71-9192

ANEFCO
ANEFCO INC.
904 Ethan Allen Hwy
P.O. Box 433
Ridgefield, Conn 06877
203•431-3358

April 9, 1985

PDR
Return
to 396SS

US NRC
Transportation Certification Branch
Division of Fuel Cycle and MaterialSupply
Washington, D.C. 20555

Attention: Charles E. MacDonald, Mail Stop 396SS

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U.S. N.R.C.
LIC. FEE MGMT. BRANCH

Subject: Model AP-300 Type A Package
Docket No. 71-9192

Dear Mr. MacDonald:

This is in response to questions in your letter, dated March 20, 1985, in which you requested additional information on our application for certificate of compliance for our Model AP-300 Shipping Container. We have responded to your questions and have made the appropriate revisions in the text of our safety analysis report.

Enclosed are the ANEFCO responses to the questions related to the structural aspects of the report, the Acceptance Tests, Section 8 and the drawings, Appendix A. Also enclosed are the revisions to the text marked 4/ to identify where changes for the fourth revision were made. Please replace the corresponding pages in the original text with the revised pages.

We appreciate your comments and hope that our responses meet with your approval, so that we may be granted a certificate of compliance at your earliest convenience.

Very truly yours,

ANEFCO, Inc.

John D. Murphy
President

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RESPONSE TO QUESTIONS

DRAWINGS

Question 1

Drawing No. 135-1, Rev. 3. The weld joining part L-3 to L-4 needs clarification. Picture shows a bevel weld and the weld symbol calls for a fillet weld.

Ans. Drawing No. 135-1 has been revised. Rev. 4 shows a bevel weld symbol for the joint between parts L-3 and L-4.

Question 2

Drawing No. 138-1, Rev. 3. The size of the weld joining item 10 to the outer shell should be given in the weld symbol. The detail of the identification plate should provide line titled Package Identification No.

Ans. Drawing 138-1 has been revised. Rev. 4 provides a line for "Package Identification No." and identifies a 3/4" weld as joining item 10 to the outer shell.

Question 3

Drawing Nos. 139-1 and 146-1. Completely specify the gasket material on the drawings.

Ans. Drawing Nos. 139-1 and 146-1 have been revised. Rev. 1 of each of these drawings specifies that Manville Red Devil Style 940 will be used as the gasket material.

Question 4

Drawing No. 143-1. It is noted that the weld symbol specifying the joint between Item 41 and L-2 calls for a 3/4" bevel weld in a plate which is only ½" thick.

Ans. Drawing No. 143-1 has been corrected. Rev. 1 specifies a 3/8" weld for the joint between Item 41 and L-2.

STRUCTURAL

Tie-down

Question 1

Since the tie-down lug makes an angle with both the horizontal and vertical axis, the force applied to the lug should be adjusted for these angles. Please revise your calculation.

Ans. The tie down lug makes an angle of 42.3° with the horizontal, as shown in Fig. 2.4-3. The design of the tie-down is based on the capability to withstand the simultaneous vertical, forward horizontal and sideward horizontal g forces, specified in 10CFR 71.31. As shown in Section 2.4.4.1, this resultant force is 748.9 kip. We have added text and calculations to Section 2.4.4.1 which identify that the maximum resultant force imposed on each tie-down lug will be 187.2 kip. The equivalent horizontal and vertical components of this force are shown to be 138.5 kip and 126.0 kip, respectively. In the calculations to verify the adequacy of the pad design, it is shown in Section 2.4.4.5.2 that the tie-down design is adequate, with a large margin of safety, even for the greater resultant force.

Question 2

Drawing No. 138-1, Rev. 3 shows 3/4" fillet welds for the tie-down devices while the analysis has assumed full penetration welds. The analysis should be revised accordingly.

Ans. The calculations in Section 2.4.4.5.2 have been revised and analyze the use of 3/4" fillet welds applied to the tie-down pads.

Question 3

While the value for the electrode is 70 Ksi, the allowable stress for a fillet weld is 21 Ksi, e.g. AISC. For full penetration welds, the allowable stress would be limited to the stress of the base metal (i.e., A516, Grade 70). The analysis should use the appropriate value.

Ans. The revised calculations use an allowable fillet weld stress of 21 ksi. The safety factor for the design is in excess of 2.

Question 4

The tie-down lugs and pads were evaluated based on a yield stress of Fy=60 Ksi. However, Drawing No. 133-1, Rev. 2 specifies that the tie-down lugs are A516 Grade 70 which has a yield stress of Fy=38 Ksi. Please revise the analysis. Also, it should be shown that the reinforcing pad is adequate for its intended purpose.

Ans. A yield stress of Fy=38 Ksi was used in the revised calculations. The safety factor for bearing and shear of the pad was calculated to be 1.52 and 2.03 respectively, so that the pad is adequate.

Free Drop

Question 1

Justify the use of dynamic yield strength of 68,000 psi for the cask instead of a dynamic flow stress. In any case, provide a reference for the value used.

Ans. The dynamic yield strength is used in conformance with the paper by K. Lee, which was enclosed in our submittal to you, February 13, 1985. S.T.Rolfe and J.M.Barsom in their book "Fracture and Fatigue Control in Structures" state on p.190 that the dynamic yield strength is approximately equal to the static yield strength plus 25ksi. Table 1 on p.17 of the WRC Bulletin 299(11/84) lists the value for the yield strength of A516 Gr70 from 38.6ksi to 45.4ksi. For our calculations, we used a dynamic yield strength of 68ksi.

Question 2

The added weight of concrete fill in the lid must be included in the free drop analyses.

Ans. We have revised all calculations in the SAR where the weight of the cask and/or lid are involved and have added the weight of the additional weight of the concrete in the lid.

Question 3

Atop end drop analysis should be performed. The analysis should reflect that the cask lifting lugs will strike the unyielding surface first. In addition, the analysis should show that the closure system (i.e. the lid and the bolts) will not be damaged by this drop condition.

Ans. The cask is indeed designed so that in case of a top end drop, the first surface which would be impacted would be four cask lifting lugs. However, an additional feature of the cask design is the fact that the cask shell extends 0.8125" above the cask lid, when the lid is fastened to the cask shell by the lid bolts. Moreover, the bolts are nested within the lid, when the lid is installed with the bolts. Therefore, if the cask lifting lugs are sheared off during an end drop, both the lid and the bolts will be protected from contact with the unyielding surface by the extension of the cask shell.

The calculations which follow show that the cask drop energy is readily absorbed by the deformation of a small fraction of the surface of either the cask lifting lugs or the cask shell extension. Both the cask shell and lifting lugs are fabricated from A516Gr70 steel.

The energy of the end drop is:
E = Wh = 66,720lb x 12 in = 800640 in-lb.

The volume of A516Gr70 steel to absorb this energy is:

$$V = \frac{E}{\sigma} = \frac{800{,}640 \text{ in-lb}}{68{,}000 \text{ lb/in}^2} = 11.77 \text{ in}^3$$

The surfaces of the lifting lugs and shell which can be impacted by a top end drop are:

a) lifting lugs $A = 4 \times (6" \times 2.5") = 60 \text{ in}^2$
b) shell $A = \pi/4(83.625^2 - 81.125^2) = 323.5 \text{ in}^2$

The depth of the lifting lugs or shell extension deformed to absorb the drop energy is:

a) lifting lugs $d = \frac{V}{A} = \frac{11.77 \text{ in}^3}{60 \text{ in}^2} = 0.196 \text{in}$
b) shell $d = \frac{V}{A} = \frac{11.77 \text{ in}^3}{323.3 \text{ in}^2} = 0.036 \text{ in}$

Consequently the drop energy can be absorbed in either the lifting lugs or the extension of the cask shell.

Question 4

For the top corner drop, show how the equivalent g-load was determined. Explain why the lid weight was multiplied by the cosine of the impact angle and the payload weight was multiplied by the sine of the angle to obtain the impact force on the lid. Also, show the derivation of the equation for the moment of inertia for the bolts. It is noted that the bolts should be evaluated for the combined effects of tension and shear forces.

Ans. The equivalent g-load is based on the use shown by K.Lee in the paper referenced in the response to question 1 above. The lid weight was multiplied by error by the cosine of the impact angle. This factor as well as the weight of the lid have been corrected in this calculation and are enclosed with the proper revisions in the text. The revision changes the induced tension from 57 ksi to 56.9 ksi.

Question 5

Provide an analysis for a bottom end drop. Show that the top cover will not be damaged. The stresses in the base plate, shell and their welds due to bottom impact should be determined and evaluated. Calculate the amount of lead's slump.

Ans. At the bottom end of the cask, the shell is provided with a lip around its circumference, which is 0.5" long, 1.25" thick and is fabricated ofA516Gr70 steel. The calculations which follow, demonstrate that cask drop energy is readily absorbed by the deformation of a very small segment of this extension of the shell and will therefore not affect the integrity of the cask.

The energy of the end drop is:
E=Wh=66,720lbs x 12in = 800,640 in-lb.

The volume of A516Gr70 steel to absorb this energy is:

$$V = \frac{E}{\sigma} = \frac{800{,}640 \text{ in-lb}}{68{,}000 \text{ lb/in}^2} = 11.77 \text{ in}^3$$

The surface area of the lip which is impacted is:
$A=\pi/4(83.625^2 - 81.125^2) = 323.5 \text{ in}^2$

The depth of shell lip deformed to absorb the drop energy is:

$$d = \frac{V}{A} = \frac{11.77 \text{ in}^3}{323.5 \text{ in}^2} = 0.036 \text{ in}$$

Lead slump due to a one foot cask drop was calculated in Section 5.4.2 of the SAR and found to be 0.74 inches.

SHIELDING

Provide a shielding analysis demonstrating the package can transport 150 thermal watts of radioactive material.

Ans. Calculations were performed in Section 4.3.1.1 which demonstrate the adequacy of the package to dissipate 150 thermal watts. If the ambient temperature is 80F and 150 watts must be dissipated, then the maximum temperature of the inside container surface will be less than 90F.

ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

Question 1

Section 8.2.2 does not specify an acceptance criteria (see Section 8.1.3)

Ans. Section 8.2.2 has been revised. The text specifies that "the pressure level will be checked over a 10 minute interval and no pressure loss or evidence of leakage during this period will be accepted".

Question 2

Section 8.2.4 should be revised to specify a minimum requirement for gasket replacement on an annual basis.

Ans. Section 8.2.4 has been revised with the following addition: "The gasket will be replaced after 12 sequential uses or if found unsatisfactory during the annual leak test."

GENERAL

The calculations performed in response to Question No. 1 (structural of our January 15, 1985, letter should be incorporated into the safety analysis report for the package design.

Ans. These calculations have already been incorporated into the safety analysis report. They can be found in Revision 3 of Section 2.4.2 (Positive Closure) dated 2/15/85. This revision was part of our last submittal.

REVISIONS TO S.A.R.

1.0 GENERAL INFORMATION

1.1 Introduction

The AP-300 A is a ferritic steel shielded shipping cask designed to meet the criteria of greater than Type A low specific activity (LSA) packages (as defined in 10CFR71.4). The container is built to comply with Title 10 Code of Federal Regulations (as amended September 6, 1983), Subpart E, parts 71.41, 71.43, 71.45, 71.47 and 71.51. In addition, it has been evaluated under Subpart F, 71.71 and 71.73 and Subpart G 71.81, 71.83, 71.89, 71.91, 71.93, 71.95 and due to capacity of the container 71.97. The cask is fabricated under Subpart H Quality Assurance License Docket Number 71-0001 and is labeled and marked in accordance with Title 49 Code of Federal Regulations Parts 176 .350, 173.24 and Part 72.

The specifications for this cask are as follows:

MODEL AP-300 A (referred to as AP-300 in remainer of text)

Classification:	"Greater Than Type A LSA"
Overall Dimensions:	83½" dia. x 96" high
Shielding:	3" lead equivalent (Cobalt 60)
Cask Weight:	45,700 lbs.
Capacity:	76" dia. x 82" high
Max. Quantity/Pkg:	20,000 lbs., not to exceed 20 curies Cobalt 60

The AP-300 is a steel encased, lead shielded cask. The cask consists of two concentric cylindrical shells. The inner shell is 1/2 inch thick by 76"I.D., made of ASTM A240 Type 304 S.S. material. The outer shell is 1 1/4 inches thick by 83.625 inches O.D., made of ASTM A516 Grade 70 steel. The annulus between the two concentric shells is filled with 2 inches of poured lead to act as a shield. The base has 2 inches of poured lead and is the same total thickness as the vertical walls of the cask. The flanged lid consists of three ASTM-A240, Type 304SS plates attached to
4 a riser ring. Concrete is placed between the two upper plates, and lead shielding is placed between the two lower plates.

A positive closure is provided by thirty-six (36) 3/4 inch diameter hex socket bolts and a J.M. "Red Devil" (or Neoprene equivalent) compressed sheet gasket. The cask is equipped with four independent (2 redundant pairs) lifting eye pads. The cask is provided with a security wire seal block that provides means for detecting tampering with the loaded cask after a wire seal is placed in position.

A double bolted seal test port is provided in the lid. This allows test pressurization of the cask cavity after loading to insure the positive seal of the cask lid and thereby provides reasonable assurance that the contents will not leak during accidents.

1.1 Introduction (Con't)

The AP-300 cask is designed to transport greater than Type A LSA waste with an approximate curie level of .09 curies/cu ft of Cobalt 60 or a total of 20 curies Cobalt 60. The waste form may be solid, dewatered or solidified. The AP-300 can accommodate one liner/catch tank up to 74" diameter by 80" high or ten (10) DOT 17-H 55 gallon drums.

1.2 Package Description

1.2.1 Packaging

1.2.1.1 Shape

The external shape of the cask is approximately a smooth-surfaced right circular cylinder. (See Figure 1.2.1.1).

1.2.1.2 Size

The cask body has an overall height of 96 inches and a diameter of 83.625 inches. The internal cavity of the cask is 82 inches high and 76 inches in diameter.

1.2.1.3 Weight

The weight breakdown of the AP-300 cask is as follows:

Components	Weight (lbs.)
Cask Body	37,255
Cask Lid	9,462
4 Total Cask (Empty)	46,717
Cask Contents	20,000
Total Cask & Contents	66,717

1.2.1.4 General Construction

Materials of construction are: stainless steel (used in the inner containment vessel), A516 Grade 70 carbon steel (used in the outer shell), chemical grade lead (used for radiation shielding) and high temperature elastomer seals.

The primary containment structure of the AP-300 cask is fabricated from ASTM - A240, Type 304 stainless steel. The inner and outer shells of the cask body are both welded to the closure ring at the top of the cavity flange.

1.2.1.4 General Construction (Con't)

Both shells are welded at the bottom to their own separate bottom closure plates. The annulus between the outer and inner shell is filled with lead for GAMMA shielding. The bottom closure plate of the 1.25 inch thick outer shell consists of a 1.25 inch ASTM A516 - Grade 70 steel plate. The outer shell is a 1.25 inch thick sheet of ASTM A516, Grade 70.

Four lifting eye pads (redundant pairs for those sites requiring four-point lifts) are attached to the upper outer shell of the cask. Four additional pad eye points are attached to the side of the cask for tie-down, providing for separate lifting and tie-down points.

The cask lid is shown in Appendix A on Drawing No. 135-1. It consists of two major components namely:

a. An outer plate with lifting lugs, which is fastened to the cask closure ring with 36 bolts. This plate is 2 inches thick and made of ASTM A240 type 304 stainless steel.

b. A gamma shielding assembly, consisting of lead, sandwiched between 2 steel plates. This assembly consists of 2.06 inches of lead between an inner,
1 ½ inch plate and an intermediate 3/8" inch plate, both of which are ASTM A240 type 304 stainless steel. All plates are permanently attached to
4 a ½" thick riser ring which is also made of ASTM A240, Type 304SS, and 3.8125" of concrete is placed between plate (a) and assembly (b).

1.2.1.5 Primary Containment Vessel

The containment vessel is a .5 inch thick inner cavity shell and a .5 inch thick bottom closure plate. The containment vessel, including all penetrations, is fabricated of 304 stainless steel. The cask cavity is closed and sealed by a bolt-on-plug-type closure lid consisting of a 2 inch thick outer stainless steel plate and a steel weldment containing lead shielding which extends into the cavity opening.

1.2.1.6 Capacity

The AP-300 cask is capable of accommodating a gross load of up to 20,000 pounds of LSA waste material of greater than Type A quantity.

1.2.1.7 Shipping Configuration

Transportation of the AP-300 cask is normally by (although not limited to) truck shipment with the cask in a vertical position, carried on a specially modified transporter. The transporter is basically of reinforced beam type construction.

1.2.1.7 Shipping Configuration (Con't)

A protective personnel barrier cover shield is not required. Four tie-down pad-eyes are used as the cask tie-downs to support the entire load of the cask and its contents under the 10 G axial load conditions. A kick plate ring is provided, to prevent movement due to the chocking forces. The transverse imposed loads are taken/shared by two of the pad eyes and the vertical load is shared by four of the pad eyes. The load is tied down with 1-1/2 inch cable with adjustment tie-down plates to provide the correct torque and flow for expansion and contraction differences between the cask and the transporter.

1.2.1.8 Outer Shell

The outer shell is a steel cylinder, which has an outer diameter of 83.625 inches, is 1.25 inches thick and is fabricated from ASTM A516, Grade 70 steel. The shell is welded to the closure ring and to a 1.25 inch thick bottom plate which is fabricated from ASTM A516, Grade 70 steel.

1.2.1.9 Closure Ring

The closure ring is fabricated from ASTM A240, Type 304 stainless steel and is 81.125 inch O.D., 76 inch I.D. and 2-1/4 inches thick. The ring is welded to the inner and outer shells to form the top closure for the lead shielded cavity. Thirty-six (36) 3/4" diameter holes with helically coiled threaded inserts are provided for bolting the closure lid to the ring.

1.2.1.10 Lid Closure Seal

The seal between the closure lid and ring is made of high temperature, compressed SBR (neoprene blend), flange gasket of Johns-Manville, Red Devil material. The mating surfaces are machined to a concentric surface. The lid is bolted to the closure ring by thirty-six (36) 3/4 inch diameter hex socket bolts; the bolt heads bear on the cask lid, the shanks penetrate through the lid flange and are threaded into the closure ring.

1.2.1.11 Cask Bottom

The cask bottom is a plate 81.125 inch O.D. and 1.25 inch thick and is fabricated from ASTM A516, Grade 70 steel. The plate is welded to the outer shell to form the bottom closure for the lead shield.

1.2.1.12 Closure Lid

The lid is bolted to the 81.125 inch diameter closure ring. The lid is fabricated from an ASTM A240, Type 304 stainless steel plate 81.125" O.D. and 2" thick. It has welded to it an ASTM A240, Type 304 stainless steel riser ring 76" O.D., 0.5" thick and 6.75 " high. An ASTM A240, Type 304 stainless steel plate 75" O.D. and 0.375" thick is welded to the riser ring at a distance 2-1/16" up from the other end, and an ASTM A240, Type 304 stainless steel plate 76" O.D. and 0.5" thick is welded to the riser ring at the other end. The cavity between the two lower plates contains the
4 top lead shield. Concrete is placed between the upper plates.

The plug portion of the lid has a radial clearance less than that of the lid bolts clearance holes, preventing contact of the lid with the closure bolts during the hypothetical accident conditions which would put a shear load on the closure bolts. There are thirty-six (36) counter bored clearance holes for the 3/4 inch closure bolts. The top surface of the lid has four lifting pad eyes constructed of 1 inch thick ASTM A516, Grade 70 steel. A seal test connection is provided in the lid. The seal test connection,constructed of a 1/4" diameter hole with heli-coil threaded inserts, is located 2 " below the outer surface of the lid. The seal test connection is in turn sealed by a 1/4 inch hex socket, ASTM 320 stainless steel bolt and a 1/8" thick Johns-Manville Red Devil gasket. The seal test connection and plug are in turn protected by a second seal plug in a 1/2" ASTM A320 hex socket bolt 1-1/2" long. This provides a gap between the two plugs to prevent shear damage to the internal plug during accident condition.

The outer seal test connection plug is in turn sealed by a 1/8" thick Johns-Manville Red Devil gasket. The outer plug is recessed below the top surface to prevent accidental damage to the plug. The entire lid assembly is located 1 inch below the top surface of the outer body shell to protect the lid during accident conditions.

1.2.1.13 Lifting Eyes

Four lifting pad eyes,13 inches high by 6 inches wide by 2-1/2 inches thick, fabricated from ASTM A516, Grade 70, are located 90° apart on the upper part of the outer shell of the cask body. Each pair of opposite lifting eyes are designed in accordance with the regulations and may be used independently of each other. The four lifting eyes design is used to meet the requirements of those reactor sites which require independent four point

1.2.1.13 Lifiting Eyes (cont)

lifts. The lifting pad eyes are covered during transport to prevent their use as tie down points during shipment.

1.2.2. Operational Features

The ANEFCO AP-300, Greater than Type A cask is not a complex package system. It is used for exempt fissile material in conformance with 10 CFR 79.53 and hence does not require a neutron shield. It also does not require fluid cooling means to dissipate the small ($<$ 150 watts) internal thermal loads of the contents to be shipped in the cask.

1.2.3 Contents of Packaging

1.2.3.1 Description of Contents

The contents shall be process solids, either dewatered, solid or solidified material meeting the requirements of low specific activity (LSA) radioactive material, or large quantities of by product material and fissile material in the form of dry, solid metallic waste material and activated reactor components which meet the requirements of 10 CFR 71.53.

Maximum quantity of material per shipment will be for greater than Type A quantities of radioactive material with the weight of contents and secondary containers not to exceed 20,000 pounds. Decay heat of contents will be less than 150 watts.

All materials will be packaged in disposable inner containers.

2.0 STRUCTURAL EVALUATION

2.1 STRUCTURAL DESIGN

2.1.1 Discussion

The principal structural members of the package consists of two major structural systems and other components. The primary containment is made up of the inner shell and its bottom plate, the closure ring and gasket, the closure bolts and closure assembly. These components are designed to contain the contents under maximum conditions of cavity pressure and temperature and prevent puncture from the top. The next major structural system is the shielding envelope which is composed of the closure lid, outer shell and bottom plate. These components keep the lead shield in tact and prevent puncture from the side and bottom.

Lifting eyes and tie-down eyes are also provided for operational and tie-down use.

2.1.2 Design Criteria

The design conditions used to evaluate the structural integrity of the packaging are specified in 10 CFR 71. Specific paragraphs that apply are: 71.41, 71.43, 71.45, 71.47, 71.51,71.71, 71.73 and 71.107. In addition, the cask is evaluated in accordance with NUREG-CR-1815, "Recommendations for Protection Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers up to 4 Inches Thick" and Reg. Guide ., Task MS 144-4, June, 1983, Draft.

For primary containment vessels, design conditions of 600°F and 100 psig were used with the assumption that it is a free standing vessel with support from the lead. All cask components and structures were designed to withstand an acceleration of 30 g's in any direction.

The theory of failure used for this SAR, was the maximum shear stress theory. In general, the approaches in the ASME Boiler and Pressure Vessel Code, Section VIII, Division 2, 1974 Edition, were used to size components, obtain material properties, and evaluate design safety margins. Both operating and accident conditions were evaluated and compared with the stress and fatigue limits of Section VIII, Division 2.

When specific design formulae were available, such as presented in ORNL-68, these were used to either size or evaluate components and parts.

Design criteria used to evaluate stresses and strains caused by the 3 foot free drop and the 6 inch bar puncture were either the static yield, or where appropriate by comparison with the dynamic yield or ultimate tensile strength. Permanent deformations were allowed to occur provided that the ultimate strain was not reached and the primary containment seals remained operable.

2.2 WEIGHTS AND CENTERS OF GRAVITY

4 The individual weights of the major individual sub-assemblies are tabulated in the table of cask weights and centers of gravity. Each sub-assembly is referenced to the cask assembly Drawing No. 133 respectively. The total empty cask weight is 46,717 pounds. The loaded cask weight, with maximum design load is 66,717 pounds.

4 The center of gravity of the loaded cask is 47.66 inches above the bottom of the cask at the center axis of the cask.

TABLE 2-1

CASK WEIGHTS & CENTERS OF GRAVITY

	PART	W LBS.	$\bar{Y}$ IN.	W $\bar{Y}$
4	Cask Lid Concrete	1462	92.09	1.35×10^5
	Cask Lid Assembly	8000	89.86	7.19×10^5
	Cask Outer Shell	8925	48.0	4.28×10^5
	Closure Ring	405	45.375	$.18 \times 10^5$
	Inner Shell	3070	43.75	1.34×10^5
	Inner Shell Bottom Plate	655	4	$.03 \times 10^5$
	Outer Shell Bottom Plate	1825	1.12	$.02 \times 10^5$
	Gamma Shield	18560	44.5	8.26×10^5
	Bottom Shield	3815	2.75	$.10 \times 10^5$
4		46717		22.75×10^5
4	$CG = \frac{\Sigma \bar{Y}W}{\Sigma W}$			48.70"
	Contents	20,000	45.25	9.05×10^5
4	Loaded $W_L \Sigma W_L$ / $\Sigma \bar{Y}W$	66,717		31.80×10^5
4	Loaded C.G. $(R, \frac{\Sigma \bar{Y}W}{W})$			(41.75", 47.66")

2.4 GENERAL STANDARDS FOR ALL PACKAGES

2.4.1 Chemical and Galvanic Reaction

The cask's materials of construction, those of the disposable canister and the contents are all metals that do not produce significant chemical galvanic or other reactions. The packing components are either stainless steel, lead or carbon steel or polyethylene canister which is carried in the stainless steel primary containment. These materials do not have any significant adverse interactions.

2.4.2 Positive Closure

The closure system is made of positive screw type devices that must be deliberately opened and will not be accidentally unscrewed. The closure assembly is secured by 36 hex socket head bolts 3/4 inch in diameter. The seal test connection is closed by a 1/4 inch hex socket bolt. This seal test connection is closed at the outer shell by a 1/2 inch hex socket bolt. Therefore, the closure bolts and seal test port bolts cannot be inadvertently opened.

The seal is made by a high temperature gasket, which is placed between the lid plate and the ring plate, and secured by the 36 hex socket head bolts. The gasket is fabricated by Johns Mansville and consists of DuPont aramid fibers which are bound by styrene butadiene rubber.

The stress on the gasket is determined as follows:

The gasket is compressed by the weight of the lid and the preload applied by the tightening of the bolts to a torque of 115 ft lbs.

The area of the gasket (81.125" OD, 16" ID - 36- 3/4" bolts) is:

$$A = \frac{\pi}{4}(81.125^2 - 76^2)\ in^2 - 36\frac{\pi}{4}(.75^2)\ in^2$$

$$= 632.45 - 15.90 = 616.55\ in^2$$

3 The force on each bolt, torqued to 115 ft lbs, can be determined from the relationship shown in ORNL-NSIC - 68 page 37, formula (2.9):

$$T = 0.2\ a\ F$$

Where: T = Torque (ft lb), a = bolt diameter (ft), F = induced force (lbs)

$$F = \frac{115\ ft\ lb}{0.2(\frac{.75}{12})\ ft} = 9200\ lb$$

The total force from each of the 36 bolts torqued to 115 ft lb and the wieght of the lid is:

$$9200(36) + 9500 = 340,700\ lbs.$$

Therefore, the stress on the gasket will be $\frac{340,000\ lbs}{616.55\ in^2} = 552.6\ psi$

The maximum stress and strain the gasket can withstand without failure is in excess of 5000 psi. Therefore, a safety factor in excess of 9 is available when the bolts are torqued to 115 ft lb.

The frequency of leak test and gasket replacement schedule is based on the following:

The fabricator data indicates that under 5000 psi the gasket material has a compressibility of 15 - 35% and a minimum recovery of 40%.

3 Assuming a maximum compressibility of 35% at 500 psi and a linear relationship between stress and compressibility, the compressibility of the gasket material at 552.6 psi can be calculated.

$$\text{compressibility} = 35\% \times \frac{552.6}{5000} = 3.87\%$$

If 40% of the compressibility is recovered, then only 60% of the compressibility is lost for each compression.

$$\text{compressibility loss} = 0.6(3.87\%) = 2.32\% \text{ per use}$$

The gasket will be replaced after six (6) sequential uses and a leak test will be performed whenever a gasket replacement takes place or at a minimum of one leak test per year.

2.4.3 Lifting Devices

2.4.3.1 Lifting Devices for Cask Assembly

1 The cask lifting device consists of a hoisting beam, four wire rope slings and a total of 8 shackles. The schematic outline is shown in Figure 2.4-1.

2.4.3.1.1 Loading

4 The empty cask weight is 46,717 lbs. For purposes of the lifting ear design it is assumed that the cask is loaded with its payload of 20,000 lbs.

Total lifting weight is therefore:

4 wt = 46,717 lbs. + 20,000 lbs.

= 66,717 lbs.

According to Title 10 of the Code of Federal Regulations, Part 71.31 (c), the lifting system should be capable of lifting three times the expected load.

$$D_L = 3(wt)$$

4 Design Load = 3(66,717)

= 200,151 lbs.

Each pair of lifting ears are designed to take the entire load, therefore, each ear is designed to take 1/2 the load
4 or 100,075 lbs.

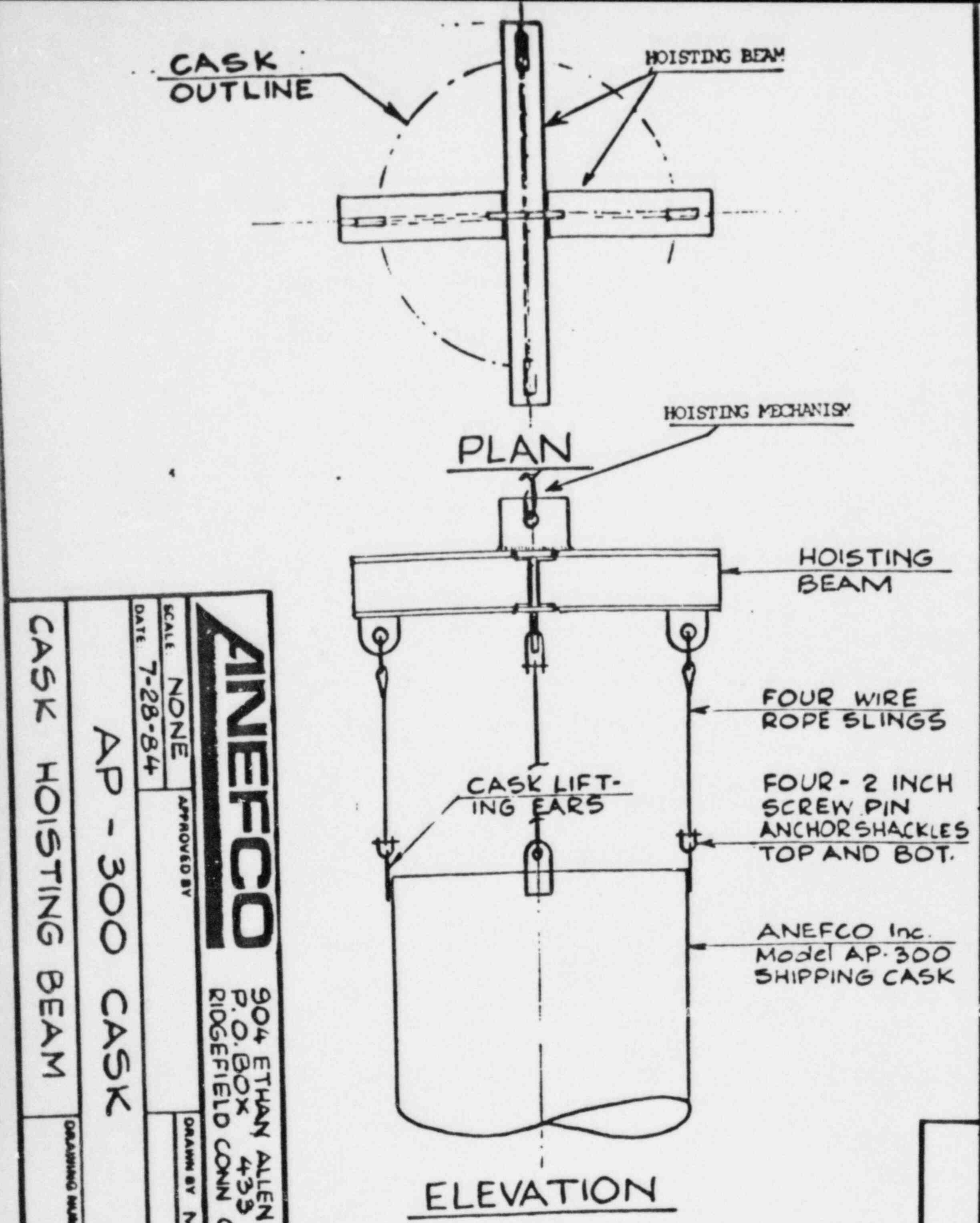


Figure 2.4-1 - Cask Lifting Device

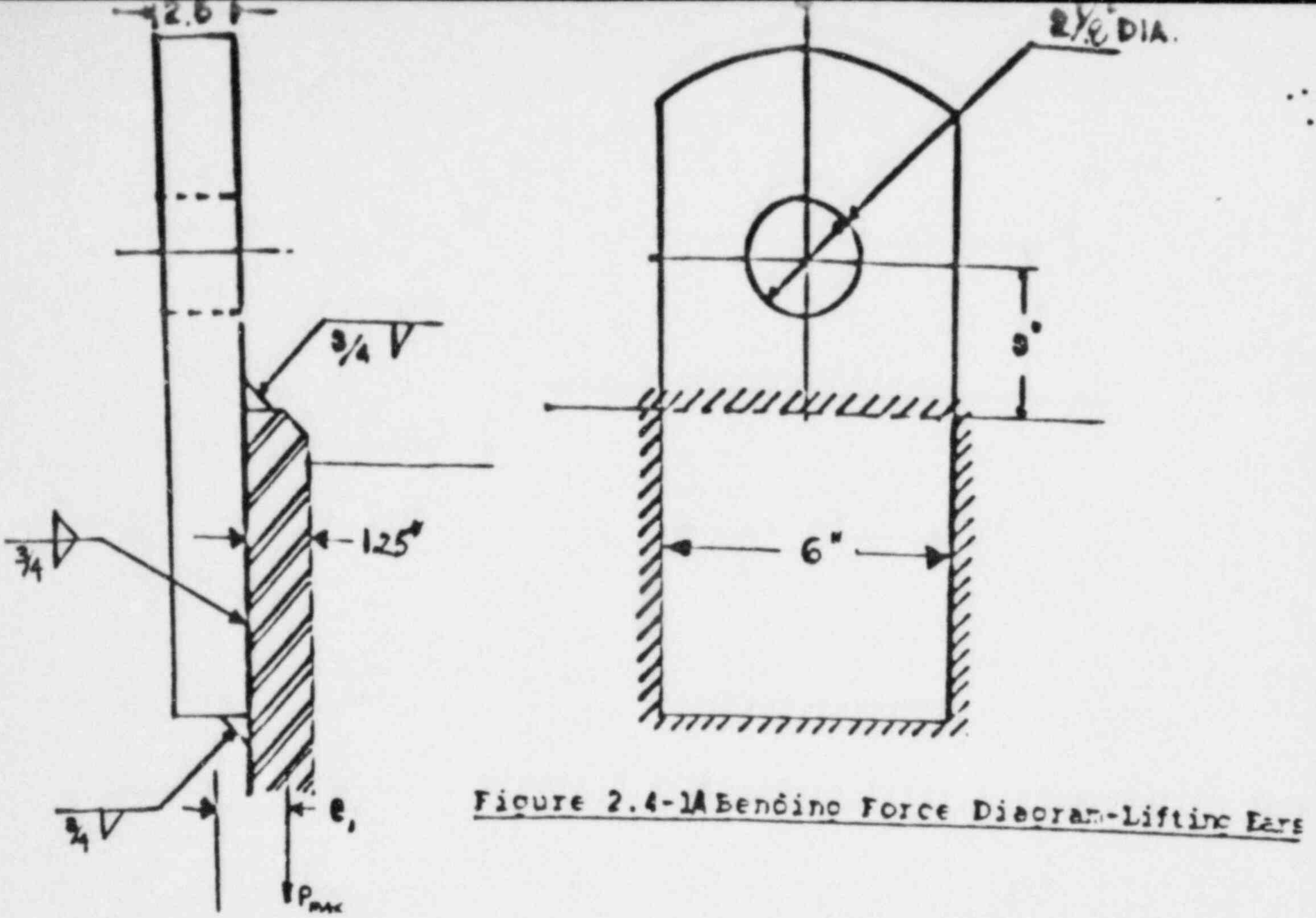


Figure 2.4-1A Bending Force Diagram-Lifting Ears

2.4.3.1.2 Bending of Ears

Assuming that the cask shell is very flexible and offers neglible restraint, the bending stress is:

$$S_m = \frac{bh^2}{6} = \frac{6\times2.5^2}{6} = 6.25 \text{ in}^3$$

$$A = 6\times2.5 = 15 \text{ in}^2$$

$$e_1 = \tfrac{1}{2}(2.5 + 1.25) = 1.88$$

4 $$f_T = \frac{100.1}{15} + \frac{100.1\times 1.88}{6.25} = 6.67 + 30.11 = 36.78 \text{ ksi}$$

Yield of A 516 is f_y = 38 Kip

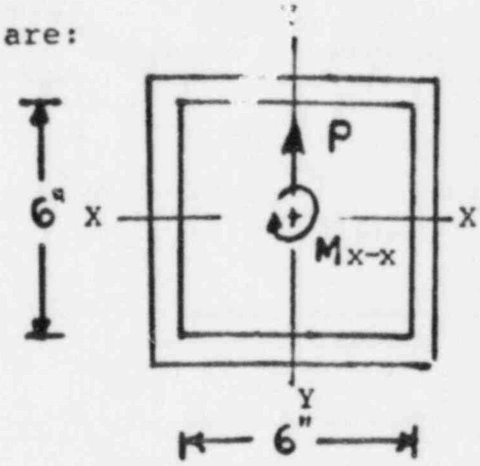
The safety factor is:

$$S.F. = \frac{38}{36.78} = 1.03$$

4 The safety factor of 1.03 assumes that only two (2) lifting ears out of four (4) are operative and that the cask weight plus contents is threefold of the actual weight.

2.4.3.1.3 EAR WELD CONNECTION

The forces acting on the weld as shown are:



EFFECTIVE AREA OF WELD

$P = 100.1 Kip$

4 $M = 100.1 \times \frac{1}{2} \times 2.5$

$_{x-x} = 125.125$ in-kip

The effective area of the weld is:

$$A = \frac{.75 \times 1}{\sqrt{2}} = 0.53 \text{ in}^2\text{/in weld}$$

The shear on the vertical welds is:

4 $$f_{shear} = \frac{100.1}{4 \times .53 \times (6+.53)} = 7.23 \text{ k.s.i.}$$

The effective section modulus of the weld throat is:

$$S_m = \frac{bh^2}{6} = \frac{1}{6} [(6+2 \times .53)^3 - (6^3)] = 22.65 \text{ in}^3$$

4 $$f_t = \frac{125.125}{22.65} = 5.524 \text{ ksi}$$

1 The combined stresses are:

$$fr = fresultant = \sqrt{f_{shear}^2 + f_{tension}^2}$$

4 $$fr = \sqrt{7.23^2 + 5.524^2} = 9.10 \text{ ksi}$$

The weld electrodes were Class E 8016 or E 8018 having a yield of 80 ksi.

The allowable stress is .3 of the weld metal or .4 of the base metal.

The safety factor for the allowable stress to weld metal is:

4 $$S.F. = \frac{80 \times .3}{9.10} = 2.64$$

The safety factor for the allowable stress of the A 516 base metal having a yield stress of 38 ksi is:

$$\frac{38 \times .4 \times \sqrt{2}}{9.10} = 2.36$$

4 The lesser, governing safety factor for the weld is 2.36

2.4.3.1.4 TENSION IN LIFTING EARS

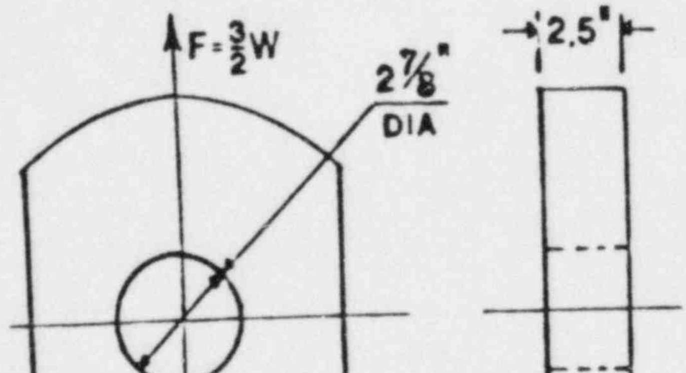


Figure 2.4-2 Tension Force Diagram - Lifting Ears

Area required is:

$$A_R = \frac{W}{S}$$

Where: W = ½ the weight of the cask = 100,075 lbs.

S = Maximum Allowable Stress (using the Spec. Minimum Yield stress for A516) = 38,000 lb/sq in

4 $A_a = \frac{100,075}{38,000}$

$A_a = 2.63$ square inches

Area available is:

Where: t = thickness of the ear = 2.5 in

w = width of the ear = 6 in.

D_h = diameter of the hole = 2.5 in.

$A_a = t(w - D_h)$

Safety Factor:

4 $S_F = A_a/A_R = \frac{8.75}{2.63} = 3.33$

$A_a = 2.5\ (6-2.5)$
$= 2.5\ (3.5)$
$= 8.75$ sq. inches

4 The lifting ears are therefore adequate in tension with a safety factor of 3.33

2.4.3.2. CASK LID LIFTING DEVICE

2.4.3.2.1 LOADING

Each opposite pair of lifting ears are designed to lift the lid, thereby providing for redundancy in the lifting of the lid.

According to Title 10 of the Code of Federal Regulations, Part 71.31 (c), the lifting system must be capable of handling three times the expected total load.

$D_L = 3(W)$

The cask lid weight is 9462 lbs.

4 Design load = (9,462)(3)
= 28,386 lbs

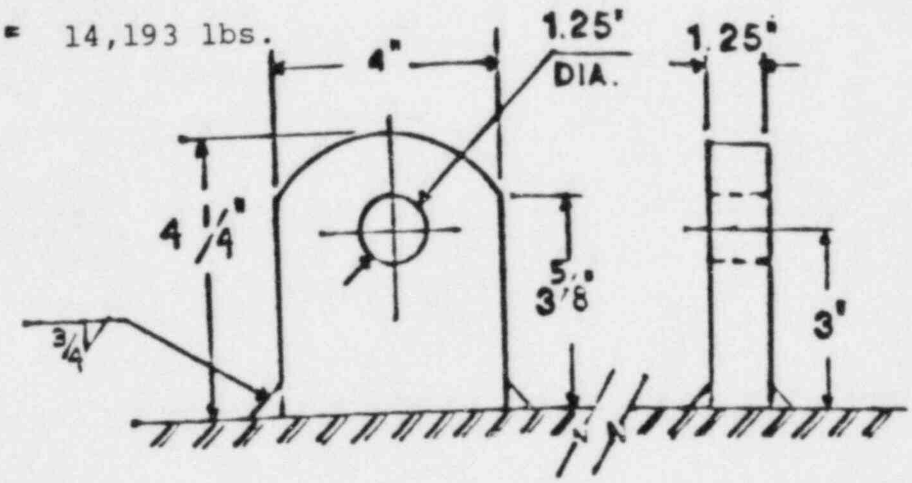
Each ear will carry half of the design load:

$W = D_L/2$

4 Where D_L = Design Load = 28,386 lbs

W = 28,386/2

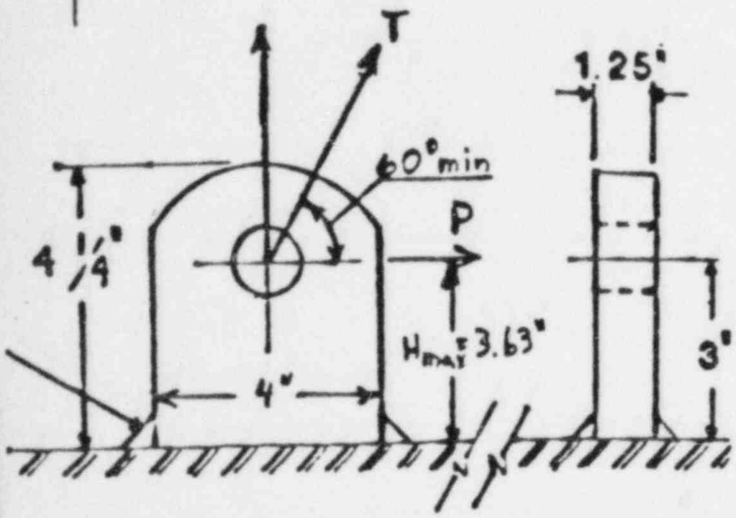
= 14,193 lbs.



2 FIGURE 2.4-2a Cask Lid Lifting Device

1

2.4.3.2.2 Bending and Tension in Lifting Device



Max. vertical force (given) = 14.2 k

$P = 14.2(\tan 30) = 8.20$ k

4 $T = 14.2^2 + 8.2^2 = 16.40$

S_m of eye =

$$S_m = \frac{bh^2}{6} = \frac{1.25 \times 4^2}{6} = 3.33 \text{ in}^2$$

Max. Stress

$$f_T = \frac{14.2}{4 \times 1.25} \pm \frac{8.2 \times 3.63}{3.33} = 11.78 \text{ k/in}^2$$

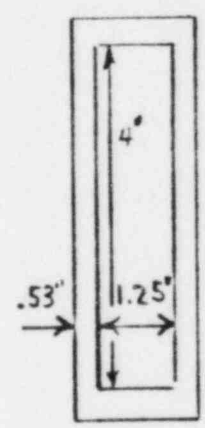
S.F. against yield

$$S.F. = \frac{38}{11.78} = 3.23$$

Each lid lifting device is adequate for bending and tension with a safety
4 factor of 3.23

2.4.3.2.3 Lid Lifting Weld Connection

Weld throat $= .75 \times \frac{1}{2} = .53$ in^2/in length



S_m of weld

$$S_m = \frac{(4+2x.53)^2 \times (1.25+2x.53)}{6} - \frac{4^2 x1.25}{6} =$$

$$S_m = 9.85 - 3.33 = 6.52 \text{ in}^3$$

$$A_{\text{weld throat}} = 5.06 \times 2.31 - 4 \times 1.25 = 6.69 \text{ in}^2$$

4 $f_{weld} = \frac{14.2}{6.69} \pm \frac{8.2(3.63)}{6.52} = 6.69$ ksi

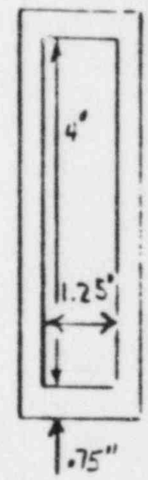
Allow in E80 electrode (weld throat)

$0.30 \times 80 = 24$ ksi

$S.F. = \frac{24}{6.69} = 3.59$

Stress at weld to base metal interface (3/4" weld)

$A = (4+2x.75)(1.25+2x.75) - 4x1.25 = 10.12\ in^2$



$S_m = \frac{1}{6}[(5.5^2 x 2.75) - (4^2 x 1.25)] = 10.53\ in^3$

$f_{\text{at weld base metal interface}} = \frac{14.2}{10.12} \pm \frac{8.2(3.63)}{10.53} = 4.23$ ksi

for ASTM A516 steel $f_{yield} = 38$ ksi

4 allowable interface stress is $.4 \times 38 = 15.2$ ksi

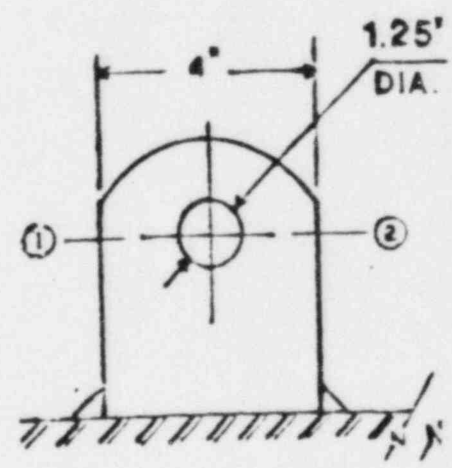
therefore $S.F._{\text{to allowable stress}} = \frac{15.2}{4.23} = 3.59$

Each lid lifting device weld is adequate with a safety factor of 3.59.

2.4.3.2.4 Stress in Lid Lifting Device

Section ① - ②

$A = (4-1.25)1.25 = 3.43\ in^2$



$f_{Tension} = \frac{14.2}{3.43} = 4.14$ ksi

$f_{shear} = \frac{8.2}{3.43} = 2.39$

Combined stress $f_{resultant} = \sqrt{4.14^2 + 2.39^2} = 4.78$ ksi

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4 $S.F._{\text{to yield}} = \frac{38}{4.78} = 7.95$

Each lid lifting device is adequate for the stresses imposed with a safety factor of 7.95

2.4.4 TIE-DOWN DEVICE

In order to satisfy the requirements of 173.412 (d) the cask tie-down blocks were designed to meet Title 10 of the Code of Federal Regulations 71.31 (d) which stipulates that the tie-down structure be capable of sustaining at the center of gravity of the cask a "g" loading component of:

Vertical	=	2 g's
Forward horizontal	=	10 g's
Sideward horizontal	=	5 g's

2.4.4.1 TIE-DOWN FORCES

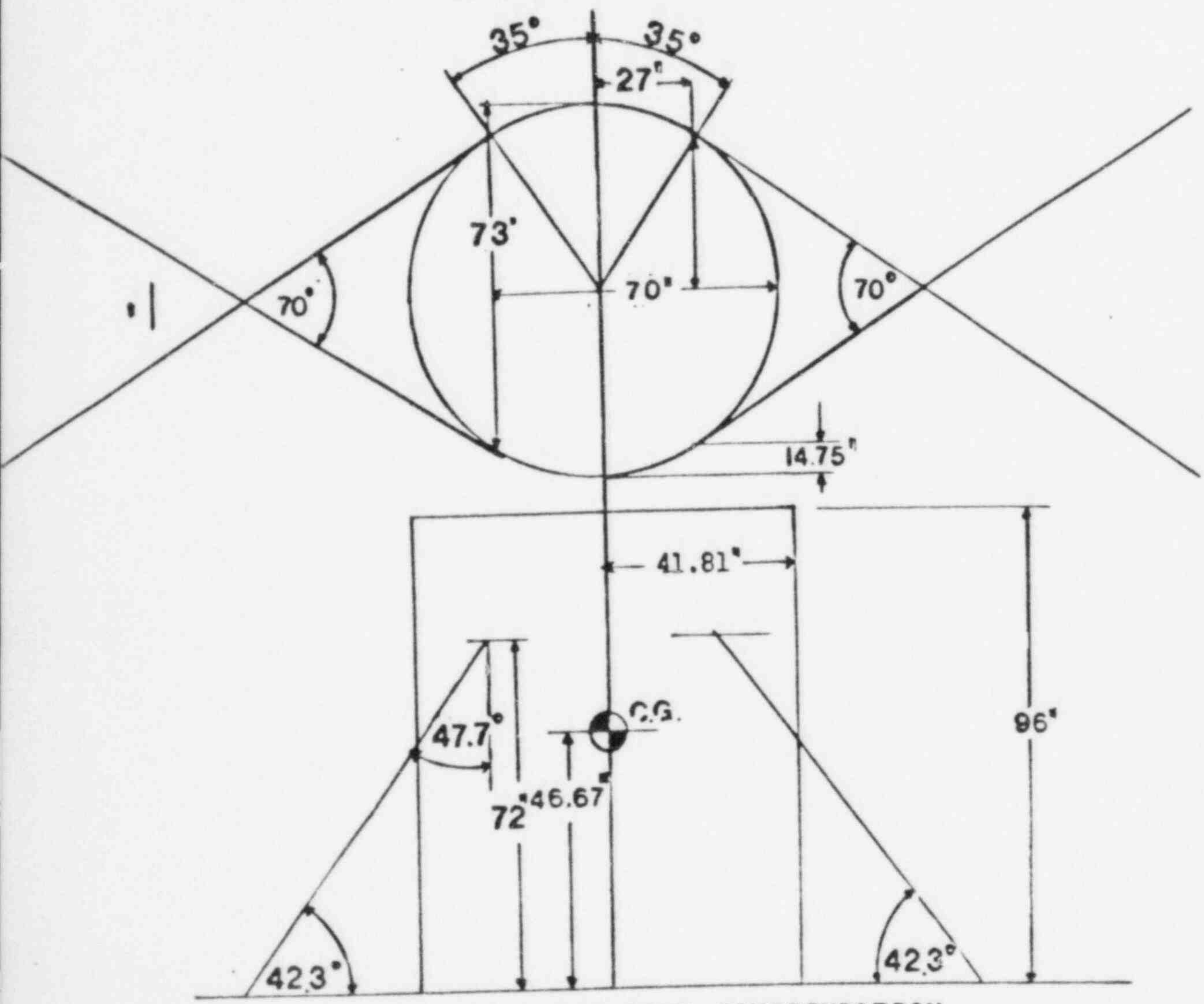


FIGURE 2.4-3 TIE-DOWN CONFIGURATION

4 Cask center of gravity	=	47.66 in. (See Section 2.2)
Cask radius	=	41.8125 in.
Overall Height	=	96 in.
4 Weight	=	66,720 lbs.

4 For a loaded cask weight of 66720 lbs, it is considered that the following forces will act simultaneously at the center of the cask in the following directions:

Vertical- V

2g will act in the upward direction and 1g will act in the downward direction
4 for a net 1g force or 66,720 lbs upward.

Forward Horizontal - H_F

4 10g will act in the forward horizontal direction or 667,200 lbs.

Sideward Horizontal - H_S

4 5g will act in the sideward horizontal direction or 333,600 lbs.

Resultant Force - F_R

3 The resultant force of the above three forces acting simultaneously can be calculated from the following relationship:

4 $$F_R = \sqrt{V^2 + H_F^2 + H_S^2} = (66,720^2 + 667,200^2 + 333,600^2)^{1/2} = 748.93 \text{ kip}$$

The resultant force will act in a direction which is approximately:

84.89° from the vertical

27.02° from the forward (longitudinal) horizontal, and

63.55° from the sideward (lateral) horizontal

The resultant force is distributed equally in each of four (4) tie-down lugs. Therefore, each lug will be subjected to a force of 187.23 kip. The tie-down makes an angle of 42.3° with the horizontal, as shown in Fig. 2.4-3.

$$F_H = 187.23(\cos 42.3°) = 138.5 \text{ kip}$$

$$F_V = 187.23 (\sin 42.3°) = 126.0 \text{ kip}$$

Therefore, horizontal and vertical forces, of 138.5 kip and 126.0 kip respectively, will be imposed on eachlug.

next page 2.4-11

2.4.4.5 TIE - DOWN PADS FOR CASK ASSEMBLY

2.4.4.5.1 LOADING

The tie-down pads must be capable of sustaining the total force
4 of the resultant force previously calculated, viz. 748.9 kip
The tie-down pads are designed to resist the resultant force
together. Each pad is designed for **187.2 kip.**

2.4.4.5.2 <u>TIE-DOWN PAD DESIGN</u>

Use steel of $Fy = 38^{ksi}$ min. weld with low hydrogen electrode. Steel to be noted in Group II Table 4.2 of AWS D1.1-80 Structural Welding Code.

Check hole for bearing and shear. (assume 2" min. for Pin)

$$F_p = \frac{187.2}{2.0 \times 2.5} = 37.45 \text{ ksi}$$ (actual bearing stress)

Allowable AISC (8th edition specification para. 1.5.1.5)

$$F_p = 1.5\ Fu = 1.5 \times 38 = 57 \text{ ksi}$$

Safety factor to allowable AISC bearing

$$SF = \frac{57}{37.45} = 1.52$$

Check tear out of hold down device along lines 1-2 and 3-4, Section A-A (page 2.4-13)

$$Av = 2 \times 3 \times 2.5 = 15.0 \text{ sq. in.}$$

The shear capacity of structural steel is 2/3 of the tensile capcity.
4 Therefore, the tear out capacity is:

$$2/3 \times 38 \times 15 = 380 \text{ kip}; \quad SF = \frac{380}{187.2} = 2.03$$

Bending along plane 1-2

$$M = 6" \times 167.2 = 1123 \text{ kip}$$

Sm for 3/4" fillet weld (Stress & Strain by Roark & Young page 63)

$$A = 2(16 + 2.5)(.75) = 27.75$$

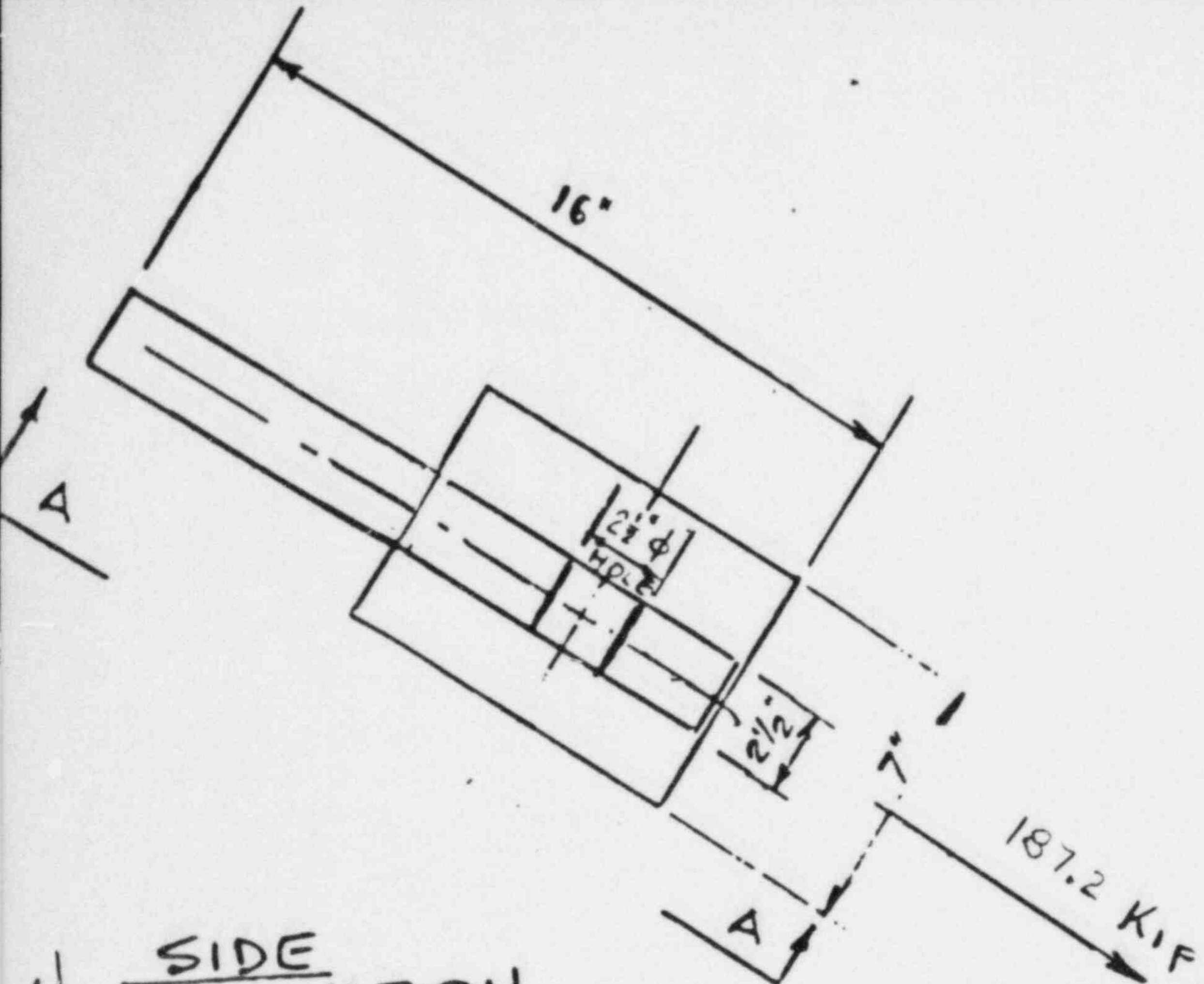
$$Sm = \frac{A^2}{6.15\ b} = \frac{27.75^2}{6.15(.75)} = 167$$

$$F_{\substack{weld \\ tension}} = \frac{1123}{167} = 6.72 \text{ ksi}$$

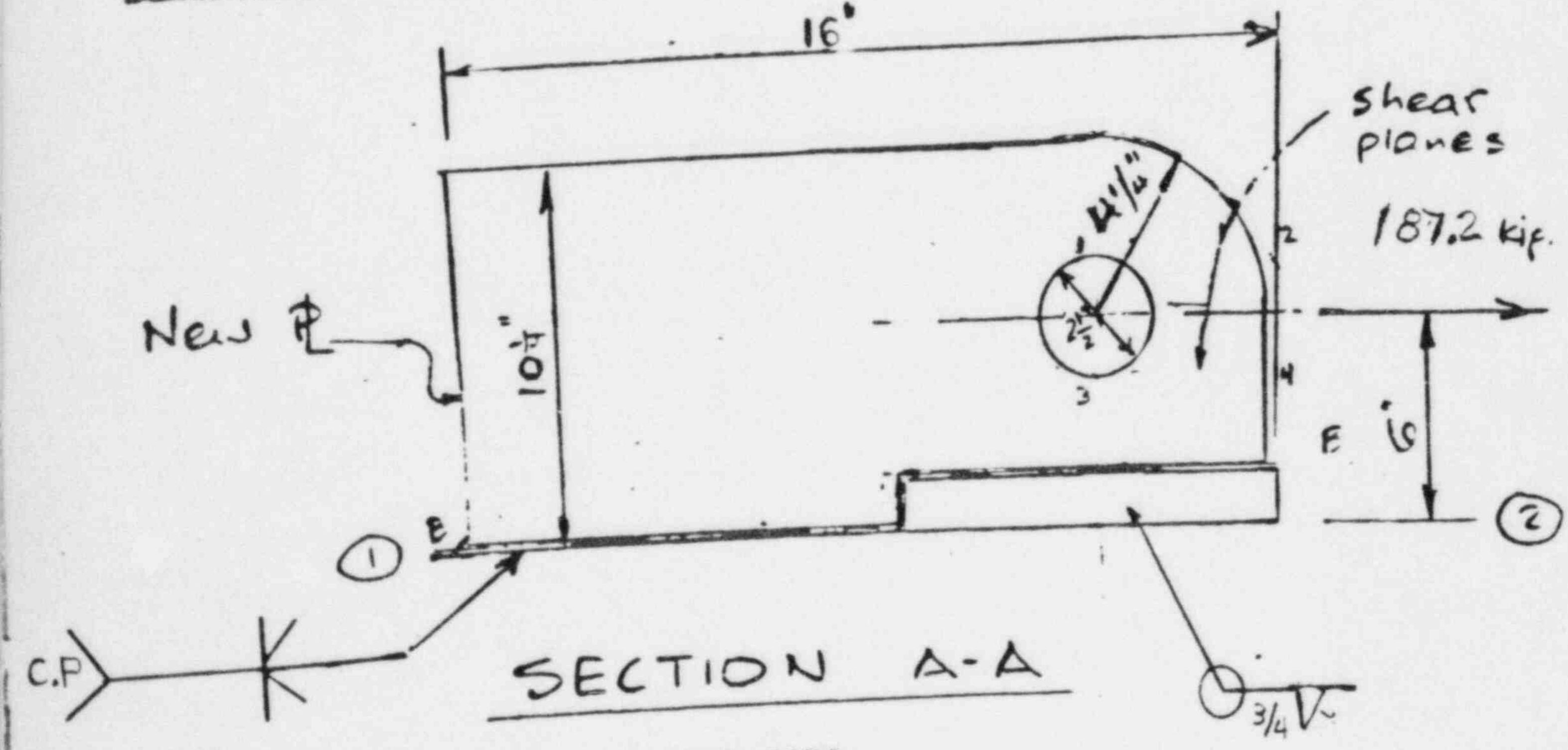
$$F_{\substack{weld \\ shear}} = \frac{187.2}{27.75} = 6.75 \text{ ksi}$$

Combined Stress

$$f_{comb.} = \sqrt{6.72^2 + 6.75^2} = 9.52 \text{ ksi}$$



4 | SIDE ELEVATION



SECTION A-A

TIE-DOWN PADS

Use E70 ksi low hydrogen electrode.

3 Allowable tensile stress = 21 ksi

4 S.F. to tensile stress $= \frac{21}{9.52} = 2.21$

<u>Tie-Down Pads</u>

As shown in the drawing, four tie-down pads are provided to attach the shipping cask to the truck bed. A 7" square, 2" high plate is welded to the cask body using a 3/4" fillet weld all around. A plate, 2.5" thick, 16" long and 10¼" high is welded at right angles to the base plate and the cask body using a full penetration weld all around. A 2½" diameter hole is provided in the latter plate and used to enable tie-down. Both plates will be fabricated from a steel having a minimum, Fy = 60 ksi and the lug plate will be welded using a E70 ksi low hydrogen electrode. The cask will be installed on the truck bed so that the center line of the 110° angle between adjacent pads is parallel with the direction of travel. The transverse line is parallel to the center line of the 70° angle between adjacent pads.

2.4.4.5.5 EXCESSIVE LOADING OF THE TIE-DOWN

It can be seen from the previous sections that extensive loading of the tie-down pad will cause failure in the tie-down pads due to bending or shear of the ear welds prior to any damage to the side wall of the container. Therefore, extensive loads will not impair the ability of the cask to meet other requirements and the conditions for 173.412 (1) are met.

2.4.4.7 CHOCKING RING

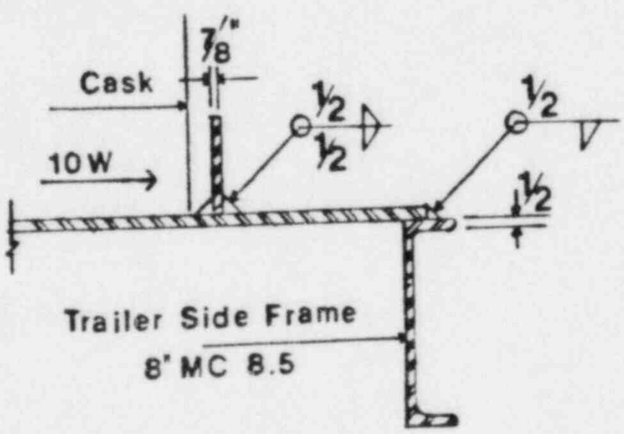


FIGURE 2.4-10 FORCE DIAGRAM CHOCKING RING

The chocking ring welded to the steel deck plate is designed to prevent sliding of the cask due to the forces imposed during the conditions of transport stated in Title 10 of the Code of Federal Regulations 71.31 (d).

Making the conservative assumptions that the friction force between the cask and support is neglible, the maximum force that would be transferred at the base (using the analogy of a simple beam on two supports) is:

4 Max. Reaction = $\frac{1}{2}\sqrt{10^2 + 5^2} \times 66.72$ kip = 373.0 kip

The chocking (restraining) ring consists of a 7/8 thick ring welded to the base by two ½ inch fillet welds, one on each face of the ring.

The shear restraint of the steel ring is:

$$F_{v\,allow.} = 0.4 \times 38 \times 7/8 \times 1 = 13.3 \text{ kip/in}$$

1 The welding electrode has a tensile strength of 80 ksi.

$$F_{v\,allow.} = \frac{0.3 \times 80 \times 2 \times .5}{\sqrt{2}} = 16.97 \text{ kip/in}$$

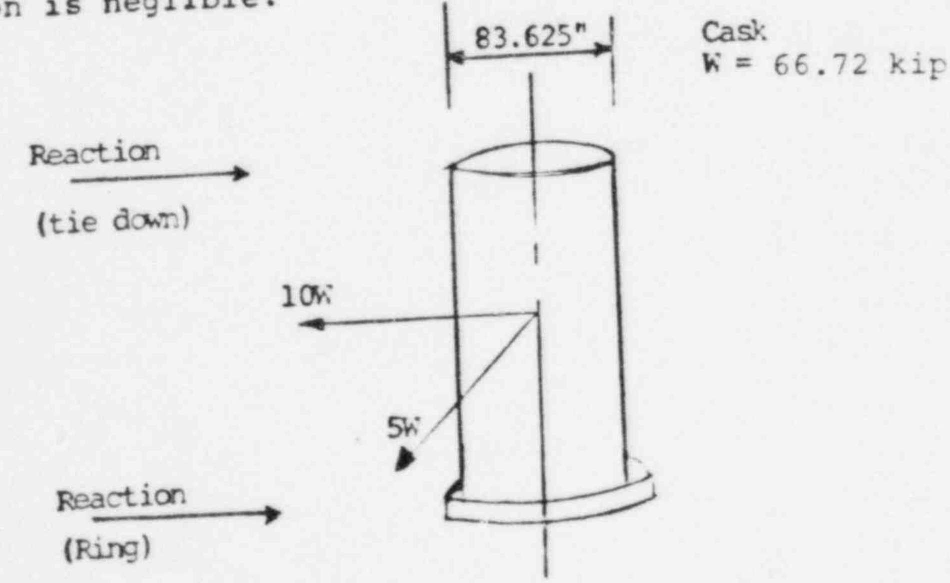
The shear of the steel ring governs.

Width of ring, required to restrain base of cask is:

4 $$\frac{373}{13.3} = 28.05 \text{ in}$$

The minimum diameter of the ring = O.D. of the cask= 83.625"

Therefore, the cask is safely restrained by the ring, assuming friction is neglible.



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2.6.5 Vibration

The approximate natural frequency of the loaded cask is based on the concentric steel shells.

Using Roark * page 576, Case lb, considering the cask a uniform beam with both ends simply supported, and a uniform load w per unit length including the cask weight.

$$f_n = (9.87/2\pi) \quad (EIg/wl^4)^{0.5}$$

Where:

E= Modulus of Elasticity

I= Area of Moment of Inertia

L= Cask height = 96 in.

l= Distance between supports = 83.5 in.

$$w = \frac{65{,}710.80 \ (lb)}{96 \quad (in)} = 684.49 \ lb/in$$

$$E = 29 \times 10^6 lb/in^2$$

$$R = \text{Outside Radius of Cask Shell} = \frac{83.625"}{2} = 41.8125 \text{ in.}$$

$$R_i = \text{Inside Radius of Cask Shell} = R - 1.25 = 40.5625 \text{ in.}$$

$$EI = E \frac{\pi}{4} (R^4 - R_i^4) = 29 \times 10^6 \times 274 \times 10^3 = 7.946 \times 10^{12}$$

$$fn = (9.87/2\pi) (7.946 \times 10^{12} \times 32.2 \times 12/684.49 \times 83.5^4)^{½}$$

$$fn = 477 \text{ HZ}$$

This natural frequency is satisfactory for truck transport, since it is well above the low frequency range of truck suspension systems (1-20 HZ)

* R.J. Roark & W.C. Young, "Formulas for Stress & Strain" Fifth edition, McGraw Hill, 1975

2.6.6 WATER SPRAY

A heavy water spray on the package will not harm the package because it is constructed of ASTM A516, Grade 70 steel. In addition, no water will leak into the primary containment because of the bolted closure and seals. Therefore, the only possible effect of the water spray would be to lower the cask temperature.

2.6.7 FREE DROP

In designing a cask for transport of radioactive material, the regulations require that a free drop through a predetermined distance (in feet) onto a flat essentially unyielding horizontal surface, striking the surface in a position for which maximum damage is expected, must be investigated. This statement implies two things. One, is direct damage at the impact plane due to deformation, and the other is the indirect damage at other locations due to deceleration. From a physical standpoint, the maximum direct damage would occur with the cask so oriented that the line passing between the center of gravity and the point of impact coincides with the direction of the fall. The geometrical representation of the corner drop is shown in Figure 2.6-1. The idealization deformation, the external damage after impact, is indicated as Z.

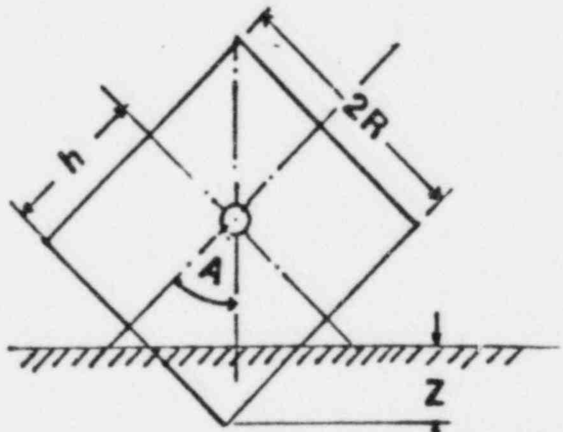


FIGURE 2.6-1 Corner Drop Deformation Geometry

4 The cask is designed so that in case of a top end drop, the first surface which would be impacted would be four cask lifting lugs. However, an additional feature of the cask design is the fact that the cask shell extends 0.8125" above the cask lid, when the lid is fastened to the cask shell by the lid bolts. Moreover, the bolts are nested within the lid, when the lid is installed with the bolts. Therefore, if the cask lifting lugs are sheared off during an end drop, both the lid and the bolts will be protected from contact with the unyielding surface by the extension of the cask shell.

For the bottom end of the cask, the shell is provided with a lip around its circumference, which is 0.5" long and 1.25" thick.

Both the cask shell and lifting lugs are fabricated from A516 grade 70 steel.

The calculations which follow show that the cask drop energy is readily absorbed by the deformation of a small fraction of the surface of either cask lifting lugs or the cask shell extension, during a top or bottom end drop of the AP-300 cask through a height of 12 inches.

S.T. Rolfe and J.M. Barsom in their book "Fracture and Fatigue Control in Structures" state on page 190 that the dynamic yield strength is approximately equal to the static yield strength plus 25ksi. Table 1 on page 17 of the WRC Bulletin 299(11/84) lists the value for yield strength of A516 Gr70 from 38.6 ksi to 45.4 ksi. For our calculations, we used a dynamic yield strength of 68 ksi.

The energy of the end drop is:
E= Wh = 66,720 lbs x 12 in = 800640 in-lb

The volume of A516 Gr70 steel to absorb this energy is:

4

$$V = \frac{E}{\sigma} = \frac{800,640 \text{ in-lb}}{68,000 \text{ lb/in}^2} = 11.77 \text{ in}^3$$

The surfaces of the lifting lugs and shell which can be impacted by a top end drop, and the shell which can be impacted by a bottom end drop are:

a) lifting lugs $A = 4 \times (6" \times 2.5") = 60 \text{ in}^2$

b) shell $A = \pi/4\ (83.625^2 - 81.125^2) = 323.5 \text{ in}^2$

The depth of the lifting lugs or shell extension deformed to absorb the drop energy is:

a) lifting lugs $d = \frac{V}{A} = \frac{11.77 \text{ in}^3}{60 \text{ in}^2} = 0.196 \text{ in}$

b) shell $d = \frac{V}{A} = \frac{11.77 \text{ in}^3}{323.3 \text{ in}^2} = 0.036 \text{ in}$

Consequently the drop energy can be absorbed in either the lifting lugs or the extension of the cask shell in the top end drop and in the extension of the shell in the bottom end drop.

2.6.8 CORNER DROP

Since the most damaging indirect damage from a physcial standpoint would occur in a drop onto the top (lid) corner. The evaluations shall consider this case.

Changing regulations in Title 49, Code of Federal Regulations as of June 30, 1983 cause the requirements for drop height to change from a required (4) four foot drop (173.398 b (3) (i)) to a (1) foot drop (173.465(c)(2)). The concept of dynamic flow pressure, an energy balance developed by K. Lee for the impact conditions of a corner drop and presented at the Third International Symposium on Packaging and Transportation of Radioactive Materials, U.S. Atomic Energy Commission, Richland, Washington, August 1971, shall be used.

2.6.8.1 CORNER DROP OF (1) ONE FOOT

2.6.8.1.1 DIRECT DAMAGE

Determination of the deformation volume is performed by relating the impact energy to the displaced volume, a parameter is obtained as

$E = K\ (Vol)$

Where: E = Impact energy
K = Energy expended to displace one unit volume or dynamic yield strength of the material

Vol = Displaced volume

Therefore:

$E/K = Vol$

Deriving E for a solid cylindrical body of weight W, dropped freely from a certain height, h.

$E = Wh$

Where: W = Weight of the loaded cask = 66,720 lbs.
h = Height of drop in inches = 12 inches

4 $E = 66{,}720 \times 12$
$E = 800{,}640$ lb-in

Equating the two equations for impact energy Vol can be found to be:

$Vol = E/K$
$Vol = WH/K$

Where: K = Dynamic yield strength of ASTM A516 GR70 = 68,000 lbs/in^2

4 $Vol = 800{,}640/68{,}000$
$Vol = 11.77\ in^3$

Determine Z value (stopping distance) for the cask to verify that no significant damage will occur as to cause release of contents.

Using Figure 2.6-1, the angle A (angle of impact) can be seen to be:

Tan∢A = R/H

Where: R = Cask Radius 41.8125"
H = Center of gravity with relation to the top (lid) end = 49.33"

Therefore: The angle of impact (a) is:

Tan∢A = 41.8125/49.33"
Tan∢A = .8476
∢A = 40.28°

Using Figure 2.6-2, it is possible to obtain the following relationships to derive and solve for the deformation or stopping dimension.

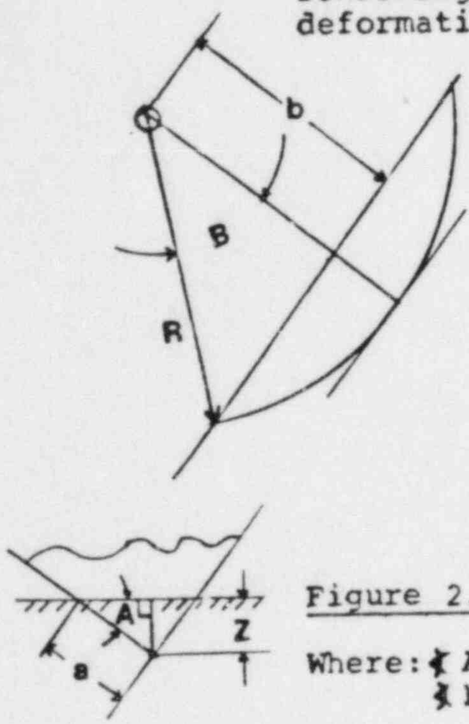


Figure 2.6-2 Deformation Geometry

Where: ∢A = Angle of impact
∢B = Half angle of the extended deformed arc

Using Figure 2.6-2, angle B may be derived as follows:

$a = Z/\sin A$
$b = R - a$

$\cos B = b/R$
$\cos B = (R-a)/R$
$\cos B = (R-Z/\sin A)/R$
$\cos B = 1-Z/(R \sin A)$

Using K. Lee's formula for volume:

$$V = R^3 \operatorname{Tan} A\ (\operatorname{Sin}B - \operatorname{Sin}^3B/3 - B\operatorname{Cos}B)$$

Where B is in radians
It can be found by trial and error that the value of Z which yields the determined volume (11.77) is:

$Z = 0.984$ in
$\operatorname{Cos}B = 1 - Z/(R\operatorname{Sin}A)$
$\operatorname{Cos}B = 1 - 0.984/[41.8125(.6465235)]$
$\operatorname{Cos}B = 0.9635997$
$B = 15.506586$
$B = 0.2706409$ Radians

The deformed volume can then be solved:

$$V = R^3 \operatorname{Tan} A\ (\operatorname{Sin} B - \operatorname{Sin}^3 B/3 - B\operatorname{Cos} B)$$

Where:

$R = 41.8125$
$\operatorname{Tan} A = .8476$
$\operatorname{Sin} B = .26734914$
$\operatorname{Cos} B = .9635997$

$V = (41.8125)^3(.8476)[\ .26734914 - (.26734914)^3/3$
4 $-\ .270640981\ (.9635997)$

$V = (41.8125)^3(.8476)\ (.0001899)$

$V = 11.77\text{in}^3$

Therefore, with $Z = .984$" and $a=1.5220$", it can be seen in the cask drawings that the deformation occurs only in the sacrificial ring and a small section of the lid outer steel plate and there would be no release of the package contents.

For the drop analysis the energy absorption of the ¼ inch deep lip was ignored. (See Figure 2.6-2a) The solid steel plate thickness measured from the intersection of the outside cylindrical surface and the projection of the underside of the circular bottom plate is:

$$T = \frac{1.25}{\sin[90 - 40°17')]} = 1.64"$$

The edge deformation of .984" is wholly within the heavy steel shell. Therefore, it is reasonable to assume that any lead fill deformation has neglible effect on the energy absorption requirements of the cask during the drop.

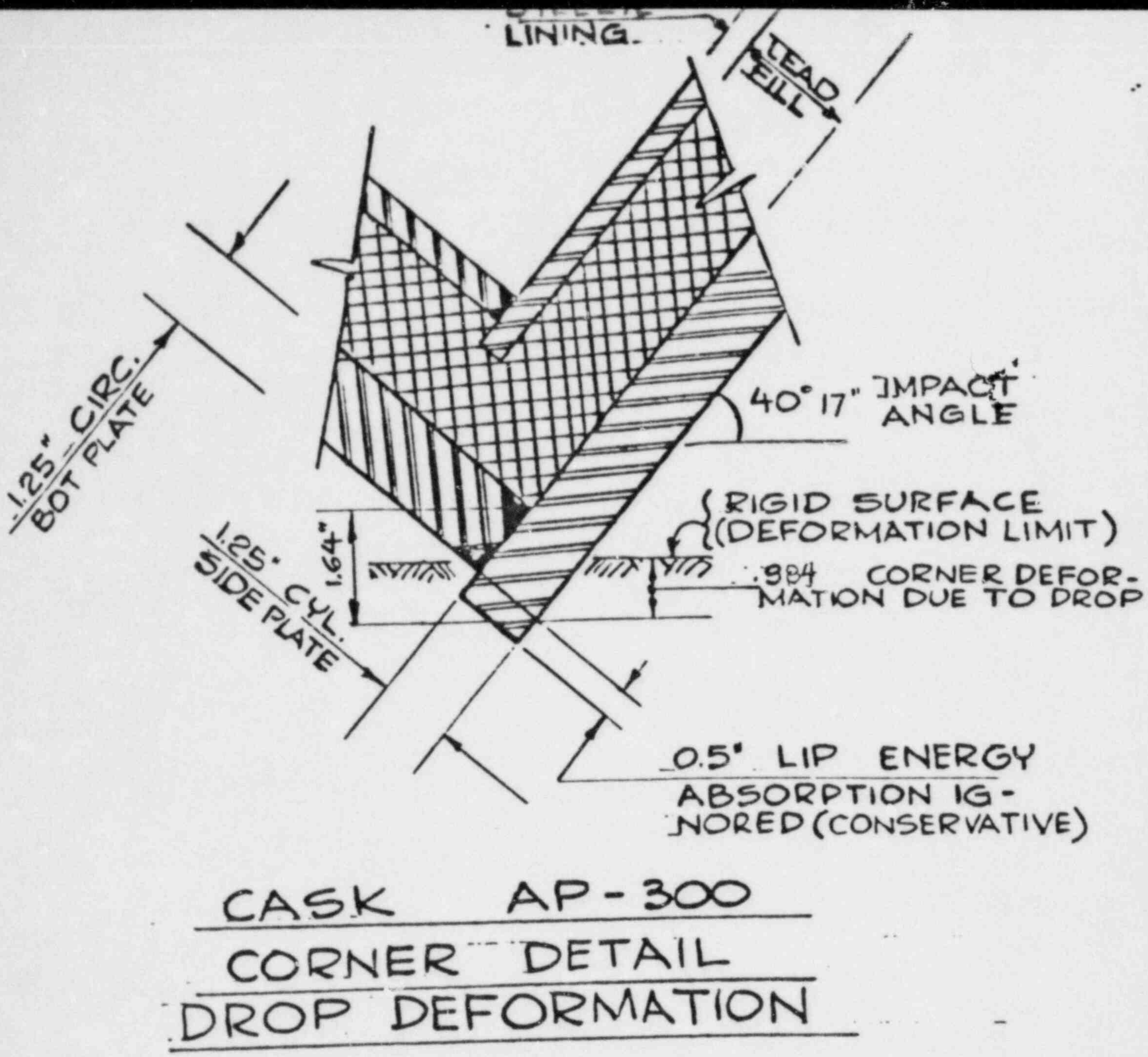
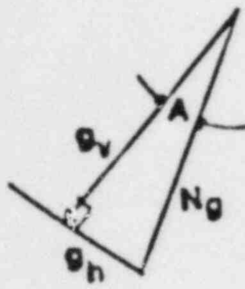


FIGURE 2.6-2a

2.6.8.1.2 INDIRECT DAMAGE

The indirect damage as a result of the drop would be a result of the vertical and horizontal "g" loadings generated by the cask lid and contents on the closure bolts. Therefore, an evaluation of the closure bolts is performed to determine the minimum bolt area and the number of bolts required to sustain these loadings.

Using Figure 2.6-3, the resulting g forces on the bolts can be obtained:



According to K. Lee the maximum "g" load can be obtained as follows:

$$\text{Max Ng} = 2.38 \frac{H}{Z}$$

Where: H = the drop height in inches = 12"
Z = the resulting crush stopping distance = .984 in

Therefore: Ng = 2.38 (12/ .984)
Ng = 29.024

Knowing Ng and ∢A it can be found that:

The vertical component is:

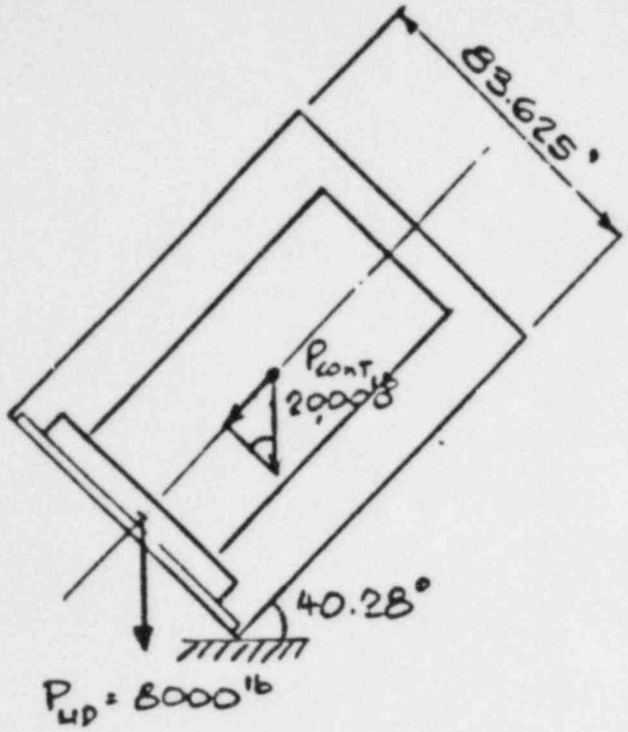
gv = g Cos A
4 gv = 29.024 (.7628941)
gv = 22.142 g's

The horizontal component is:

gh = g Sin A
= 29.024 (.6465235)
gh = 18.764 g's

3 The moment produced by the payload impacting on the lid with respect to the impacted corner is shown below.

CLOSURE BOLT EVALUATION FOR TOP CORNER DROP.



Negative acceleration at impact = 22.27 g

3

ELEVATION AP-300

Lid Moment

4 $$M_{LID} = 22.14 \times 9.46^{kip} \times \frac{83.625}{2} \times \sin 40.28 = 5{,}666 \, ''^{kip}$$

(R = $\frac{83.625}{2}$)

Content Moment on Lid (assuming no friction between Lid and casket)

$$M_{content} = 22.14 \times 20^{kip} \times \frac{83.625}{2} \times \sin 40.28 = \underline{11{,}970} \, ''^{kip}$$

$$\underline{\underline{17{,}636}} \, ''^{kip}$$

4 Bolt Circle = Lid Radius - Edge Dist.

$$R_{\text{Bolt Circle}} = \frac{81.125}{2} - 1.562 = 39.0''$$

Equivalent Nominal Bolt area = 36 × 3/4" φ Bolts

$$A = 36 \times 0.4418 = 15.905 \text{ sq in}$$

$$\text{Nominal Bolt dia. width} = \frac{15.905}{39 \times 2\pi} = 0.0612 \text{ in}$$

Moment of Inertia of Bolt ϕ $= I = \frac{A \times d^2}{8} = \frac{15.905 \times (2 \times 39)^2}{8}$

$= 12095 \ in^4$

4 Moment induced Tension $f_s = \frac{My}{I} = \frac{17,636 \times 39}{12095} = 56.9 Ksi$

Safety Factor against yield of extremely stressed Bolt

3 Yield (.2% offset) 105 Ksi min

$S.F. = \frac{105}{57} = 1.84$

In the calculations, the friction of the payload inside the cask has been neglegted. The moment is developed by the cask lid during the negative acceleration at time of impact and the payload pressing on the lid. The moments induced have been superimposed and are assumed to be restrained by the closure bolts. The incremental force produces a tension of
4 56.9 Kips in the bolts. The ultimate strength of the bolts is 125 Ksi and the yield strength is 105 Ksi. Therefore, a safety factor of 1.84 is available against the yield of the most extremely stressed bolt.

2.6.8.1.2.1 BOLTS IN TENSION

Solving for the force in tension on the bolt due to the vertical "g" component using ORNL-NSIC-68 P.37 Formula (2.7) the minimum bolt area for tensile is:

$$A_{min} = \frac{FWV + FG + FP}{Sa}$$

Where:

FW = Tension on the bolts due to the vertical drop force

FG = Tension on the bolts due to the gasket using Fsg or Foc, whichever is greater

Where:

Fsg = Tension due to gasket seating
Foc = Tension due to maintenance of a tight seal on the gasket
Fp = Tension due to internal pressure at reduced atmospheric pressure
Sa = Ultimate strength of the bolts

Using ORNL-NSIC-68 P.36 Formula (2.4), the tension on the bolts due to the drop (FW) is found to be:

$FWV = W\ (2gv)$

Where:

4 W = cask lid and contents weight = 29,462 lbs.
gv = Vertical "g" component of the drop = 22.271

4 Therefore: $FWV = 29{,}462\ [2(22.14)]$
$FWV = 1{,}304{,}577$ lbs.

Using ORNL-NSIC-68 P.36 Formula (2.5), the tension load due to gasket seating (Fsg) is found to be:

$Fsg = b \pi dy$
Where:
d = Mean diameter of the gasket, in = 77.25
y = Minimum yield design seating strength (ASME Section VIII, Table VA-49.1 (1974) for self sealing type gaskets (Neoprene), lb/in^2=0
b = Effective gasket seating width, in = 1.875

Since the y value is "0" the Fsg value is negligible and can be considered "0".

Using ORNL-NSIC-68 P.36 Formula (2.6) to determine the tensile load on the bolts created to maintain a tight seal on a flat gasket (Foc) is found to be:

$$Foc = bdmp$$

Where:

m = gasket factor (ASME Section VIII Table VA-49.1)=0
b = effective seating width in = 1.875
d = mean diameter of the gasket in = 77.25
p = differential pressure, psi = 11.2 (See Section 1.5.2)

Since the m value is "0", the Foc value is negligible and can be considered "0".

Using ORNL-NSIC-68 P.35 (Formula 2.3) the force due to the internal pressure as a result of the case given in Section 1.5.2 yields:

$$Fp = \frac{p\ (d)^2}{4}$$

Where:

p = differential pressure across the gasket = 11.2
d = mean diameter of the gasket, in = 77.25

$$Fp = \frac{(11.2)(77.25)^2}{4}$$

Fp = 16,709 lbs.

Substituting the derived values into the Formula (2.7) for the minimum bolt area it is found to be:

$$AM = \frac{FWV + Fp}{Sa}$$

Where Sa = Ultimate tensile strength of the bolts (A320-L7a from Table 1.3.1) = 125 K psi.

Therefore:

$$AM = \frac{1{,}304{,}577 + 16{,}709 \text{ lbs.}}{125{,}000}$$

4 $AM = 10.570$ sq. in.

Evaluations for the 3/4" bolts yields

$$NB = \frac{AM}{AB}$$

Where:

N_B = number of bolts required
A_{min} = minimum bolt area due to tension
A_B = root Area of the bolts = .34

Therefore:

$$N_B = \frac{10.570}{.34} = 31.1$$

4 $N_B \approx 32$ bolts

Since the cask uses 36 - 3/4" bolts, the lid will remain in place during the drop.

2.6.8.1.2.2 BOLTS IN SHEAR

Solving for the force in shear on the bolts due to the horizontal "g" component ORNL-NSIC-68, P.37 Formula (2.7).

$$A_{min} = \frac{FWH}{Sa}$$

Where:

A_{min} = Minimum bolt area for shear
FWH = Tension due to the horizontal drop free
Sa = Ultimate tensile strength = 105K psi

Using ORNL-NSIC-68 P. 36, Formula (2.4) the shear on the bolts due to the drop (FWH) is found to be:

$FWH = W\ (2g_h)$

Where:

W = cask lid weight - 9,462 lbs.
g_h = Horizontal g component of the drop - 18.764

Therefore:

$FWH = 9{,}462\ [2(18.764)]$

4 $FWH = 355{,}100$ lbs.

Substituting the results into the Formula (2.7), the minimum bolt area for shear is:

$$A_{min} = \frac{FWH}{Sa}$$

$$A_{min} = \frac{355{,}100}{105{,}000}$$

4 $A_{min} = 3.382$ sq. in.

Evaluating for the 3/4" bolts yields:

$$N_B = \frac{A_{min}}{AB}$$

Where:

N_B = Number of bolts required
A_{min} = Minimum bolt area due to shear = 3.382 sq. in.
AB = Nominal shank diameter = .44 sq. in.

Therefore:

$$N_B = \frac{3.382}{.44} = 7.7$$

4 N_B = 8 bolts

Since the cask is designed with 36 - 3/4" bolts, the lid will remain in place.

2.6.8.1.3 Conclusions

4 Since the stopping distance $Z = .984"$ and $a = 1.522"$, all the damage will occur in the sacrificial ring and lid top corner and the bolts are sufficient to retain the lid in both shear and tension, therefore, no release of radioactive contents will occur due to direct or indirect damage in the (1) one foot corner drop.

2.6.9 Compression

The AP-300 cask weighs in excess of 5000 Kg. Therefore, no compression load was considered.

2.6.10 Penetration

The regulations in 49 CFR 173.465 (c) stipulate that the cask must be able to withstand the impact of a 1.25 inch diameter bar with hemispherical end weighing 13.2 lbs. being dropped from a height of 3.3 feet on the most vulnerable region of the cask. The most vulnerable region of the cask is the 1.25 inch thick outer steel shell.

If the ASTM-A516 Grade 70 steel plate is assumed perfectly rigid, the kinetic energy of the falling bar must be absorbed by the shear deformation of the plate. This is conservative because any bending deformation of the plate will also absorb energy and reduce the tendency for shear failure. The energy required to cause shear can be expressed as:

$$E_S = K \pi D t^2 S_S$$

Where: K = ductility factor = .60

S_S = Ultimate strength in shear 27,000 psi

D = Bar diameter = 1.25 in.

t = Plate thickness = 1.25 in.

Thus the energy the outer shell can absorb is:

$$E_S = 99,400 \text{ in-lbs.}$$

The kinetic energy of the falling bar is found to be:

$$E_b = Wh$$

$$E_b = 13.2 \ (3.3 \times 12)$$

$$E_b = 523 \text{ in-lbs.}$$

Thus, the most vulnerable part of the cask will not be penetrated by the falling bar.

$A_1 = 9.4 - \alpha_1 = 0.0825$

$A_2 = -8.4\alpha_2 = 0.0525$

$$B_{Fe} = (9.4)e^{(0.0825)(0.39)(3.18)} - (8.4)e^{(-0.0525)(0.39)(3.18)}$$

B_{Fe} (Selected) = 2.54

5.4.1 Gamma Flux

Calculation of gamma flux at P1 per curie

$$\frac{\phi\alpha}{N} = \frac{B\ S_v R_o^2 [F(\theta_1 b_2)]}{2\ (a+z)} \quad \frac{\gamma}{cm^2\text{-sec-curie}}$$

Sv = Volumetric source strength/cm^3

$$\frac{S_v}{N} = \frac{\gamma \times 3.7 \times 10^{10}}{\text{Volume}} = \frac{\gamma}{cm^3\text{-sec-curie}}$$

The volume of the liner is: $5.79 \times 10^6\ cm^3$

$$\text{So: } \frac{S_v}{N} = \frac{2 \times 3.7 \times 10^{10}}{5.79 \times 10^6} = 1.278 \times 10^4 \quad \frac{\gamma}{cm^3\text{-sec-curie}}$$

$$\text{and: } \frac{\phi}{N} = \frac{(2.54)(1.278 \times 10^4)(95.25)^2(8 \times 10^{-5})}{2\ (10.80 + 55)} =$$

$$1.79 \times 10^2 \quad \frac{\gamma}{cm^2\text{-sec-curie}}$$

Determination of dose rate/curie at P1 (contact)

$$\frac{\text{Dose Rate}}{\text{Curie}}\ (\text{mR/hr/curie}) = (1.79 \times 10^2)(2.22 \times 10^{-3})$$

$$\frac{\text{Dose Rate}}{\text{Curie}} = 0.4\ \text{mR/hr/curie}$$

For Maximum quantity of curies

$$\text{Dose Rate} = 0.4\ \frac{mR}{hr/Ci} \times 20\ Ci = 8\ \frac{mR}{hr}$$

Case #2. Top & bottom shielding calculations

1. The gamma flux ($\phi\gamma$) is = $2.1 \times 10^2\ \frac{\gamma}{cm^2\text{-sec-curie}}$
2. The dose rate per curie = $(2.1 \times 10^2)(2.22 \times 10^{-3})$ =

   $\frac{0.46\ \text{mR/curie}}{\text{hr}}$

3. For Maximum quantity of curies
   dose rate (mR/hr = 0.46 $\frac{mR}{hr}$/curie x 20 Ci

   = 9.2 mR/hr

5.4.2 Free Drop Gamma Shielding

An end drop of a cask in which the lead is not bonded to the steel shells, can cause the lead to settle, thus creating a void in the end opposite the impact end. According to Shappert (ORNL-NSIC-68) the change in lead height is:

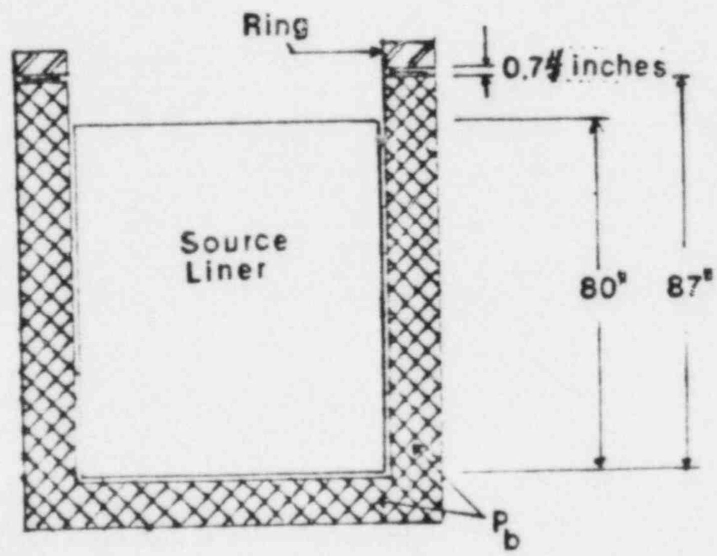
$$\Delta H = \frac{R\,W\,H}{(R^2 - r^2)(t_s \sigma_s + R\sigma_L)}$$

Where: R = outer radius of lead = 40.5 inches
r = inner radius of lead = 38.5 inches
4 W = weight of cask plus contents = 66,720 lbs.
t_s = thickness of outer steel shell = 1.25 inches
σ_s = dynamic flow stress of steel shell = 60,000 psi
σ_L = dynamic flow stress of lead = 5,000 psi
H = height of drop = 12 inches (1 ft)

4 Thus: $H = \frac{(40.5)\,(66,720)\quad(12)}{[(40.5)^2 - (38.5)^2]\,[(1.25)\,(60,000) + (40.5)\,(5,000)]}$

4 H = 0.74 inches

The geometry will be:



4 As a result, the contact dose rate will not be affected by the 0.74" lead slump, since there will not be a source window without lead shielding. The cask is designed to withstand a lead slump of 6.71".

8.2 Maintenance Program

The maintenance program is established to ensure continued performance of the cask. The cask will be routinely inspected prior to each departure to the reactor site. In addition, periodic inspections of the cask will be made requiring testing and/or replacement of critical components as follows:

8.2.1 Structural and Pressure Tests

8.2.1.1 Structural

On an annual basis, the lifting pads will be closely inspected for cracks or other signs of failure. If signs of failure are found, the lifting pads will be replaced and load tested.

8.2.1.2 Pressure Tests

On an annual basis, the cask cavity will be hydrostatically pressure tested to one and one half (1-1/2) times the maximum normal operating pressure. Should a leak be found, it will be repaired and the test rerun.

8.2.2 Leak Tests

Red Devil Gasket (or neoprene equivalent) and pressure port plug tests.

On an annual basis, the containment cavity will be pressurized
1 to 1.5 the maximum pressure of the containment cavity during design conditions. The pressure level will be checked over a
4 10 minute interval and no pressure loss or evidence of leakage during this period will be accepted. Should a pressure drop be noted, The cause will be found, repaired and the test rerun.
1 An annual leak test will be performed using a helium leak detector with a sensitivity of $1x10^{-3}$ atm-cc/sec.

8.2.3 Subsystem Maintenance

There are no subsystems provided for the AP-300 cask which require maintenance.

8.2.4 Valves, Rupture Discs and Gaskets on Containment Vessel

The gaskets will be visually inspected before and after each use of the AP-300 cask. The gaskets will be tested during the annual pressure and leak tests, described in Sections 8.2.1.2 and 8.2.2. The gaskets will be replaced after twelve (12) sequential uses
4 or if found unsatisfactory during the annual leak test. There are no other components of the AP-300 cask which need maintenance.

Each of the 36 closure bolts will be inspected before use to insure that the screw threads are intact. Bolts which bind when manually installed in a test tap shall be repaired or replaced.

1 Each bolt hole will be checked before use by manually checking bolt rotation with a test bolt. Should test bolt bind,tap hole will be repaired before use.

8.2.5 Shielding

Before each shipment, a gamma radiation survey of the cask will be conducted to verify that the cask is within acceptable limits for shipment.

8.2.6 Thermal

The 150 watt thermal load capacity does not require thermal tests.

8.2.7 Cask Surface Inspection

1 On an annual basis, the cask will be inspected visually to verify protective coating integrity. Defects which are noted will be refurbished, in accordance with specification A83-GCPO, to restore the integrity of the protective coating.

NO	DESCRIPTION	MATERIAL	REQ
34	½"-20-2A-1.50" L. BOLT HEX. SOCKET. CS S.A.320	GRADE-L7A	1
35	GASKET 0.500" I.D. 0.750" O.D. 0.125" TH.	MANVILLE RED DEVIL TYPE 940	1
36	HELI-COIL INSERT -1185-8 SEE NOTES (1) TO (4)		1
37	¼"-20-2A-2.125" L. BOLT HEX. SOCKET S.A.320	GRADE-L7A	1
38	GASKET 0.30" I.D. 0.50" O.D. 0.125" TH.	MANVILLE RED DEVIL TYPE 940	1
39	HELI-COIL INSERT -1185-4CN SEE NOTES (5) TO (8)		3
40	SLEEVE 0.75" DIA. 6.75" L. ASTM A 240 TYPE 304	S.S. BAR	1
41	PLUG 1.50" DIA. 0.50" L.	A.240 TYPE 304	2
42	ROD 0.750" DIA. 3.313" L.	A-240 TYPE 304	1
43	PLUG 1.50" DIA. 1.25" L.	A-516 GRADE 70	3
44	PLUG 0.50" DIA. 1.25" L.	A-516 GRADE 70	1
45	PLUG 0.50" DIA 0.50" L	A-240 TYPE 304	1

Nº	REVISIONS	APPR.	DATE
1	GASKET MATERIAL SPEC. ADD REV BOX	[illegible]	4/25/85

ANEFCO
904 Ethan Allen Hwy.
P.O. Box 433
Ridgefield, Conn. 06877

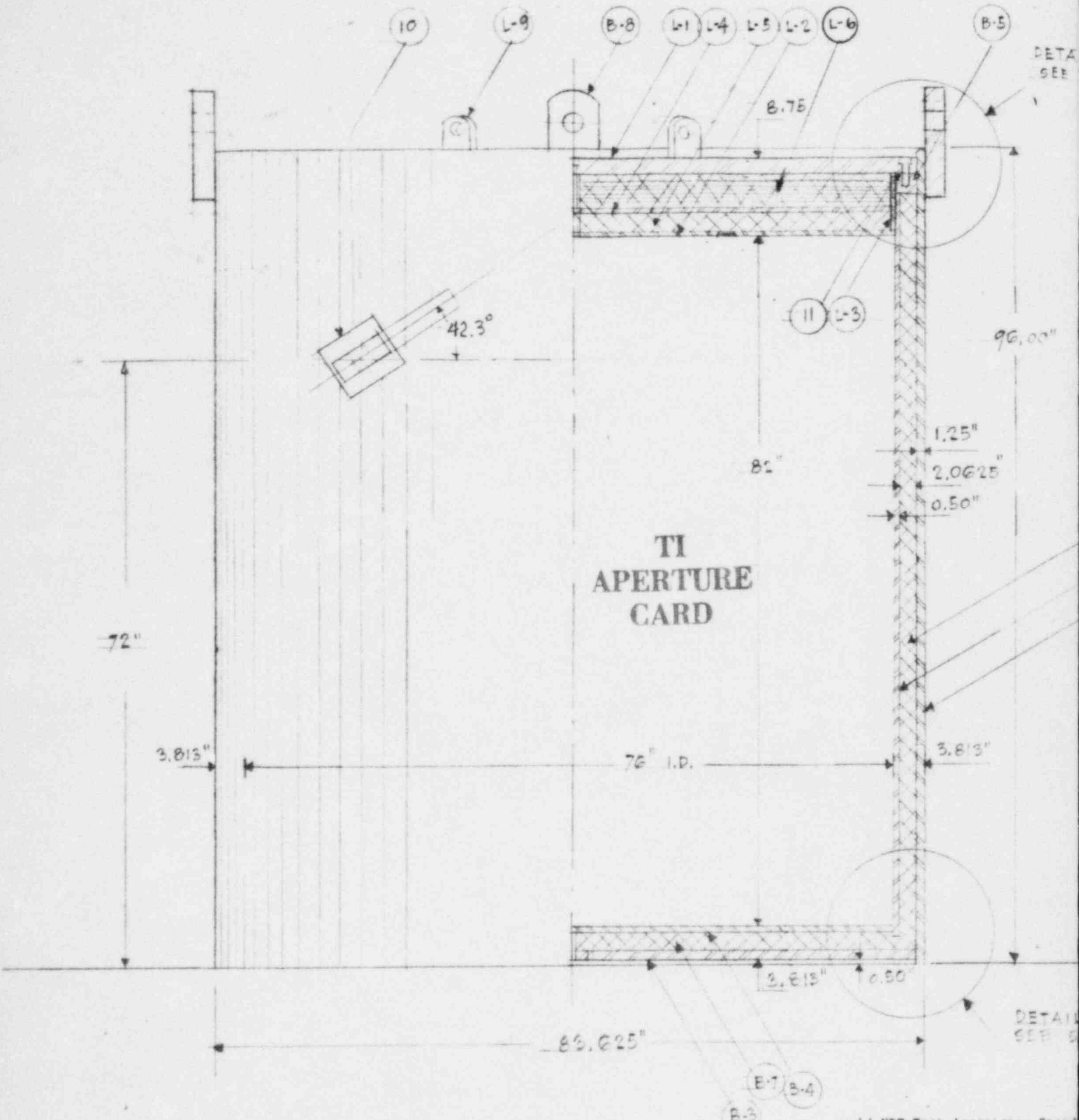
SCALE:
DATE: 2-17-83
APPROVED BY [signature]
DRAWN BY C.C

AP-300 CASK

MATERIAL LIST — HOLE PLUGS TEST PRESSURIZATION PORT

DRAWING NUMBER 146-1 REV. 1

DIETZGEN MASTER FORM 198MF



weld NDT Test Acceptance Stand

Liquid Penetrant (LP) - ASME S

Mag Particle (MP) ASME Sectio

Radiographic Inspection (RI) A

Plate B-1 to be fillet welded using multipass string technique using SMAW & SAW processes. Groove design to be double bevel with 52° bends and 1/8" maximum root gap. Weld to be 100% NDT using x-ray.

Plate B-2 (Inner shell) to be fillet welded using multipass string technique using SMAW & SAW processes. Groove design to be single bevel with 53° with1/8" maximum gap. Weld to be 100% RI.

Nº	REVISIONS	APPR.	DATE
1	NOT REQ - ADD REV. BOX	[illegible]	1/5/85
2	LID GASKET SPEC. - TIE DOWN PAD +	[illegible]	2/15/85
3	ADD CONCRETE IN LID VOID	[illegible]	3/20/85

Also Available On Aperture Card

L"B"
SH'T Nº 134-1

Nº	DESCRIPTION	MATERIAL	RQ
L-6	CONCRETE - 3.8125 × 75" ϕ	CONCRETE	1
L-1	PLATE 2.00" TH × 81.125" O.D.	A 240 TYPE 304	1
L-2	PLATE 0.50" TH × 76.00" O.D. ± .03 O.D.	A 240 TYPE 304	1
L-3	PLATE RING 0.50" TH. 76.00 O.D. × 6.25" H	A 240 TYPE 304	1
L-4	PLATE RING 0.375" TH. 75.00" O.D. H.	A 240 TYPE 304	1
B-1	SHELL 1.25" TH. × 96.00" H. × 262.82 ± L. 81.125 $^{+0.25}_{-0.00}$ I.D.	A 516 GRADE 70	1
B-2	INNER SHELL 76.00" I.D. 0.50 TH × 87.40" H 242.00" ± L SS	A 240 TYPE 304	1
B-3	PLATE 1.25" TH. × 81.125" ϕ S.S.	A 516 GRADE 70	1
B-4	PLATE 0.50" TH × 76.00 ϕ S.S.	A 240 TYPE 304	1
B-5	RING 2.25" TH × 76.00 I.D. × 81.125 O.D. H.	A 240 TYPE 304	1
B-6	LEAD 2.0625" $^{+0.125}_{-0.00}$ TH × 87.50" H × 254.00 ± L CHEMICAL GRAD LEAD	B-29-55	1
B-7	LEAD 2.0625" $^{+0.125}_{-0.00}$ TH × 77.00" ϕ CHEMICAL GRADE LEAD	B-29-55	1
B-8	LIFTING PAD 13" H × 6" W × 2.50" TH C.S.	A 516 GRADE 70	1
L-9	LIFTING PAD FOR LID 3.75 H × 4" W × 1.25" TH.	A 516 GRADE 70	4
10	TIE DOWN PAD SEE DWG Nº 138 - 16" × 10.25" × 2.5" TH	A 516 GRADE 70	4
11	LID GASKET 76.00" I.D. × 81.125" O.D. × 2½" × ⅛"	ARAMID FIBER W/ SYN. RUB. COMP'D BIND.	1
12	CLOSURE BOLTS ¾" ϕ × 2¾" UNC 3 A BOLT HEX SOCKET	ASTM A320 L7A	36
L-5	LEAD 2.0625" $^{+0.125}_{-0.00}$ × 75.00 ϕ B-29 CHEMICAL GRADE LEAD	B-29-55	1
32	SECURITY LEAD WIRE SEAL 12" LONG		1
33	LID SEAL BLOCK ¼" TH × ½" W × ½" W.		1

B-6
B-2
B-1

1. Welders and welding operators shall conform to Section IX of the ASTM Boiler and Pressure Vessel Code.
2. Welding procedures shall conform to Section IX of the ASME Boiler and Pressure Vessel Code.
3. Carbon steel surfaces shall have a protective coating (i.e. Paint) in accordance with ANEFCO spec. A83-GCPO dated 1/12/83, "General Specifcation for Painting & Coating Work, Ship Applied, for ANEFCO Shipping Casks".

"A"
T Nº 134-1

ards
ection VIII Div. 1 Appendix 8
VIII Div. 1 Appendix 6 or MIL STD 271E
ME Section VIII Div. 1 UW-51

ANEFCO
904 Ethan Allen Hwy.
P.O. Box 433
Ridgefield, Conn. 06877

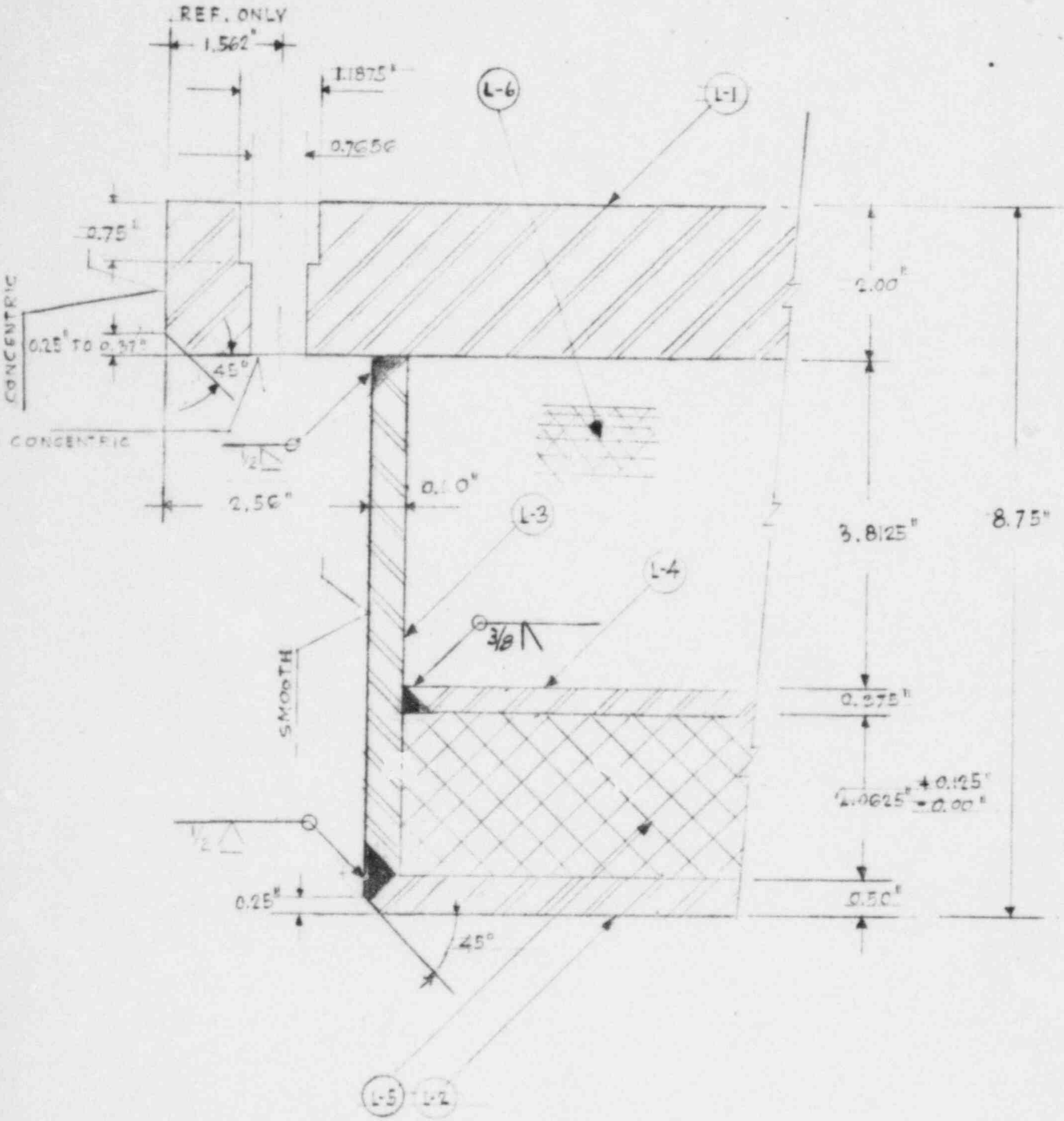
SCALE: 1/16" = 1"	APPROVED BY [illegible]	DRAWN BY C.C.
DATE: 2-15-83		

AP-300 CASK

HALF ELEVATION — HALF SECTION

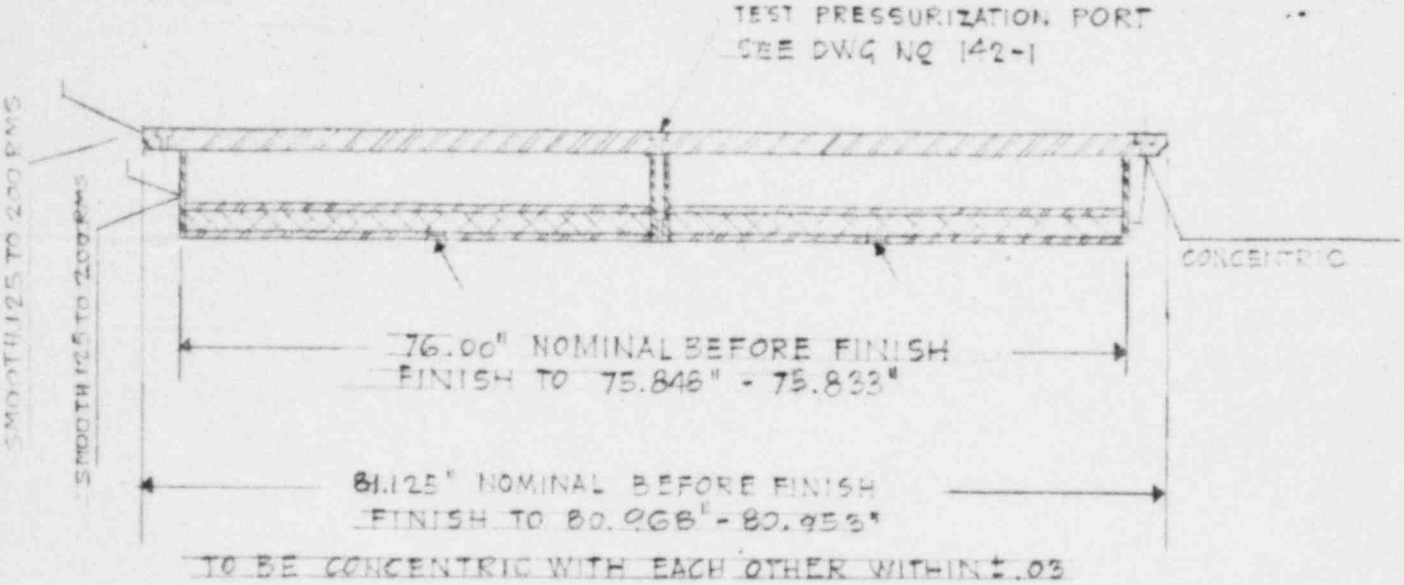
DRAWING NUMBER: 133-1 REV. 3

3505070453-01



ALL WELDS TO BE 100% MT OR LP

SEE DWG. 133-1 FOR SPECIFICATIONS



LID FINISH
SCALE : 1/16" = 1"

TI APERTURE CARD

Also Available On Aperture Card

Nº	REVISIONS	APPR.	DATE
4	ADD CONCRETE TO LID CAVITY - CORR. L-3 to L-4 WELD SYMB.	[illegible]	3/20/85
3	CORR WELD SYMBOLS - DELETE BACKING RING	[illegible]	2/1/85
2	WELD NDT REQUIREMENTS	[illegible]	11/20/84
1	WELDING SYMBOLS - ADD REV. BLOCK	[illegible]	7/15/84

ANEFCO
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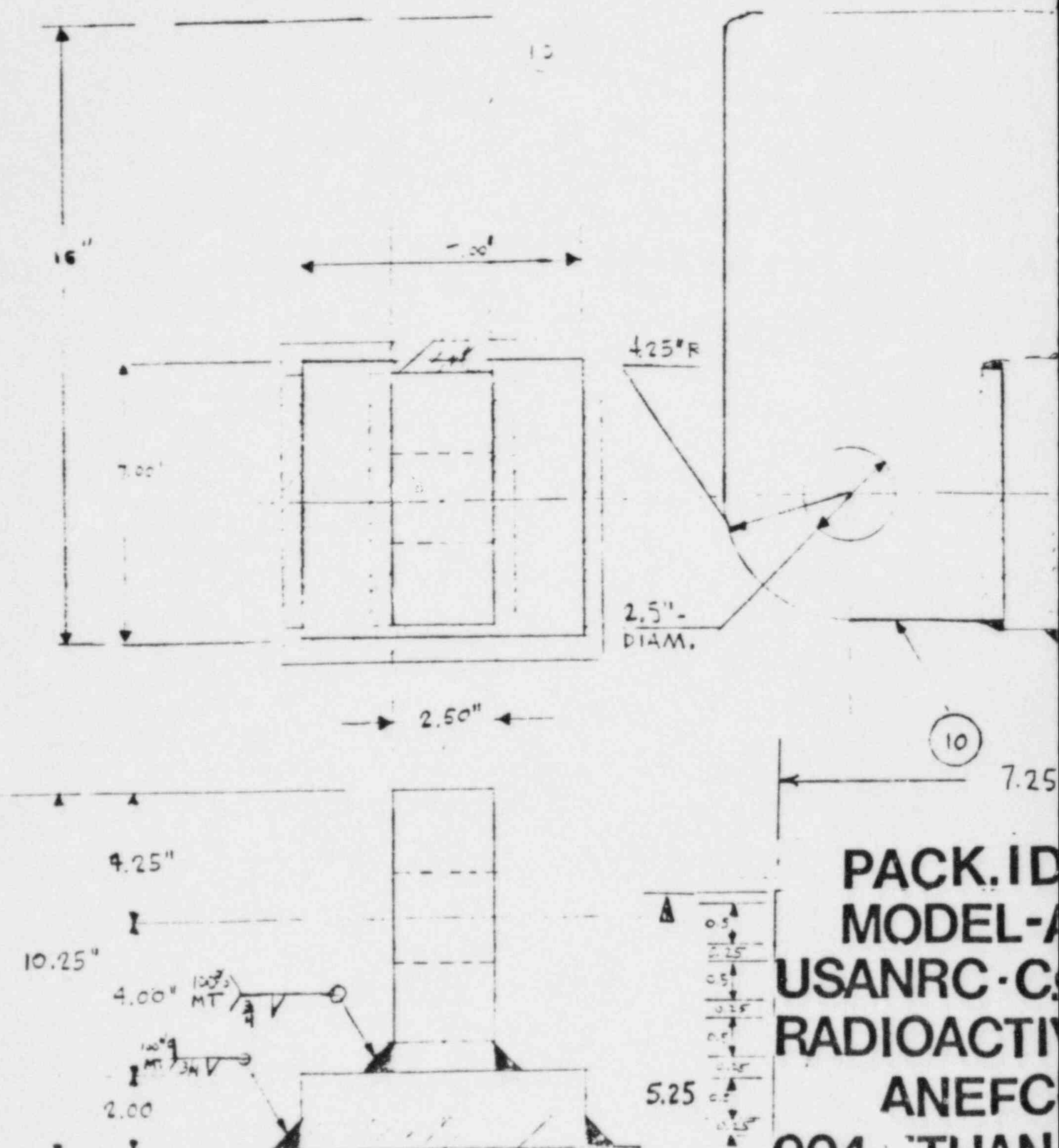
SCALE: 1/2" = 1"	APPROVED BY	DRAWN BY C.C.
DATE: 2-15-83		

AP-300 CASK

LID AND LID FINISH

DRAWING NUMBER 135-1 REV 4

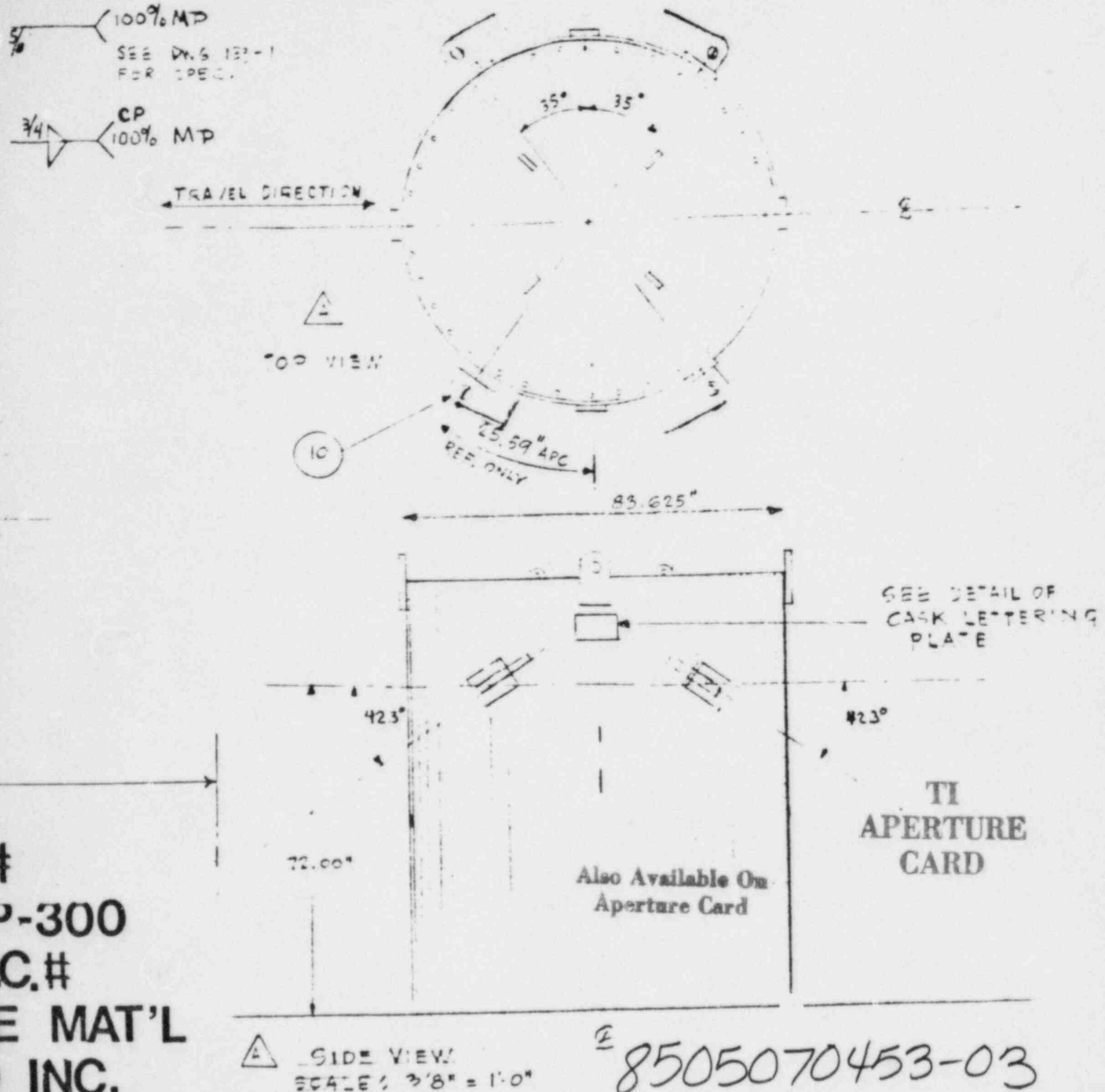
8505070453-02



4	PACK ID#; WELD for TIE DOWN PAD		3/25/85
3	TRAVEL DIRECTION		2/1/85
3	CORR. WELD SYMBOLS - TIE DOWN BOLT #		2/1/85
2	TIE DOWN PAD, NDT REQ.		11/5/84
2	REV. TIE-DOWN PAD DIM		11/5/84
2	REV. CASK LETTERING PLATE		11/5/84

CASK LETTERING

1	CORR. WELD SYMB.
△	ADDED TOP & SIDE
Nº	REVISIONS



TI
APERTURE
CARD

Also Available On
Aperture Card

8505070453-03

.#
AP-300
O.C.#
VE MAT'L
O INC.
ALLEN HY.
D, CT.
LBS-65,711

PLATE SCALE: 1/2" = 1"

	β	5/10/85
VIEWS - RD REVIEW	JDM	3/5/83
	APPR	DATE

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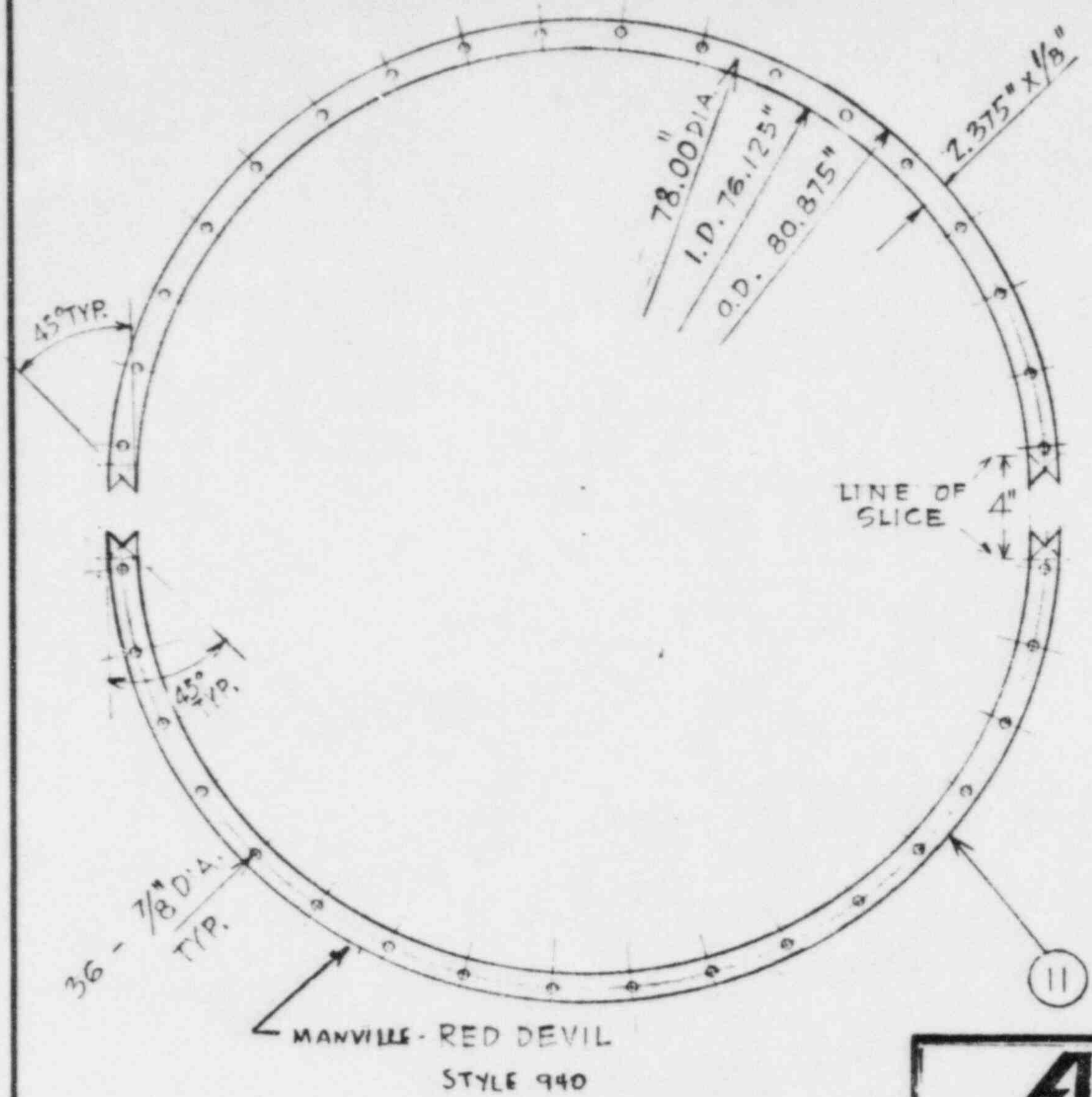
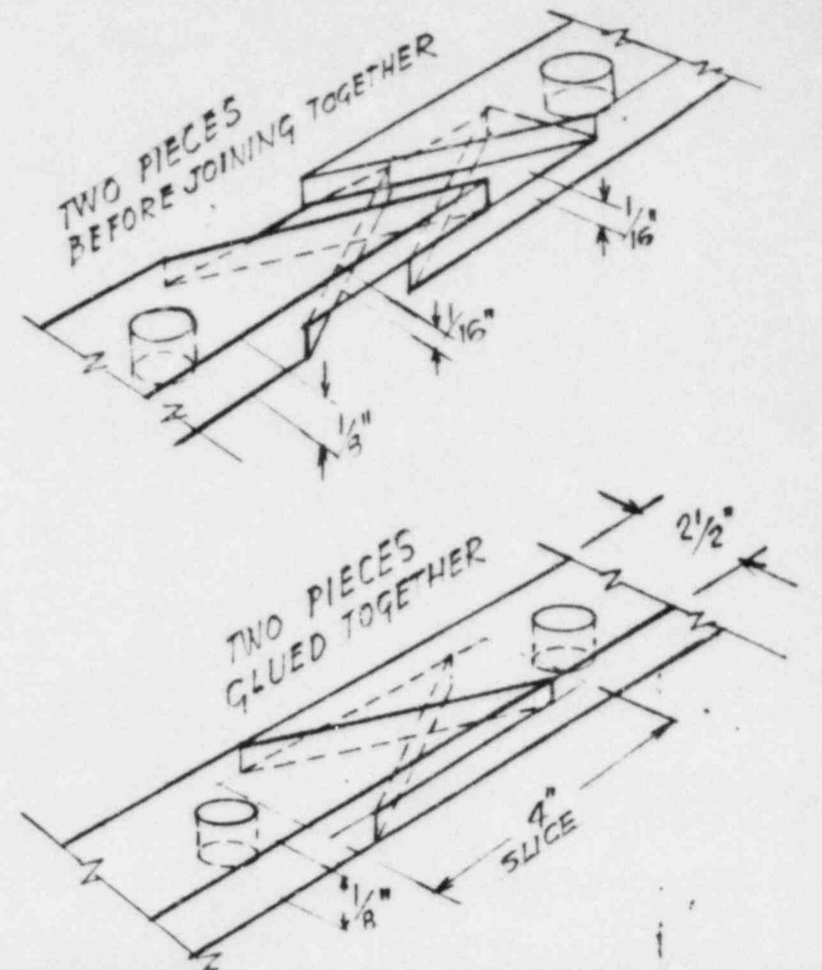
SCALE AS NOTED	APPROVED BY	DRAWN BY C.C
DATE 10-21-82		

AP-300 CASK

TIE-DOWN PAD (4 PLACES)

DRAWING NUMBER 138-1 REV. 4





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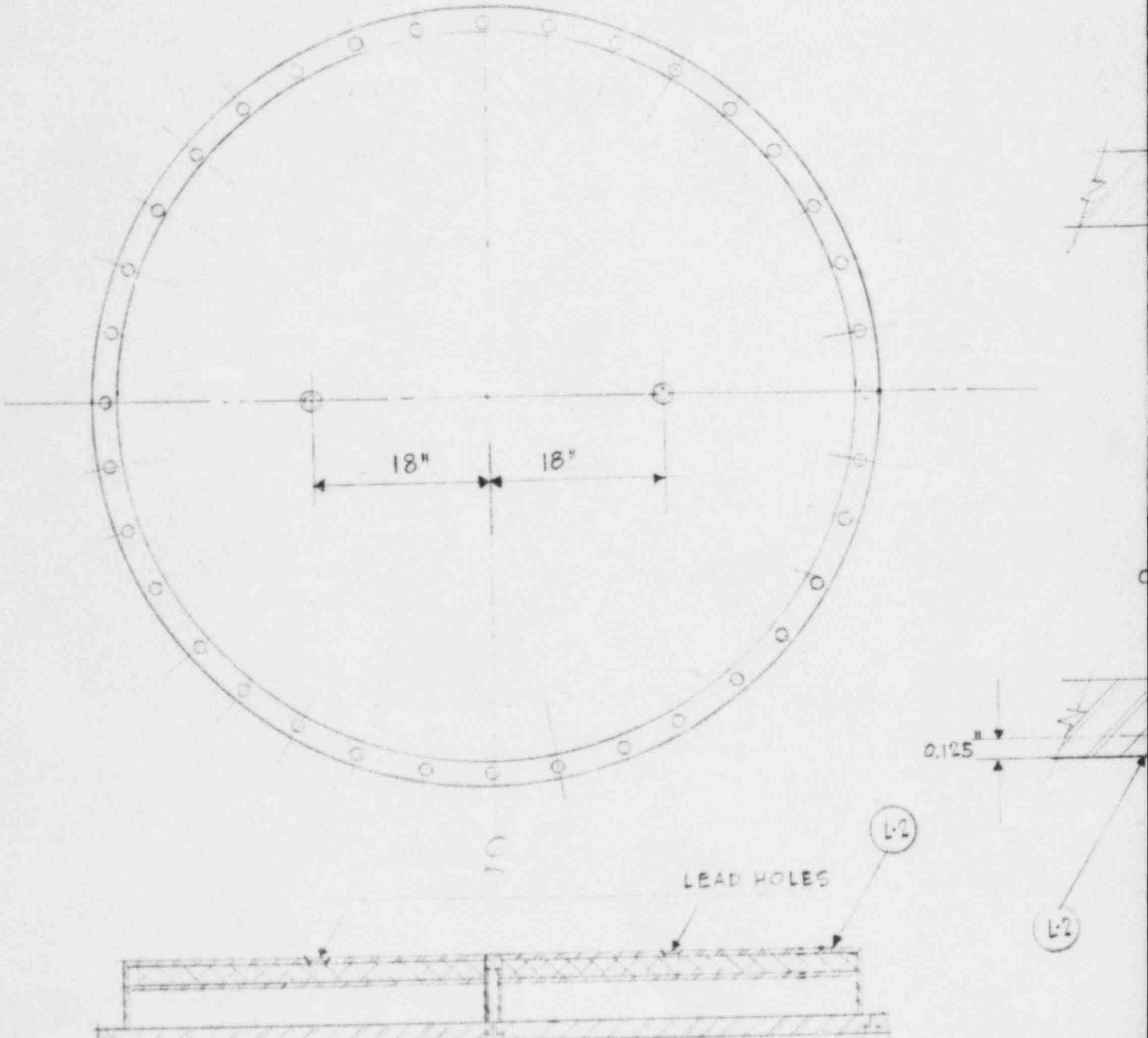
SCALE: 1/16" = 1"	APPROVED BY	DRAWN BY C. C.
DATE: 10-20-82		

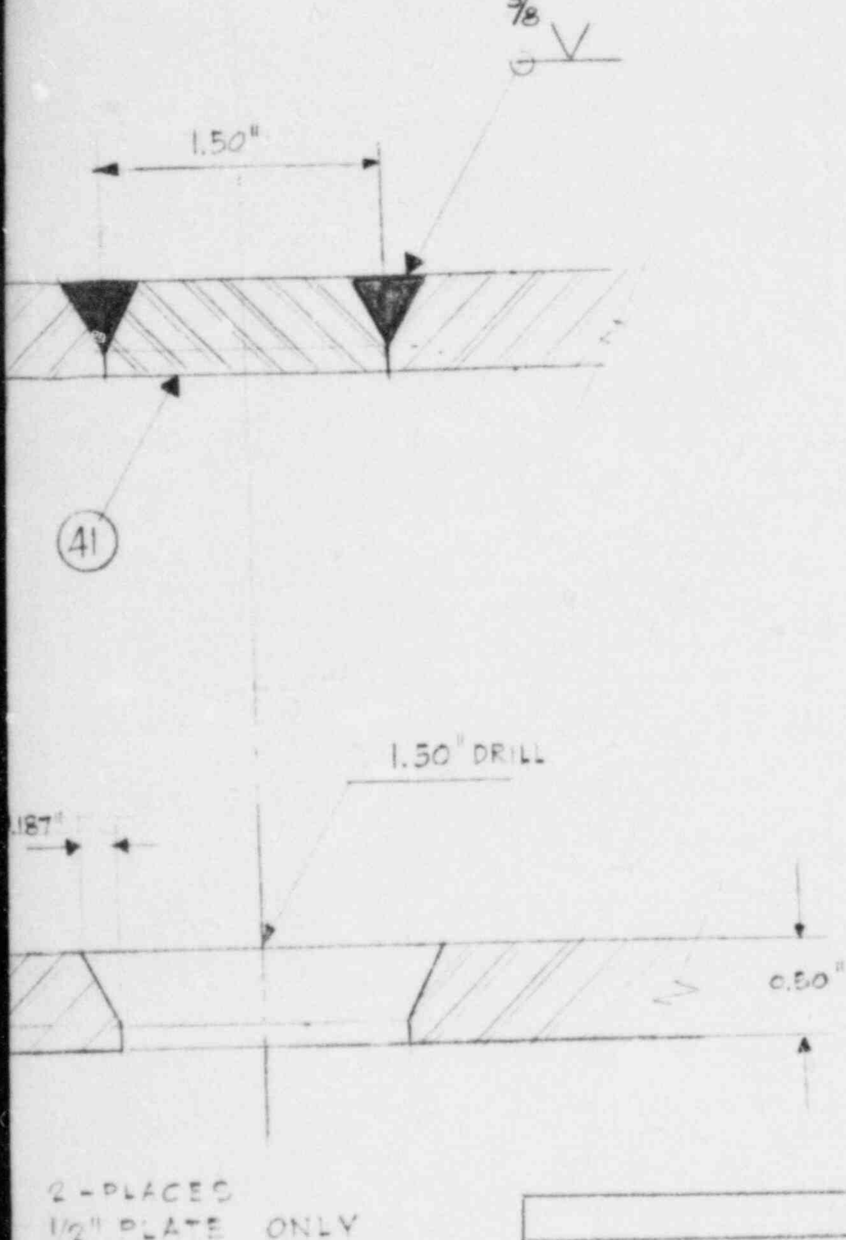
AP-300 CASK

LID GASKET ASSEMBLY

DRAWING NUMBER 139-1 REV. 1

1	GASKET MAT. SPEC. - ADD REV. BOX		3/25/85
NO	REVISIONS	APPR	DATE


18"
18"
LEAD HOLES
L-2
0.125"
L-2



No	REVISIONS	APPR	DATE
1	CHANGED WELD TO 3/8" - ADD REV BOX	JJ	3/15/85

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SCALE: 1/2" = 1"	APPROVED BY	DRAWN BY C.C.
DATE: 4-8-83		

AP-300 CASK

HOLES IN LEAD COVER

DRAWING NUMBER 143 - 1 REV. 1