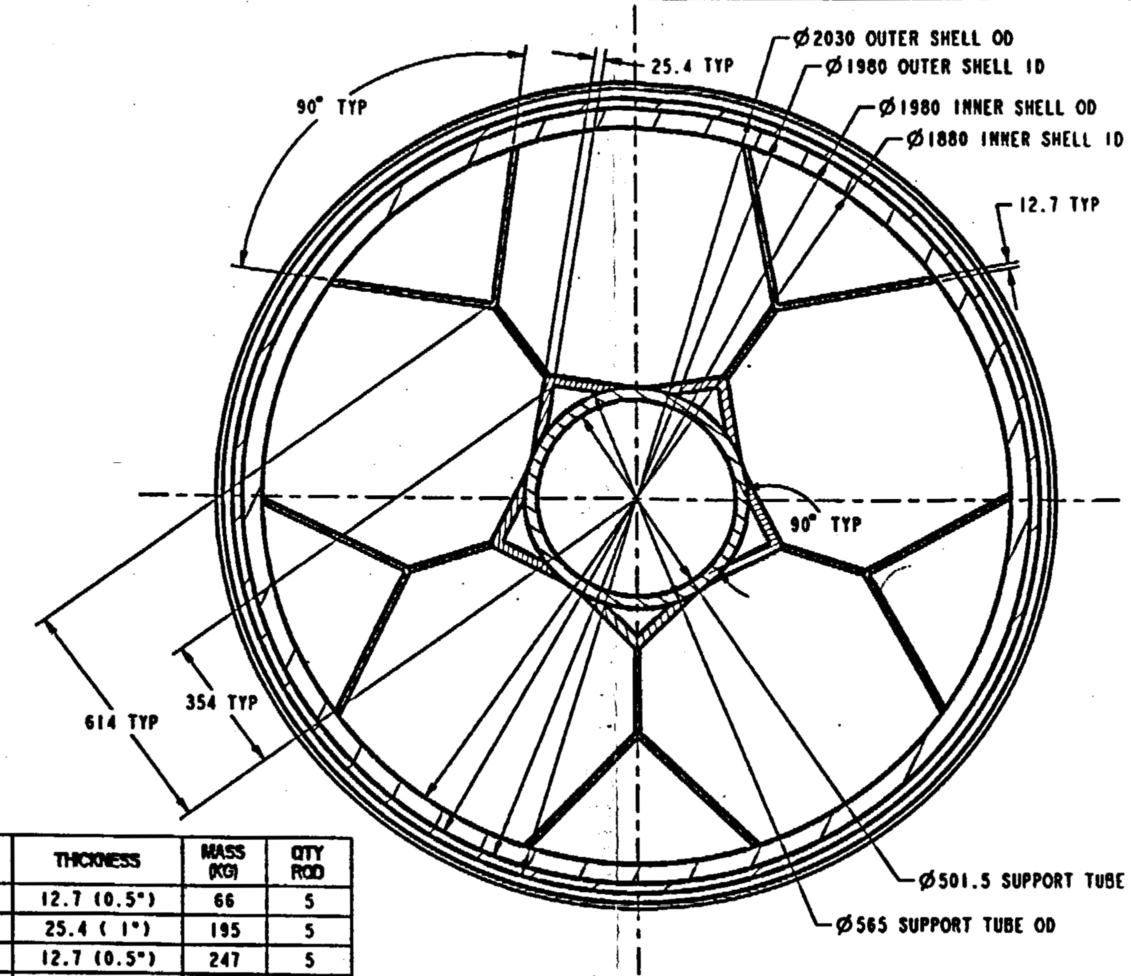
TITLE
44-BWR WASTE PACKAGE ASSEMBLY WELD CONFIGURATION

SKETCH NUMBER SK-0193 | REVISION 00 | SCALE .094 | SHEET 1 OF 1





SECTION A-A



SECTION B-B

COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG)	QTY ROD
DIVIDER PLATE	SA-516 K02700	12.7 (0.5")	66	5
INNER BRACKET	SA-516 K02700	25.4 (1")	195	5
OUTER BRACKET	SA-516 K02700	12.7 (0.5")	247	5
SUPPORT TUBE	SA-516 K02700	31.75 (1.25")	1265	1
INNER SHELL	SA-240 S31600	50	7621	1
INNER SHELL LID	SA-240 S31600	80	1765	2
INNER LID LIFTING FEATURE	SA-240 S31600	27	12	1
OUTER SHELL	SB-575 N06022	25	4692	1
EXTENDED OUTER SHELL LID	SB-575 N06022	25	172	1
EXTENDED OUTER SHELL LID BASE	SB-575 N06022	25	629	1
EXTENDED OUTER LID REINFORCING RING	SB-575 N06022	50	129	1
OUTER LID LIFTING FEATURE	SB-575 N06022	27	13	2
OUTER SHELL FLAT CLOSURE LID	SB-575 N06022	10	268	1
OUTER SHELL FLAT BOTTOM LID	SB-575 N06022	25	669	1
UPPER TRUNNION COLLAR SLEEVE	SB-575 N06022	40	655	1
LOWER TRUNNION COLLAR SLEEVE	SB-575 N06022	40	642	1
INNER SHELL SUPPORT RING	SB-575 N06022	20	53	1
TOTAL ALLOY 22 WELDS	SFA-5.14 N06022	-	325	***
TOTAL 316 WELDS	SFA-5.9 S31680	-	133	***
WASTE PACKAGE ASSEMBLY	-	-	23360	1
HLW GLASS ASSEMBLY	-	-	2500*	5
18" CANISTER SHORT	-	-	2270**	1
WP ASSEMBLY WITH SNF	-	-	38130	-

* WASTE ACCEPTANCE SYSTEM REQUIREMENTS DOCUMENT. E00000000-00811-1708-00001 REV 03, DOE/RW-315P. ACC: HOO.19990226.0001, PAGE 18, SECTION 4.2.3.1.A.4. (Ref. 22)

** UNITED STATES DEPARTMENT OF ENERGY 1998. DESIGN SPECIFICATION FOR DEPARTMENT OF ENERGY STANDARDIZED SPENT NUCLEAR FUEL CANISTERS, VOLUME 1, DESIGN SPECIFICATION, REV 01. WASHINGTON D.C.: UNITED STATES DEPARTMENT OF ENERGY. TIC: 241528 (Ref. 23)

*** SEE SK-0197 FOR WELD CONFIGURATION AND MASSES

UNITS: mm

DO NOT SCALE FROM SKETCH

REVISION TABLE	
REV	DESCRIPTION
01	IN SECTION B-B Ø565 SUPPORT TUBE OD WAS ID
02	REVISION TABLE MODIFIED
02	CLEARANCE DIMENSION FROM OUTER SHELL FLAT CLOSURE LID TO OUTER SHELL WAS ADDED TO DETAIL A
02	CROSS HATCHING WAS MODIFIED ON DETAIL A

"FOR INFORMATION ONLY"

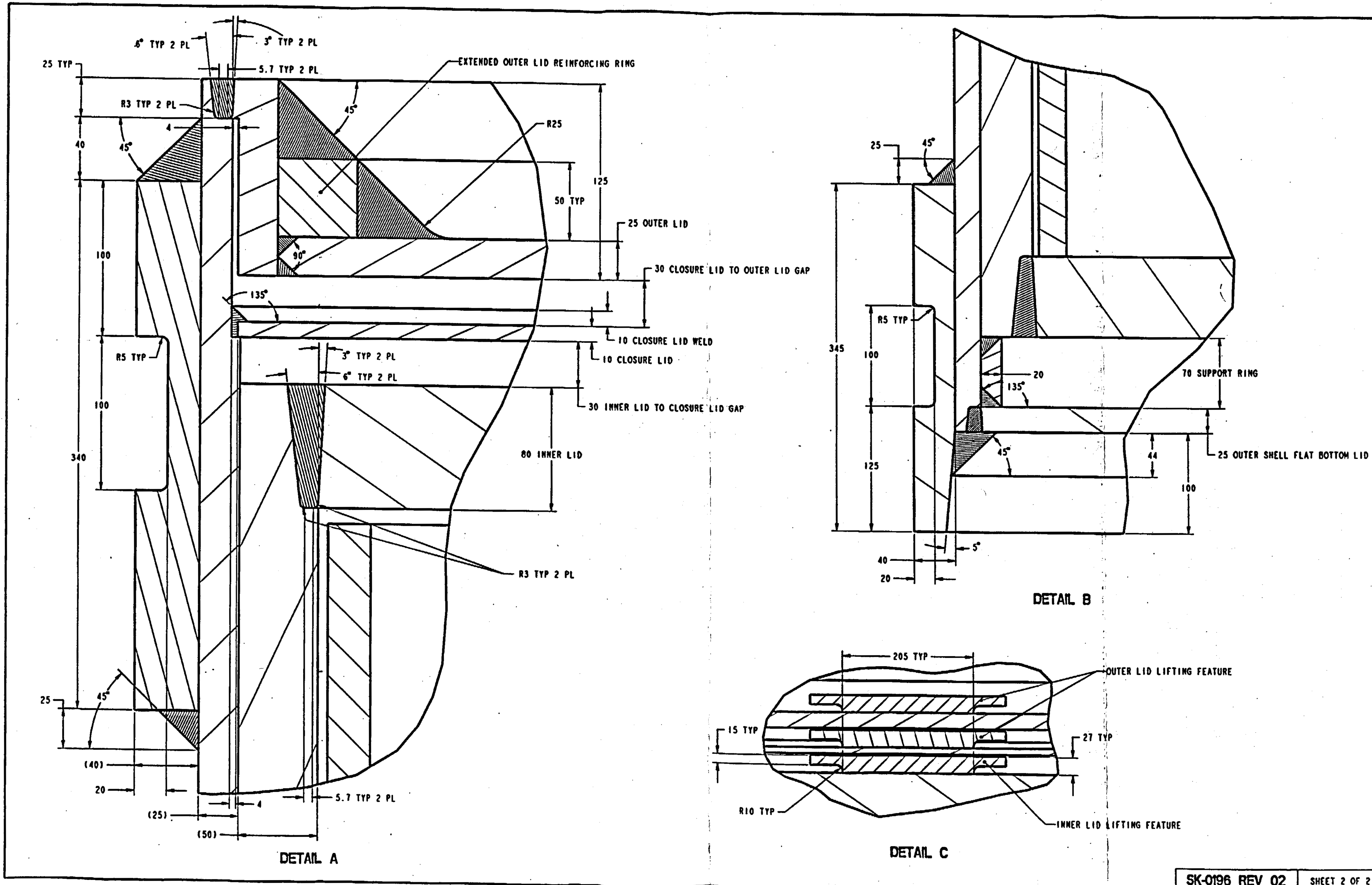
5 DHLW/DOE SNF - SHORT WP ASSSEMBLY CONFIGURATION FOR SITE RECOMENDATION

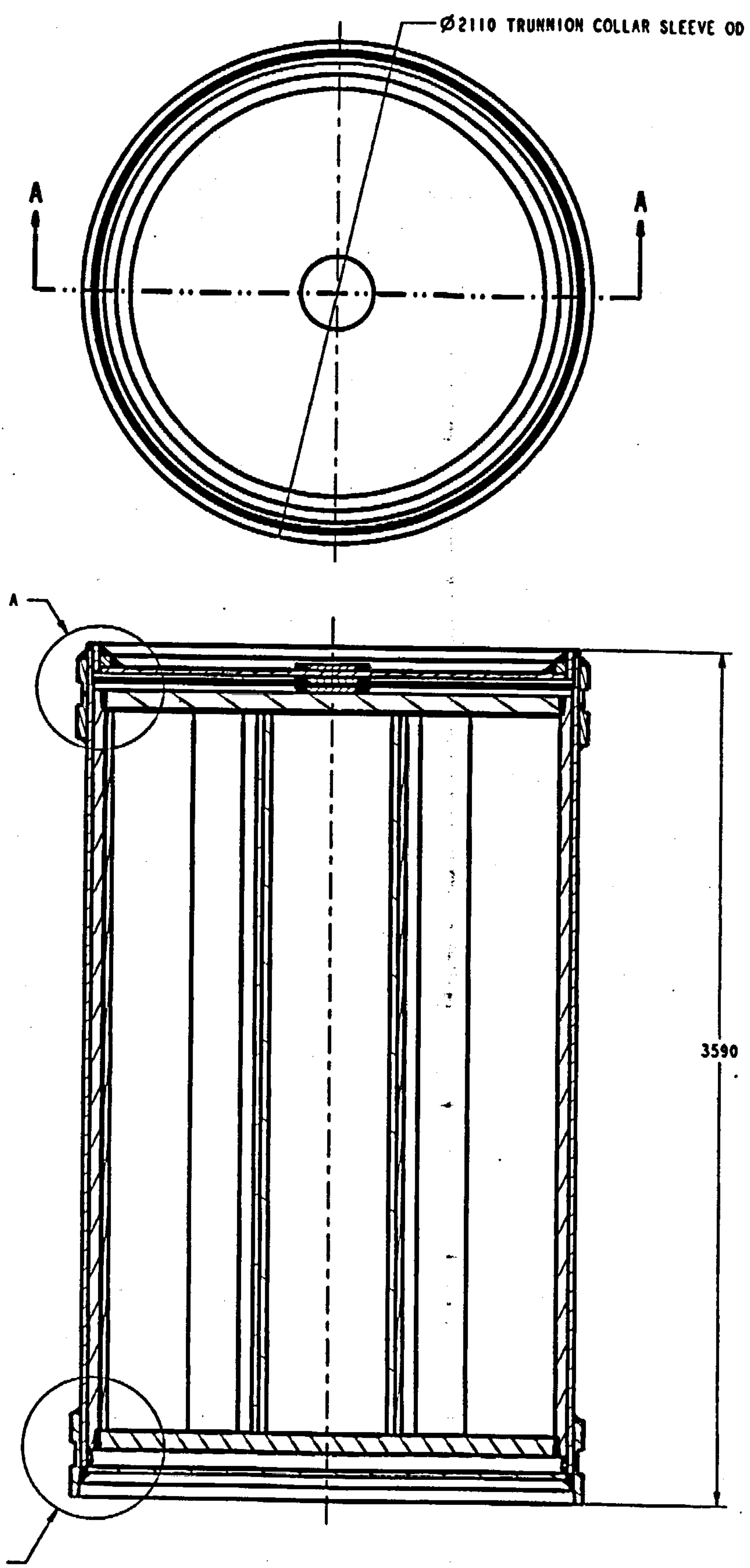
SKETCH NUMBER: SK-0196 REV 02 SHEET 1 OF 2

ORIGINATOR: BRYAN HARKINS BH 25April00 SMB 04/26/00

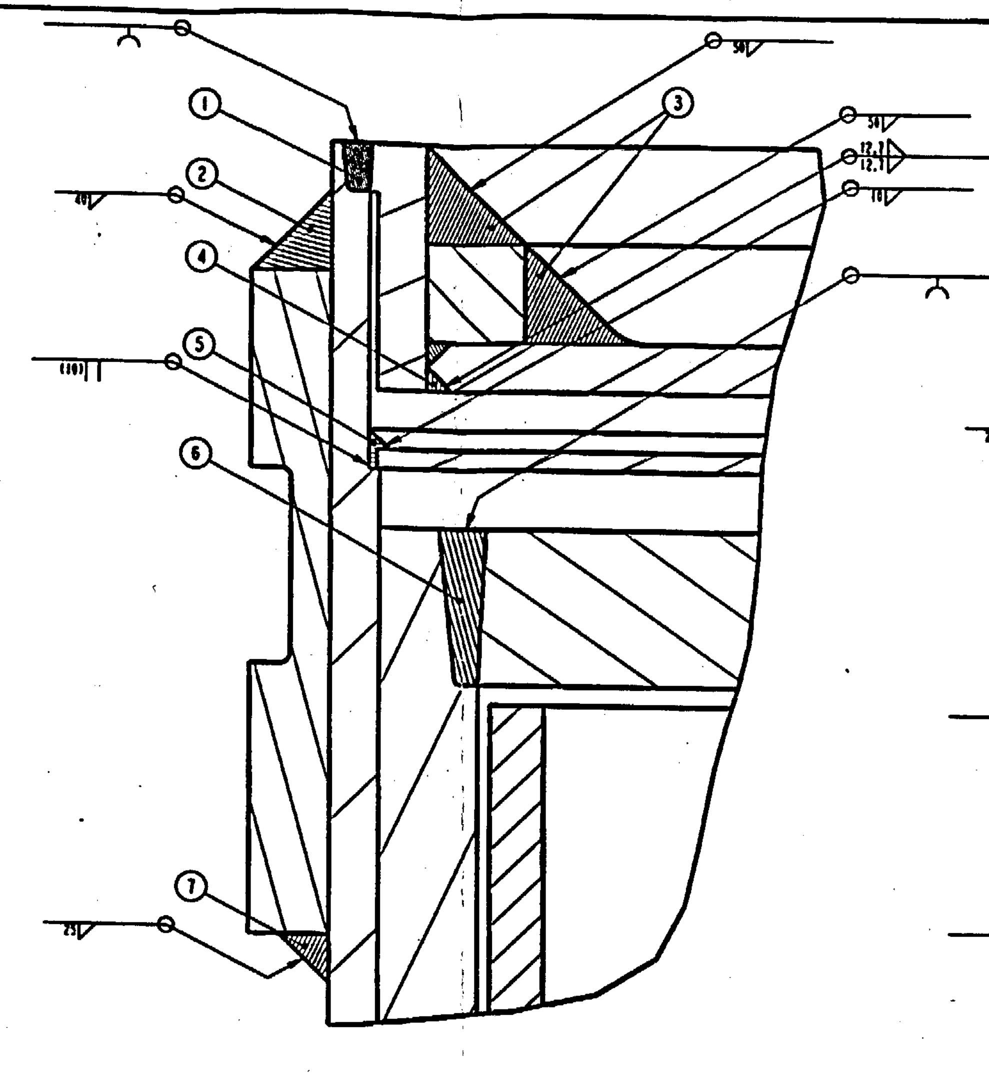
DATE: 04/25/00

FILE: /home/pro_library/checkout/sketches/5dhlw_short/sk-0196_rev02.dwg

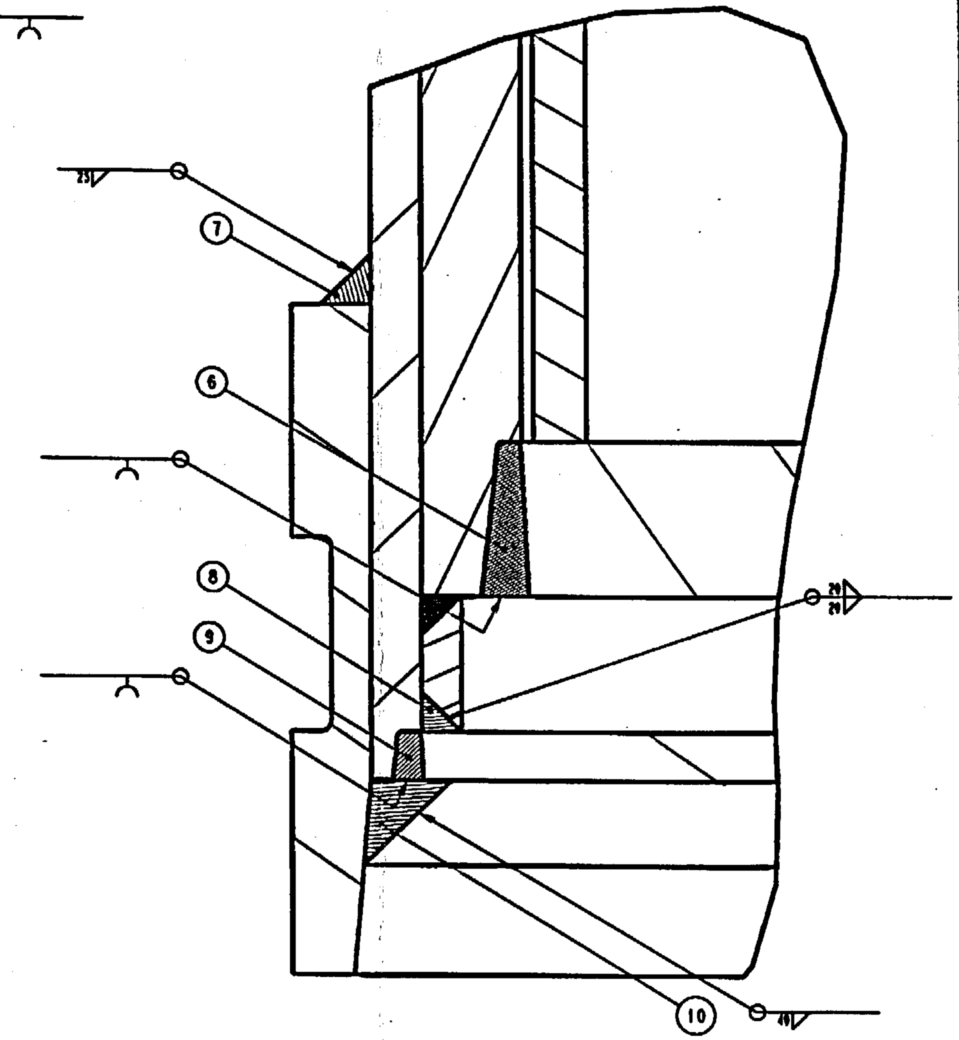

6° TYP 2 PL
3° TYP 2 PL
25 TYP
5.7 TYP 2 PL
EXTENDED OUTER LID REINFORCING RING
R3 TYP 2 PL
4
45°
R25
40
125
50 TYP
25 OUTER LID
100
90°
30 CLOSURE LID TO OUTER LID GAP
135°
10 CLOSURE LID WELD
R5 TYP
10 CLOSURE LID
3° TYP 2 PL
6° TYP 2 PL
100
30 INNER LID TO CLOSURE LID GAP
340
80 INNER LID
R3 TYP 2 PL
25
45°
(40)
20
(25)
4
5.7 TYP 2 PL
(50)
DETAIL A
25
45°
R5 TYP
345
100
20
135°
70 SUPPORT RING
125
45°
44
25 OUTER SHELL FLAT BOTTOM LID
100
40
5°
20
DETAIL B
205 TYP
OUTER LID LIFTING FEATURE
15 TYP
27 TYP
R10 TYP
INNER LID LIFTING FEATURE
DETAIL C
SK-0196 REV 02
SHEET 2 OF 2



SECTION A-A



DETAIL A



DETAIL B

WELD	MATERIAL	MASS (KG)	QTY ROD
1	SFA-5.14 N06022	18	1
2	SFA-5.14 N06022	45	1
3	SFA-5.14 N06022	127	1
4	SFA-5.14 N06022	4.1	2
5	SFA-5.14 N06022	4.9	1
6	SFA-5.9 S31680	67	2
7	SFA-5.14 N06022	17	2
8	SFA-5.14 N06022	11	2
9	SFA-5.14 N06022	18	1
10	SFA-5.14 N06022	48	1
TOTAL ALLOY 22 WELDS	SFA-5.14 N06022	325	-
TOTAL 316 WELDS	SFA-5.9 S31680	133	-

UNITS: mm

DO NOT SCALE FROM SKETCH

REVISIONS

REV	DESCRIPTION	DRN BY	DATE
00	ISSUED APPROVED	BH	03/10/00

"FOR INFORMATION ONLY"

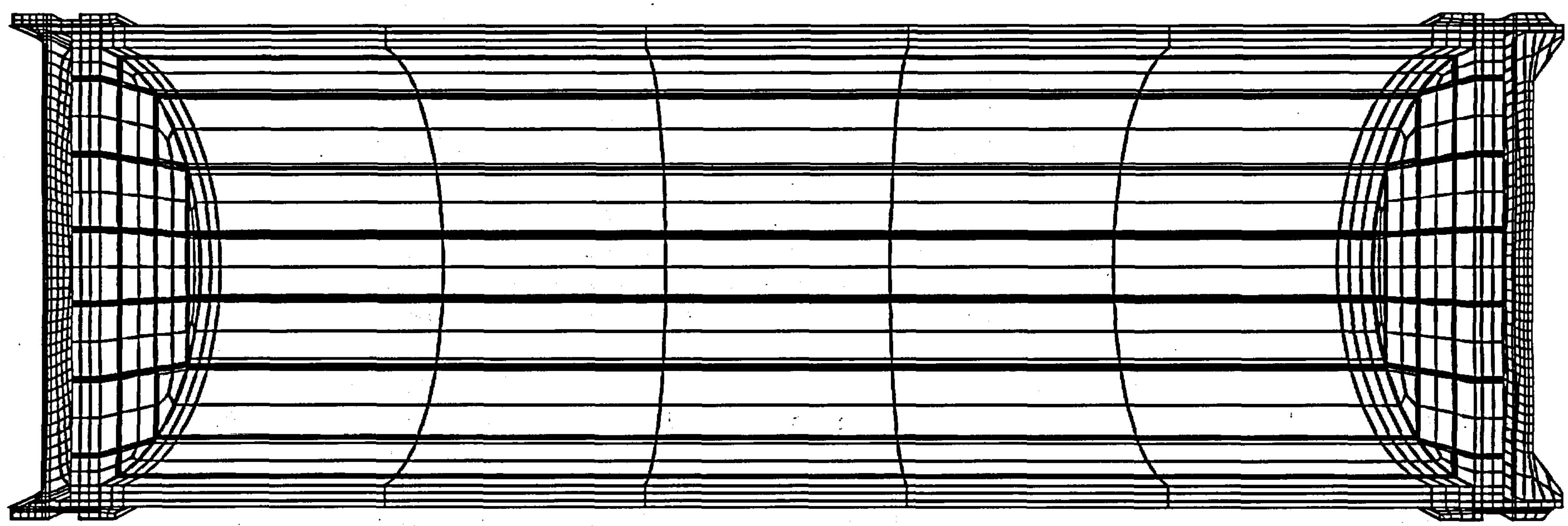
5-DHLW/DOE SNF - SHORT WELD CONFIGURATION

SKETCH NUMBER: SK-0197 REV 00

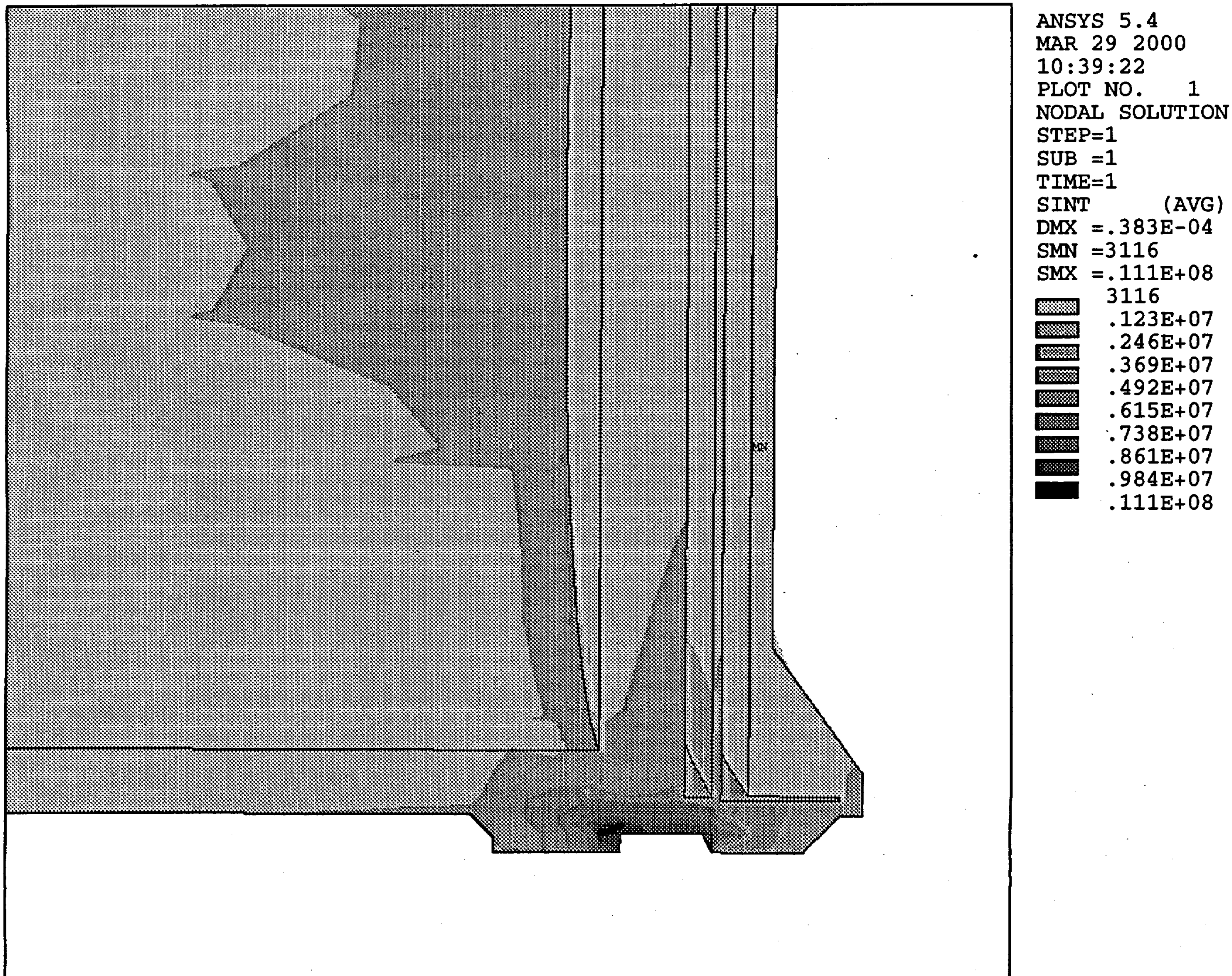
SKETCHED BY: BRYAN HARKINS BH 10 March 00 SMG 03/13/00 JOE 3/13/00 TWD 3.13.00

DATE: 03/10/00

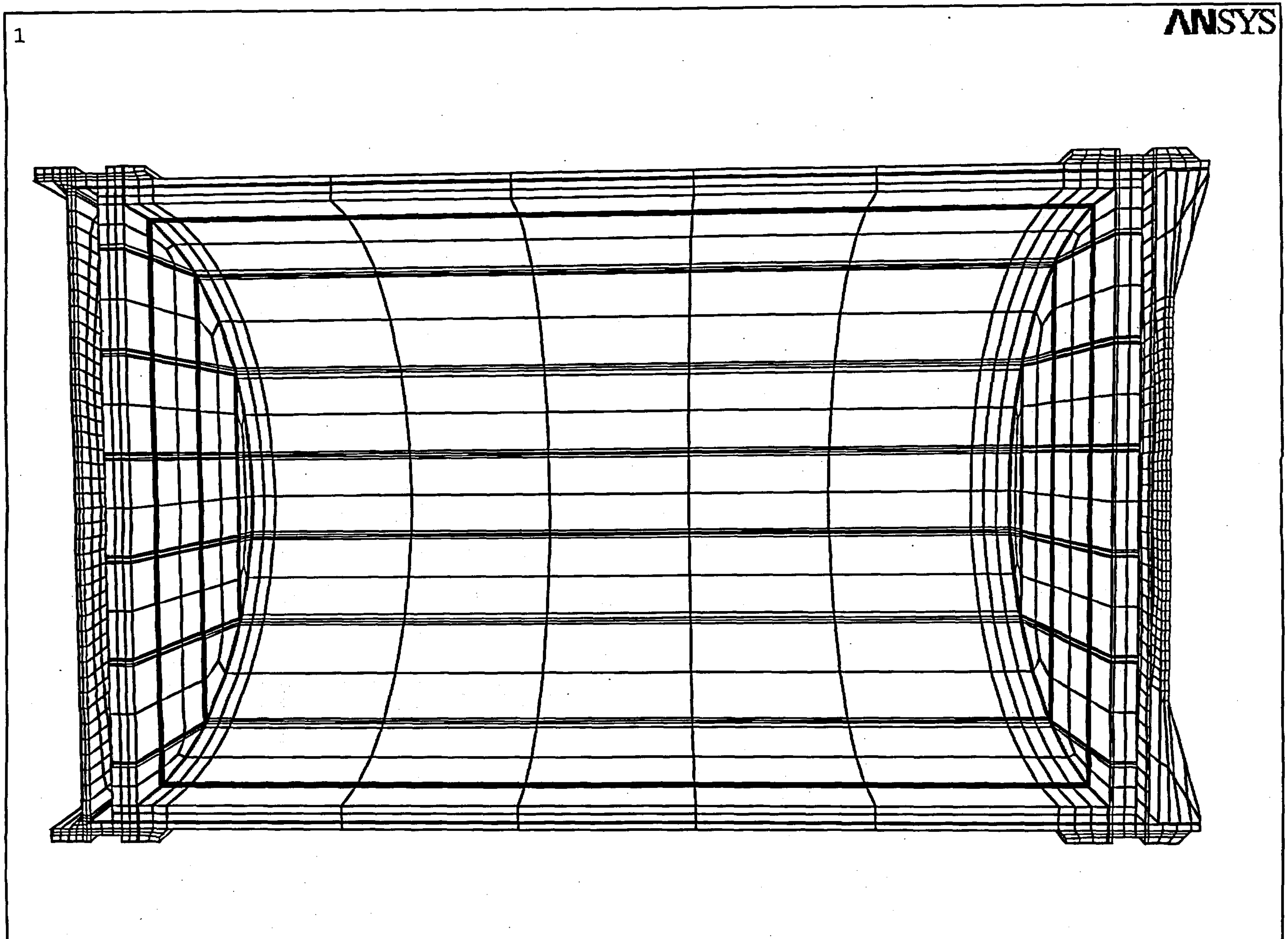
FILE: /home/pro_library/checkout/sketches/5dhlw/5dhlw_short/sk-0197rev00.dwg



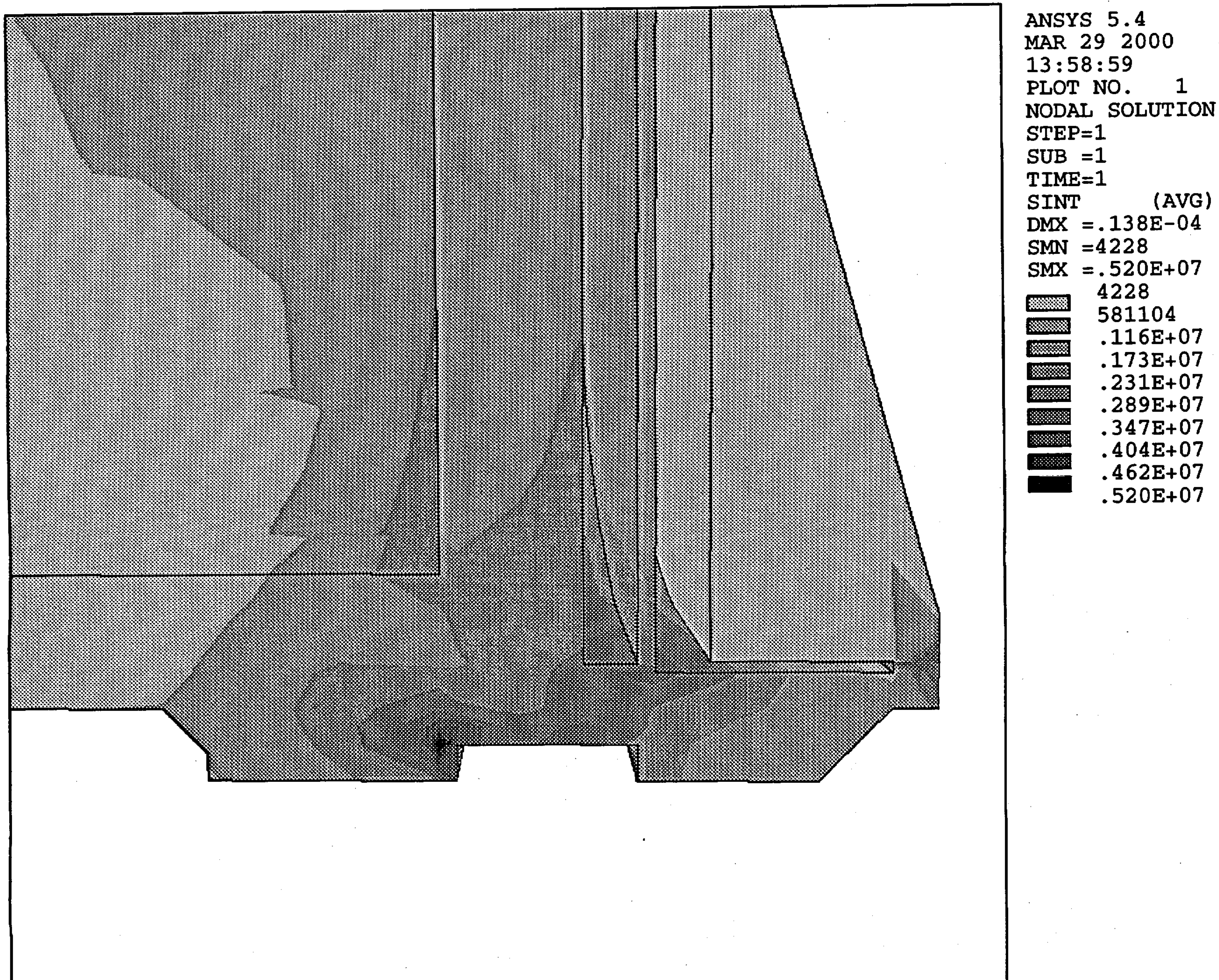
44 BWR Waste Package Horizontal Lifting - Mesh



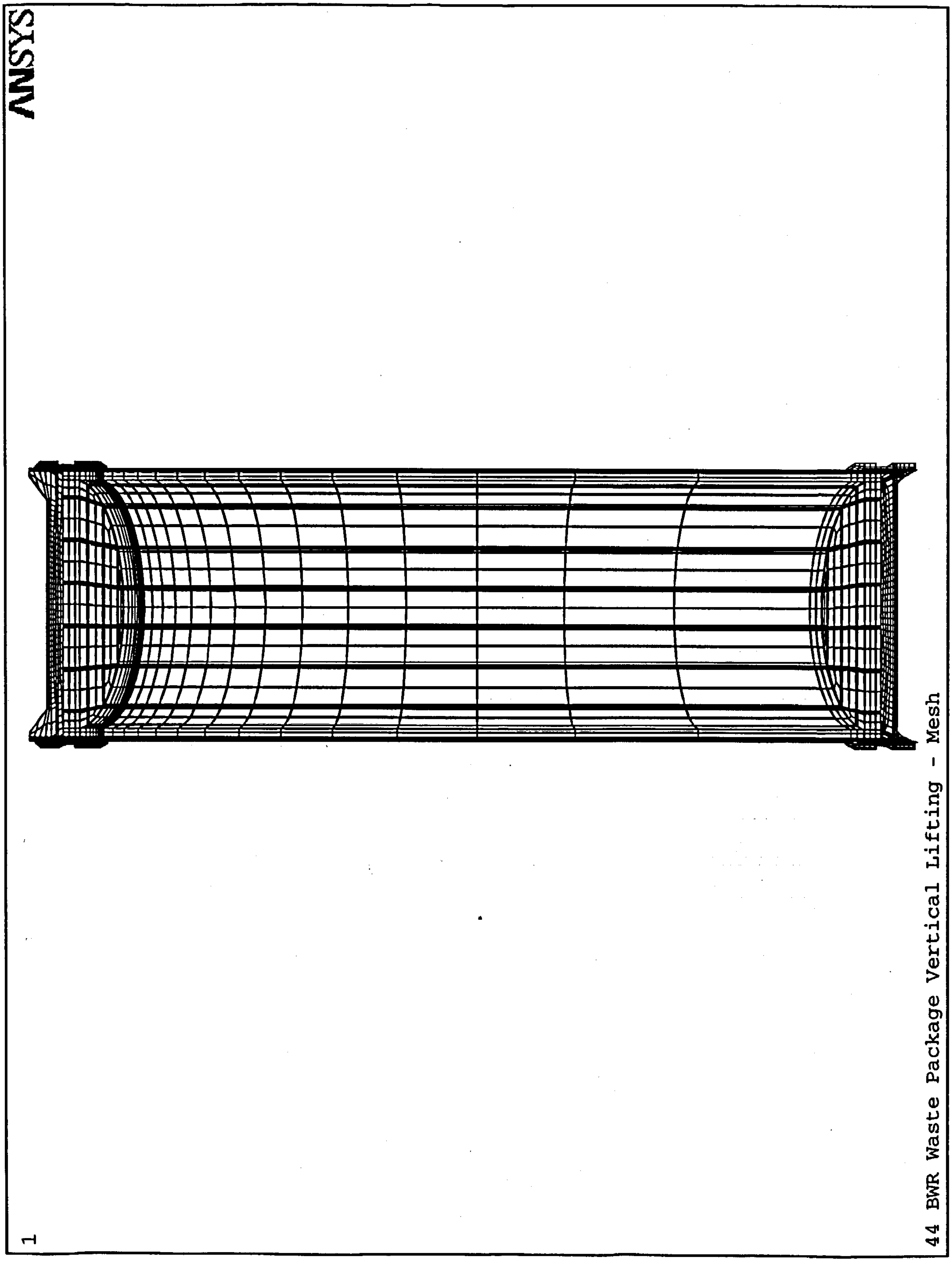
44 BWR Waste Package Horizontal Lifting - Stress Contours

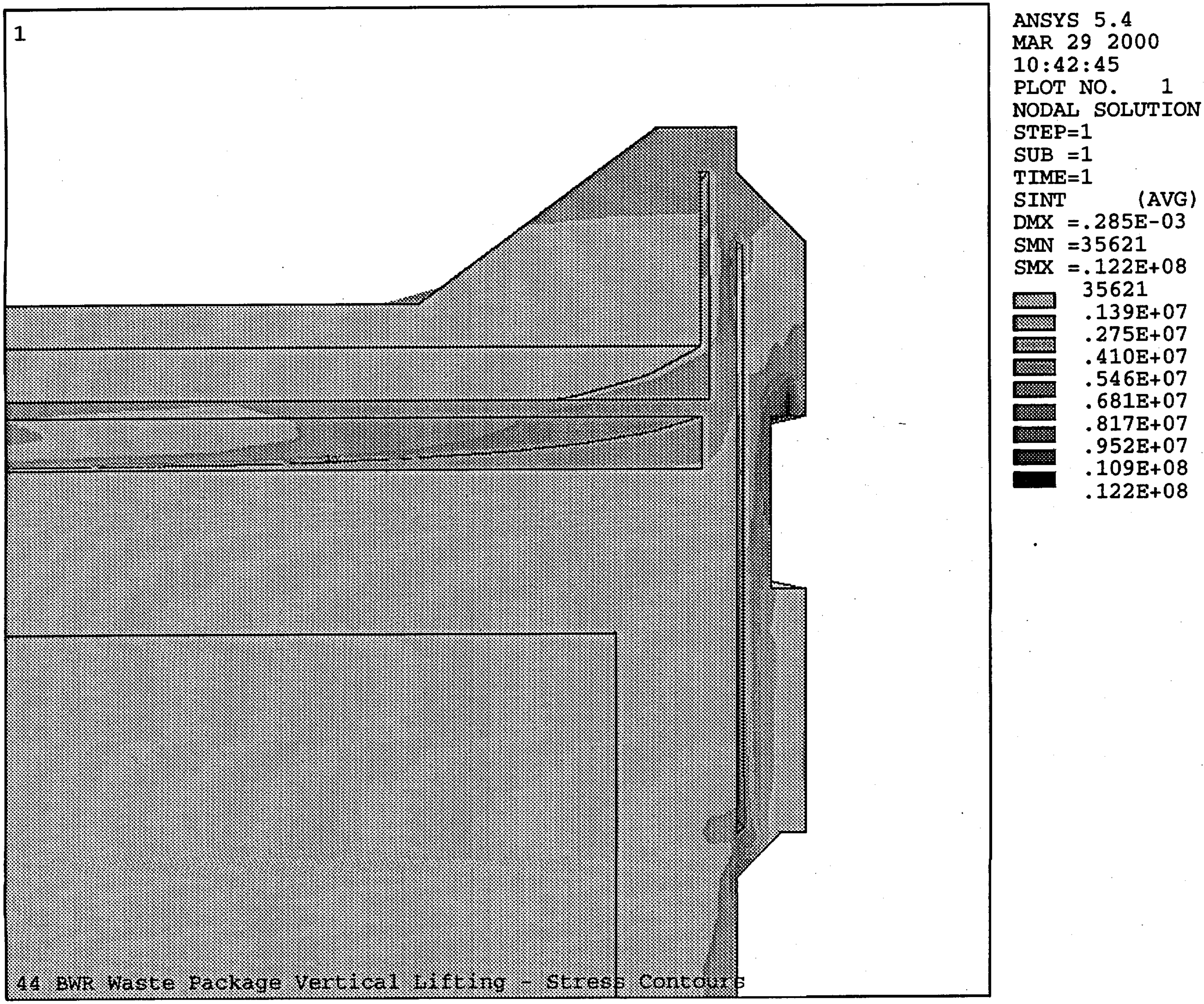


5 DHLW/DOE SNF - Short Waste Package Horizontal Lifting - Mesh



5 DHLW/DOE SNF - Short Waste Package Horizontal Lifting - Stress Contours


ANSYS
1
44 BWR Waste Package Vertical Lifting - Mesh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MAR 29 2000
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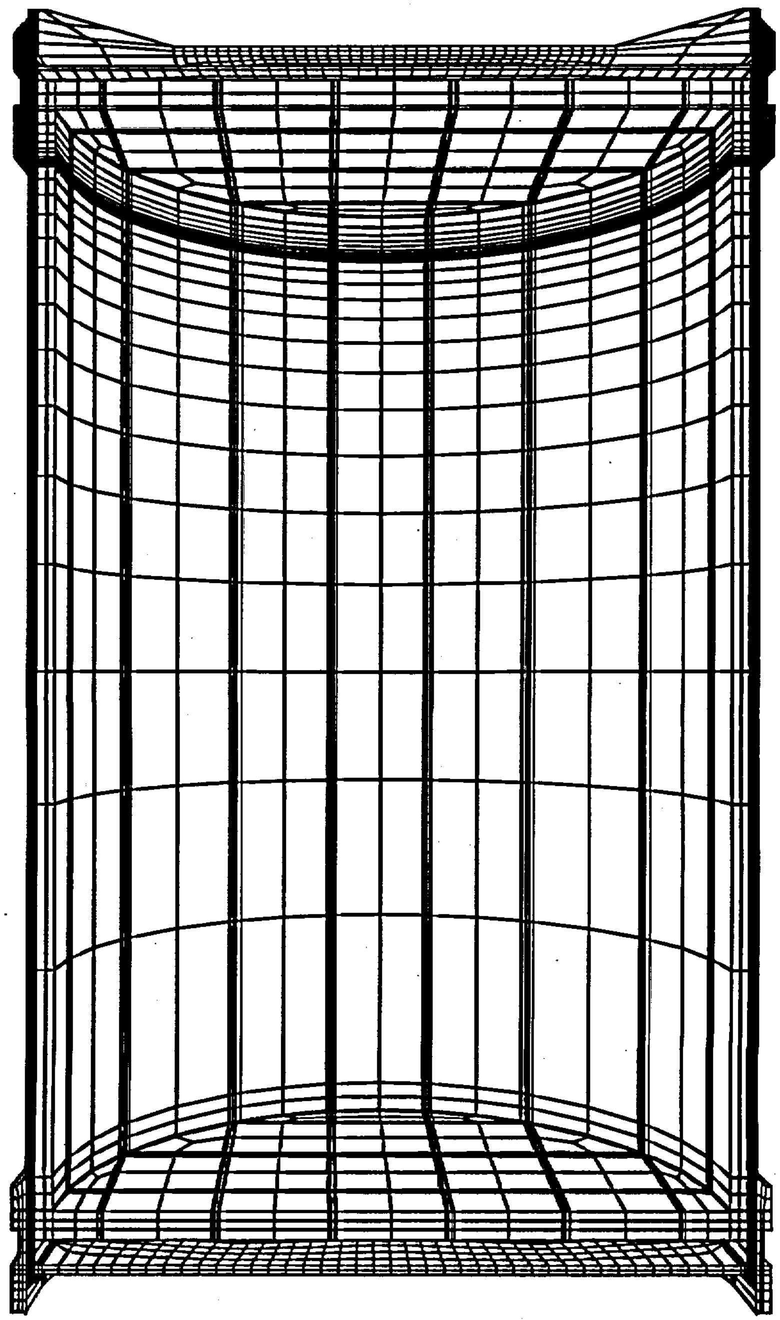
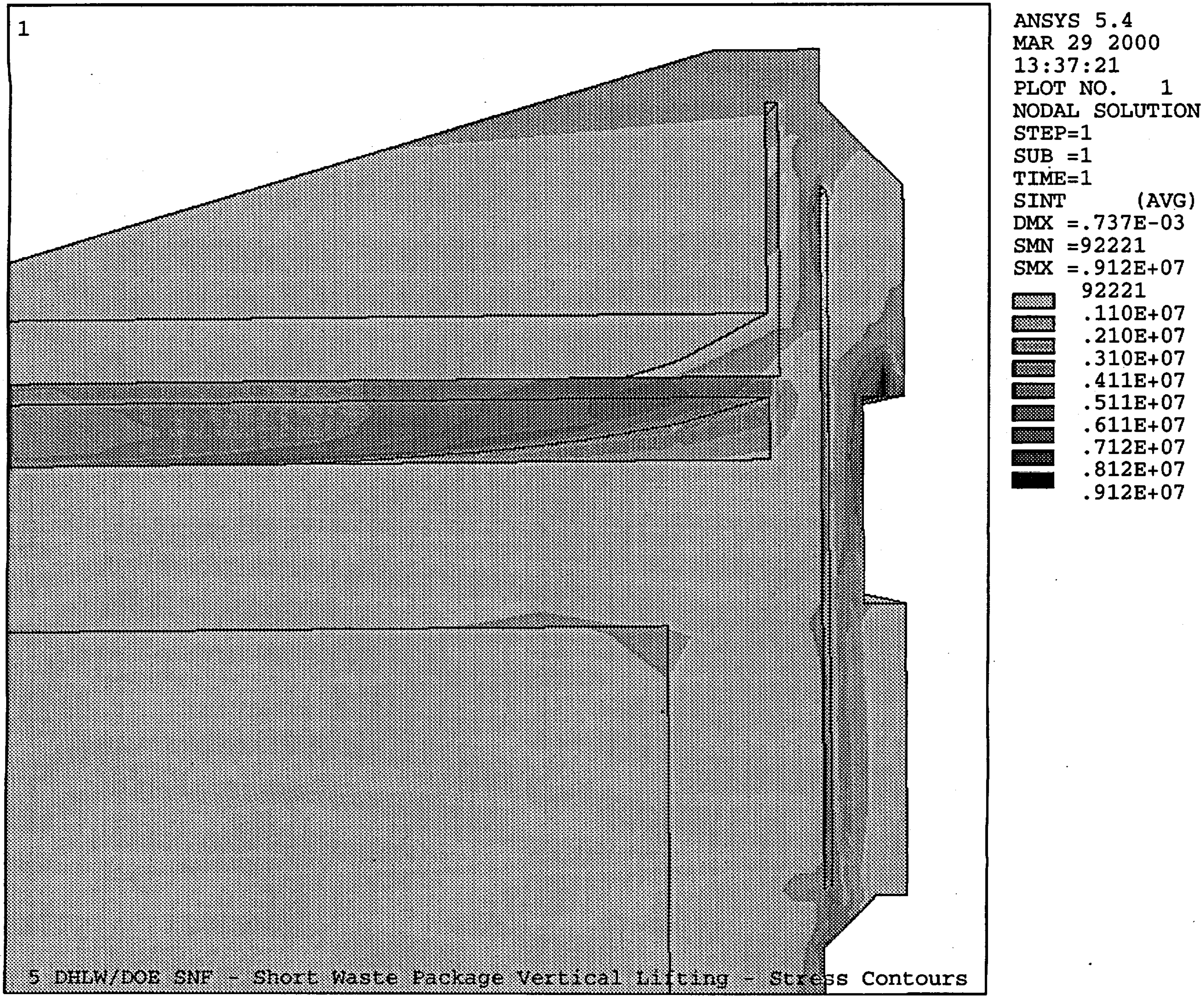
TIME=1
SINT (AVG)
DMX =.285E-03
SMN =35621
SMX =.122E+08
35621
.139E+07
.275E+07
.410E+07
.546E+07
.681E+07
.817E+07
.952E+07
.109E+08
.122E+08
44 BWR Waste Package Vertical Lifting - Stress Contours

1

ANSYS



5 DHLW/DOE SNF - Short Waste Package Vertical Lifting - Mesh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ANSYS 5.4
MAR 29 2000
13:37:21
PLOT NO. 1
NODAL SOLUTION
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SUB =1
TIME=1
SINT (AVG)
DMX =.737E-03
SMN =92221
SMX =.912E+07
92221
.110E+07
.210E+07
.310E+07
.411E+07
.511E+07
.611E+07
.712E+07
.812E+07
.912E+07
5 DHLW/DOE SNF - Short Waste Package Vertical Lifting - Stress Contours