SAFETY ANALYSIS REPORT

CNS 14-170 SERIES III

TYPE A RADWASTE SHIPPING CASK

REVISION 0

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1.0 PURPOSE

The purpose of the following document is to provide the information and engineering analysis that demonstrates the performance capability and structural integrity of the CNS 14-170 Series III Radwaste Shipping Cask and its compliance with the requirements of 10 CFR 71, Section 71.21 and Appendix A.

2.0 DESCRIPTION

The CNS 14-170 Series III Shipping Cask is a top-loading, shielded container designed specifically for the safe transport of Type "A" quantities and greater than Type "A" LSA radioactive waste materials between nuclear facilities and waste disposal sites. The radioactive materials can be packaged in a variety of different type disposable containers.

The CNS 14-170 Series III Shipping Cask is a primary containment vessel for radioactive materials. It consists of a cask body, cask lid, and a shield plug being basically a top-opening right circular cylinder which is on its vertical axis. Its principal dimensions are 81-1/2 inches outside diameter by 81-1/2 inches high with an internal cavity of 75-1/4 inches inside diameter by 73-3/8 inches high.

2.1 Cask Body

The cask body is a steel-lead-steel annulus in the form of a vertical oriented, right circular cylinder closed on the bottom end. The side walls consist of a 3/8-inch inner steel shell, a 1 7/8-inch thick concentric lead cylinder, and a 7/8-inch thick outer steel shell. The bottom is four inches thick (two 2-inch thick steel plates welded together) and is welded integrally to both the internal and external steel body cylinders. The steel shells are further connected by welding to a concentric top flange designed to receive a gasket type seal. Positive cask closure is provided by a gasket seal and the required lid hold-down ratchet binders. Four lifting lugs are welded to the outer steel shell.

2.2 Cask Lid

The cask lid is four inches thick (two 2-inch thick steel plates welded together) which is stepped to mate with the upper flange of the cask body and its closure seal. Three steel lug lifting devices are welded to the cask lid for handling. The cask lid also contains a "shield plug" at its center.

2.3 Shield Plug

The shield plug is five inches thick (two 2 inch thick steel plates and one 1 inch thick steel plate welded together) fabricated in a design similar to the cask lid. It has a gasket seal and uses eight hold-down bolts to provide positive cask closure. The shield plug also has a lifting device located at its center to facilitate handling.

2.4 Cask Closure

The shipping cask has two closure systems: (1) the cask lid is closed with eight high-strength ratchet binders and a gasket seal, (2) the shield plug is closed with eight 3/4-inch bolts and the same seal system used for the cask lid but smaller.

2.5 Cask Tiedown System

The shipping cask tiedown system consists of two sets of crossed tiedown cables (totaling 4). Four shear blocks or a shear ring (affixed to the vehicle load bed) firmly position and safely hold the cask during transport.

2.6 Cask Internals

The internals of the CNS 14-170 Series III shipping cask can be any one of an extensive variety of configurations. Some examples are given in terms of weight in 2.7. Other arrangements are possible, providing the gross weight and the decay heat rate limits are observed, and the material secured against movement relative to the cask with an internal structural members such as bottoms and pallets. Basically, the internal's consist of the waste, containers if process waste is being transported, and the structures used to fix the waste relative to the cask. The container may be constructed of high integrity plastics, steel or other metals.

2.7 Gross Package Weights

The respective gross weights of the cask components and its designated radwaste loads are as follows:

Cask body	29,030 pounds
Closure lid	5,800 pounds
Shield plug	370 pounds
Total cask (unloaded)	35,200 pounds
Large container(s) and waste	17,800 pounds
Total cask (loaded)	53,000 pounds

2.8 Radwaste Package Contents

2.8.1 Type and Form of Material

The contents of the various internal containers can be process solids in the form of spent ion exchange resins, filter exchange media, evaporator concentrates, and spent filter cartridges. Materials will be either dewatered, solid, or solidified.

2.8.2 Maximum Quantity of Material Per Package

Type A materials and greater than Type A quantities of low specific activity radioactive materials in secondary containers with weights not exceeding 17,800 pounds.

3.0 DESIGN CONDITIONS

3.1 General Standards

(Reference 10 CFR 71 Section 71.31)

3.1.1 Chemical Corrosion

The cask is constructed from heavy structural steel plates. All exterior surfaces are primed and painted with high quality epoxy. There will be no galvanic, chemical, or other reaction among the packaging components.

3.1.2 Positive Closure System

As noted, the primary lid is secured by means of eight high strength ratchet binders. The secondary lid is affixed with eight 3/4 inch diameter bolts. Therefore, the package is equipped with a positive closure system that will prevent inadvertent opening.

3.1.3 Design Criteria on which Structural Analysis is Based

3.1.3.1 Stresses in material due to pure tension are compared to the minimum yield of that material. The safety factor is found by dividing the minimum yield by the calculated stress. A safety factor greater than 1.0 is required for acceptability. (f_y = 38,000 psi for ASTM A516 Grade 70). For the shell, steel having a minimum yield strength of 49,000 psi is specified. For the tie down lugs, steel having a minimum yield strength of 46,000 psi is specified.

3.1.3.2 Stresses in material due to shearing is analyzed using the "Maximum Energy - Distortion Theory" which states the shearing elastic limit is $1/\sqrt{3}$ = 57.7% of the tensile elastic limit[1]. As with 3.1.3.1, a factor of safety greater than 1.0 is required for acceptability.

f_{sy} = (0.577)(38,000) = 21,926 psi (for A516 Grade 70)

3.1.3.3 The weld filler material rod is E70 Grade. Analysis is based on American Welding Society Structural Code D1.1-79. For fillet welds, shear stress on effective throat regardless of direction of loading is 30% of specified minimum tensile strength of weld metal. For complete joint penetration groove welds with tension normal to the effective area the allowable stress is the same as the base metal.

Fillet weld allowable stress = (70,000 psi)(0.3) = 21,000 psi

In order to be more conservative, a weld efficiency of 85% is also added. Since all welds have been nondestructively examined, weld efficiency is known to be greater than this.

[1] Design and Behavior of Steel Structures, Salmon & Johnson, page 47.

3.1.4 Lifting Devices

3.1.4.1 Package Weight

The package weights used for analysis are as follows:

Empty package	35,200 pounds
Payload: large container and waste	17,800 pounds
Gross Weight	53,000 pounds

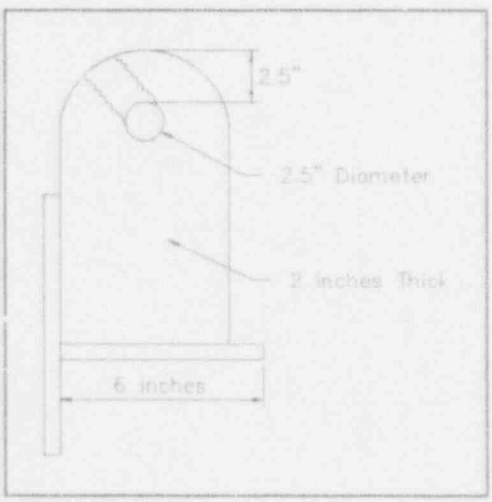
3.1.4.2 Cask Lifting Lugs

The cask lifting lug material is ASTM A516 Grade 70 with a minimum of 38 ksi Tensile Yield Strength and 21,926 psi shear yield strength (57.7% of 38,000 psi).

The maximum load is 53,000 lbs, and four lugs are used to lift the cask.

(53,000 lbs)(3 g's/4 lugs) = 39,750 lbs/lug (Vertical)

TEAR OUT



Sling Angle to Lift 45°

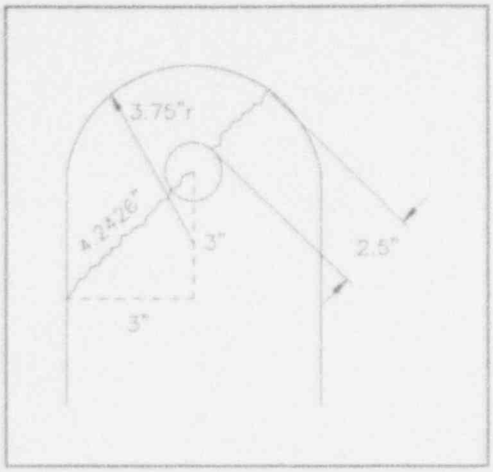
Load = 39,750 lbs/sin (45°)

Load = 56,215 lbs

Stress = 56,215 lbs/[(2)(2 in)(2.5 in)]
σ = 5,622 psi

5,622 psi << 21,926 psi F.S. = 3.9

TENSION



Sling Angle to Lift 45°

Load = 56,215 lbs.

Stress = 56,215 lbs/[(2 in)(5.4926 in)]

σ = 5,117 psi

5,117 psi << 38,000 psi F.S. = 7.4

4.2426 - 1.25 + 2.5 = 5.4926 in

TEAR OUT

Vertical Lift

Stress = 39,750 lbs/[2(2 in)(2.5 in)]

σ = 3,975 psi

3,975 psi << 21,926 psi F.S. = 5.5

TENSION

Vertical Lift

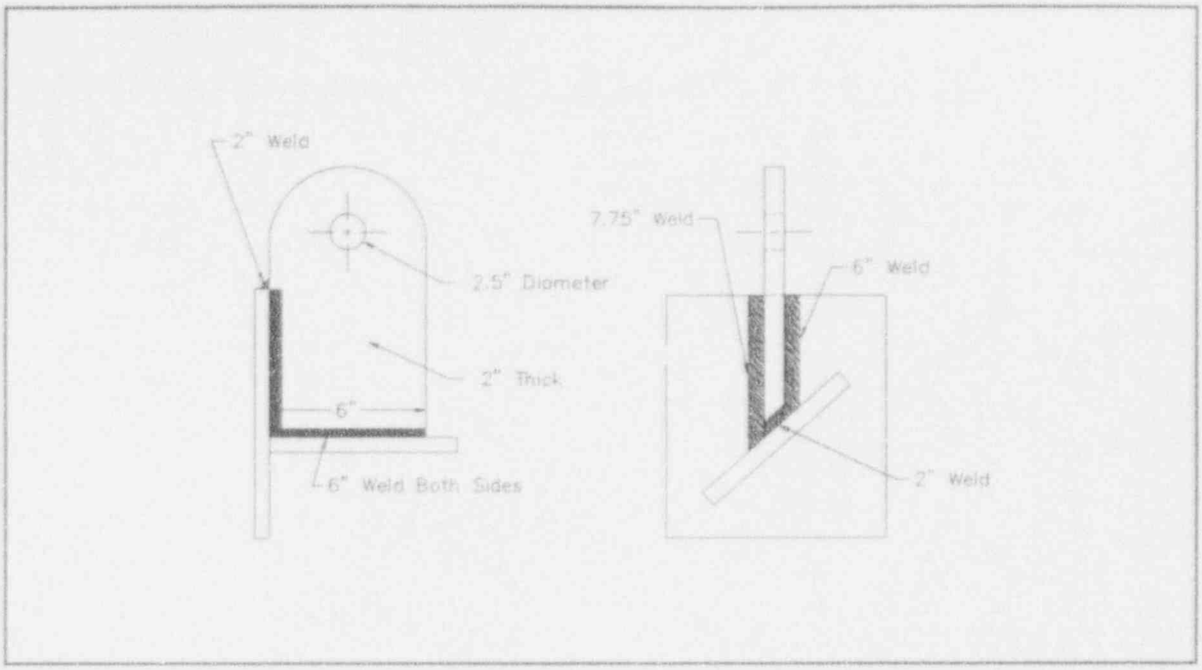
Stress = 39,750 lbs/[(2 in)(6 in - 2.5 in)]

σ = 5,679 psi

5,679 psi << 38,000 psi F.S. = 6.7

3.1.4.3 Cask Lifting Lug Welds

All welds are 3/4-inch fillet. The allowable shear stress on the effective area of the weld is 0.3 times the nominal tensile strength of the weld metal, E 70 rod, or (0.3)(70,000) = 21,000 psi.



Vertical Lift

Assume weld to be 85% efficient.

Minimum throat of weld = sin (45°)(3/4 in) = 0.53 inch
Weld strength per inch = 0.85(0.53 in)(1)(21,000 psi) = 9460 lbs/in of weld
Weld required = 39,750 lbs/9460 lbs/in of weld = 4.2 in of weld

4.2 in. << (2 in + 2 in + 12 in + 7.75 in + 6 in) F.S. = 7.1

3.1.4.4 Tiedown Lugs for Lifting Cask (inadvertent use)

If it is assumed the entire load is carried by the tiedown lug, the section modulus equals $(bh^2)/6$; where b = 15.5 inches (length of tiedown lug); and h = 2 inches (thickness of tiedown lug). (See Diagram on page 3-15).

Tiedown lug section modulus = $15.5\ (2^2/6) = 10.33\ in^3$

Stress = $(39{,}750\ lbs)(3\ in/10.33\ in^3) = 11.5\ ksi$ where 3" is the distance from the cask surface to the centerline of the hole.

11.5 ksi < 46 ksi F.S. = 4.0

Weld required on lift lug is 4.2 inches; 4.2" < 12" F.S. = 2.9

Weld to Tiedown Lug

Shear = 39,750 lbs/(2)(15.5 in) =	1282 lbs/inch of weld compression or tension due to moment couple
39,750 lbs(3 in/15.5 in) tiedown lug =	7,694 lbs-in/inch of lug and moment couple with 2-inch thick lug (2 inch(3847 lbs) = 7,694 lb/in

Moment of Rotation

(39,750)(4.34)/15.5 in - 11,130 lb-in/in lug
For 2" lug, then 5565 lb/in

Stress on weld to tiedown lug

$$\sigma = \sqrt{1281^2 + 3847^2 + 5565^2}$$

= 6886 lbs per inch

6886 lbs per inch of weld < maximum of 9640 lb per inch of weld

F.S. = 1.37

3.1.4.5 Lift Lugs with 45° Sling Angle

The forces are 39,750 lbs vertical and 39,750 lbs horizontal. These forces will be restrained by the 7.75 and 6.0-inch long, 3/4-inch welds attaching the lift lugs to the reinforcing plate and the two 6.0-inch long, 3/4-inch welds attaching the lift lugs to the tiedown lugs.

The shear stresses due to the vertical component of the force is:

f = 39,750/(7.75 in + 6.0 in + 6.0 in + 6.0 in)(0.75)(0.707)(0.85)
= 39,750/11.6 = 3,427 psi

The centroid of the welds is located as follows:

$\overline{y}$ = [7.75(7.75/2) + 6(6/2) + 6(7.75) + (6)(6)] + (7.75 + 6 + 6 + 6) in
= (30.0 + 18 + 46.5 + 36) + 25.75 in
= 5.06 in

Total Moment = (2.75 in)(39,750 lb) = 109,313 in-lb

Total Moment = Compressive Moment + Tensile Moment

Compressive Moment = Tensile Moment

Total Moment = 2(Tensile Moment)

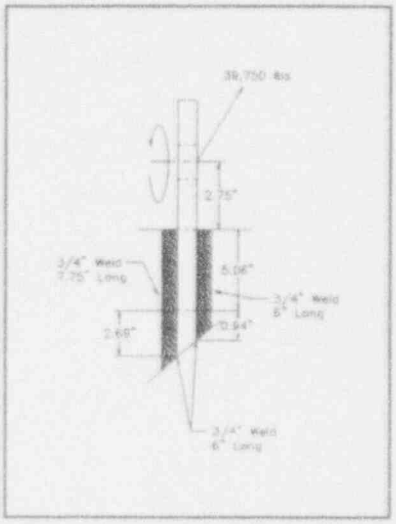
$= 2f[(6)(2.69) + (2.69)(2.69)(1/2) + (6)(0.94) + (0.94)(0.94)(1/2)(0.75)(0.707)(0.85)]$

$= 2f[(16.1 + 3.6 + 5.6 + 0.4)(0.75)(0.707)(0.85)]$

$= 2f(25.7)(0.75)(0.707)(0.85)$

$= 23.29f$

$f = 109{,}313/23.29 = 4{,}694$ psi



Combined Stress $= \sqrt{4694^2 + 3427^2}$

$= 5{,}812$ psi

F.S. = 9460/5,812 = <u>1.63</u>

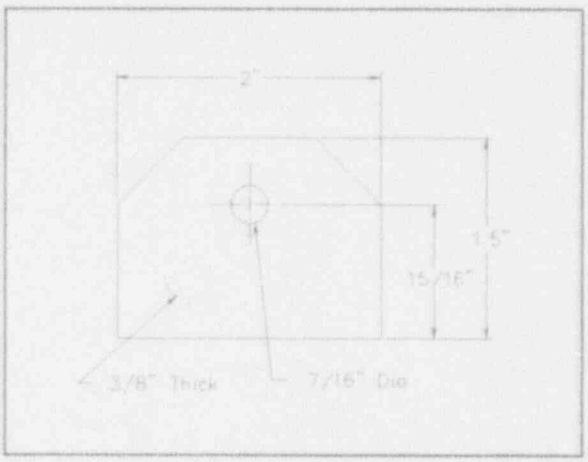
Therefore, it can be safely concluded that the lug will not yield under a load equal to three times the weight of the package.

3.1.4.6 **Lid Lifting Lugs** (Secondary and Primary)

A. <u>Secondary Lid Lifting Lug</u>

Material is ASTM A516 Grade 70

Maximum load carried by one lug is 370 lbs.



<u>TEAR OUT</u>

Area = 2[(1-1/2 - 15/16) - 7/32][3/8]

Area = 0.258 in^2

Stress = (3 g's)(370/0.258 in^2) = 4,310 psi

4,310 psi << 21,926 F.S. = 5.0

TENSION

Area = (2.0 - 7/16)(3/8) = 0.586 in^2

Stress = (3)(370)/0.586 = 1,900 psi

1,900 psi << 38,000 psi F.S. = 20

B. Secondary Lid Lifting Lug Weld

1/2" fillet weld with allowable stress of 21,000 psi

Effective size = sin (45°)(0.5) = 0.353 in

Area of weld = (2 + 2 + 3/8 + 3/8)(0.353) = 1.68 in^2

Stress = (3)(370)/1.43

σ = 660 psi

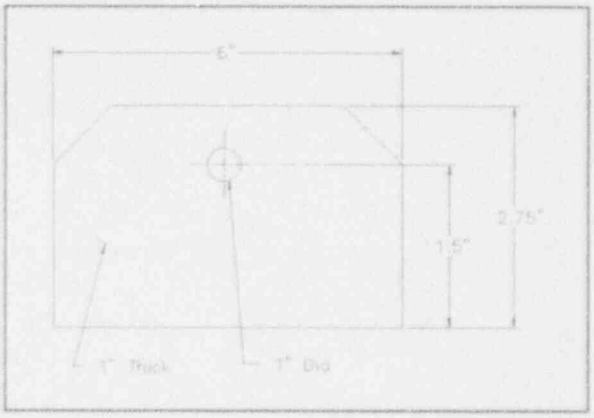
660 psi << 21,000 psi F.S. = 31.8

Therefore, the secondary lid lug is able to resist a load of three times its weight without reaching a yield stress.

C. Primary Lid Lifting Lugs

Material is ASTM A516 Grade 70.

Maximum Load = Primary Lid 5800 lbs
Secondary Lid 370 lbs
6170 lbs



TEAR OUT (Vertical Lift)

Area = (2)(2.75 - 1.5 - 0.5)(1) = 1.5 in^2

Stress = 6,170/1.5

σ = 4,113 psi

4,113 psi << 21,926 psi F.S. - <u>5.3</u>

<u>TEAR OUT</u> (45° Sling Angle)

Area (short path) = $(\sqrt{0.75^2 + 0.75^2})(1) = 1.06$ inch^2

Load = $\sqrt{(6170^2)(2)}$ = 8,726 lbs

Stress = (0.5)(8726)/1.06 = 4,116 psi

4,116 psi << 21,926 psi F.S. = <u>5.3</u>

<u>TENSION</u> (Vertical Lift)

Area = (6 - 1) 1 = 5 in^2

Stress = 6170/5 = 1,234 psi

1,234 psi << 38,000 psi F.S. = <u>30.8</u>

<u>TENSION</u> (45° Sling Angle)

Area (short path) = $\sqrt{(2)(1.25^2)} - 0.5 = 1.2678$ inch^2

Stress = (0.5)(8726)/1.2678 = 3,441 psi

3,441 psi << 38,000 psi F.S. = <u>11.0</u>

F. <u>Primary Lid Lifting Lug Weld</u>

1/2" weld at shear of 21,000 psi

(a) Shear stress due to vertical = horizontal component

$\sigma v = \sigma h$ = 6170/(6+6+1+1)[sin (45°)](0.5)(0.85)

= 1467 psi

(b) Stress due to moment

Total Moment = Compression Moment + Tensile Moment

Compression Moment = Tensile Moment

Total Moment = 2 (Tensile Moment)

= 2 (2)(3)(0.67)(f)(0.5)(0.707)(0.85)

= 2.4f

f = 9,255/2.4 = 3,856 psi

$$\text{Combined Stress} = \sqrt{3856^2 + 1467^2 + 1467^2}$$

σ = 5521 psi

F.S. = 21,000/5521 = 3.8

Therefore, it can be concluded that the lifting lugs for the lid are more than adequate to resist a load at three times its weight.

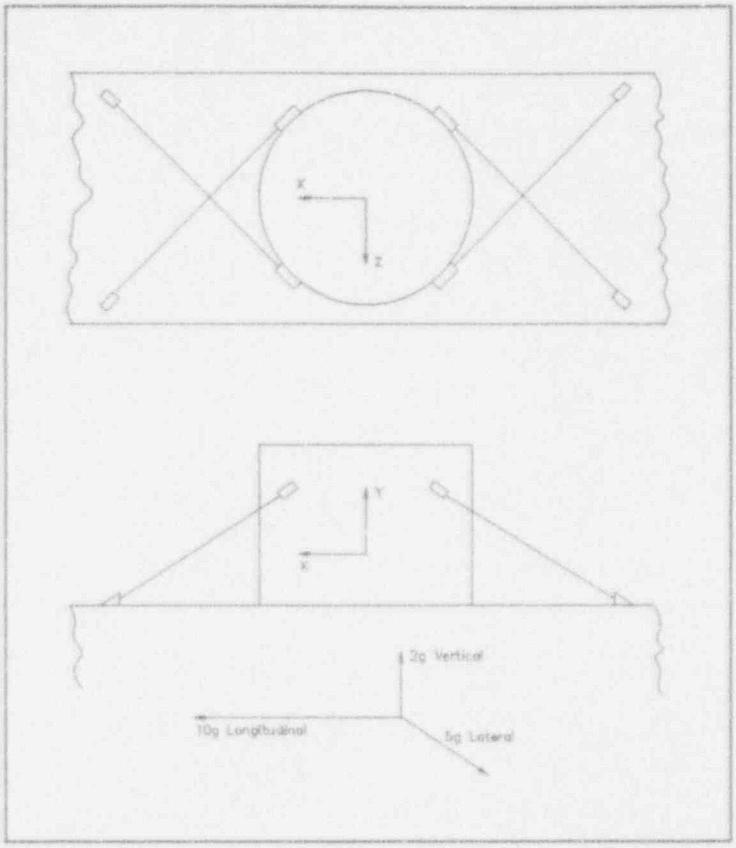
3.1.4.7 Lifting Lug Covers

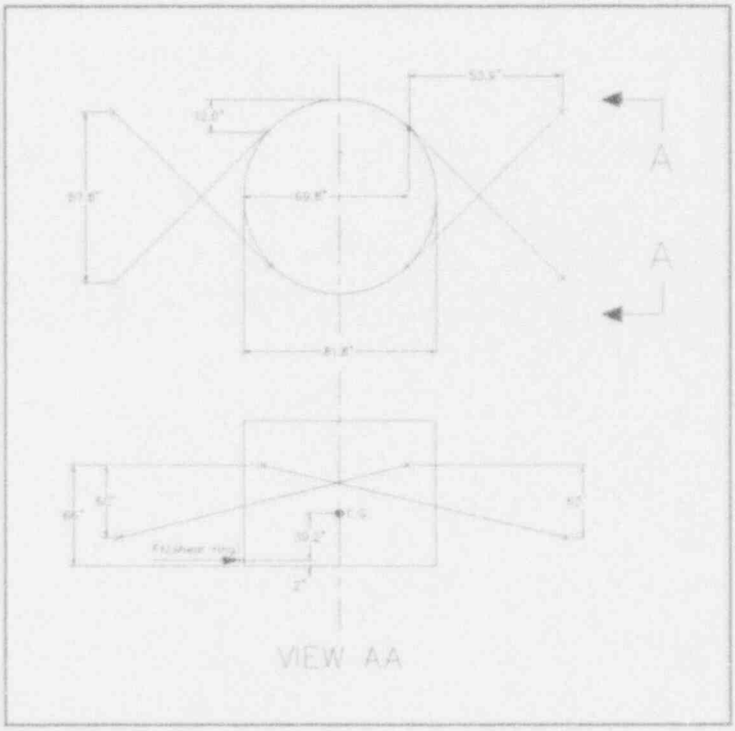
Since the primary and secondary lid lifting lugs are not capable of resisting the full weight of the package, they will be covered during transit.

3.1.5 Tie Downs

The tie down lug material is ASTM A516 Grade 70 with a minimum yield of 46 KSI and a 26.5 KSI usable shear (57.7% of 46 KSI). The cask outer shell material has a minimum yield of 49 KSI, which will be specified for fabrication and certified by test of the material.

A system of tie downs is provided as part of the package. They will be utilized as follows:


X
Z
Y
X
2g Vertical
10g Longitudinal
5g Lateral


53.9"
A
A
VIEW AA

3.1.5.1 Cask Center of Gravity

Item	Weight		Arm	Blower
Cask	35,300 lbs	X	42.9"	1,510,080 lbs-in
Liner/Waste	17,700 lbs	X	37.7"	671,060 lbs-in
	53,000 lbs			2,181,140 lbs-in

Center of Gravity - 2,181,140/53,000

CG = 41.2 inches

3.1.5.2 Tie Down Forces

Reference frame with respect to the trailer is shown on the tie down drawing.

up-down Y; front-rear X; side-side Z

Accelerations: Y axis - 2 g's
X axis - 10 g's
Z axis - 5 g's

Tie Down Lengths

Long tie downs (low trailer attachment points)

$$\text{length} = \sqrt{63^2 + 57.8^2 + 53.9^2} = 101.0 \text{ inches}$$

Short Tie Downs (high trailer attachment points)

$$\text{length} = \sqrt{60^2 + 57.8^2 + 53.9^2} = 99.2 \text{ inches}$$

Tie Down Tensions

Tie down tensions resolved by vector direction

Long tie down at tension T_L

Along Y axis: $(63.0/101.0)(T_L) = 0.623 \cdot T_L$

Along X axis: $(53.9/101.0)(T_L) = 0.5333\ T_L$

Along Z axis: $(57.4/101.0)(T_L) = 0.5718\ T_L$

Short tie down at tension T_S

Along Y axis $(60/99.2)(T_S) = 0.6047\ T_S$

Along X axis $(53.9/99.2)(T_S) = 0.5432\ T_S$

Along Z axis $(57.8/99.2)(T_S) = 0.5825\ T_S$

<u>10W Force (Front-Rear)</u>

Overturning (front-rear) due to 10W along X axis

Overturning moment (taken about the axis of rotation @ Point A)
= 10 (53,000 lb) 39.2 in = 20,776,000 in-lb

Each of the two rear (or front) tie downs (one long and one short) must restrain half the above moment of 10,388,000 in-lb.

Tension in the long tie down

$$10{,}388{,}000 \text{ in-lb} = (64 \text{ in})(0.5333\ T_L) + (69.8 \text{ in})(0.6233\ T_L)$$

$$T_L = 133{,}801 \text{ lb}$$

Tension in the short tie down

$$10{,}388{,}000 \text{ in-lb} = (64 \text{ in})(0.5432\ T_S) + (69.8 \text{ in})(0.6047\ T_S)$$

$$T_S = 134{,}957 \text{ lb}$$

<u>5W Force (Side-Side)</u>

Overturning (side-side) due to 5W along Z axis

Overturning moment (taken about the axis of rotation @ Point A)
= 5 (53,000 lb)(39.2 in) = 10,388,000 in-lb

Each of two side tie downs (one long and one short) must restrain half the above moment, 5,194,000 in-lb.

Tension in the long tie down

$$5{,}194{,}000 \text{ in-lb} = (64 \text{ in})(0.5718\ T_L) + (12.0")\ (0.6233\ T_L)$$
$$T_L = 117{,}845 \text{ lb}$$

Tension in the short tie down

$$5{,}194{,}000 \text{ in-lb} = (64 \text{ in})(0.5825\ T_S) + (12.0 \text{ in})(0.6047\ T_S)$$
$$T_S = 116{,}624 \text{ lb}$$

2W Force (Up-Down)

Lifting (up) due to 2W along Y axis

$$\text{Lift} = 2\ (53{,}000 \text{ lb}) - 53{,}000 \text{ lb} = 53{,}000 \text{ lb}$$

Each of two long and two short tie downs will carry a quarter of the load, 13,250 lb.

$$13{,}250 \text{ lb} = 0.6233\ T_L$$

$$T_L = 21{,}258 \text{ lb}$$

$$13{,}250 \text{ lb} = 0.6047\ T_S$$

$$T_S = 21{,}912 \text{ lb}$$

Total Tension

Total tension with all forces acting simultaneously:

$$T_L = 133{,}801 + 117{,}845 + 21{,}258 = 272{,}904 \text{ lb}$$

$$T_S = 134{,}957 + 116{,}624 + 21{,}912 = 273{,}493 \text{ lb}$$

3.1.5.3 Tie Down Lugs

The tie down lugs are constructed of ASTM A516 Grade steel having a minimum yield stress of 46 ksi, and a maximum ultimate stress of 78 ksi. The following values are used in the design of the tie down lugs:

Tensile Yield - 46,000 psi

Allowable Bearing Stress - 0.9 Tensile Yield Strength

Maximum Ultimate Tensile - 78,000 psi

Shear Yield = (0.577)(46,000)

= 26,542 psi

Shear Ultimate = (0.577)(78,000 psi)

= 45,006 psi

Allowable Shear Stress on Welds - 21,000 psi

Bearing Stress on Lug and Pin

Maximum Load - 273,493 lbs

Diameter of Hole - 2.5 inches

Diameter of Pin - 2.25 inches

Thickness of Lug - 3.0 inches

Projected Area of Pin = (3.0)(2.25) = 6.75 in^2

Bearing Stress = (273,493/6.75) = 40,517 psi

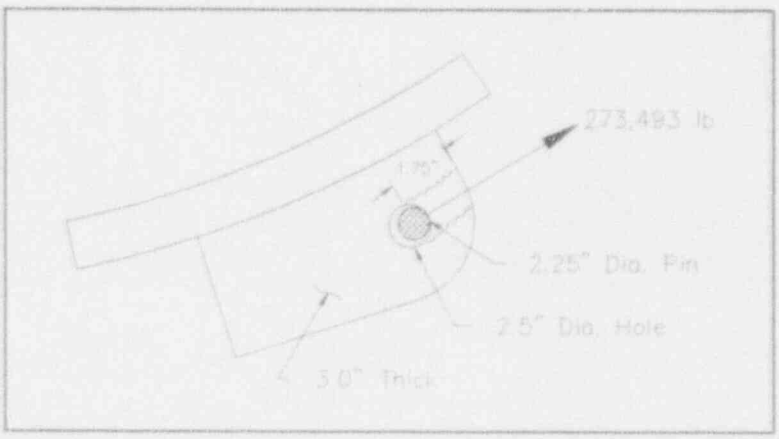
F.S. = 41,000/40,517 = 1.02

Tear Out

The shear plane associated with the projected area of the pin is shown as follows:

$$y_1 = \sqrt{1.25^2 - 1.125^2} = 0.545 \text{ inch}$$

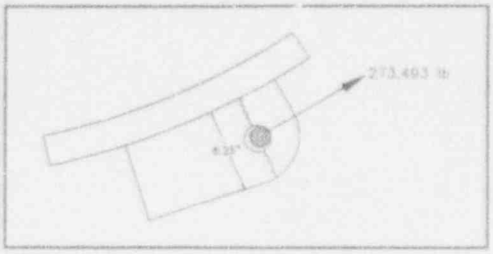
$$y_2 = 1.25 - 0.545 = 0.705 \text{ inch}$$



Shear Stress = 273,493/(2)(2.0)(1.75) = 26,047 psi

F.S. = 26,542/26,047 = 1.02

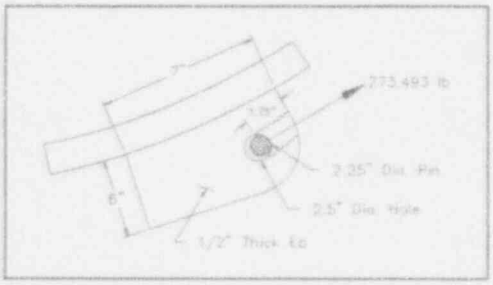
Tension



Stress = 273,493/(3.0)(8.25 - 2.5)
= 15,855 psi

F.S. = 46,000 / 15,855 = 2.90

Reinforcing Plate Weld



Thickness main lug 2 inches

Thickness reinforcing plates 2 @ 1/2 inch

Total thickness 3.0 inches

Load on 1/2" reinf. plate = (1/6)(273,493)
= 45,582 psi

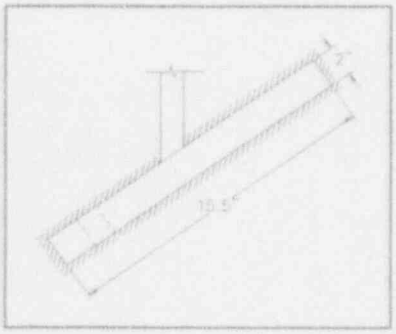
Length of weld = 6 + 7 + 7 = 20 inches

Area of shear = (20)(0.5) sin (45°)(0.85) = 6.01 in^2

Shear = 45,582 / 6.01 = 7,584 psi

F.S. = 21,000 / 7,584 = 2.77

3.1.5.4 Tie Down Lug Welds



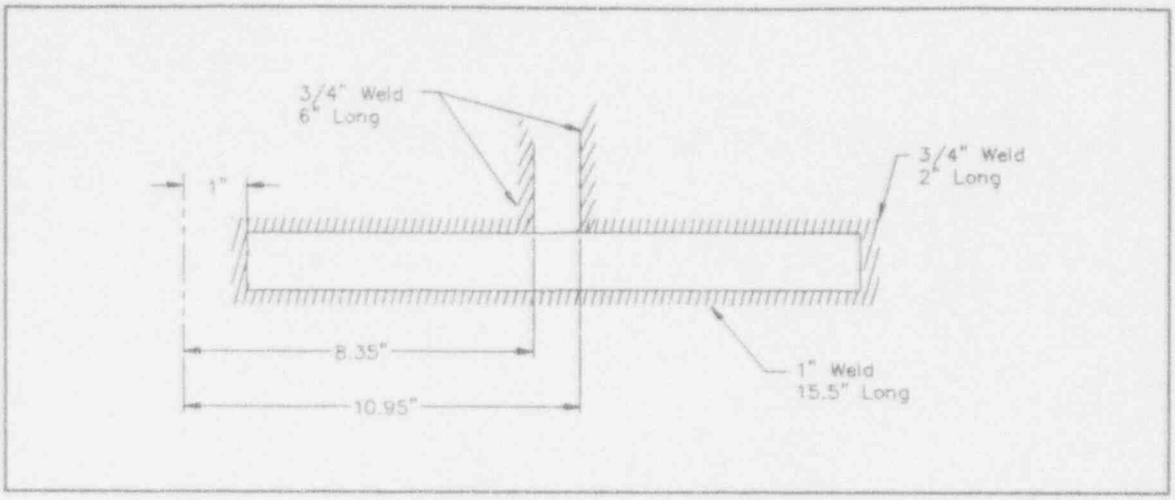
(a) Pure shear

Area of shear = 2 (15.5) sin (45°)(1)(0.85) +
(6 + 6 + 2) sin (45°)(0.75)(0.85) = 25 in^2

Stress = 273,493 / 25 = 10,940 psi

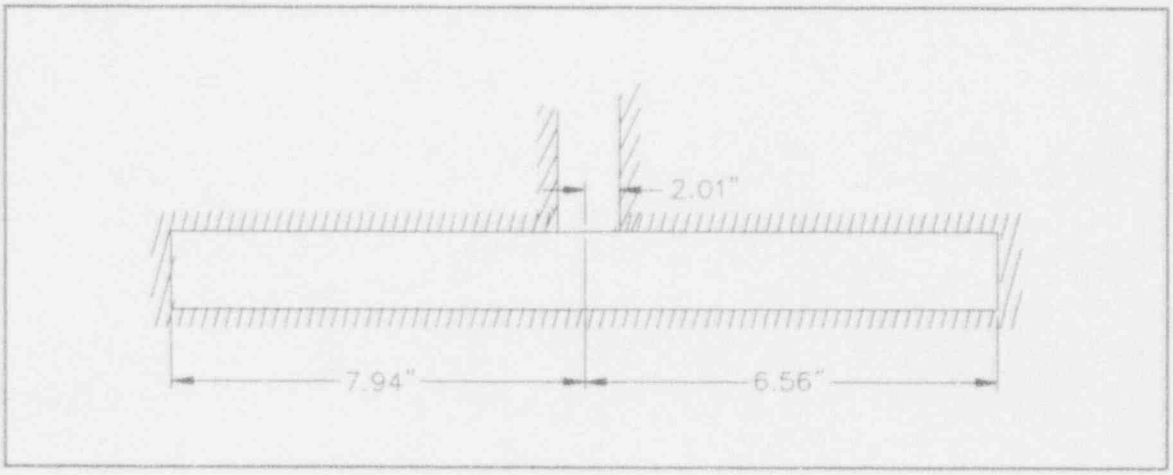
(b) Moment forces on weld

Maximum Moment = (273,493) (2.75) = 752,106 in-lbs



$$X = \frac{2(1)(0.75) + (2)(15.5)(8.75) + (6)(0.75)(8.33) + (6)(0.75)(10.95) + (16.5)(2)(0.75)}{(0.75)(2) + (15.5)(2) + (6)(0.75) + (6)(0.75) + (2)(0.75)}$$

$= 8.94$ in



M = compressive moment + tension moment

compressive moment = tension moment

M = 2(tension moment)

$$M = 2f\,[(2.01)(6)(0.75)(0.707)(0.85) + (6.56)(2)(0.5)(6.56)(0.67)(0.707)(0.85) + 2(6.56)(0.707)(0.85)(0.75)]$$

$M = 57.2f = 752{,}106$ in-lb

$f = 13{,}149$ psi

Combined stress

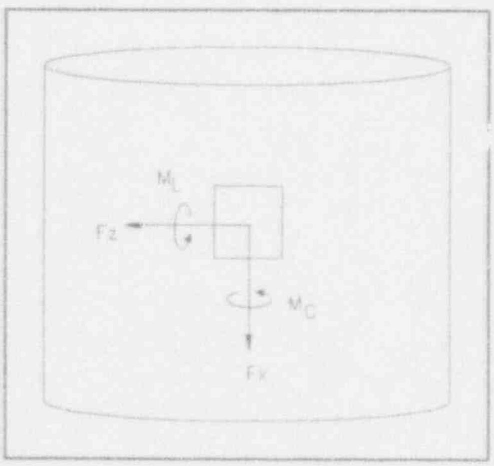
$$f = \sqrt{10{,}940^2 + 13{,}149^2}$$

$$= 17{,}105 \text{ psi}$$

F.S. = 21,000 + 17,105 = <u>1.23</u>

3.1.5.5 Analysis of Tie Down Loads on Cask Shell

The tie down loads are transmitted into the cask shell as external moments. These moments are the product of the tie down forces and the offset distance between the line of action of the tie down force and the attachment plate.



The offset distance between the line of action of the tie-down force and the attachment plate is 4.25 inches.

F_z = 273,493 cos (39)° 30′ = 211,034 lb

F_x = 273,493 sin (39°) 30′ = 173,963 lb

M_c = Circumferential moment
= (211,034 lb)(4.25 in) = 896,895 in-lb

M_L = Longitudinal moment
= (173,963 lb)(4.25 in) = 739,343 in-lb

<u>Reference</u> for method of calculation: Welding Research Council, Bulletin No. 107 (WRC 107), Stress in Cylindrical Pressure Vessels from Structural Attachments.

T = r/t = radius to thickness ratio = 40.9/0.875 = 46.7

C_1 = 1/2 the circumferential width of the loaded plate
= (33°/360°)(2π)(40.9)(0.5)
= 11.78 in

C_2 = 1/2 the longitudinal width of the loaded plate
= 23.5/2
= 11.75 inches

$B_1 = C_1/r$ = 11.78/40.9 = 0.288

$B_2 = C_2/r = 11.75/40.9 = 0.287$

Check that $5 \leq T \leq 100$

The highest stress on the outer shell is 42.3 ksi. The steel used in the outer shell will be specified to have a minimum yield strength of 49 ksi, and will be certified by testing.

3.1.5.6 Failure Under Excessive Load

The tie down lugs are designed to fail first under excessive load and preclude damage to the package. Based on ultimate strength of the shell material, the force required to cause extensive deformation to the shell would be:

$F = (273{,}493)\,(78{,}000/42{,}300) = 504{,}313$ lbs (Where 78,000 psi is the ultimate strength of the shell material.)

The tie down lugs are designed to fail by tear out when excessive forces are applied. The force required to cause tear out is as follows:

$F = (45{,}006)(2)(3.0)(1.75) = 472{,}563$ lbs.

Compared to the force required to damage the shell, the factor of safety will be:

$F.S. = 504{,}313 / 472{,}563 = \underline{1.07}$

3.2 Normal Conditions of Transport (Appendix A-10 CFR 71)

3.2.1 Heat

Since the package is constructed of steel and lead, temperatures of 130°F will have no effect on the package.

3.2.2 Cold

Same as 3.2.1, above.

3.2.3 Reduced Pressure

A 1/2-atmosphere pressure will produce an equivalent internal pressure of 7.35 psi. This pressure acting over the lid will produce a load of:

$$F = (75.5)^2 (\pi)(7.35)/4 = 32{,}906 \text{ lbs}$$

Since there are eight binders, the load per binder will be:

$$F = 32{,}906/8 = 4{,}113 \text{ lbs/binder}$$

Each binder has an ultimate strength of 135,000 lbs.

Therefore, it can be concluded that the reduced pressure will produce no detrimental effects.

3.2.4 Vibration

All components are designed for a transportation environment. No loss of integrity will be experienced.

3.2.5 Water Spray

Not applicable.

3.2.6 Free Drop

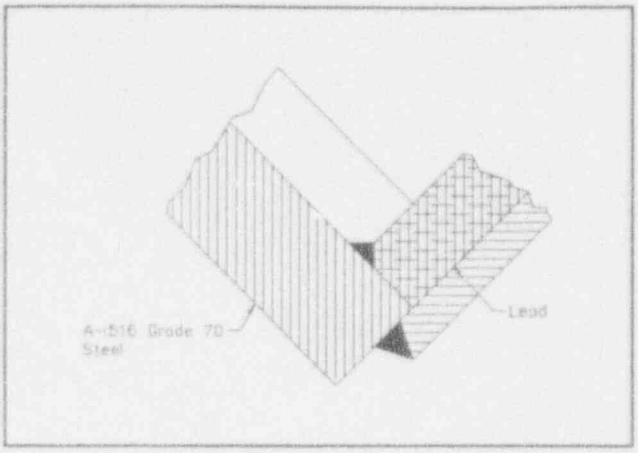
Since the package weighs in excess of 30,000 lbs., it must be able to withstand a one foot drop on any surface, without loss of contents.

3.2.6.1 One Foot Drop on Bottom Corner

Energy to be absorbed = 53,000 lb x 12 in.

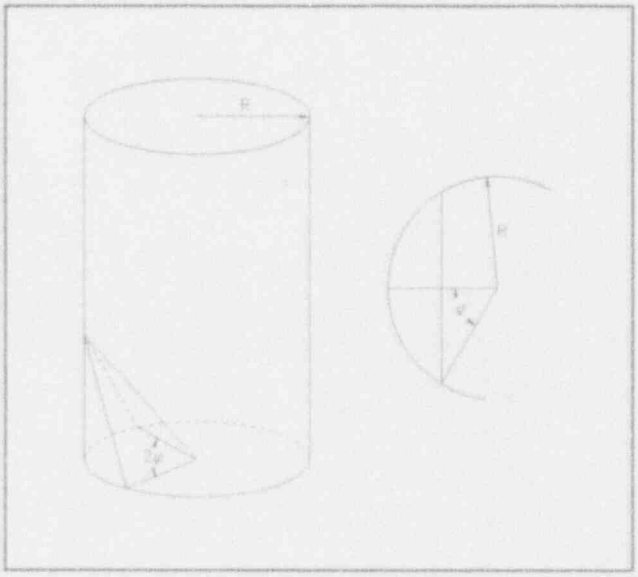
Maximum energy = 6.36×10^5 in. lb.

Energy will be absorbed by crushing of corner.



The volume of the crushed ungula, assuming the worst case of a 45° impact angle, is calculated by the following equation:

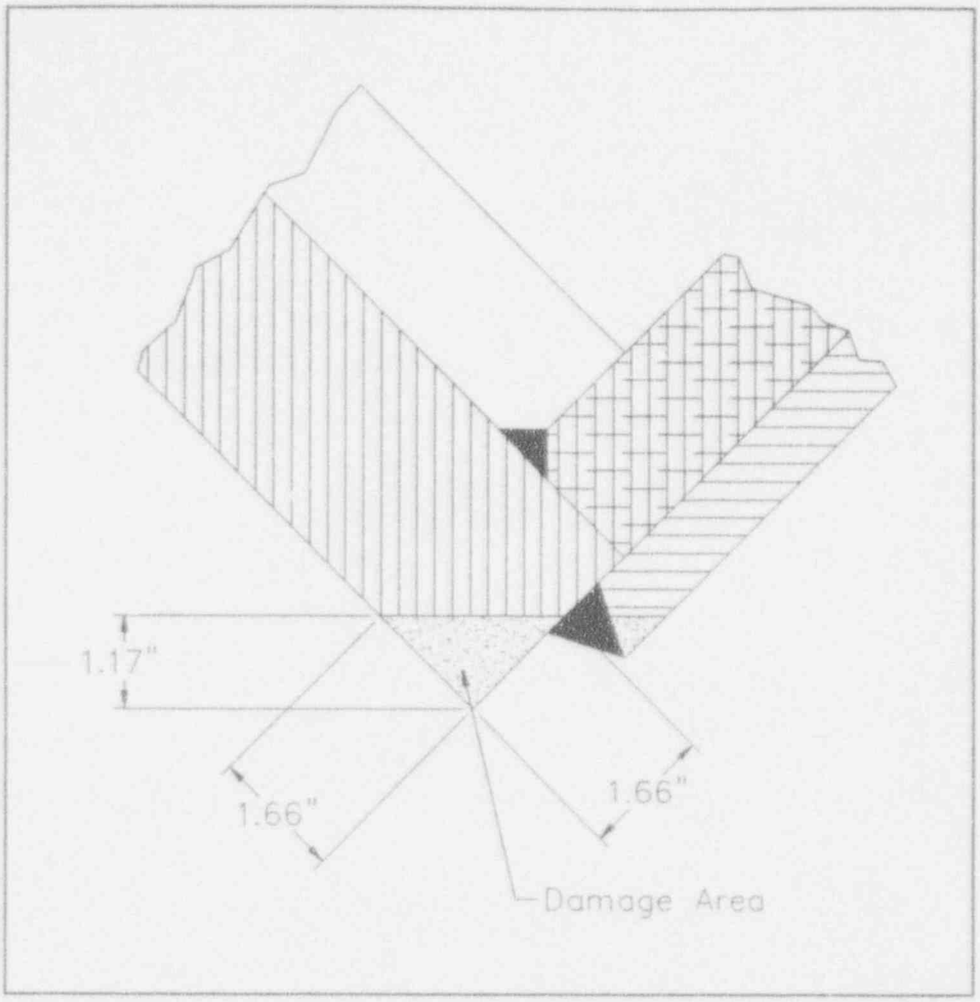
$$V_s = R^3 \{\sin \phi - \frac{\sin^3 \phi}{3} - \phi \cos \phi \}$$



The maximum amount of steel crushed will be:

$$b = R(1 - \text{Cos}\ \phi) = 1.66$$

The effect on the cask body due to the corner impact event is shown below. Even though the weld will be crushed locally, there will be no loss of the cask's integrity.



The deceleration force exerted on the cask is calculated as the product of contact surface area, and the yield strength of the steel (38,000 psi).

$$Au = \frac{\pi ab}{2} - (xy + ab \sin^{-1} \frac{x}{a})$$

Where for 45° angle = Θ:

$R = 40.5$ in

$a = R/\cos 45° = 57.275$ in

$b = R = 40.5$ in

$b = 1.66$ in

$C = R - h = 40.5 - 1.66 = 38.84$ in

$$y = \sqrt{R^2 - C^2} = \sqrt{40.5^2 - 38.84^2} = 11.47 \text{ in}$$

$x = C / \cos 45° = 54.928$ in

$Au = \pi(57.275)(40.5)/2 - (54.928)(11.47) + (57.275)(40.5) \sin^{-1}(54.928/57.275)$

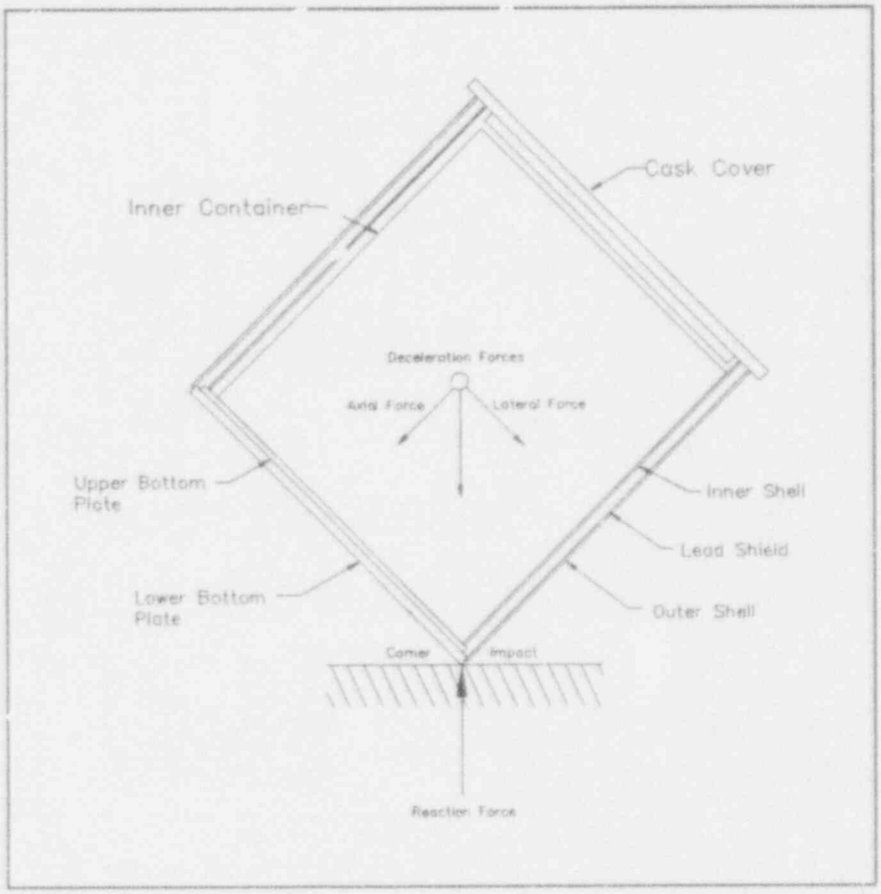
$A_u = 36.32\ in^2$

$F = (36.32)(38{,}000\ psi) = 1{,}380{,}160\ lb.$

$g\ Force = 1{,}380{,}160/53{,}000 = 26.0\ g's$

3.2.6.2 Effects of Bottom Corner Drop on Balance of Cask

The 26.0 g deceleration will be transmitted to the outer portions of the cask. This force will be composed of two components, one force will act laterally with respect to the bottom plate. The other component will act axially with respect to the plate.



Summary of cask component weights as used in the following drop analyses:

Primary Lid	5,800 lb
Shield Plug	370 lb
Outer Body Shell*	7,224 lb
Inner Body Shell	1,900 lb
Upper Bottom Plate	2,645 lb
Lower Bottom Plate	2,864 lb
Lead Shield	14,397 lb
Waste Contents	17,800 lb

*This includes the weight of lid ratchet binders, tiedown lugs, etc.

The following design criteria and assumptions are the basis for the bottom corner drop analysis. The following load distributions are considered:

1) Load from primary lid and shield plug will be distributed to the inner and outer shells in accordance with the shell cross-sectional areas.

2) The inner shell will receive loadings at its connection to the upper bottom plate consisting of:

- Load from lid and shield plug
- Load from self weight of inner shell
- Load from waste considered to act on one-half of the shell perimeter nearest corner of impact.
- Load from one-half lead shield considered to act on the half of inner shell perimeter not receiving waste loading.

All other loads on the inner shell will be considered to act uniformly around shell perimeter.

3) The outer shell will receive loadings at its connection to the lower bottom plate consisting of:

- Load from lid and shield plug
- Load from self weight of outer shell
- Load from one-half of the shield considered to act on that half of the shell perimeter nearest the corner of impact.

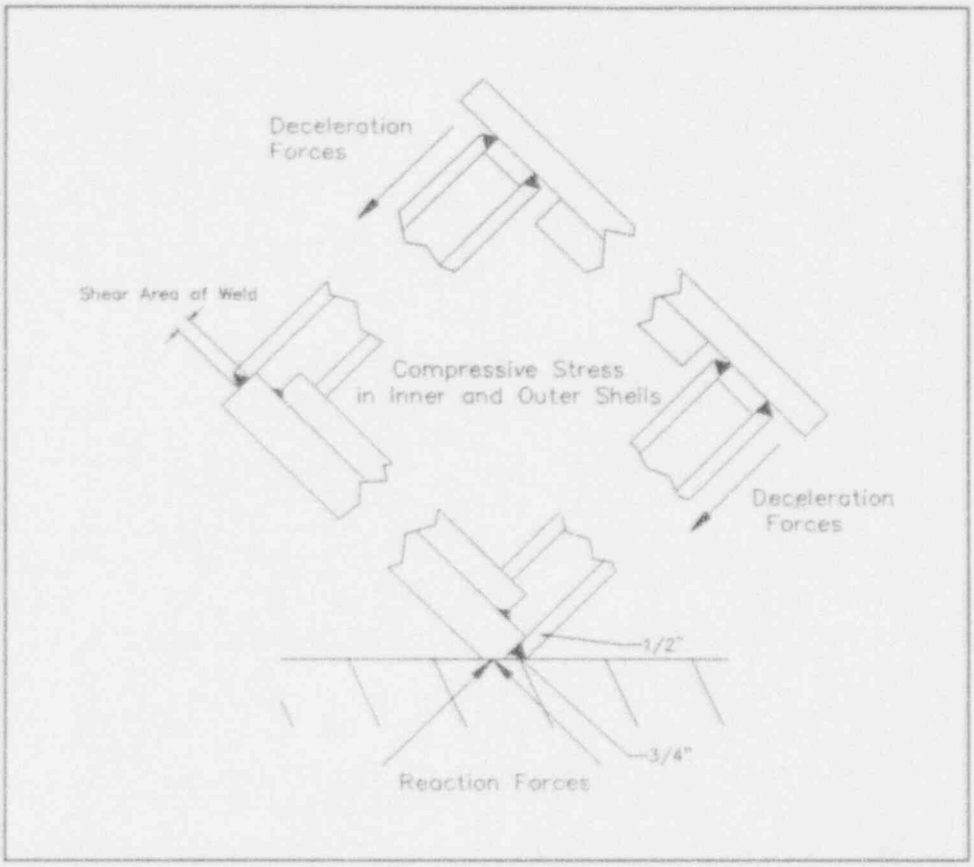
4) The upper bottom plate will receive loadings consisting of:

- Loads transferred through the inner shell weld
- Load from self weight of the upper bottom plate.

Due to the rigidity of the upper bottom plate, all loadings on this plate will activate the entire perimeter weldment to the lower bottom plate.

Cask Analysis

1) Load From Primary Lid and Shield Plug



Loading = (5800 + 370)26.0 = 160,420 lbs

Lateral force = 160,420 (sin 45°) = 113,434 lbs

Axial force = 160,420 (cos 45°) = 113,434 lbs

Inner shell area = $\pi/4(76.25^2 - 75.5^2)$ = 89.388 in^2

Outer shell area = $\pi/4(81.75^2 - 80^2)$ = 222.317 in^2

Total Area = 89.388 + 22.317 = 311.705 in^2

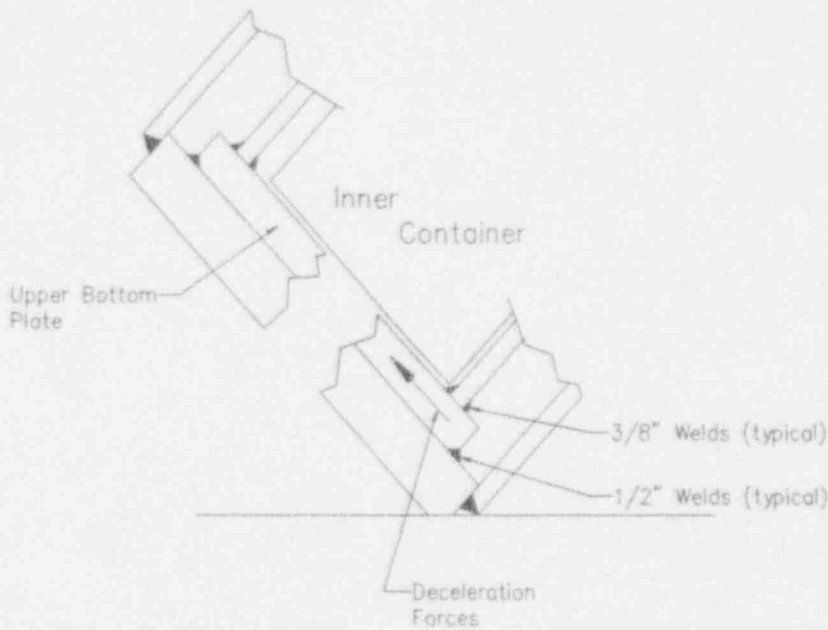
Inner area = 89.388 / 311.705 = 28%

Outer area = 222.317 / 311.705 = 72%

Force on inner shell = (113,434)(0.28) = 31,762 lbs lateral and axial

Force on outer shell = (113,434)(0.72) = 81,672 lbs lateral and axial

2) Stresses Developed in Inner Shell and Attachment Welds



Reaction on Inner Shell

Stress in weld around perimeter of inner shell at cask lid:

$$31{,}762 \text{ lb}/\pi\,(75.5)(3/8)(0.707)(0.85) = 594 \text{ psi}$$

$$\text{Total stress} = \sqrt{2}\;594 = 840 \text{ psi}$$

$$\text{F.S.} = 21{,}000/840 = \underline{25.0}$$

Stress in weld connecting inner shell to upper bottom plate:

Total force = 1/2 self weight of inner shell
+ 1/2 lid and shield plug (1/2 of weight acting on 1/2 of shell)
+ waste

$$\text{Total force} = (2900/2)(26.0)\sin 45^\circ + (31{,}762/2) + (17{,}800)(26.0)\sin 45^\circ$$
$$= 360{,}596 \text{ lb}$$

Lateral weld stress = $360,596/\pi(75.5/2)(2)(3/8)(\sin 45°)(0.85)$
= 6745 psi (lateral)

Axial weld stress is caused only by lid load and shell self weight:

31,762 + 35,200 = 66,693 lbs

Axial weld stress = $66,693/[\pi(75.5)(3/8) \sin 45° (0.85)(2)]$ = 624 psi

Total stress = $\sqrt{6745^2 + 624^2}$ = 6774 psi

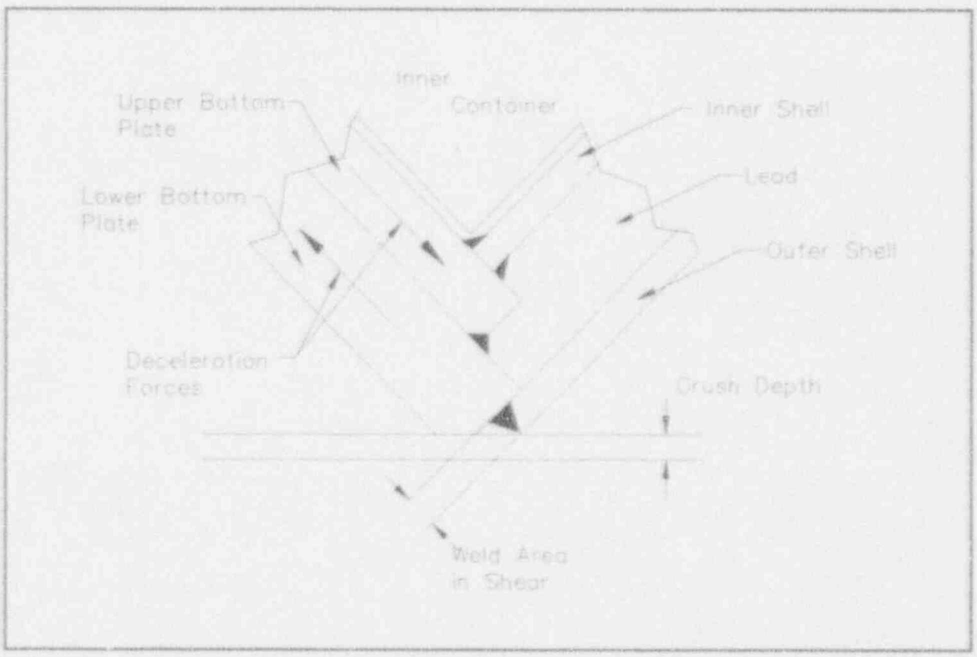
Axial shell stress = $66,693/(76.25^2 - 75.5^2)(\pi/4)$
= 746 psi (less than the weld stress)

Shear shell stress = lateral force/area

$$\frac{(1900)(26.0)(\sin 45°) + (31,752) + (17,800)(26.0)(\sin 45°)}{(76.25^2 - 75.5)^2 (\pi/4)(1/2)} = 8814 \text{ psi}$$

F.S. = 21,926 / 8814 = <u>2.49</u>

3) <u>Stresses Developed in Outer Shell & Attachment Welds</u>



Stress in weld around perimeter of outer shell at cask lid

$81,672 \text{ lb}/[\pi(80.875)(0.5) \sin 45° (0.85)]$ = 1070 psi (axial and lateral)

Total stress = $\sqrt{2}$ (1070) = 1513 psi

F.S. = 21,000/1513 = <u>13.9</u>

Stress in weld connecting outer shell to lower bottom plate:

Lateral force = 1/2 load of outer shell
+ 1/2 load shield
+ 1/2 lid and shield plug (the 1/2 supported by 1/2 outer shell)

= (7224/2)(26.0) sin 45° + (81,672/2) +
(14,397/2)(26.0) sin 45°

= 239,585 lbs

Lateral stress = 239,585/[π(80/2)(0.5) sin 45° (0.85)] = 6344 psi

Axial load = (7224)(26.0) sin 45° + 81,672 = 214,484 lbs

Axial stress = 214,484 lb/[π(80)(0.5) sin 45° (0.85)] = 2840 psi

Total stress in weld = $\sqrt{6344^2 + 2840^2}$ = 6951 psi

F.S. = 21,000/6951 = <u>3.02</u>

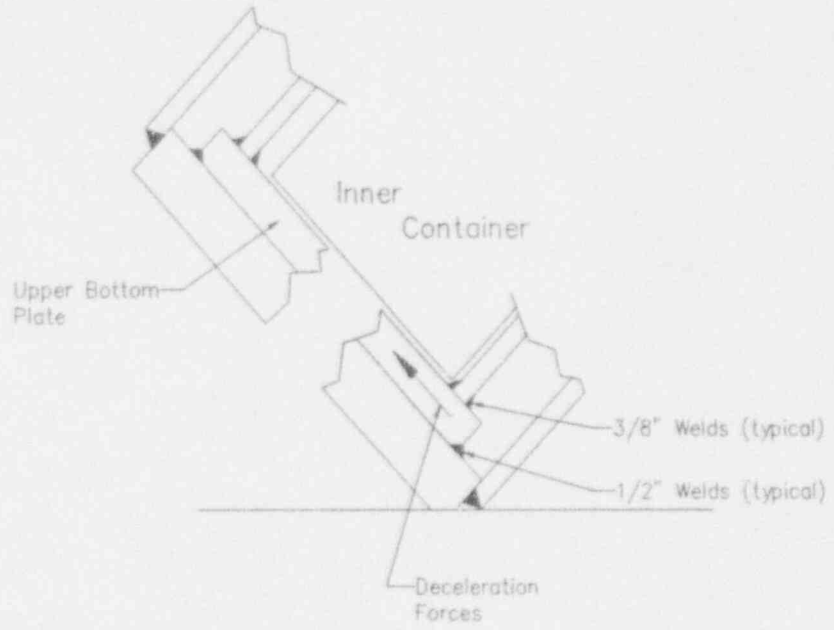
Axial stress in outer shell = 214,484/(81.75^2 - 80^2)(π/4)

= 965 psi < 38,000 psi yield

Lateral shear stress in outer shell = (239,585)/(81.75^2 - 80^2)(π/4)(1/2)

= 2155 psi < 21,926 psi yield

4) Stress in Weld Joining Upper to Lower Bottom Plates



Reaction on Inner Shell

Load on weld = Upper bottom plate
+ Inner shell
+ Shear from lid on inner shell
+ Waste
+ 1/2 lead

Load = [2645 + 1900 + 17,800 + (14,397/2)] (26.0) sin 45° + 31,762

= 574,913 lb

Stress due to lateral load:

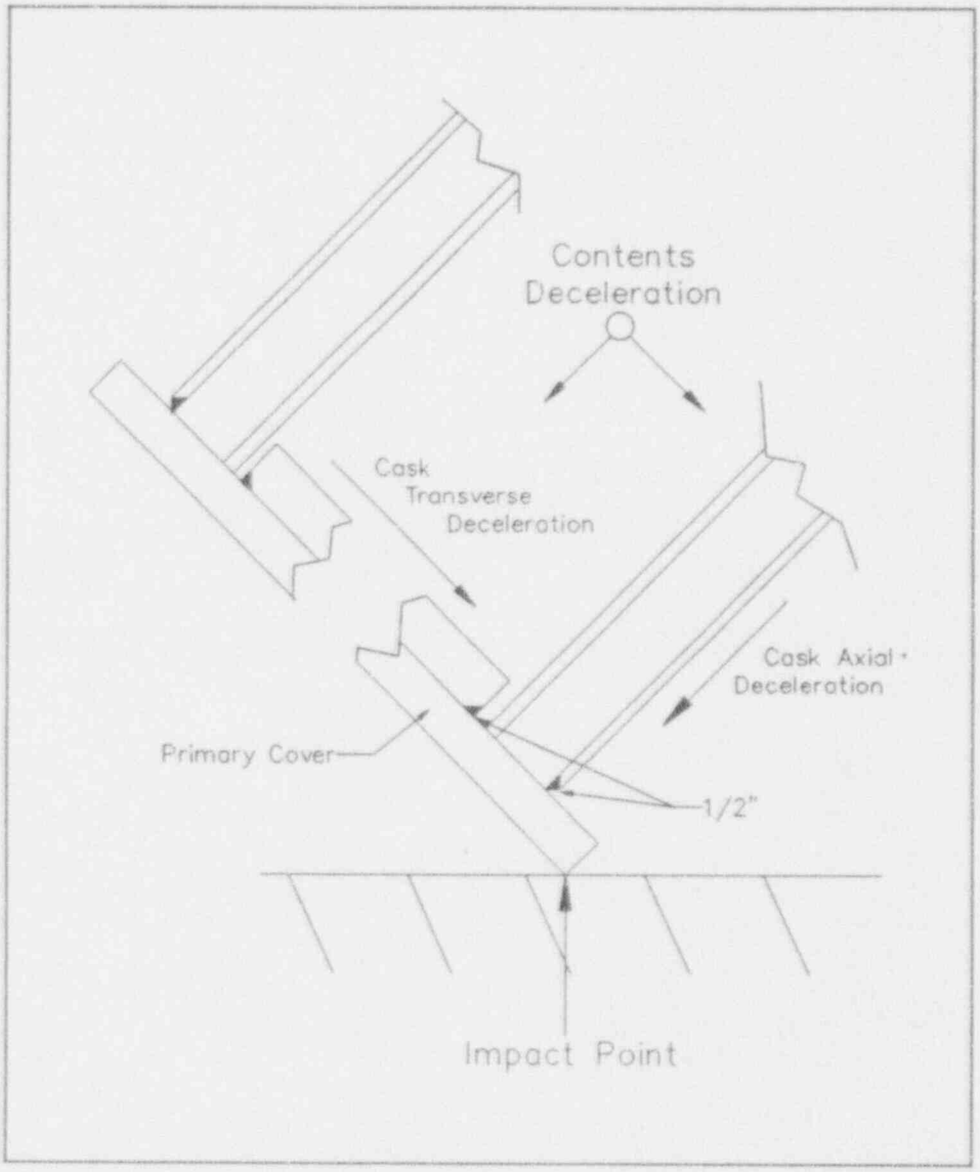
σ_L = 574,913 lb/[(76)(π) sin 45° (0.5)(0.85)]

σ_L = 8,012 psi

Since all axial loads are transferred in bearing, the maximum weld stress will be equal to 8,012 psi. This is within acceptable limits.

3.2.6.3 One Foot Drop on Top Corners

A drop on the upper corners of the cask would decelerate the cask, and would result in axial and transverse deceleration forces between the cover and the balance of the cask.



The top cover is stepped and the inner plate has a nominal clearance of 1/8-inch. Upon impact, this plate would immediately contact the inner shell. The transverse deceleration force must be resisted by the bearing stress between the inner cover plate and the cask inner shell and by the weld between the two cover plates. The magnitude of the transverse deceleration force will depend upon the orientation of the cask and the corresponding deceleration forces. As shown later, the maximum deceleration force will occur when the cask is dropped on a long flat edge of the primary cover. The maximum deceleration for this case is 17.88 g's.

The weight of the cask less the upper cover plate is 53,000 - 3250 = 49,740 lbs. The transverse deceleration force acting on the weld betw... the two plates is:

$$(49{,}740)(17.88)/\sqrt{2} = 628{,}866 \text{ lbs}$$

The weld is a 1/2-inch weld, 75 1/4 inches in diameter. The stress in the weld is:

$$f = \frac{628{,}866}{75.25(\pi)(0.5)(0.85)(0.707)} = 8{,}853 \text{ psi}$$

$$\text{F.S.} = \frac{21{,}000}{8{,}853} = \underline{2.37}$$

The weight of the cask less the cover and shield plug is 53,000 - 5800 - 370 = 46,830 lbs. The transverse force between the inner cover plate and the inner shell of the cask will be:

$$F = \frac{46{,}830(17.88)}{\sqrt{2}} = 592{,}075 \text{ lbs}$$

A 40° arc length on the inside diameter of the inner shell plate times the thickness of the lower primary cover plate is assumed as the bearing area between the two surfaces.

$$\text{Area} = D\left(\frac{40^\circ\,\pi}{360^\circ}\right)t = 75.25\left(\frac{40^\circ\,\pi}{360^\circ}\right)(2) = 52.5 \text{ in}^2$$

The bearing stress between the two plates will be:

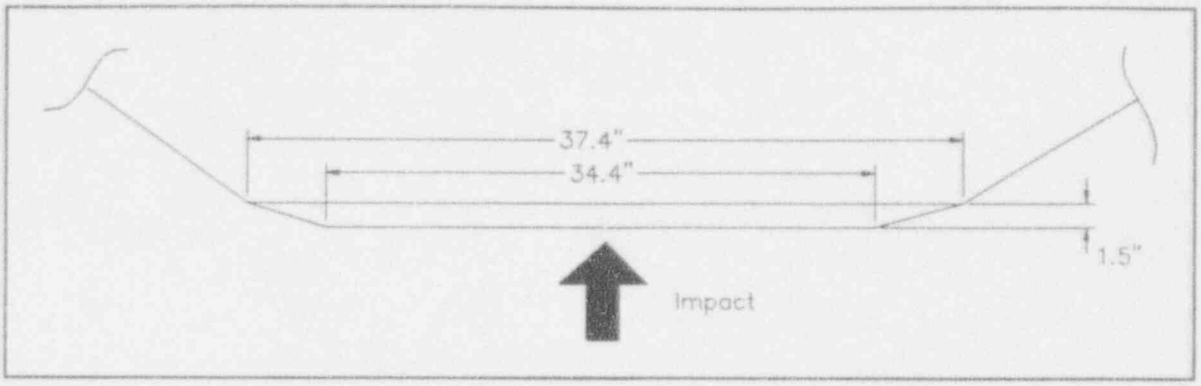
$$F = 592{,}075 / 52.5 = 11{,}278 \text{ psi}$$

Allowable Bearing Stress = (0.9) Tensile Yield Strength

$$\text{F.S.} = 0.9(49{,}000) / 11{,}278 = \underline{3.91}$$

3.2.6.4 One Foot Drop on Top Corner of the Long Flat Edge

In a top drop on a corner, one of the extreme conditions would be the impact of the cask along the top edge on one of the long flat sides of the cover. An angle drop of 45° is considered to be worst case.

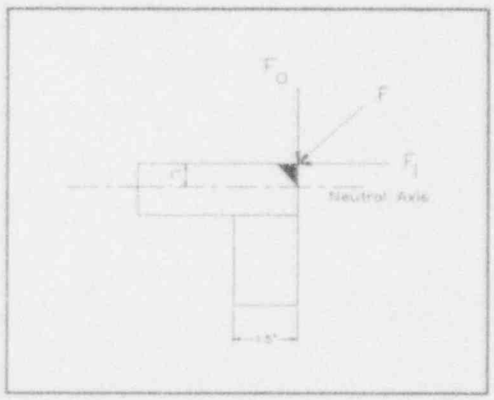


An impact in this orientation will cause minimum bending of the cover, and will result in high impact loads on the cover. The majority of the energy will have to be absorbed by crushing of the steel. The bending and crushing of the cover will occur in steps as illustrated below:

<u>Crushing</u>

Following impact, the edge of the corner will begin crushing until inelastic rotation around the bend point occurs.

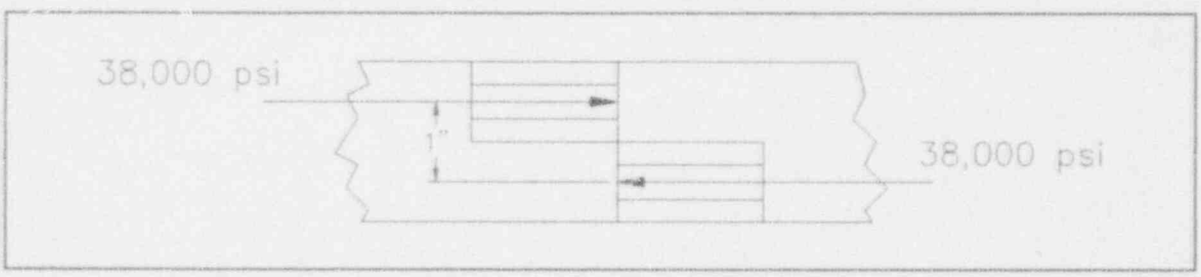
The point at which this will occur is calculated as follows:



Width at bend = 37.4 in

Thickness = 2 in

M = (38,000 psi)(1 in)(37.4 in)(1 in)
= 1,421,200 in-lb



F_a = Force required to initiate bending

$$F_a = M/X = \frac{1,421,200}{1.5} = 947,467 \text{ lbs}$$

947,467/53,000 = 17.88 g's (axial and lateral)

$F = F_a \sqrt{2} = 1,339,920$ lbs

1,339,920 / 53,000 = 25.28 g's (total)

Area crushed steel F ÷ 38,000 = 35.26 in^2

Width of crushed steel 35.26 / 34.4 = 1.025 in

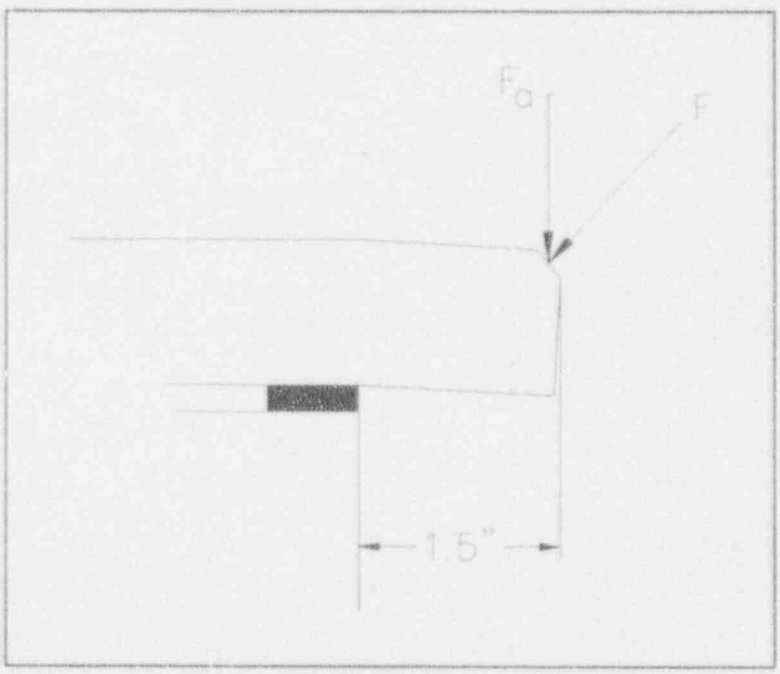
Depth of crushed steel 1.025/2 = 0.512 in

Volume crushed steel = $\frac{(0.512)(1.025)(34.4)}{2}$ = 9.036 in^3

Energy absorbed in crushing = 9.036 (38,000) = 343,364 in-lb

Bending

When the force due to crushing reaches the above value noted, the cover will bend inelastically. The bending will occur around the impact limiter ring and with the shell of the cask.



The balance of the energy will be absorbed by bending of the lid.

Total Energy - Energy Absorbed in Crushing = Energy Absorbed in Bend

(53,000 lbs)(12 in) - 343,364 in-lbs = 292,636 in-lbs

With an axial force of 947,467 lb required to cause bending, this amount of energy will be absorbed by an axial displacement of:

$$292{,}636 \text{ in-lbs} / 947{,}467 \text{ lbs} = 0.309 \text{ in}$$

The g force developed during the bending process is calculated using a kinematic approach.

The velocity at start of bending is:

$$v = \sqrt{\frac{2\ KE\ g}{W}} = \sqrt{\frac{(2)(292{,}636)(386.4)}{53{,}000}}$$

$$v = 65.3 \text{ in/sec}$$

As calculated before, the inelastic bending deformation is 0.309 in

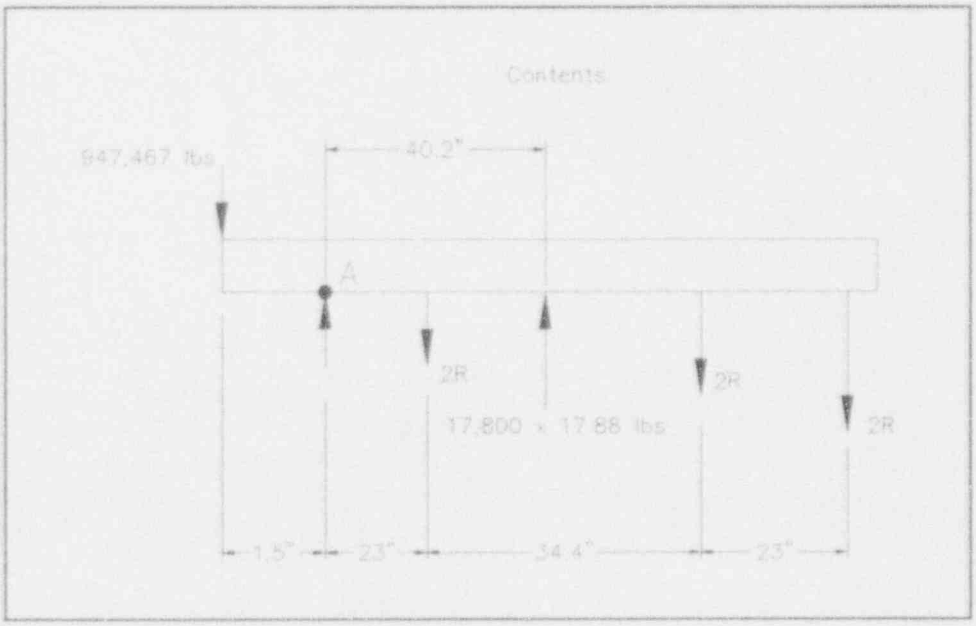
The time it takes the cask to move this distance, based on average velocity is:

$$\Delta X/V_{avg} = (0.309 \text{ in})/[(65.3)(0.5)\text{in/sec}] = 0.00946 \text{ sec}$$

$$\begin{aligned} g \text{ force} &= (\Delta V/\Delta t)/(386.4 \text{ in/sec}) \\ &= (65.3/.00946)/(386.4) \\ &= 17.86 \text{ g's (both axial and lateral direction)} \end{aligned}$$

The above shows that maximum g force is 17.88 g's in crushing and bending in both axial and lateral directions.

The force of impact on the corner is 947,467 lbs (axial component).



The loads on the ratchet binders will be proportional to their distance from the pivot point of the cover on the cask.

Forces tending to open the lid consist of weights from waste, lid, and shield plug.

$$(17{,}800 + 5800 + 370)(17.88) = 428{,}584 \text{ lbs}$$

Summing the moments about point 'A' = (947,467)(1.5) + (428,584)(40.2)
= 18,650,277 in-lbs

$$18{,}650{,}277 \text{ in-lbs} = 2R(23)(23/80.4) + 2R(57.4)(57.4/80.4) + 2R(80.4)$$

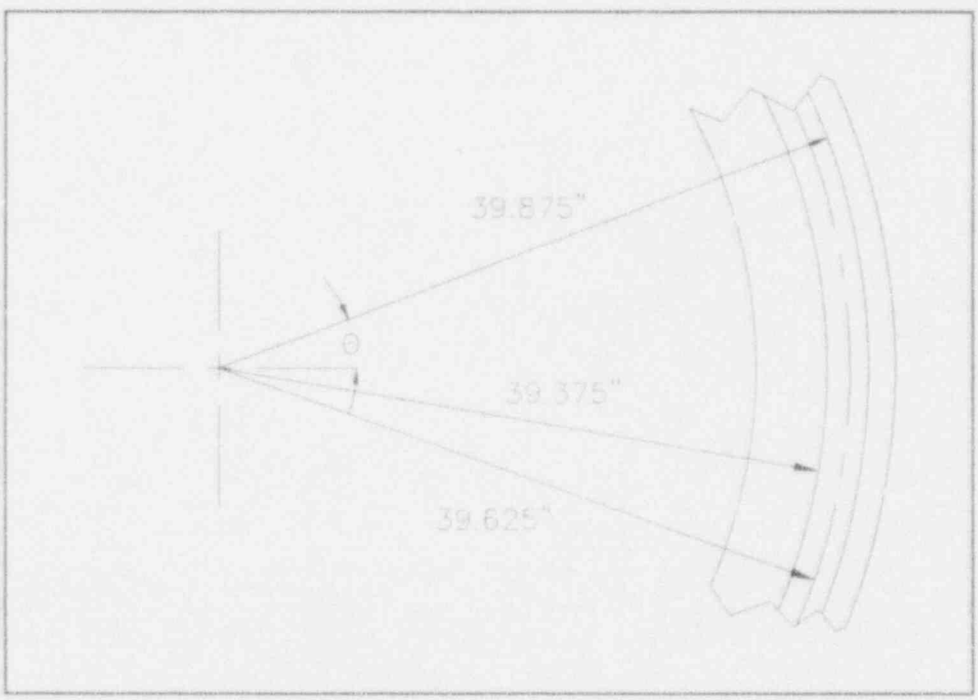
$$18{,}650{,}277 \text{ in-lbs} = 255.92 R$$

R = 72,875 lbs (in farthest binder from impact)

R = 72,875 (57.4/80.4) = 52,028 lbs (in middle binder)

R = 72,875(23/80.4) = 20,847 lbs (in binder closest to impact)

The 1/4-inch thick seal ring made of AISI 1020 steel, located on the outer periphery of the top of the cask wall, will experience some pressure resulting from a top corner drop. This worst case appears in a top corner drop on a large flat. The force exerted is equal to that which is required to bend the lid, or 947,467 lbs.



The yielding surface area reacting against this force is proportional to the angle Θ and the radius.

$$\frac{(39.625)(\cos \Theta - 1/2°)}{39.875}\ (35{,}000\ \text{psi}) = \text{pressure (psi)}$$

$$(\text{Pressure})\ \frac{\pi(39.875^2 - 39.375^2)}{360}\ \text{in}^2/\text{degree} = \text{force/degree}$$

As seen from Table 3-1, the entire force is distributed over a 88° arc of the ring. This is approximately the angle between two long flats.

By dividing the incremental pressure by Young's Modulus ($E \times 30 \times 10^6$), the ratio of the strain may be calculated, and by multiplying by the ring thickness, an actual deformation may be predicted. As seen in Table 3-3, the maximum deformation is 0.30 mils. This causes no great deformation or damage to the spacer ring.

The force will be transmitted to the shell by the double one-half inch weld to the outer shell and the double three-eighth inch weld on the inner shell. Based on an 88° distributed load, the effective area of these two welds is:

$$\text{Area} = \frac{88}{360}\ \pi\{(79.5)(0.5) + (76.25)(0.375)\}2 = 105\ \text{in}^2$$

$$f = 947{,}467 / 105 = 9023\ \text{psi}$$

The actual stress values will be lower since the upper ring will cause the load on the weld to be distributed over a larger area. The spacer ring has a width of 0.5 inches, compared to a combined width of 1.25 inches for the inner and outer shell. Accordingly, the stresses in the shell will be 40 percent of the stresses in the spacer ring.

Table 3-1 - Pressure Exerted on 1/4" Seal Ring due to Top Drop on Large Flat

ANGLE	PRESSURE	FORCE/ DEGREE	Σ E	PRESSURE	STRAIN
1	34,780	12,026	12,026	0.001160	0.000290
2	34,769	12,022	24,048	0.001159	0.000289
3	34,748	12,015	36,063	0.001158	0.000289
4	34,715	12,004	48,067	0.001157	0.000289
5	34,673	11,990	60,057	0.001155	0.000288
6	34,620	11,971	72,028	0.001154	0.000288
7	34,557	11,950	83,978	0.001152	0.000288
8	34,483	11,924	95,902	0.001150	0.000287
9	34,398	11,895	107,797	0.001146	0.000286
10	34,303	11,862	119,659	0.001143	0.000285
11	34,198	11,825	131,484	0.001140	0.000285
12	34,082	11,785	143,269	0.001136	0.000284
13	33,956	11,742	155,011	0.001131	0.000283
14	33,820	11,695	166,706	0.001127	0.000282
15	33,673	11,644	178,350	0.001122	0.000280
16	33,515	11,590	189,940	0.001117	0.000279
17	33,348	11,531	201,471	0.001111	0.000277
18	33,170	11,470	212,941	0.001105	0.000276
19	32,983	11,405	224,346	0.001100	0.000275
20	32,785	11,337	235,683	0.001092	0.000273
21	32,577	11,265	246,948	0.001086	0.000271
22	32,360	11,190	258,138	0.001078	0.000269
23	32,133	11,111	269,249	0.001071	0.000267
24	31,895	11,029	280,278	0.001063	0.000265
25	31,649	10,944	291,222	0.001055	0.000263
26	31,392	10,855	302,077	0.001046	0.000261
27	31,126	10,763	312,840	0.001037	0.000259
28	30,850	10,668	323,508	0.001028	0.000257
29	30,565	10,569	334,077	0.001018	0.000254
30	30,271	10,467	344,544	0.001009	0.000252

Table 3-1 - <u>Pressure Exerted on 1/4" Seal Ring due to Top Drop on Large Flat</u> (cont.)

ANGLE	PRESSURE	FORCE/ DEGREE	Σ E	PRESSUR E	STRAIN
31	29,968	10,363	354,907	0.000999	0.000249
32	29,655	10,255	365,162	0.000988	0.000247
33	29,333	10,143	375,305	0.000977	0.000244
34	29,003	10,029	385,334	0.000966	0.000241
35	28,663	9,911	395,245	0.000955	0.000238
36	28,315	9,791	405,036	0.000944	0.000236
37	27,958	9,668	414,704	0.000932	0.000233
38	27,593	9,541	424,245	0.000919	0.000229
39	27,220	9,412	433,657	0.000907	0.000226
40	26,837	9,280	442,937	0.000894	0.000223
41	26,447	9,145	452,082	0.000881	0.000220
42	26,049	9,007	461,089	0.000868	0.000217
43	25,643	8,867	469,959	0.000854	0.000213
44	25,229	8,724	478,680	0.000841	0.000210

Entire force 2(478,680) = 957,360 > 947,467 lbs will be distributed over an area of ~ 2(44) = 88°

Lid Ratchet Binder Assembly

Based on the 72,875 lb developed in the far ratchet binder during a top corner drop, the ratchet binder, the ratchet binder pin, and lug assemblies are analyzed as follows:

Ratchet Binders

The ratchet binder will have a shank diameter of 1 3/4 inches and rated generically for an ultimate failure load of 135,000 pounds. The binders will generally fail in the threaded portion of the shank. The shank is fabricated from Grade C1040 or equivalent cold worked steel having a generic yield strength of 70,000 psi and an ultimate strength of 85,000 psi. The minimum root diameter of the thread portion of the shank is 1 1/2 inches. The strength of the shank is calculated as follows:

$$\text{Yield Strength} = 70{,}000\ (1.5^2)\ \pi + 4 = 123{,}700 \text{ lbs}$$

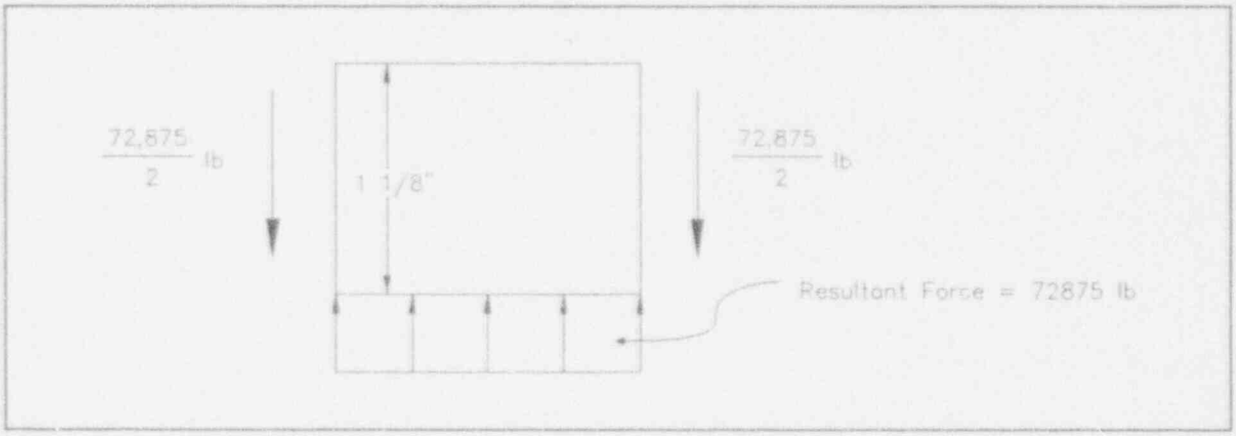
$$\text{Ultimate Strength} = 85{,}000\ (1.5^2)\ \pi + 4 = 150{,}207 \text{ lbs}$$

Based on yield strength, the factor of safety will be:

$$\text{F.S.} = 123{,}700 / 72{,}875 = \underline{1.70}$$

Ratchet Binder Pin

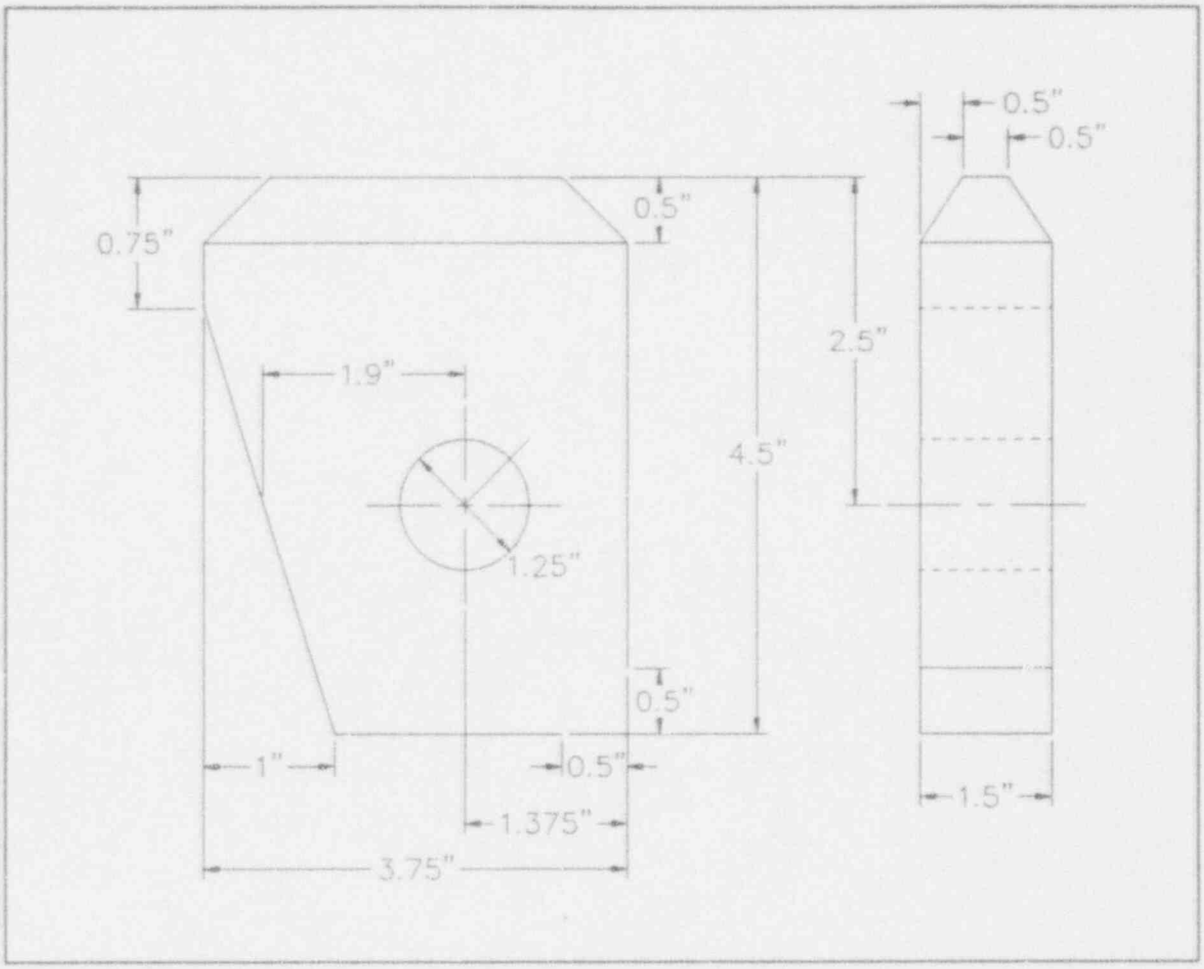
The pin is a 1 1/8 inch diameter bolt, made of SAE Grade 5 or equivalent, having a yield strength of 74,000 psi based on double shearing of the bolt during loading.



$$\sigma = (72{,}875/2)/(1.125)^2(\pi/4) = 36{,}657 \text{ psi}$$

$$\text{F.S.} = (74{,}000)(0.577) / (36{,}657) = \underline{1.16}$$

Lid Ratchet Binder - Upper Lug



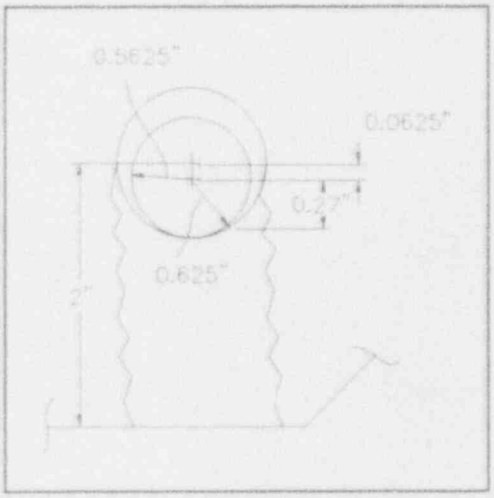
Tear Out

Shear:

σ_s = 72,875 lbs / (1.5)(2 - 0.0625 - 0.27)(2)

= 14,568 psi

F.S. = (38,000)(0.577) / (14,568) = 1.51



Bearing:

σ_B = 72,875 lb / (1.125)(1.5) = 43,185 psi

$$F.S. = \frac{L_e/d}{\sigma/fu} = \frac{2/1.125}{43,185/70,000} = \underline{2.88}$$

Tension

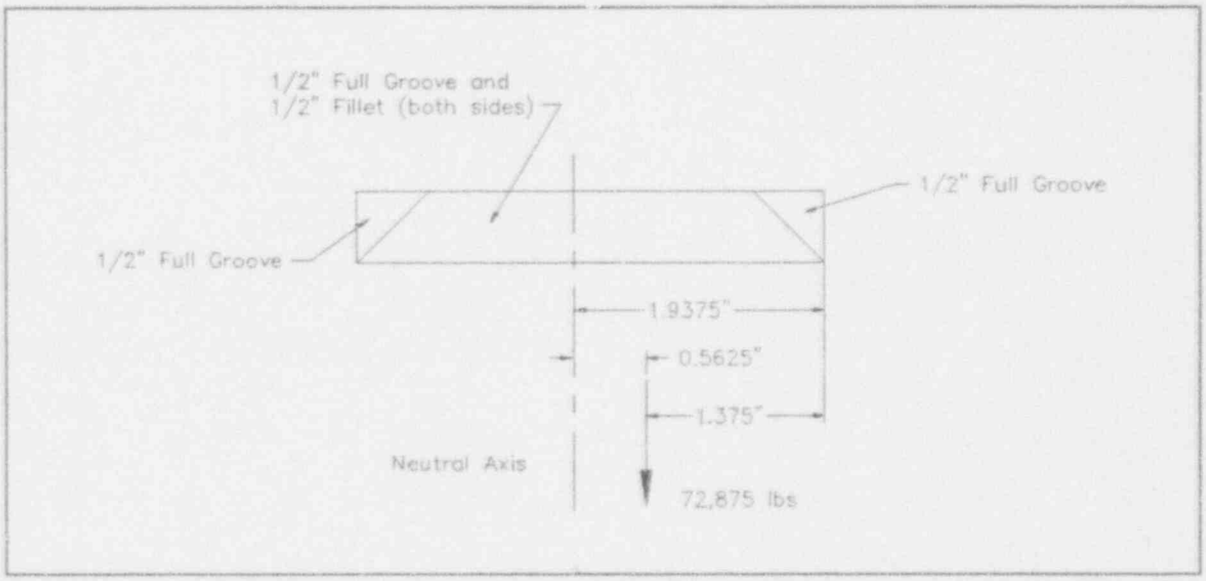
$\sigma_T = 72{,}875 / (1.9 + 1.375 - 1.25)(1.5)$

$\sigma_T = 23{,}992$ psi

F.S. = 38,000 / 23,992 = <u>1.58</u>

Weld

1/2" double groove weld, complete joint penetration with tension normal to effective area. Allowable stresses same as base metal.



Tension

$\sigma_T = 72{,}875 / [(2)(0.5)(1.5) + (2)(0.5)(\sqrt{2})(2.75)]\ (0.85)$

$\sigma_T = 15{,}909$ psi

Moment

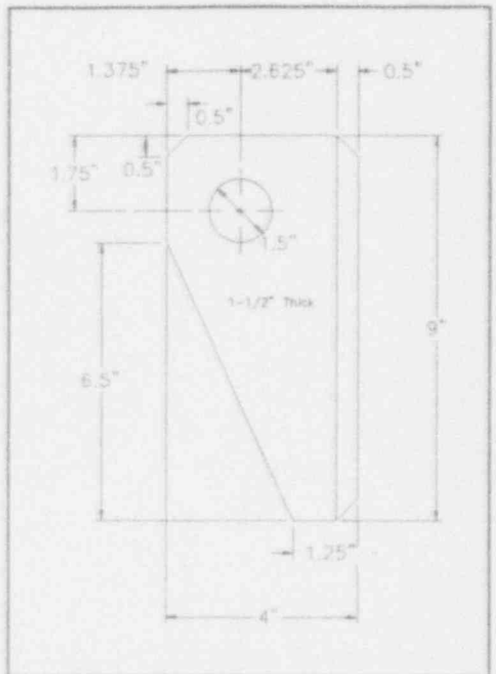
$(72{,}875)(0.5625) = 2\sigma_m[(0.5)(1.5)(1.9375) + (2)(0.5)(1.4375)^2\ (0.67)(\sqrt{2})(0.5)](0.85)$

$\sigma_m = 9{,}934$ psi

$\sigma_{tot} = \sigma_m + \sigma_T = 25{,}843$ psi

F.S. = 38,000 / 25,843 = <u>1.47</u>

Lid Ratchet Binder - Lower Lug



Tear Out

Shear

σ_s = 72,875 / (1.5)(1.75 - 0.0625 - 0.27)(2)

σ_s = 17,137 psi

F.S. = 21,926 / 17,137 = 1.28

Bearing

σ_B = 72,875 / (1.125)(1.5)

= 43,185 psi

$$F.S. = \frac{L_e/d}{\sigma_B fu} = \frac{(1.75)/(1.125)}{(43,185)/(70,000)} = \underline{2.52}$$

Tension

σ_t = 72,875 / (3.5-1.25)(1.5) = 21,593 psi

F.S. = 38,000 / 21,593 = 1.76

Weld

Shear

σ_s = 72,875 / (9 + 1.5)(0.5)(2)(0.85)(2)(0.707)

σ_s = 5775 psi

Moment

$$(72,875)(2.625) = 2\sigma_m[(0.5)(1.5)(4.5) + (2)(0.5)(4.5)^2(0.67)(0.5)]\ (0.85)(t\sqrt{2})$$

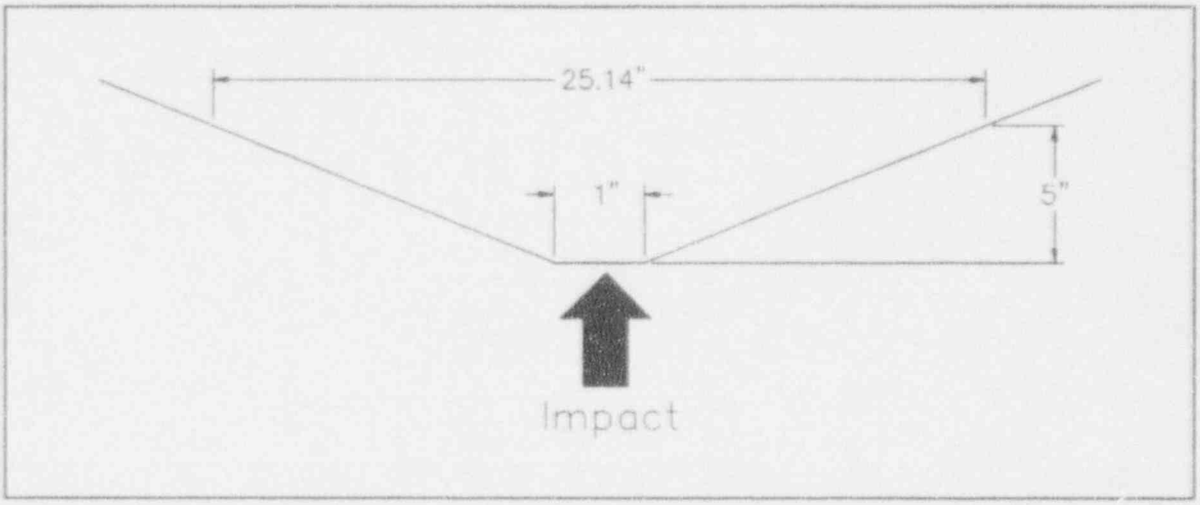
σ_m = 7859 psi

$$\sigma_T = \sqrt{\sigma_m^2 + \sigma_s^2} = 9,753 \text{ psi}$$

F.S. = 21,000 / 9,753 = 2.15

3.2.6.5 One Foot Drop on Top Corner at One Inch Flat

In a top drop on a one inch corner, the other extreme condition would be the impact of the cask on one of the one inch corners of the cover over one of the tiedown lugs.



The energy absorption sequence will be the same as that previously shown for the drop on the long flat edge, and will consist of initial crushing, bending, and crushing. Because the cover overhangs the cask to a greater extent, the cover will act more as an energy absorber.

<u>Crushing</u>

Width at bend = 25.14 in (depth of 5.0 inch)

Thickness = 2 in

M = (38,000 psi)(1 in)(1 in)(25.14 in) = 955,320 in-lbs

Fa = M/x = 955,320 in-lbs / 5 in = 191,064 lbs

F = 191,064 ($\sqrt{2}$) = 270,205 lb

Area of crushed steel = F / 38,000 psi = 270,205 lbs / 38,000 psi = 7.1 in^2

The area of the trapezoid is described by $(1.4d + 3.44d^2)$ where $d\sqrt{2}$ = depth of crush.

$$7.1 = 1.4d + 3.44d^2$$

or,

d = 1.25 in

Therefore:

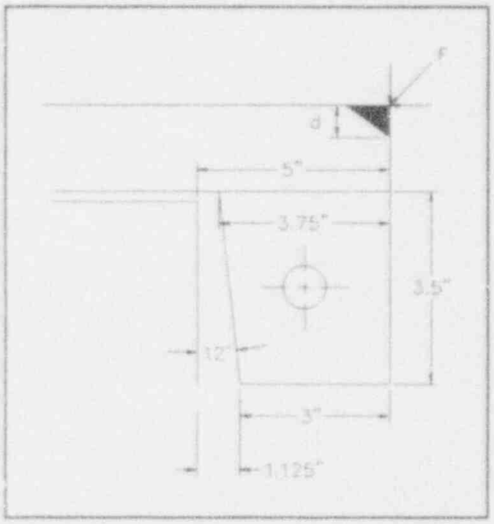
$d/\sqrt{2}$ = 0.882 inch

Width of crush = 1 + 4.87d = 7.08 in

Volume of crushed steel = $d^2/2$ + 1.925d + 1 = 4.18 in^3

Energy absorbed in crushing = (4.18 in^3)(38,000 psi)

= 158,840 in-lb



<u>Deceleration Force During Initial Crushing</u>

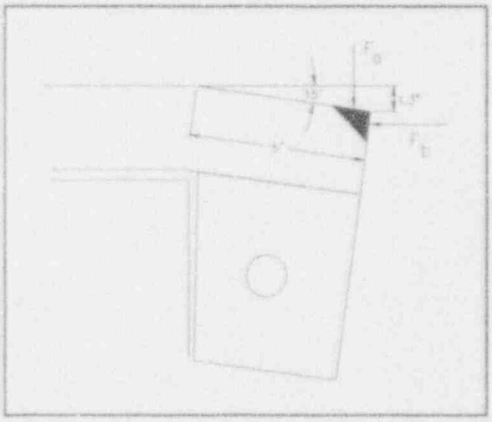
Energy absorbed 158,840 in-lbs

Energy remaining = 477,160 in-lbs

Force = (7.1 in^2)(38,000 psi)
= 270,205/53,000 = 5.1 g's

<u>Bending of Cover</u>

After the initial crushing of the corner and the buildup of force noted above, the corner of the cover will bend inelastically until the lug under the corner contacts the shell of the cask. The amount of axial displacement will be 1.05 inches and the energy absorption, and deceleration forces will be as follows:



Bending of lid (15° until lug hits outer shell of cask).

Energy remaining = 477,160 in-lbs

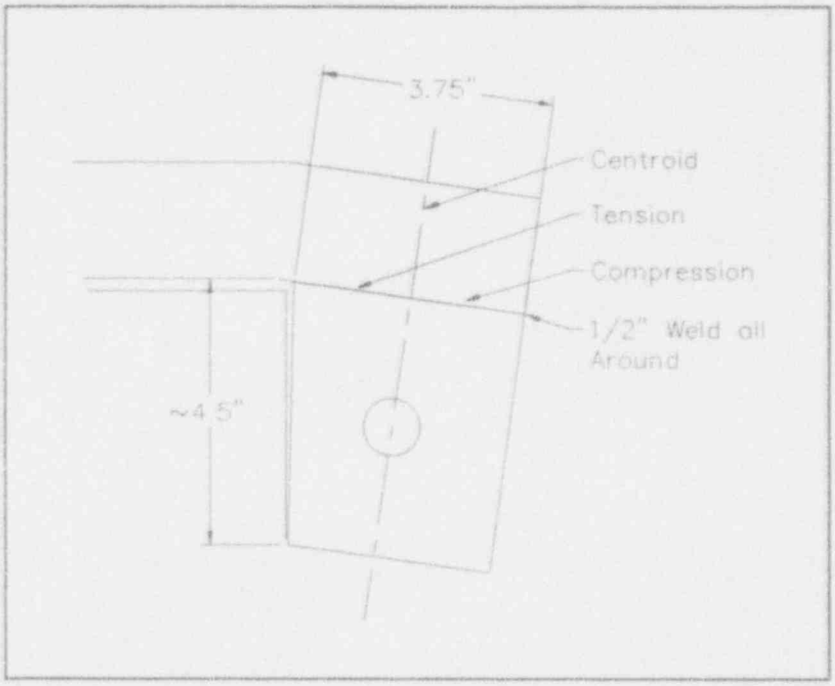
Energy absorbed in bending (1.3" travel):

E = (Fa)(d) = (191,064 lbs) (1.3")
= 248,383 in-lbs

Energy remaining = 228,777 in-lbs

Failure of the Lug

After coming in contact with the shell, the lug will fail due to tensile shear in the weld to the cask cover. The moment which will cause failure of the weld is calculated as follows:



$$M = 2\sigma_m\,[(1.5)(0.5)(1.875) + (0.5)(t\sqrt{2})(1.875)^2(0.67)(0.5)(2)]\ 0.85$$

$$M = 5.2\ (21{,}000\ \text{psi}) = 109{,}368\ \text{in-lbs}$$

The compressive strength of the shell of the cask will be equal to or greater than the tensile yield strength of 49,000 psi. The lug is 1.5 inches wide and will contact with the cask about 4.5 inches from the spacer ring. The lug will locally deform the shell until the moment that will shear the weld is attained.

$$F = 49{,}000\ (1.5)(y_1)\ 0.5 = 36{,}750\ y_1\ \text{lbs}$$

$$y_2 = 4.5 - y_1/3\ \text{in}$$

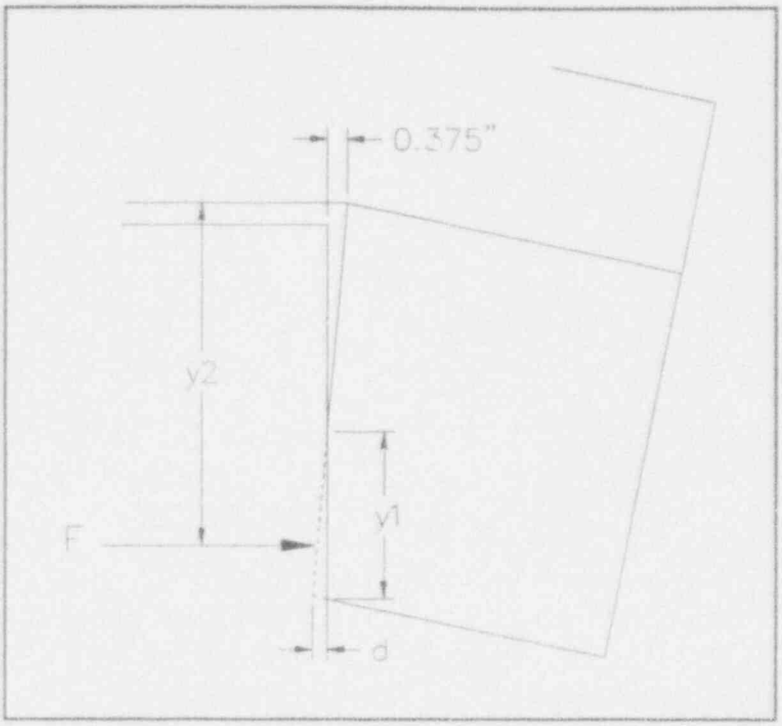
$$M = (F)\ (y_2) = (F)(4.5 - y_1/3)\ \text{in-lbs}$$

$$= 165{,}375\ y_1 - 12{,}250\ y^2_1 = 109{,}368\ \text{in-lbs}$$

$$12{,}250\ y^2_1 - 165{,}375\ y^2_1 + 109{,}368 = 0$$

$$y_1 = \frac{165{,}375 - \sqrt{165{,}375^2 - 4(12{,}250)(109{,}368)}}{2(12{,}250)}$$

$$y_1 = 0.70\ \text{in}$$



The depth of shell deformation or, d, will be as follows:

$$\frac{d}{0.375} = \frac{y_1}{4.5-y_1} = \frac{0.70}{4.5 - 0.70}$$

$d = 0.07$ in

Deflections or deformations of this magnitude in the shell will not effect the integrity of the cask.

Secondary Bending

During and following the shearing of the tiedown lug weld, the corner of the cask cover will continue to bend and absorb energy. Neglecting the energy that would be absorbed in the shearing of the tiedown lug from the cover, the amount of energy to be absorbed in secondary bending will be:

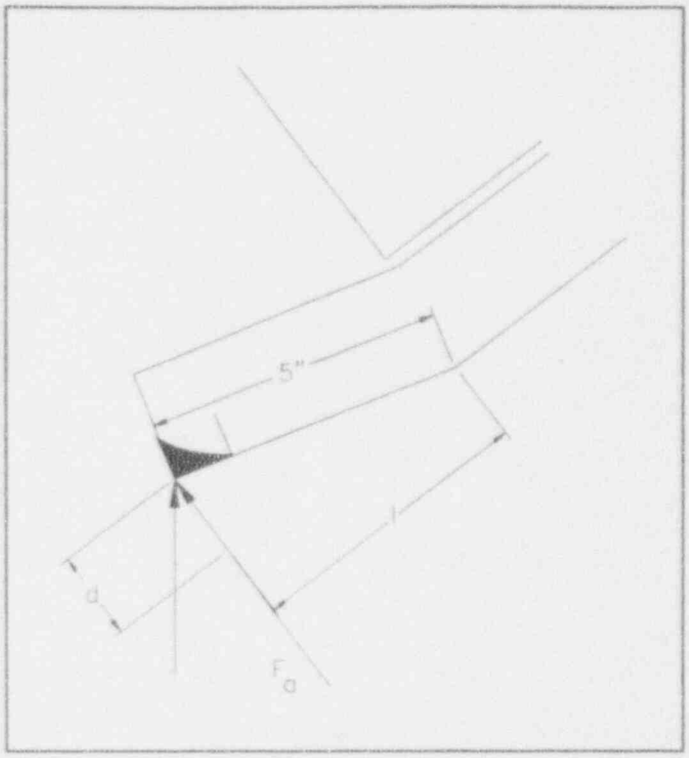
Initial Kinetic Energy	636,000 in-lbs
Less Initial Crushing	158,840 in-lbs
Less Initial Bending	248,383 in-lbs
Remaining Energy	228,777 in-lbs

In secondary bending, the bending of the corner of the cover will reduce the moment arm for the axial force and the force required to cause bending will increase.

$\ell = \sqrt{25 - d^2}$

$M_a = F_a \ell = 955{,}320$ in lbs

$$F_a = \frac{955{,}320}{\sqrt{25 - d^2}}$$



The energy absorbed is computed as follows:

Displacement	ℓ	Fa	Fa (Avg)	d	E	Σ E
1.3	4.83	199,034				
1.5	4.77	200,290	199,662	0.45	89,450	89,450
2.0	4.58	208,468	204,380	0.50	102,190	191,640
2.18	4.5	212,306	210,387	0.18	37,870	229,500

The secondary bending is capable of absorbing the remaining energy. The additional displacement of the lid during secondary bending is:

2.18 - 1.3 = 0.88 in

<u>Deceleration Forces</u>

It was calculated that the initial crushing caused a deceleration force of 5.1 g's. Calculate the deceleration forces of secondary bending since this is the shortest distance traveled in any of the phases discussed.

$$v = \sqrt{\frac{2\ KE\ g}{W}} = \sqrt{\frac{2\ (228{,}777)\ 386.4}{53{,}000}} = 57.76 \text{ in/sec}$$

v_{avg} = 28.88 in/sec

$\Delta t = \Delta X / v_{avg} = 0.88 / 28.88 = 0.0305$ sec

$a = \Delta V / \Delta t = 57.76/0.0305 = 1893.8 \text{ in/sec}^2$

$a = (1893.8 \text{ in/sec}^2)/(386.4 \text{ in/sec}^2) = 4.9$ g's

This indicates that the maximum deceleration force during a 12 inch drop on a short flat corner on the lid is 5.1 g's. This does not exceed the g forces calculated in the drop on a long flat.

3.2.6.6 Side Drop

The cask is dropped on its side. The energy is assumed to be absorbed entirely on the lid edge.

Total energy = 636,000 in-lbs

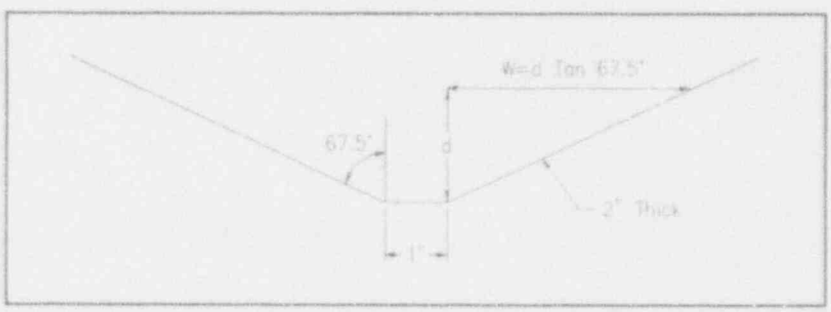
636,000 in-lbs = $1/2\ mv^2$

Initial velocity, v = 96.3 in/sec

Let d = depth of crush

Volume of steel required to absorb energy:

636,000 in-lbs/38,000 psi = 16.7 in^2



The volume of steel can be described by:

$V_s = 2\ (0.5\ dw)(2\ in) + (1\ in)(2\ in)$

Final depth = $4.82\ d^2 + 2d = 16.7\ in^3$

d = 1.67 in

As shown on Table 3-2, the highest g force exerted on the lid is 12.0 g's.

TABLE 3-2

d (in)	Vol. (in^3)	Energy Absorbed (in-lbs)	Energy Remaining (in-lb)	Velocity (in/sec)	Incremental Time (sec) (based on avg.vel.)	Deceleration (in/sec^2)	(g's)
0	0	0	636,000	96.3			
0.1875	0.54	20,689	615,311	94.7	0.00196	806	2.1
0.375	1.43	54,256	581,744	92.1	0.00200	1310	3.4
0.5	2.21	83,790	552,210	89.7	0.00137	1752	4.5
0.75	4.21	160,027	475,973	83.3	0.00290	2207	5.7
1.0	6.82	259,160	376,840	74.1	0.00320	2875	7.5
1.25	10.03	381,187	254,813	61.0	0.00370	3540	9.1
1.5	13.85	526,110	109,890	40.0	0.00500	4200	10.9
1.67	16.7	636,000	0	0	0.00850	4705	12.0

The weight of the cask less the upper cover plate is 53,000 -3260 = 49,740 lbs. The deceleration force acting on the weld between the two cover plates will be:

F = 49,740 (12.0 g's) = 596,880 lbs

The weight of the cask less the cover and shield plug is 53,000 - 5800 - 370 = 46,830 lbs. The deceleration force between the cover plate and the inner shell of the cask will be:

F = 46,830 (12.0 g's) = 561,960 lbs

The loads calculated for the weld and the inner shell due to a one foot drop on the top corners in section 3.2.6.3 are higher than the respective loads calculated here. Therefore, the cask will safely survive a side drop as well.

3.2.7 Penetration

Impact from a 13 pound rod will have no effect on the package.

3.2.8 Compression

This requirement is not applicable since the package exceeds 10,000 pounds.

<u>CONCLUSION</u>

From the above analysis, it can be concluded that the CNS 14-170 Series III cask is in full compliance with the requirements set forth in 10 CFR 71 for Type "A" Packaging.

4.0 THERMAL EVALUATION

The CNS 14-170 Series III casks will be used to transport waste primarily from nuclear electric generating plants. The principal radionuclides to be transported will be Cobalt 60 and Cesium 137. The shielding on the cask will limit the amount of these materials that can be transported as follows:

Isotope	Gamma Energy Mev	Specific[1] Activity μCi/ml	Total[2] Activity Ci
Cobalt 60	1.33	5.0	23.2
Cesium 137	0.66	140.0	650

[1]Based on cement solidified waste and 10 mR at six feet from cask.

[2]Based on 164 cubic feet of solidified material.

With the maximum amount of these materials that can be transported in the CNS 14-170 Series III cask, the heat generated by the waste will be as follows:

	Heat Generation (Watts/Curie)	Total Activity (Curies)	Total Heat (Watts)	(Btu/Hr)
Cobalt	0.0154	23.2	0.35	1.19
Cesium	0.0048	650	3.14	10.7

The weight of waste per container will be about 15,700 pounds. Based on a specific heat of 0.156 Btu per degree F., 2449 Btu's, or over 9 days with cesium would be required to heat the waste one degree Fahrenheit. Accordingly, the amount of heat generated by the waste is insignificant.

5.0 CONTAINMENT

The shipping cask is a vessel which encapsulates the radioactive material and provides primary containment and isolation of the radioactive material from the atmosphere while being transported.

The cask is an upright circular cylinder composed of layers of structural steel with lead for radiation shielding, between the steel sheets. The lamina are of 3/8 inch inner steel, 1-7/8 inch of lead shield and a 7/8 inch outer steel shell. The heavy steel flange connecting the annular steel shells at the top provides a seat for a neoprene gasket seal used to provide positive atmospheric isolation when the lid is closed by tightening the eight (8) ratchet binders which are equally spaced at 45° intervals on the outer circumference of the cask. The shield plug is located in the center of the cask lid, has a neoprene gasket and is bolted to the outer portion of the lid with 8 equally spaced 3/4 inch studs on a 20-7/8 inch diameter circle.

5.1 Primary Lid Gasket

Determine the amount of compression of the primary lid gasket due to tightening of the ratchet binders.

Gasket O.D. = 77.75 inches   I.D. = 76.25 inches

$$\text{Area} = \pi(Ro^2 - Ri^2) = \pi(38.875^2 - 38.125^2) = 181.43 \text{ in}^2$$

Gasket is a 3/8 inch thick by 3/4 inch wide Durometer 40.

Based on past experience from the manufacturer, a torque of 175 to 200 ft-lbs exerted on the handle of the ratchet binder will develop about 3,500 pounds of tension in the binder.

Therefore, the force downward on lid compressing the gasket is:

(8 binders)(3,500 lb/binder) + 6,170 lb lid weight = F = 34,170 lb.

$$\text{Equivalent pressure on gasket} = \frac{F}{A} = 34{,}170 \text{ lb}/181.43 \text{ in}^2 = 188 \text{ lb/in}^2$$

As shown on Appendix D-1, the compression of the gasket due to tightening of the ratchet binder to this minimum is 20% of the gasket thickness, or about 3/32 inch.

5.2 Shield Plug Gasket

Similarly, the compression for the shield plug is calculated. Based on the stud torquing procedure for the shield plug, the minimum torque value is 120 ft-lb.

The gasket dimensions are 22.75 in. O.D., 20.25 in. I.D., and 3/8 in. thick. The gasket is Durometer 50.

$$\text{Area} = \pi(Ro^2 - Ri^2) = \pi(11.375^2 - 10.125^2) = 84.43 \text{ in}^2$$

Force downward on the lid is the sum of the weight of the lid, plus the force of the studs (P).

$$P = \frac{T}{KD} = (120 \text{ ft-lb})(12 \text{ in/ft})/(0.15)(0.75 \text{ in})$$

$$P = (12{,}800 \text{ lb/stud})(8 \text{ studs}) = 102{,}400 \text{ lb}$$

$$W = 370 \text{ lb}$$

$$\text{Total Force} = 102{,}400 + 370 = 102{,}770 \text{ lb}$$

$$\text{Pressure on gasket} = \frac{F}{A} = 102{,}770 \text{ lb}/84.43 \text{ in}^2 = 1217.2 \text{ psi}$$

As shown on Appendix D-2, the compression of the shield plug gasket is 33% of initial thickness or 1/8 inch.

5.3 Seal With Internal Pressurization

The inner steel shell is designed to act as a pressure vessel when the cask lid is in place and tightened. As shown in Section 3.2, the cask will withstand an internal pressure of 7.5 psig as required by 10 CFR 71, Appendix A. As described in Section 1.0, the nature of the waste being transported is such that phase change or gas generation which may over-pressurize the cask, will not occur. The stepped flanged surface at the end of the cask body has been designed to minimize effects of columnated radiation streaming and problems associated with gasket damage during impact.

If the cask is pressurized to 7.5 psig, the resultant force on each ratchet binder (as calculated in Section 3.2) is 4 113 pounds.

The resultant strain on the steel ratchet binder (1-3/4" diameter) is:

$$P/AE = (4.113)/(1.77)(30 \times 10^6) = 0.000093 \text{ in./in.}$$

$$P = 4{,}113 \text{ lb}$$

$$A = \text{Area of 1-1/2" minor diameter} = 1.77 \text{ in}^2$$

$$E = \text{Youngs Modulus} = 30 \times 10^6 \text{ psi}$$

and for a 24 inch long binder, total strain is:

$$(24 \text{ in.})(0.000077 \text{ in/in.}) = 0.0019 \text{ in.}$$

This is less than 2% of the initial compression of the gasket.

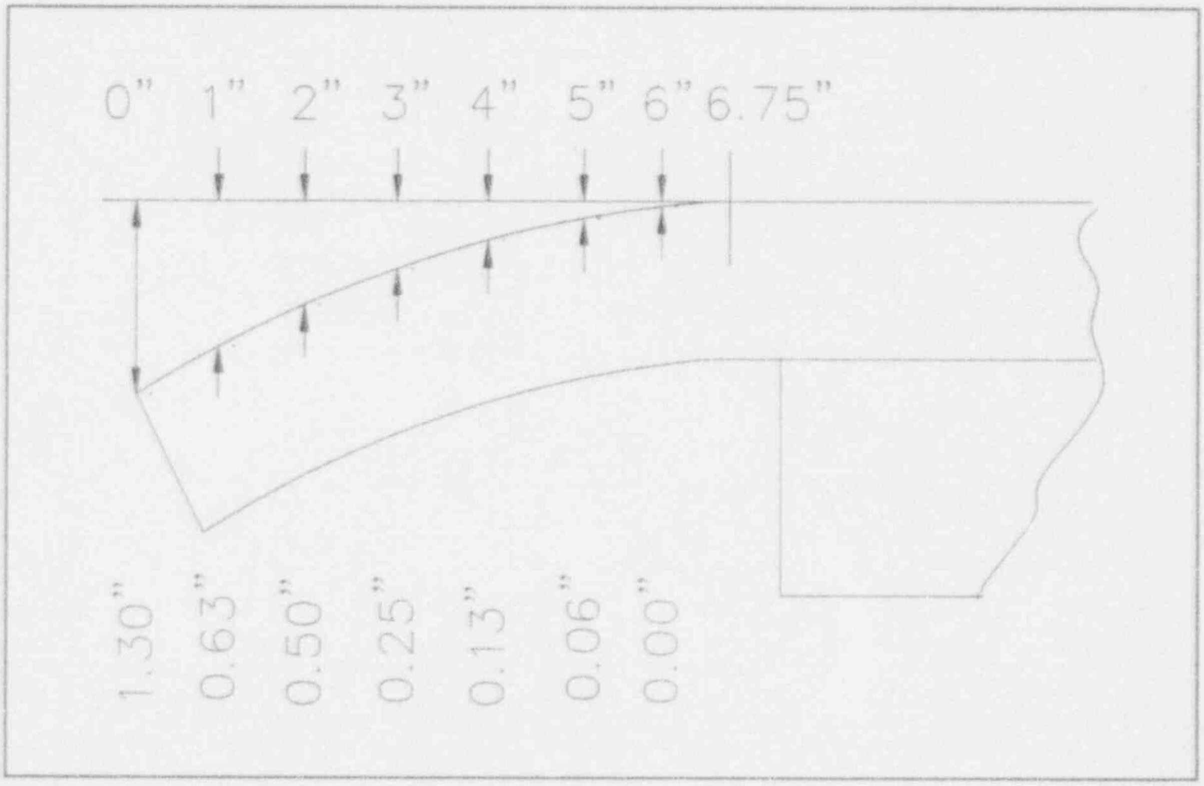
5.4 Gasket Compression Test

A compression test to check resiliency was done on Items 4 and 5 on CNSI Drawing C 110-D-0016, Revision C, the primary lid and secondary shield plug gaskets. The samples were each 1 in^2 by 3/8 inch thick made of Durometer 40 neoprene and Durometer 50 neoprene, respectively. Each sample was put in a compression device and compressed. The final results indicated that it required about 4,500 lb to compress the 1 in^2 Durometer 40 sample to a thickness of 1/8 inch. After removing the sample from the test stand, the sample returned to its original thickness of 3/8 inch. Similarly, the 1 in^2 Durometer 50 sample was compressed to 1/8 inch thick, and it required 10,000 lb. It also returned to its original thickness when the load was removed. The test compressed each gasket material 66 percent of its original height and each survived. The spacer rings have been increased to 1/4 inch which limits gasket compression to 33 percent of the gasket thickness; thereby, further reducing possible damage to the gasket material.

5.5 Warping of Covers

The possible distortion of the cover and possible leakage due to distortion has been addressed on a cask of nearly identical design. A cask having an octagonal cover by Nuclear Packaging, Inc. The identification number of the package which was dropped is 71-9130. The package, Model No. 50-256, had a weight of 19,160 lbs, and was loaded with a liner containing sand with a weight of 4200 lbs for a gross weight of 23,360 lbs. The package was dropped on an essentially unyielding surface from a height of 46 inches. The package was pressure tested before and after the drop test and no leakage was detected.

The deformation of the corner subjected to the drop test is shown below:



The energy absorbed in dropping a 23,360 lb package from 46 inches is 1.07×10^6 in-lbs. The energy to be absorbed in a one foot drop of an CNS 14-170 Series III cask is 12 x 53,000 = 6.36×10^5 in-lbs or less than 60 percent of the unit tested.

The covers are the same thickness and the overhang of the corners are approximately the same. Accordingly, the CNS 14-170 Series III should experience less deformation. All of the deformation occurred outside of the impact limiter and no deformation of the cover was found in the areas which could affect the seal.

6.0 OPERATING PROCEDURES

This section describes the general procedures for preparation, loading, and unloading of the CNS 14-170 Series III Cask. Detailed procedures developed, reviewed, and approved in accordance with the requirements of the CNSI Quality Assurance Program are issued to authorized users.

6.1 Loading Procedure For 55-Gallon Drums

(or for installation of pre-filled liners)

6.1.1 Remove cask rain cover, if installed.

6.1.2 Loosen and disconnect ratchet binders from cask lid.

6.1.3 Using a lifting sling attached to the three symmetrically located primary lid lifting lugs, lift the primary lid.

6.1.4 Lay down lid on a suitable protected surface, treating lid underside as potentially contaminated.

6.1.5 Using crane and suitable rigging, remove pallet(s) and any shoring materials from cask cavity.

6.1.6 Visually inspect cask cavity to verify integrity. Clean and inspect gasket sealing surfaces.

NOTE: REMOVE ANY MATERIAL OR MOISTURE FROM CASK CAVITY UNDER THE SUPERVISION OF QUALIFIED HEALTH PHYSICS PERSONNEL USING THE NECESSARY H.P. MONITORING AND RADIOLOGICAL HEALTH SAFETY PRECAUTIONS AND SAFEGUARDS.

6.1.7 Load each pallet with a maximum of seven (7) 55-gallon drums. Shielding effectiveness may be optimized by placing drums with highest surface dose rate near the center to the pallet.

6.1.8 Attach crane to the lifting ring on the pallet slings and carefully lower into cask cavity, use caution to prevent damage to gasket sealing surfaces in inner walls of cask cavity.

6.1.9 Place shoring where appropriate between drums and cask cavity walls to prevent movement during transport.

6.1.10 Repeat the loading procedure for the next layer of palletized drums.

NOTE: FOR PRE-FILLED LINERS, USE CRANE TO LOWER LINER INTO CASK CAVITY. USE CAUTION TO PREVENT DAMAGE TO GASKET SEALING SURFACE OR INNER WALLS OF CASK CAVITY.

6.1.11 Lift the primary lid onto cask and position using the alignment pins and the alignment marks painted on cask body and lid.

6.1.12 Replace the lid ratchet binders and tighten to 175-200 ft.-lbs. torque. Return the handles to their storage position.

6.1.13 Install anti-tamper seal wires on cask lid or ratchet binders.

6.1.14 Perform cask survey and verify that the following requirements are satisfied:

A. Cask external radiation levels do not exceed 200 mR/hour on contact, 10 mR/hour at 2 meters, and 2 mR/hour in the tractor cab in accordance with 10 CFR 71.47 and 49 CFR 173.441.

B. Cask external removable contamination is ALARA, and does not exceed 22 dpm/cm^2 beta-gamma and 2.2 dpm/cm^2 alpha in accordance with 10 CFR 71.87 and 49 CFR 173.443.

C. That trailer placarding and cask labeling meet DOT specifications 49 CFR Part 172.

6.1.15 Install cask rain cover (if required) and secure to cask.

6.2 Unloading Procedure

NOTE: **UPON RECEIPT OF CASK, PERFORM SURVEY FOR DIRECT RADIATION AND REMOVABLE CONTAMINATION USING APPROVED PROCEDURES TO ASSURE COMPLIANCE WITH APPLICABLE REQUIREMENTS OF 10 CFR 20.205.**

6.2.1 Remove cask rain cover, if installed.

6.2.2 Loosen and disconnect ratchet binders from cask lid.

6.2.3 Using a lifting sling attached to the three symmetrically located primary lid lifting lugs, lift the primary lid.

6.2.4 Inspect and verify integrity of lid gasket.

6.2.5 Lay down lid on a suitable protected surface, treating lid underside as potentially contaminated.

6.2.6 After survey by Health Physics personnel, attach crane to liner or drum pallet(s) and remove from cask cavity.

6.2.7 Visually inspect cask cavity to verify integrity. Clean and inspect gasket sealing surfaces.

NOTE: REMOVE ANY MATERIALS OR MOISTURE FROM CASK CAVITY UNDER THE SUPERVISION OF QUALIFIED HEALTH PHYSICS PERSONNEL USING THE NECESSARY H.P. MONITORING AND RADIOLOGICAL HEALTH SAFETY PRECAUTIONS AND SAFEGUARDS.

6.2.8 Install new liner or drum pallet(s) in cask.

NOTE: IF LINER OR DRUMS CONTAIN MATERIALS THAT COULD PRODUCE HYDROGEN GAS AS DESCRIBED IN THE CERTIFICATE OF COMPLIANCE, ASSURE PROPER VENTING OR OTHER PROTECTIVE MEASURES ARE TAKEN.

6.2.9 Lift the primary lid onto cask and position using alignment pins and the alignment marks pointed in the cask body and lid.

6.2.10 Replace the lid ratchet binders and tighten to 175-200 ft.-lbs. torque. Return the handles to their storage position.

6.2.11 If CNSI seal is broken on secondary lid, remove lid and check integrity of gasket. Reinstall lid and torque nuts to 120 ± 10ft.-lbs., using a star pattern.

6.2.12 Install anti-tamper seals on primary and secondary lids.

6.2.13 Prior to departure from site, ensure that exterior radiation levels (fixed and removable) are below site release and applicable Federal limits.

6.2.14 Ensure proper placarding of cask and trailer.

6.3 Processing Liners Inside Cask

(For empty liners pre-installed in cask cavity.)

6.3.1 Remove cask rain cover, if installed.

6.3.2 Loosen and remove the eight (8) nuts that secure the secondary lid.

6.3.3 Attach a lifting sling to the lifting lug on the secondary lid, and lift off lid.

6.3.4 Inspect and verify integrity of gasket.

6.3.5 Lay down lid on a suitable protected surface, treating lid underside as potentially contaminated.

6.3.6 Inspect and clean gasket sealing surfaces.

6.3.7 Proceed with filling the liner following appropriate personnel precautions and operational procedures.

<u>NOTE</u>: **PRIOR TO CLOSING THE LINER LID AND CASK, ASSURE TEN DAY VENT PERIOD CAN BE MET PRIOR TO SHIPPING THE CASK. (SEE HYDROGEN GENERATION CONDITIONS OF CERTIFICATE OF COMPLIANCE.)**

6.3.8 Lift the secondary lid onto the primary lid and position using indicated alignment marks and alignment pins.

6.3.9 Replace the eight (8) hex nuts and torque to 120 ± 10 ft.-lbs., using a star pattern.

6.3.10 Ensure primary lid ratchet binders are tightened to 175-200 ft.-lbs. torque and their handles are returned to the storage position.

6.3.11 Install anti-tamper seal on primary and secondary lids.

6.3.12 Perform cask survey and verify that the following requirements are satisfied.

A. Cask external radiation levels do not exceed 200 mR/hour on contact, 10 mR/hour at 2 meters, and 2 mR/hour in the tractor cab in accordance with 10 CFR 71.47 and 49 CFR 173.441.

B. Cask external removable contamination is ALARA, and does not exceed 22 dpm/cm^2 beta-gamma and 2.2 dpm/cm^2 alpha in accordance with 10 CFR 71.87 and 49 CFR 173.443.

C. That trailer placarding and cask labeling meet DOT specifications 49 CFR Part 172.

6.3.13 Install cask rain cover (if required) and secure to cask.

6.3.14 Check the cavity drain line to determine that the drain plug is properly installed using a pipe thread sealant.

7.0 ACCEPTANCE TEST AND MAINTENANCE PROGRAM

7.1 Initial Acceptance Test

During and after fabrication of the cask, various tests and inspections are required prior to the first use of the cask. The tests and inspections required to be performed are enumerated below:

7.1.1 Visual inspection and dimensional verification of the entire cask and its accessories shall be performed to verify compliance with the requirements of appropriate drawing, specifications, applicable codes and other pertinent data indicating qualitative and quantitative acceptable criteria. All visual inspection shall be carried out either directly or remotely as described hereafter. The following shall be inspected: surface condition, dimension, finishes, shape, locations, details, size of holes, cleanlines, etc.

7.1.2 Lifting Lugs Load Test shall also be performed. The Load Test of all lifting lugs shall be performed in accordance with a procedure approved by Chem-Nuclear Systems, Inc. Each lug shall be load tested to one and a half times the calculated load capacity of the lug and held ten minutes as a minimum. After the load test, all welding on the lugs will be examined by magnetic particle testing using the procedure approved by Chem-Nuclear Systems, Inc. and performed by qualified personnel. Magnetic Particle Test shall meet the requirements of ASME Code Section III, Division I Subsection NF, Article NF-5000 and Section V, Article 7. Test Reports shall be documented and included to Quality Assurance Records of the cask.

7.1.3 Test for Shielding Integrity shall be performed after the lead pouring operations. A Gamma Scan shall be applied to verify lead thickness, shielding capacity and to determine existence of any voids or impurities in the poured lead. The Gamma Scan procedure shall specify an acceptance criteria for verification that the lead thickness is not less than 1-3/4 inches. The Gamma Scan must show no grater than ten percent loss of shielding at any point based on a four inch grid spacing. The Gamma Scan shall be performed by qualified personnel in accordance with a procedure approved by Chem-Nuclear Systems, Inc. Results of the Gamma Scan shall be documented and included in the Quality Assurance Records of the cask.

Test for Seal Integrity shall also be performed prior to first use of the cask. A Leak Test shall be applied to the cask to assure leak tightness of the seals. The cask shall be pneumatically pressurized to 8 psi and while under pressure, seals are soap bubble checked for leakage acceptance criteria - no visible bubbles. Test Report shall be documented and included in the Quality Assurance Records of the cask.

7.2 Maintenance Program

The Chem-Nuclear Systems, Inc. maintenance requirements for the CNS 14-170 Series III

Cask are articulated in this section. These requirements reflect the specific operating conditions, limitations and regulatory requirements.

7.2.1 Painted Surfaces

A. Painted surfaces shall be cleaned by steam or pressurized hot water using standard commercial equipment, chemical solutions, and procedures. There are no special precautions required in this cleaning operation.

B. Chipped or scratched surfaces shall be retouched or repainted using Chem-Nuclear Systems, Inc. approved paints.

C. Alignment stripes shall be repainted when they are chipped, peeled off, faded, or not legible. Only localized surface preparation (sanding and cleaning) is required prior to repainting of alignment stripes.

7.2.2 Structural Members and Welds

A. All structural members and welds shall have been checked prior to initial use of the cask. Inspections of structural members and welds are not required during routine use unless the cask has been involved in an accident or has been lifted improperly or in an overload condition. In those cases, inspection must be performed as follows:

- o <u>Drop or Accident</u> - All accessible structural members, welds, ratchet binders, shall be visually inspected. In addition, all accessible welds must be magnetic particle tested. The Magnetic Particle Test shall be performed by qualified personnel using a Chem-Nuclear Systems, Inc. approved procedure. Magnetic Particle ^Test shall meet the requirements of ASME Code, Section III, Division 1 Subsection NF, Article NF-5000 and Section V, Article 7. The Gamma Scan must be repeated and evaluated to the initial acceptance criteria. Test reports shall be documented and included in the Quality Assurance Records of the cask.

- o <u>Improper or Overload Lift</u> - All welds on the primary or secondary lid which were used during the time of improper or overload lift shall be load tested and magnetic particle tested. Load and Magnetic Particle Test shall be performed in the same manner as delineated in the above paragraphs.

B. Whenever the cask requires total repainting and is sandblasted, all structural members and welds shall be visually inspected for any indications. Suspect members and welds shall be magnetic particle tested. Magnetic Particle Test shall be performed in the same manner as delineated in the above paragraphs.

C. Weld repairs if any shall be performed by qualified personnel using Chem-Nuclear Systems, Inc. approved procedures. Welding shall meet the requirements of ASME Code Section IX and/or AWS D1.1.

7.2.3 Gaskets and Test For Seal Integrity (Leak Test)

A. All Gaskets shall be inspected for proper installation prior to each cask loading.

B. All Gaskets shall be replaced once a year as a minimum regardless of condition.

C. Gaskets which cannot be sealed or are damaged must be replaced or repaired. Damages may include cuts, nicks, chips, indentations, or any other defects apparent to the naked eye which would affect sealing functions.

D. Any painted surfaces in contact with the gaskets shall be maintained in good condition. Any paint surface defect shall be properly retouched or repaired per Paragraph 4.2.1.B.

E. Tests for seal integrity shall be performed after the annual replacement of all gaskets as a minimum. A Leak Test shall be performed in the same manner as delineated in above Paragraph 4.1.4.

7.2.4 Fasteners

A. All fasteners shall be inspected for damage after each use. Fasteners shall be replaced if the following conditions exist:

- o Deformed or stripped threads.
- o Cracked or deformed hexes on bolt heads or nuts.
- o Elongated or scored grip length area on bolts or studs.
- o Severe rusting or corrosion pitting.

B. Fasteners shall be inspected for clean lines and presence of lubricant in the threads prior to use. Any fastener found dirty shall be cleaned and relubricated.

7.2.5 Ratchet Binders

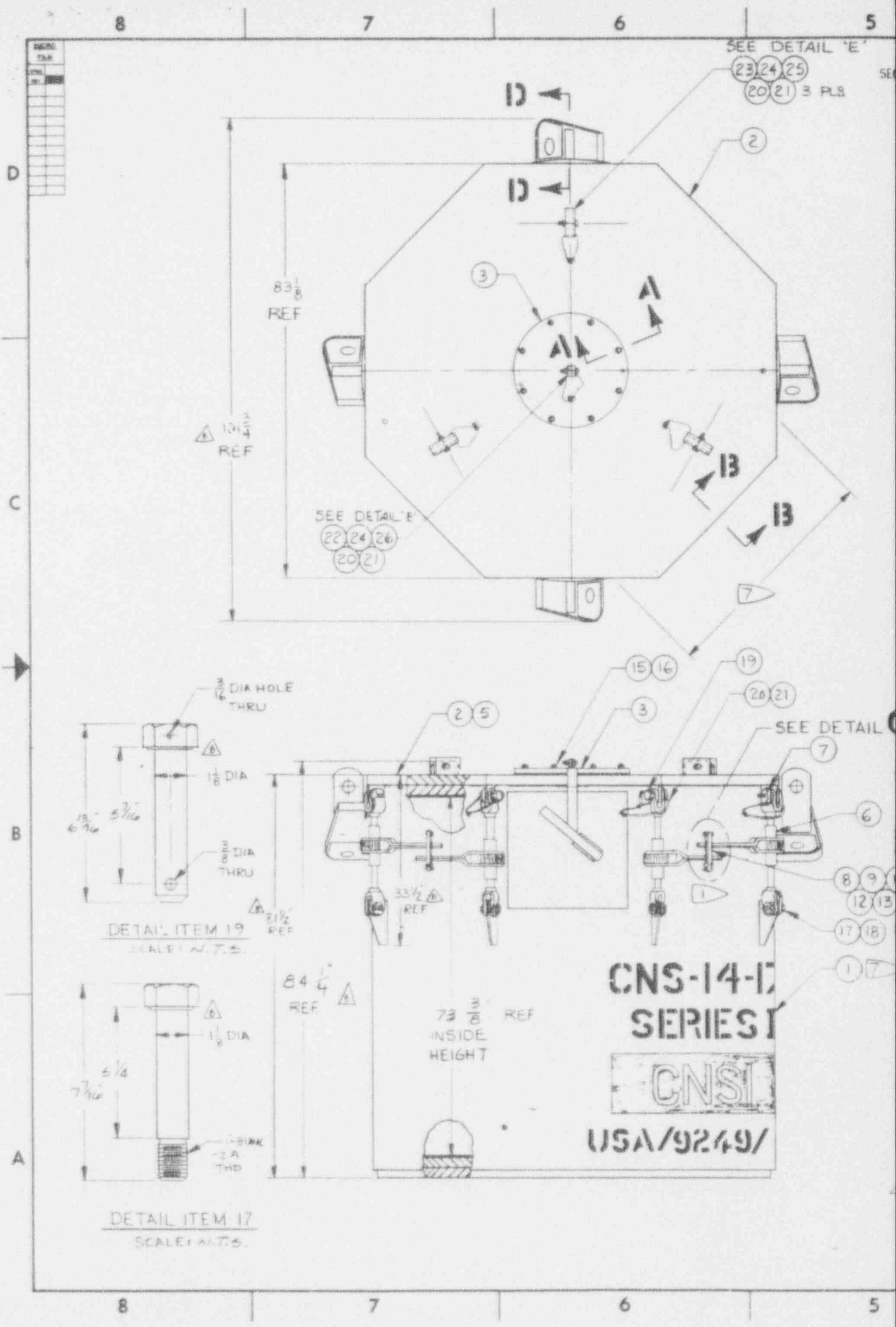
A. The ratchet binders are designed for long rugged use with minimal maintenance. All ratchet binders shall be inspected for operation and general condition prior to use.

B. Lubrication is required very infrequently and can be achieved by disassembly of the binder and lubricating the threads. A good indication for the need to lubricate the ratchet binder will be dry threads on the joining bolt or hard operation.

8.0 QUALITY ASSURANCE

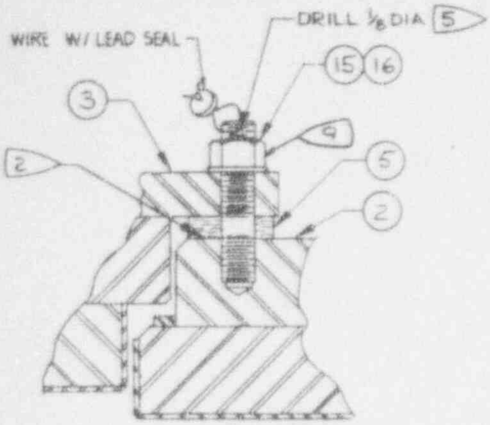
8.1 On December 21, 1978, Chem-Nuclear Systems, Inc. filed with the NRC a description of its Quality Assurance Program in accordance with 10 CFR 71.51(a). The Chem-Nuclear Systems, Inc. Quality Assurance Program was initially approved by the NRC on October 26, 1979 and Approval Certificate No. 0231 was issued. The Chem-Nuclear Systems, Inc. Quality Assurance Program was subsequently re-approved on September 6, 1983, January 23, 1985, and January 17, 1990. Under this certificate, the continued use of the program is authorized.

8.2 The Licensed CNS 14-170 Series III Casks owned by Chem-Nuclear Systems, Inc. which are certified under the provisions of 10 CFR 71 and built after January 1979 are designed, fabricated, assembled, tested, modified, maintained and repaired in accordance with a Nuclear Regulatory Commission approved Quality Assurance Program (Docket #71-0231).

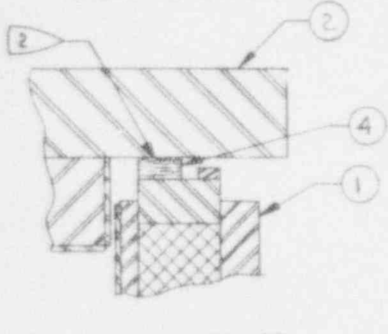


SEE DETAIL 'E'
23 24 25
20 21 3 PLS
D
2
3
A
83 1/8 REF
121 3/4 REF
B
SEE DETAIL 'E'
22 24 26
20 21
7
15 16
19
20 21
3
2 5
SEE DETAIL
6
8 9
12 13
17 18
1 7
3/16 DIA HOLE THRU
1 1/8 DIA
6 13/16
5 3/16
3/8 DIA THRU
DETAIL ITEM 19
SCALE: N.T.S.
33 1/2 REF
31 1/2 REF
84 1/4 REF
73 3/8 REF
INSIDE HEIGHT
CNS-14-I
SERIES I
CNSI
USA/9249/
5 1/4
7 7/16
DETAIL ITEM 17
SCALE: N.T.S.

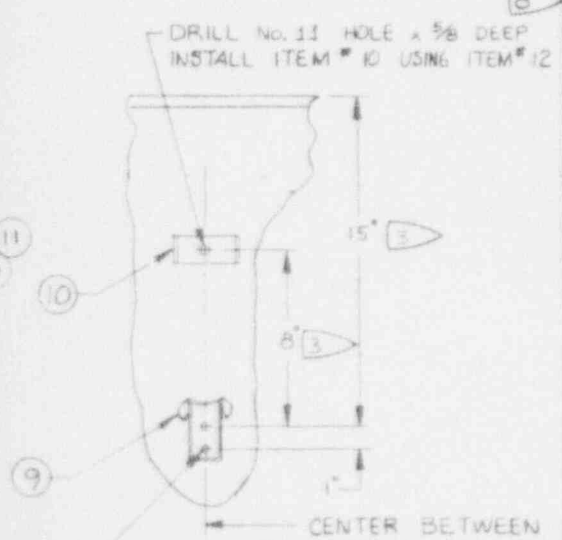
ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED
	A	SEE ECO# C-110-D-0016-001		
	B	SEE ECO# C-110-D-0016-002		
	C	SEE ECO# C-110-D-016-003 REVISED NOTE 1 ADDED NOTE 9		



SECTION A-A 5
SCALE: 1/2
GASKET SHOWN UNCOMPRESSED



SECTION B-B
SCALE: 1/2
GASKET SHOWN UNCOMPRESSED



DETAIL C
SCALE: 1/4

DRILL NO 27 HOLE x 5/8 DP
INSTALL ITEM 9 USING ITEM 13'S

9. TORQUE SECONDARY LID CLOSURE TO 120 ± 10 FT-LB.
1. INSTALL ITEM 6 RATCHET BINDERS AS SHOWN. TORQUE TO 175-200 FT-LB.
2. INSTALL ITEMS 4 & 5 TO ITEM #2 USING A PRESSURE SENSITIVE ADHESIVE.
3. VERIFY DIMENSIONS PRIOR TO DRILLING & INSTALLING ITEMS 9 & 10.
4. NOT USED
5. THE SECURITY WIRE SYSTEM IS TO BE INSTALLED ON ONE TIE-DOWN LUG AND ONE SECONDARY LID STUD ONLY.
6. THIS DRAWING IS EQUIVALENT TO HITTMAN DRAWING NUMBERS: C001-5-9139 REV. 4, C001-5-9140 REV. 4, C001-5-9141 REV. 2, C001-5-9142 REV. 1, C001-5-9143 REV. 5, AND C001-5-9144 REV. 3.
7. STENCILING SHALL BE CENTERED ON CASK BETWEEN LIFTING LUG CENTER LINES AS SHOWN
8. CHAIN MAY BE SUBSTITUTED FOR ITEMS 20 AND 21.

ITEM	QTY	DESCRIPTION	MATERIAL OR PART NO	MAT'L SPEC
26	1	BOLT HEX HEAD 1/4-20 UNC 2A x 1 1/4" LG	C.S. PLATED	
25	3	BOLT, HEX HEAD, 1/4-20 UNC-2A x 1 3/4" LG	C.S. PLATED	
24	4	NUT, HEX 1/4-20 UNC-2B, SELF-LOCKING	C.S. PLATED	
23	3	COVER, PRIMARY LIFTING LID LUG	S.S. 304	A-240
22	1	COVER, SECONDARY LIFTING LID LUG	S.S. 304	A-240
21 (8)	20	SLEEVE, SWAGE FOR 1/16 WIRE ROPE	S.S.	—
20 (8)	A/R	METAL LANYARD 1/16 DIA WIRE ROPE	S.S.	—
19	8	FASTENER PIN 1 1/8 DIA SEE DETAIL	C.S.	SAE GR5
18	8	NUT, HEX 1"-8 UNC-2B, SELF-LOCKING	C.S./CAD PLATE	
17	8	SHOULDER BOLT 1 1/8 DIA - SEE DETAIL	C.S.	SAE GR5
16	8	WASHER, LOCK 3/4 NOM. DIA	C.S./CAD PLATE	
15	8	NUT, HEX 3/4-10 UNC-2B	C.S./CAD PLATE	
14	4	NUT, HEX 3/8-16 UNC-2B SELF-LOCKING	S.S. TYPE 304	
13	8	DRIVE SCREW, TYPE U, No. 8 x 1/2 LG	C.S.	
12	4	DRIVE SCREW, TYPE U, No. 12 x 1/2" LG.	C.S.	
11	4	BOLT, HEX HD 3/8-16 UNC-2A x 1 3/4 LG	S.S. TYPE 304	
10	4	HOOD BRACKET	HRC No. 028-561	—
9	4	ANCHOR BRACKET	HRC No. 277-A-80	—
8	4	RUBBER HOOK	HRC No. 66D638	—
7	8	BALL LOCK PIN	CL-6-BLP-T-1.5 OR EQUIV	—
6	8	RATCHET BINDER	TYPE J 1 1/4 x 8 GALV.	—
5	1	GASKET - SECONDARY	NEOPRENE - 50 DURO 22 1/2 O.D. x 18 I.D. x 3/8 THK	
4	1	GASKET - PRIMARY	NEOPRENE - 40 DURO 78 1/4 O.D. x 76 1/4 I.D. x 3/8 THK	
3	1	SECONDARY LID WELDMENT	C-110-D-0019	—
2	1	PRIMARY LID WELDMENT	C-110-D-0018	—
1	1	CASK WELDMENT	C-110-D-0017	—

BILL OF MATERIAL

UNLESS OTHERWISE NOTED: DIMENSIONS ARE IN INCHES
DO NOT SCALE PRINT
TOLERANCES (UNLESS OTHERWISE SPECIFIED): DEC. .XX ± DEC. .XXX ± DEC. .X ± HOLE DIA. AND LOC. ± 1/32 DEG. ± FRACTIONAL ± 1/8
DOES NOT APPLY TO REF. DIMENSIONS

PROJECT NO: 22955
FSCM NO: 54643

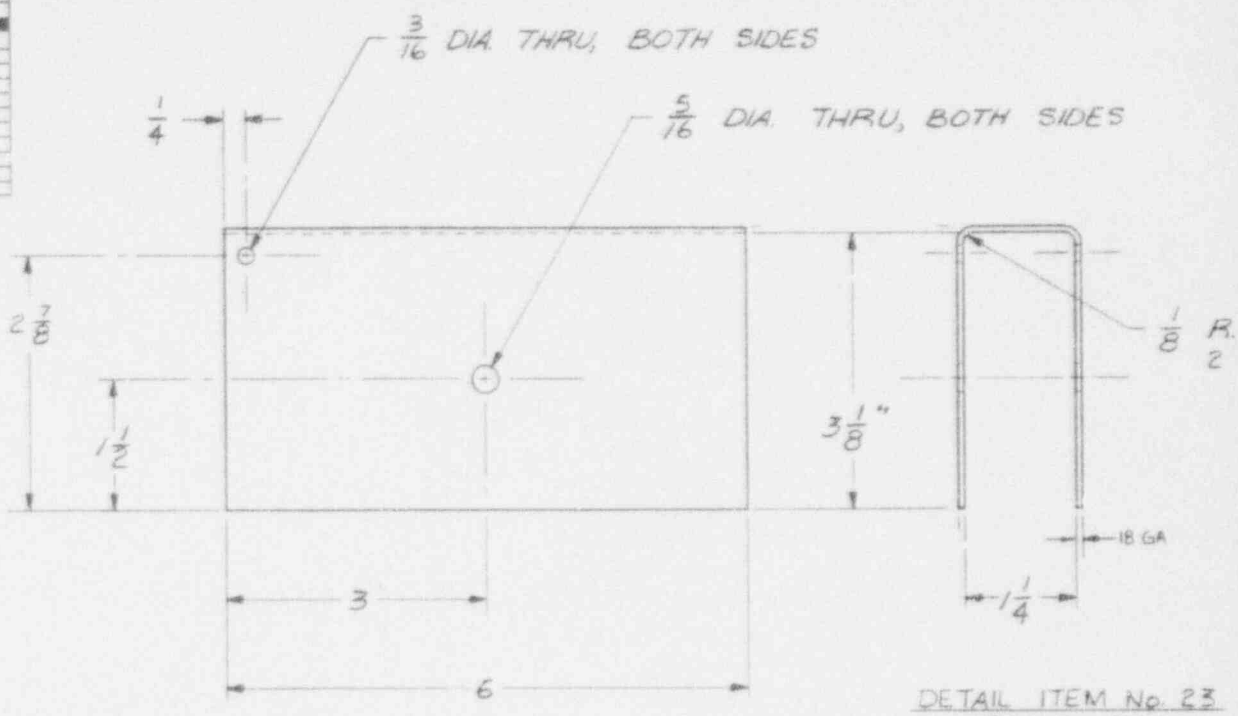
CHEM-NUCLEAR SYSTEMS, INC.

DRAWN: R. BREHON 6/29/93
CHECKED: 6/29/93
ENGINEER: 6/29/93
QUALITY: 6/29/93
APPROVED: 6/29/93

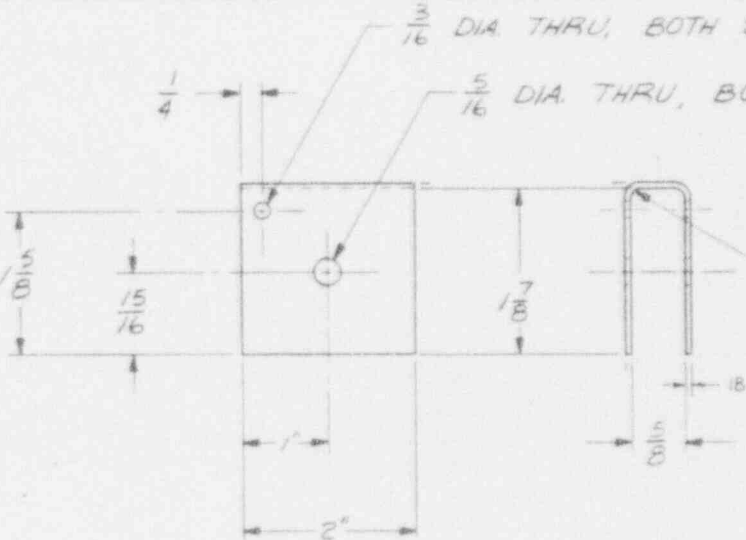
TITLE: ASSEMBLY TRANSPORTATION SHIELD 14-170 SERIES III CASK

SIZE: D
DRAWING NUMBER: C-110-D-0016
REV: 4
SCALE: 1:10 EXCEPT AS NOTED
SHEET 1 OF 2

9307080157-01

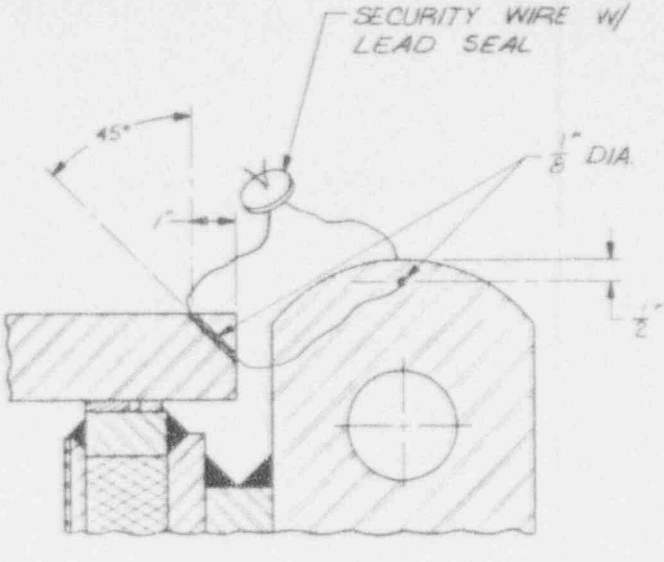


DETAIL ITEM No. 23
SCALE: FULL

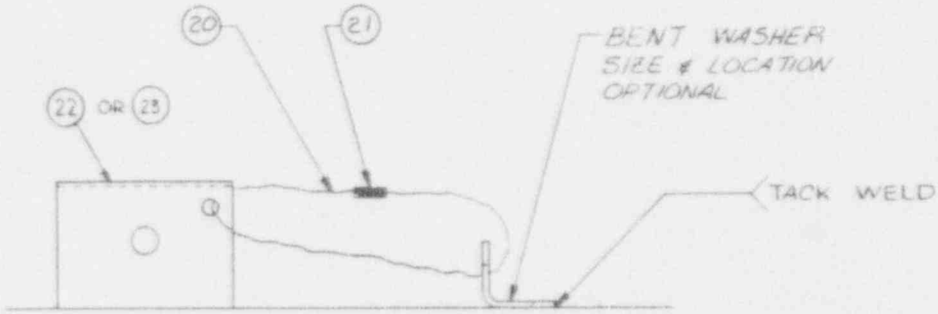


DETAIL ITEM No. 2
SCALE: FULL

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	B	CHANGE TO SHT 1 of 2 ONLY / ECO-C-110-D-0016-002	1-14-86	[illegible]
	C	CHANGE TO SHT 1 of 2 ONLY ECO# C-110-D-0016-003		[illegible]



SECTION D-D 5
SCALE: 1/2



DETAIL E TYP 4 PLS
SCALE: NONE

SI APERTURE CARD

Also Available On Aperture Card

ITEM	QTY	DESCRIPTION	MATERIAL OR PART NO	MAT'L SPEC	WT
BILL OF MATERIAL					

UNLESS OTHERWISE NOTED DIMENSIONS ARE IN INCHES
DO NOT SCALE PRINT
TOLERANCES (UNLESS OTHERWISE SPECIFIED)
DEC .XX ± DEC .XXX ±
DEC .X ± HOLE DIA. AND LOC. ± 1/32
DEG ± FRACTIONAL ± 1/8
DOES NOT APPLY TO REF. DIMENSIONS

THIS DRAWING IS THE PROPERTY OF CHEM-NUCLEAR SYSTEMS, INC. AND IS LOANED UPON THE CONDITION THAT IT IS NOT TO BE REPRODUCED OR COPIED, RELEASED TO OTHERS WITHOUT THE WRITTEN PERMISSION OF CHEM-NUCLEAR SYSTEMS, INC. AND IS TO BE RETURNED UPON REQUEST.

PROJECT NO: 22455
FSCM NO: 54643

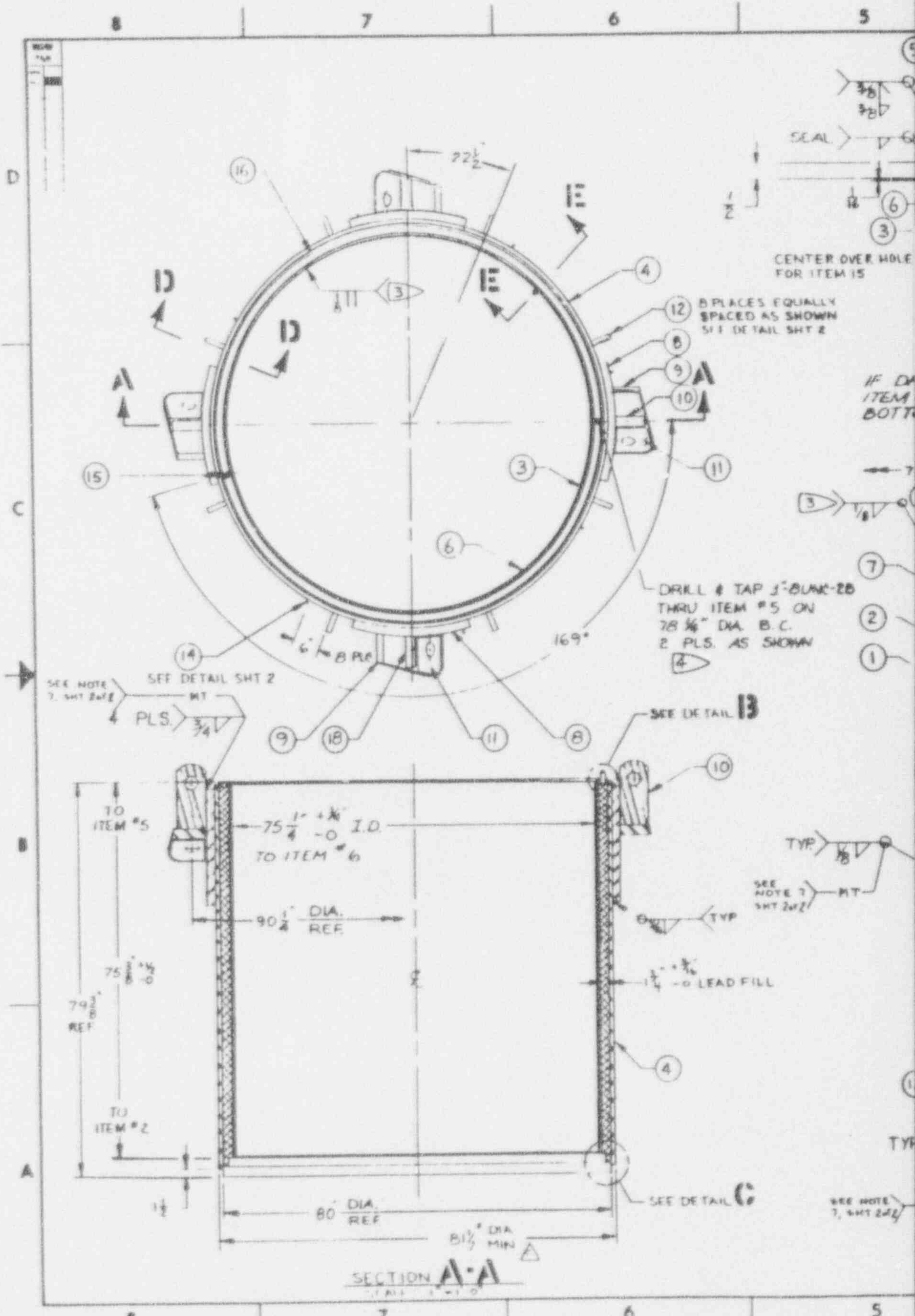
DRAWN: R BREHEW — DATE: 4/25/83
CHECKED: [illegible] — 6/13/83
ENGINEER: [illegible] — 6/14/83
QUALITY: MO Mohundro — [illegible]
APPROVED: [illegible] — 6/14/83

CHEM-NUCLEAR SYSTEMS, INC.

TITLE: ASSEMBLY TRANSPORTATION SHIELD 14-170 SERIES III CASK

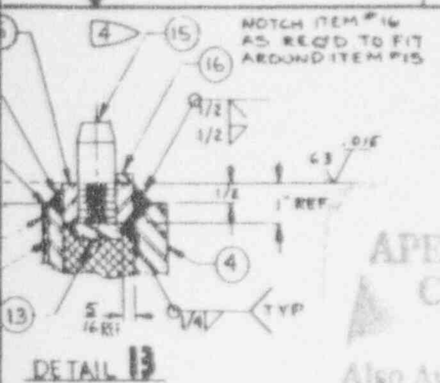
SIZE: D
DRAWING NUMBER: C-110-D-0016
REV: 4
SCALE: NOTED
SHEET 2 OF 2

9307080157-02



SEAL
CENTER OVER HOLE FOR ITEM 15
8 PLACES EQUALLY SPACED AS SHOWN SEE DETAIL SHT 2
DRILL & TAP 1"-8UNC-2B THRU ITEM #5 ON 78 3/4" DIA. B.C. 2 PLS. AS SHOWN
169°
SEE DETAIL SHT 2
8 PLS
SEE NOTE 7, SHT 2 of 2
4 PLS.
SEE DETAIL B
TO ITEM #5
75 1/4" +1/16 -0 I.D. TO ITEM #6
90 1/4" DIA. REF
75 3/8 +1/2 -0
79 3/8" REF
TO ITEM #2
1 3/4" +1/16 -0 LEAD FILL
SEE DETAIL C
80" DIA. REF
81 1/2" DIA MIN
SECTION A-A

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	B	SEE ECO C-110-D-0017-002 ADDED NOTE 6, ADDED PT WELD NOTE TO CONN. ADDED 7B ITEM #5 ... 1½" ... WAS 1⅝" ... 81½" DIA WAS 81⅝" DIA.		
1B	A	SEE ECO #C-110-D-0017-001		



DETAIL B
SCALE: 1/2

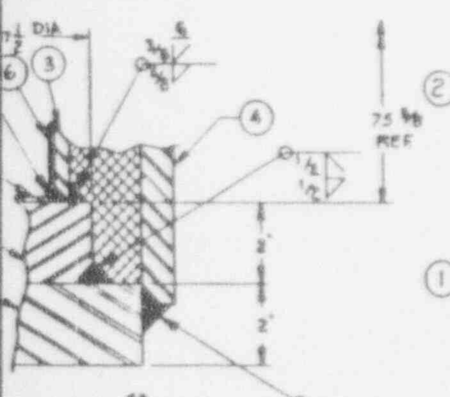
SI APERTURE CARD

Also Available On Aperture Card

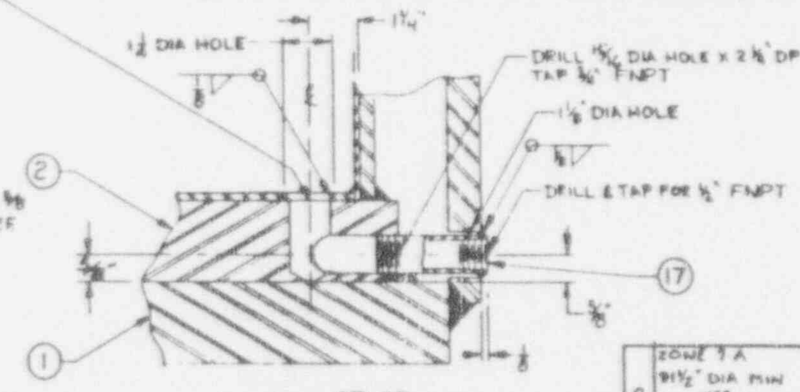
NOTES:

1. REMOVE ALL BURRS AND SHARP EDGES
2. WELDING SHALL BE PERFORMED BY WELDERS QUALIFIED PER ASME SECTION IX OR AWS SECTION D1.1.
3. SEAM WELDS SHALL BE GROUND FLUSH AND SMOOTH. PLUG AND FILLET WELDS SHALL BE PLACED AND MADE IN SUCH A MANNER AS TO REDUCE WARPAGE TO THE ABSOLUTE MINIMUM.
4. INDEX PIN (ITEM 15) HOLES SHALL BE MATCH DRILLED WITH CORRESPONDING HOLES ON PRIMARY LID DETAILS DWG NO. C-110-D-0018.
5. SEE DRAWING No. C-110-D-0016 FOR ASSEMBLY.
6. SEE SHEET 2 of 2 FOR ADDITIONAL WELDING INFO

DRILL 1" DIA x 1¾" DP. ...RILLED HOLE PIERCES THRU ...# 2, THEN SEAL WELD ...OM OF HOLE.

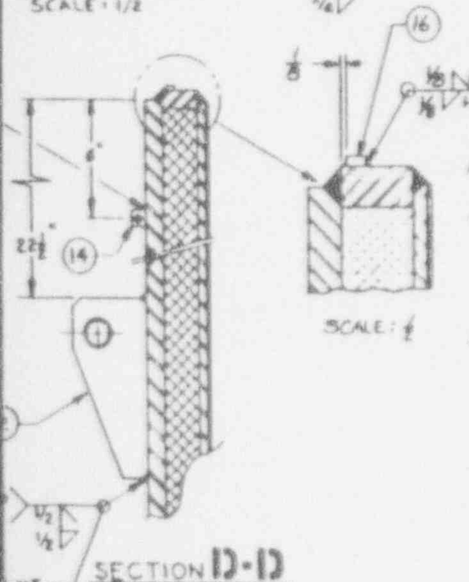


DETAIL C
SCALE: 1/2



SECTION E-E
SCALE: 1/2

C	ZONE 3A 81½" DIA MIN; 81½" DIA REF; ECO #C-110-D-0017-003



SCALE: ¼

SECTION D-D
SCALE: 1/4

ITEM	QTY	DESCRIPTION	MATERIAL OR PART NO	MAT'L SPEC
19	A/R	LEAD	QQ-L-171e GRADE A or C	
18	2	PLATE	C.S.	[illegible]
17	1	NIPPLE ¾" MNPT x 3" LG SCH 80	C.S.	A-53
16	1	PLATE ½" WIDE x ¼" THK.	C.S.	A1S1 A1020 OR EQUIVALENT
15	2	RD. BAR	S.S. TYPE 304	ASTM A276
14	8	STRIP	C.S.	ASTM A516 GR 70
13	2	PLATE 1¼ x 1¼ x ½ THK.	C.S.	[illegible]
12	8	PLATE	C.S.	ASTM A516 GR 70
11	8	PLATE	C.S.	[illegible]
10	2	PLATE	C.S.	ASTM A516 GR 70
9	4	PLATE	C.S.	ASTM A516 GR 70 [illegible]
8	4	PLATE	C.S.	ASTM A516 GR 70
7	1	SHEET 12 GA	S.S. TYPE 304	ASTM A240
6	1	SHEET 12 GA	S.S. TYPE 304	ASTM A240
5	1	PLATE, 1" THK	C.S.	ASTM A516 GR 70
4	1	PLATE	C.S.	[illegible]
3	1	PLATE	C.S.	ASTM A516 GR 70
2	1	PLATE	C.S.	ASTM A516 GR 70
1	1	PLATE	C.S.	ASTM A516 GR 70

BILL OF MATERIAL

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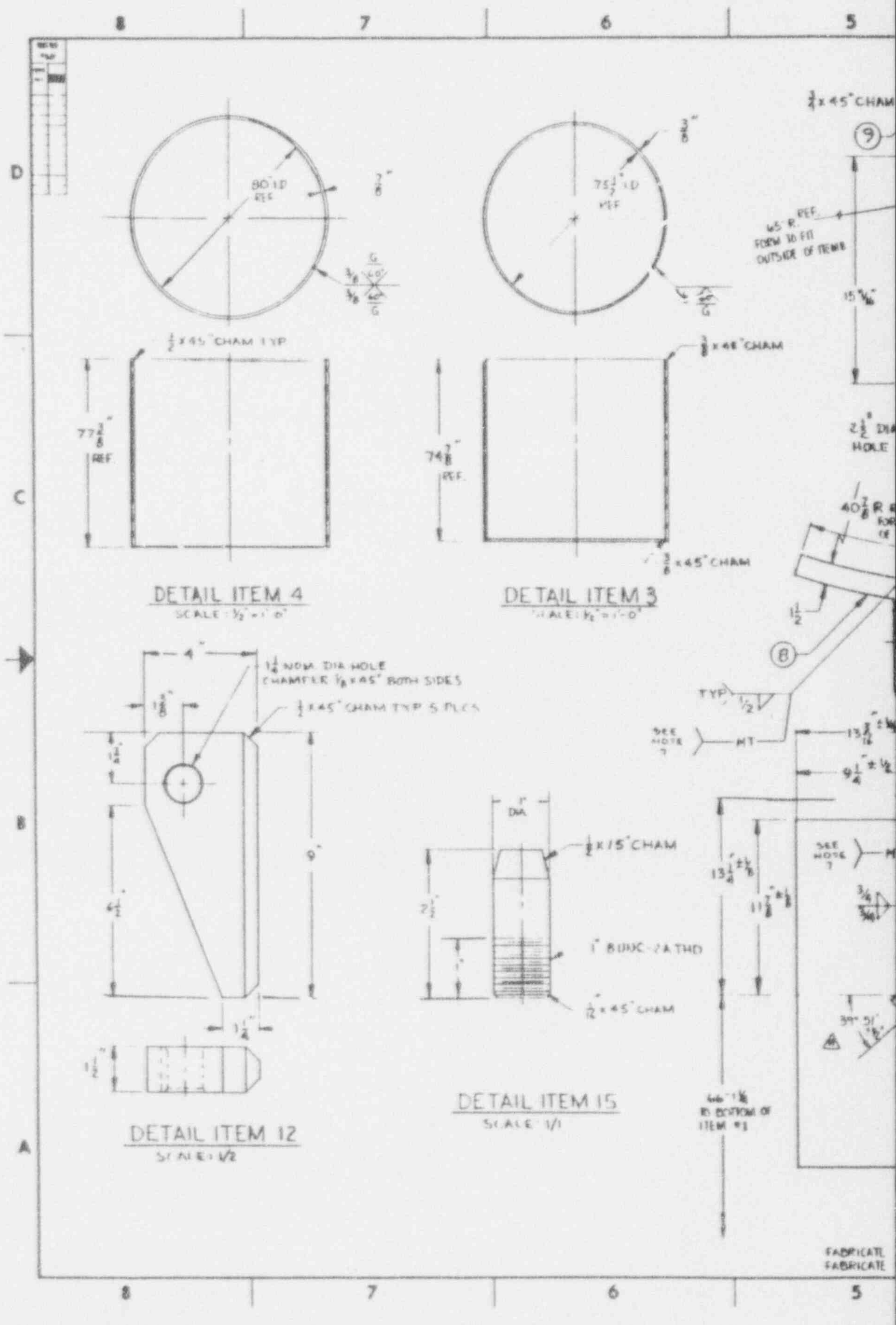
PROJECT NO	PECN NO	
E0548	54643	CHEM-NUCLEAR SYSTEMS, INC.

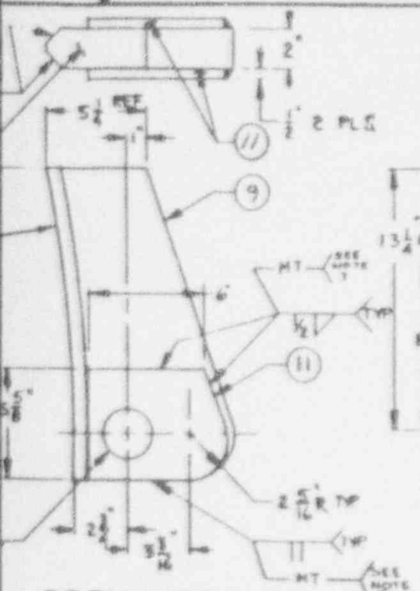
DRAWN: STEINER	2-24-83	TITLE: CASK WELDMENT 14-170 SERIES III CASK
CHECKED: [illegible]	3/1/83	
[illegible]	9-27-83	
[illegible]	5-4-83	SIZE D — C-110-D-0017 — REV C
APPROVED: [illegible]	5/4/83	SCALE NOTED — SHEET 1 OF 2

9307080157-03



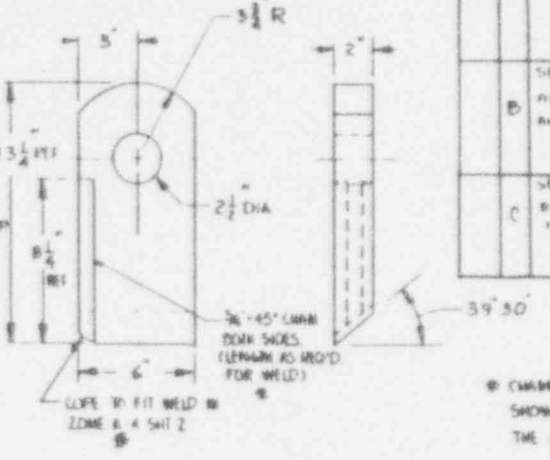
DETAIL ITEM 4
SCALE: 1/2" = 1'-0"
80" I.D. REF.
1/2 x 45° CHAM TYP
77 7/8" REF.
DETAIL ITEM 3
SCALE: 1/2" = 1'-0"
75 1/2" I.D. REF.
3/8 x 45° CHAM
74 7/8" REF.
DETAIL ITEM 12
SCALE: 1/2
1 1/4 NOM. DIA HOLE CHAMFER 1/8 x 45° BOTH SIDES
1/2 x 45° CHAM TYP 5 PLCS
DETAIL ITEM 15
SCALE 1/1
1/8 x 15° CHAM
1" 8UNC-2A THD
1/16 x 45° CHAM
3/4 x 45° CHAM
65" R. REF. FORM TO FIT OUTSIDE OF ITEM 8
2 1/2" DIA HOLE
SEE NOTE 7
MT
66-1/16 TO BOTTOM OF ITEM #1
FABRICATE
FABRICATE

ZONE	LTR	DESCRIPTION	DATE	APPROVED
A5	A	SEE ECO # C-110-D-0017-001		
	B	SEE ECO # C-110-D-0017-002 ADDED NOTE 7 ADDED MT NOTE TO LUG WELDING		
	C	SEE ECO # C-110-D-0017-003 REMOVED " & TIEDOWN" FROM NOTE 7		



DETAIL ITEMS 9 & 11

SCALE: 1/4

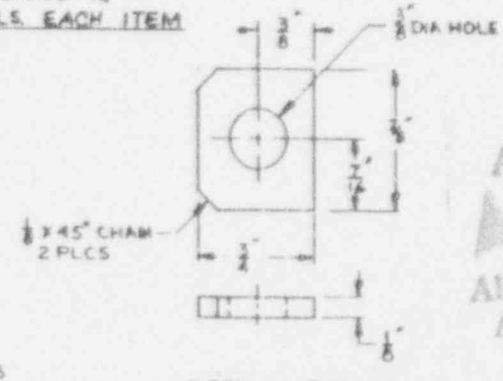


* CHAMFER AND COPE TO BE LOCATED ON THE END AS SHOWN FOR ITEM 10 AND ARE TO BE LOCATED ON THE OPPOSITE END FOR ITEM 18.

DETAIL ITEM 10 AND 18

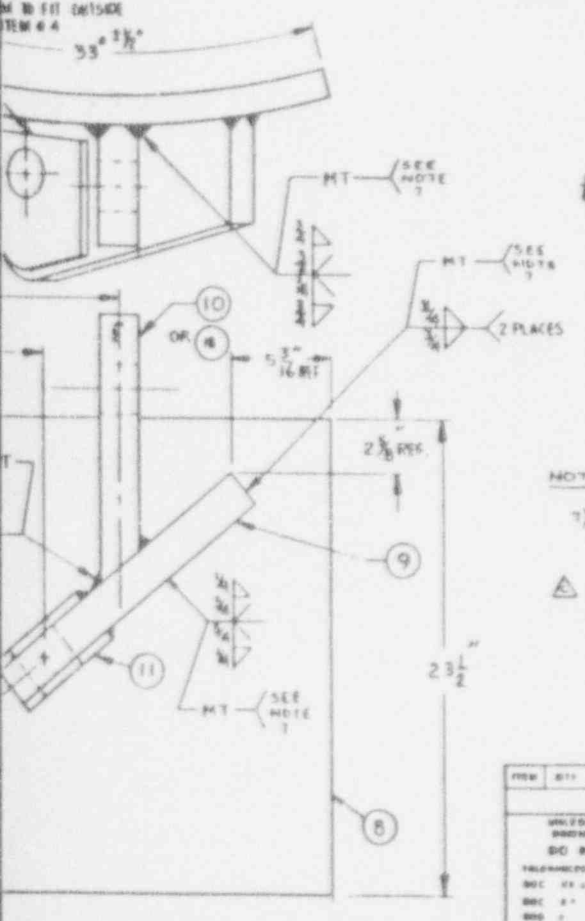
SCALE: 1/4

2 PLS. EACH ITEM



DETAIL ITEM 14

SCALE: 2/1



DETAIL

SCALE: 1/4

2 AS SHOWN USING ITEMS 8, 9, 10 & 11 (RIGHT HAND)
2 OPPOSITE SHOWN USING ITEMS 8, 9, 11 & 18 (LEFT HAND)

NOTES: (CONTINUED FROM SHT 1 of 2)

7) ALL WELDS SHALL BE VISUALLY EXAMINED IN ACCORDANCE WITH ASME CODE, SECTION III, DIV 1, SUBSECTION NF, ARTICLE NF-5000 AND SECTION V, ARTICLE 9. IN ADDITION, ALL WELDS ON LIFTING LUGS SHALL BE MAGNETIC PARTICLE (MP) INSPECTED BEFORE & AFTER 150% LOAD TEST IN ACCORDANCE WITH ASME CODE, SECTION III DIV 1, SUBSECTION NF, ARTICLE NF-5000, AND SECTION V, ARTICLE 7.

ITEM	QTY	DESCRIPTION	MATERIAL OR PART NO	MAT'L SPEC	WT

BILL OF MATERIAL

UNLESS OTHERWISE NOTED DIMENSIONS ARE IN INCHES

DO NOT SCALE PRINT

PROJECT NO	PROC NO
20548	54643

CHEM-NUCLEAR SYSTEMS, INC.

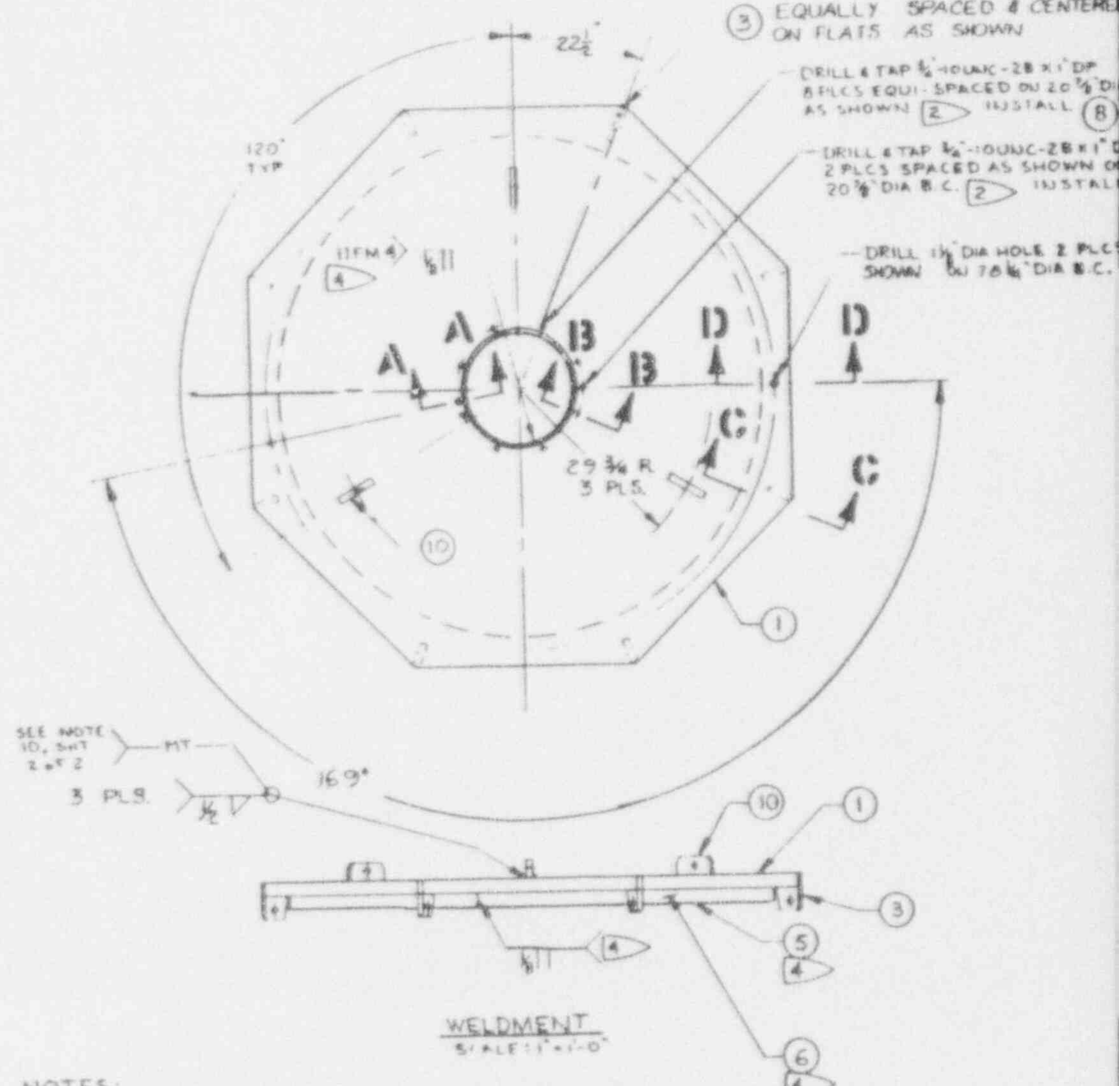
DRAWN: STEINER 2-25-86

TITLE: CASK WELDMENT 14-170 SERIES III CASK

SIZE: D DRAWING NUMBER: C-110-D-0017 REV: C

SCALE: NOTED SHEET 2 of 2

9307080157-04



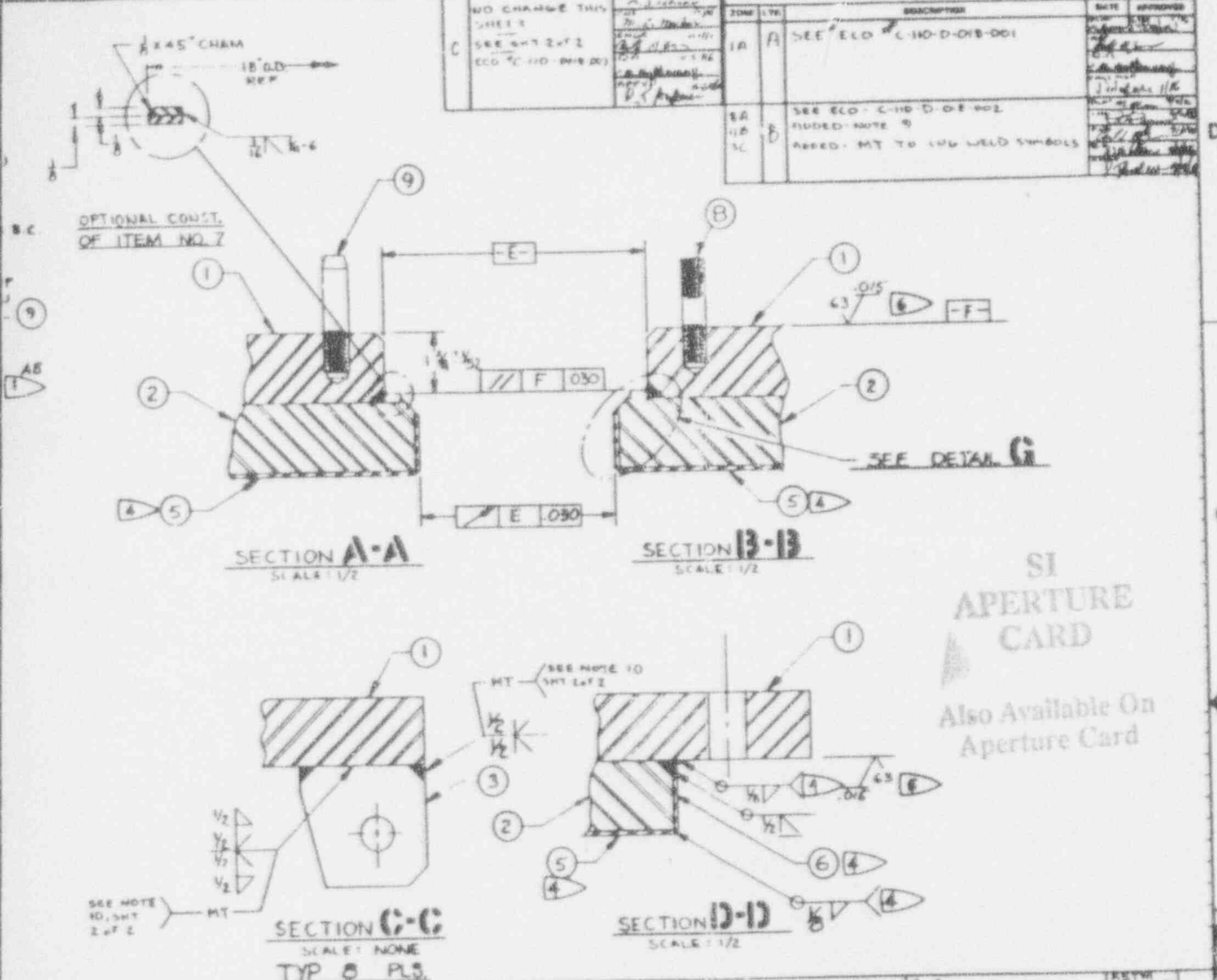
WELDMENT
SCALE: 1" = 1'-0"

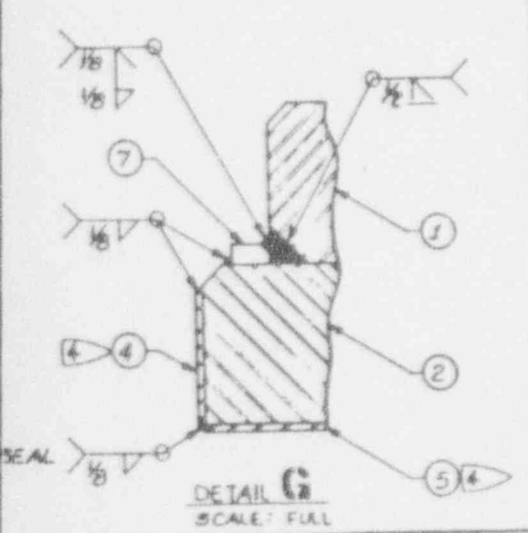
NOTES:

1. HOLES TO BE MATCH DRILLED WITH CORRESPONDING HOLES IN CASK BODY WELDMENT DWG NO. C-110-D-0017.
2. TAPPED HOLES TO BE MATCH DRILLED WITH CORRESPONDING HOLES IN SECONDARY LID WELDMENT DWG NO. C-110-D-0019.
3. WELDING SHALL BE PERFORMED BY WELDERS QUALIFIED PER ASME SECTION IX OR AWS SECTION D1.1.
4. SEAM WELDS TO BE GROUND FLUSH AND SMOOTH. PLUG & FILLET WELDS TO BE PLACED AND MADE IN SUCH A MANNER AS TO REDUCE WARPAGE TO THE ABSOLUTE MINIMUM.
5. SURFACE FINISH TOL. ZONE IS FROM 75 1/2" I.D. TO 80 1/2" O.D. SURFACE FINISH INDICATED IS PRIOR TO PAINTING.
6. SURFACE [-F-] FINISH TOL. ZONE IS FROM 18" I.D. TO 22 3/4" O.D. SURFACE FINISH INDICATED IS PRIOR TO PAINTING.
7. BREAK ALL SHARP EDGES & REMOVE ALL BURRS.
8. SEE DRAWING No. C-110-D-0016 FOR ASSEMBLY.
9. SEE SHEET 2 of 2 FOR ADDITIONAL WELDING INFO.

C	NO CHANGE THIS SHEET SEE SHT 2 of 2 ECO # C-110-0018-003	

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
1A	A	SEE ECO # C-110-D-018-001		
8A 11B 3C	B	SEE ECO - C-110-D-018-002 ADDED NOTE 9 ADDED MT TO LUG WELD SYMBOLS		





ITEM	QTY	DESCRIPTION	MATERIAL OR PART NO	MAT'L SPEC	
10	3	PLATE	C.S.	ASTM A516 GR 70	
9	1	RD BAR	S.S. TYPE 304	ASTM A240	
8	8	STUD 3/4"-10 UNC-2A X 3 1/2" LG	C.S. SAE J429 GR. 5		
7	1	SPACER 1/4" X 18" O.D. X 17" I.D.	C.S. C1018 OR EQUIV		
6	1	SHEET 12 GA X 2"	S.S. TYPE 304	ASTM A240	
5	1	SHEET 12 GA	S.S. TYPE 304	ASTM A240	
4	1	SHEET 12 GA X 1 1/4	S.S. TYPE 304	ASTM A240	
3	8	PLATE 1 1/2" THK	C.S.	ASTM A516 GR 70	
2	1	PLATE 2" THK	C.S.	ASTM A516 GR 70	
1	1	PLATE 2" THK	C.S.	ASTM A516 GR 70	

BILL OF MATERIAL

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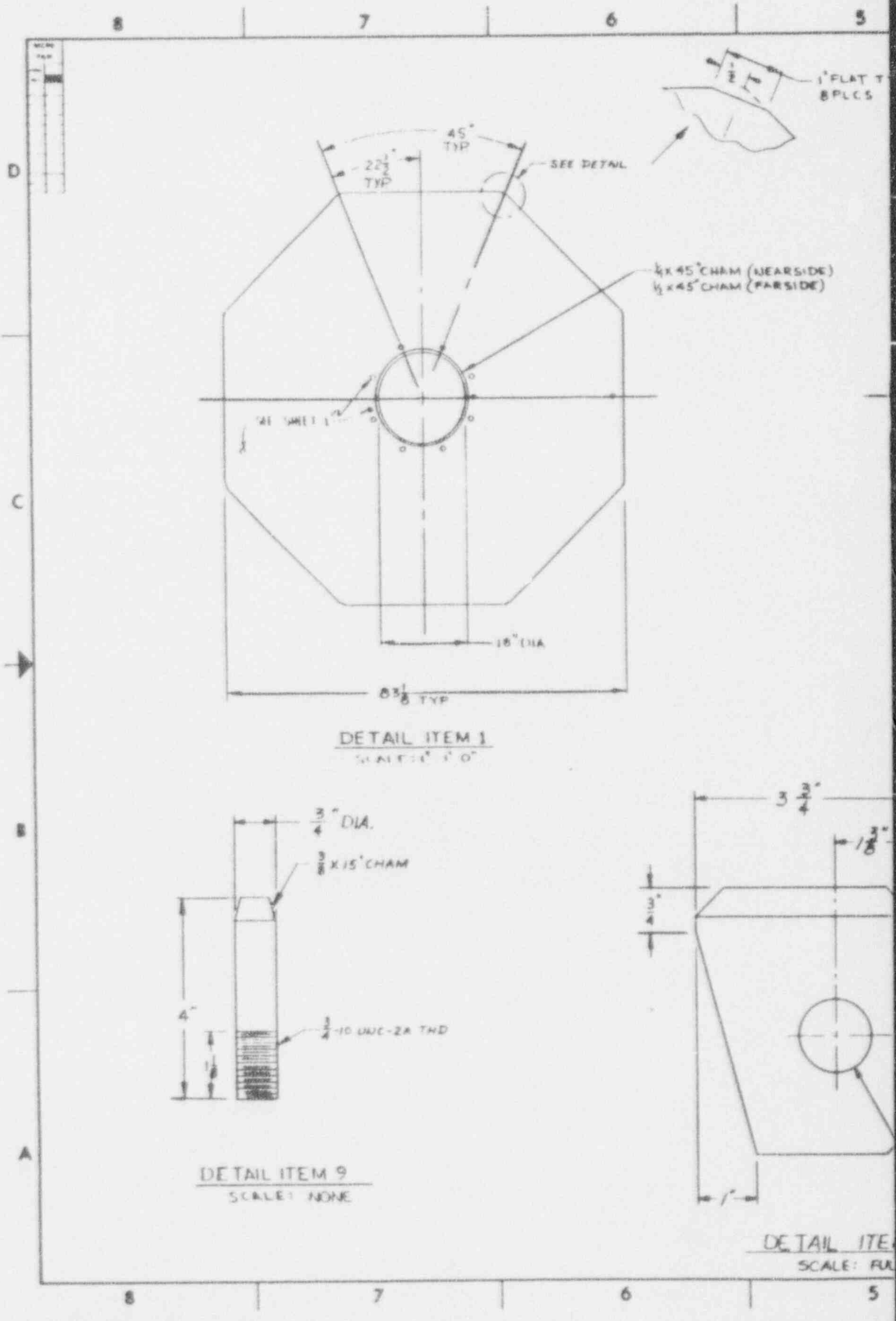
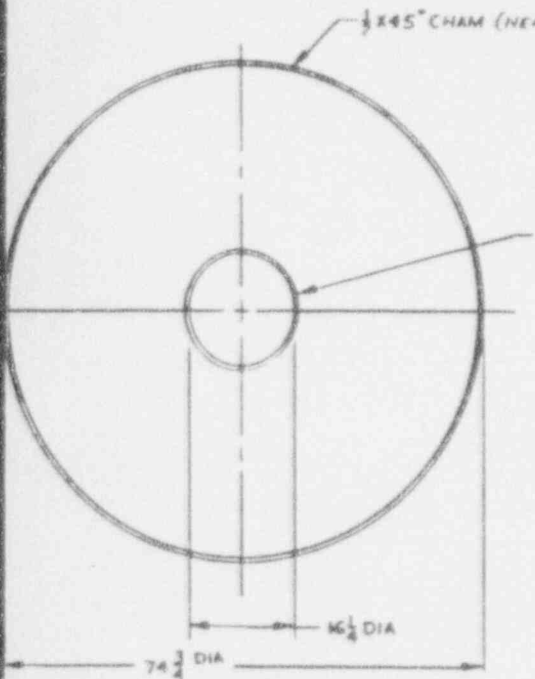
PROJECT NO	TBCW NO	
20545	84843	CHEM-NUCLEAR SYSTEMS, INC.

DRAWN STEINER	3-2-85	TITLE PRIMARY LID WELDMENT N-170 SERIES III CASK
CHECKED	3/1/85	
	9-27-85	
		SIZE D — DRAWING NUMBER C-110-D-0018 — REV C
APPROVED		SCALE NOTED — SHEET 1 OF 2

9307080157-05


8
7
6
5
D
C
B
A
45°
TYP
22½°
TYP
SEE DETAIL
1" FLAT
8 PLCS
¼ x 45° CHAM (NEARSIDE)
½ x 45° CHAM (FARSIDE)
18" DIA
83⅛ TYP
DETAIL ITEM 1
¾" DIA.
⅜ x 15° CHAM
4"
¾-10 UNC-2A THD
DETAIL ITEM 9
SCALE: NONE
3 ¾"
1⅜"
¾"
1"
DETAIL ITE
SCALE: FU

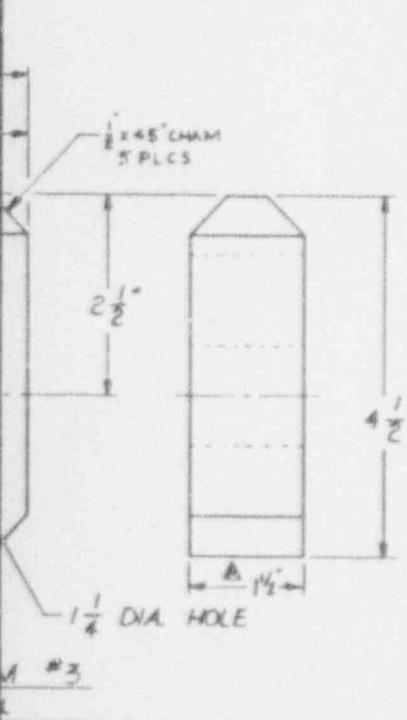
ZONE	LTR	DESCRIPTION
4A	A	SEE ECO# C-110-D-0018-001
2C	B	SEE ECO# C-110-D-0018-002 ADDED NOTE # 10
1C	B	SEE ECO# C-110-D-0018-003 REMOVED: " & "TIEDOWN" FROM NOTE 10

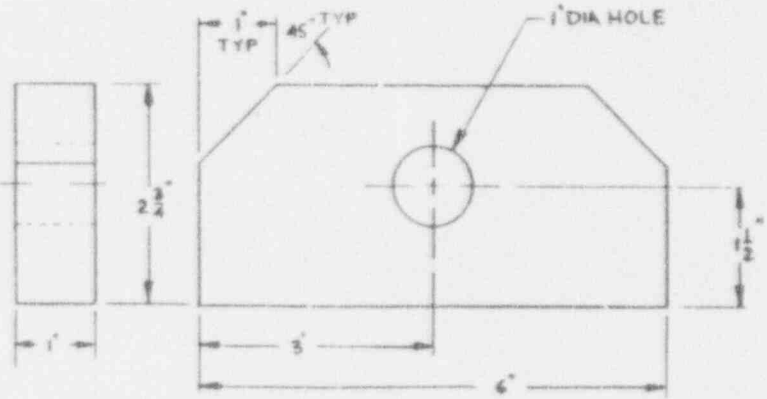


DETAIL ITEM 2
SCALE: 1"=1'-0"

NOTE: (CONTINUED FROM SHEET 1 of 2)

10) ALL WELDS SHALL BE VISUALLY INSPECTED IN ACCORDANCE WITH ASME CODE, SECTION III, DIV 1, SUBSECTION NF, ARTICLE NF-5000 AND SECTION V, ARTICLE 9. IN ADDITION, ALL WELDS ON LIFTING LUGS SHALL BE MAGNETIC PARTICLE (MT) INSPECTED BEFORE & AFTER 150% LOAD TEST IN ACCORDANCE WITH ASME CODE, SECTION III, DIV. 1, SUBSECTION NF, ARTICLE NF-5000, AND SECTION V, ARTICLE 7. (C)





DETAIL ITEM 10
SCALE: 1/1

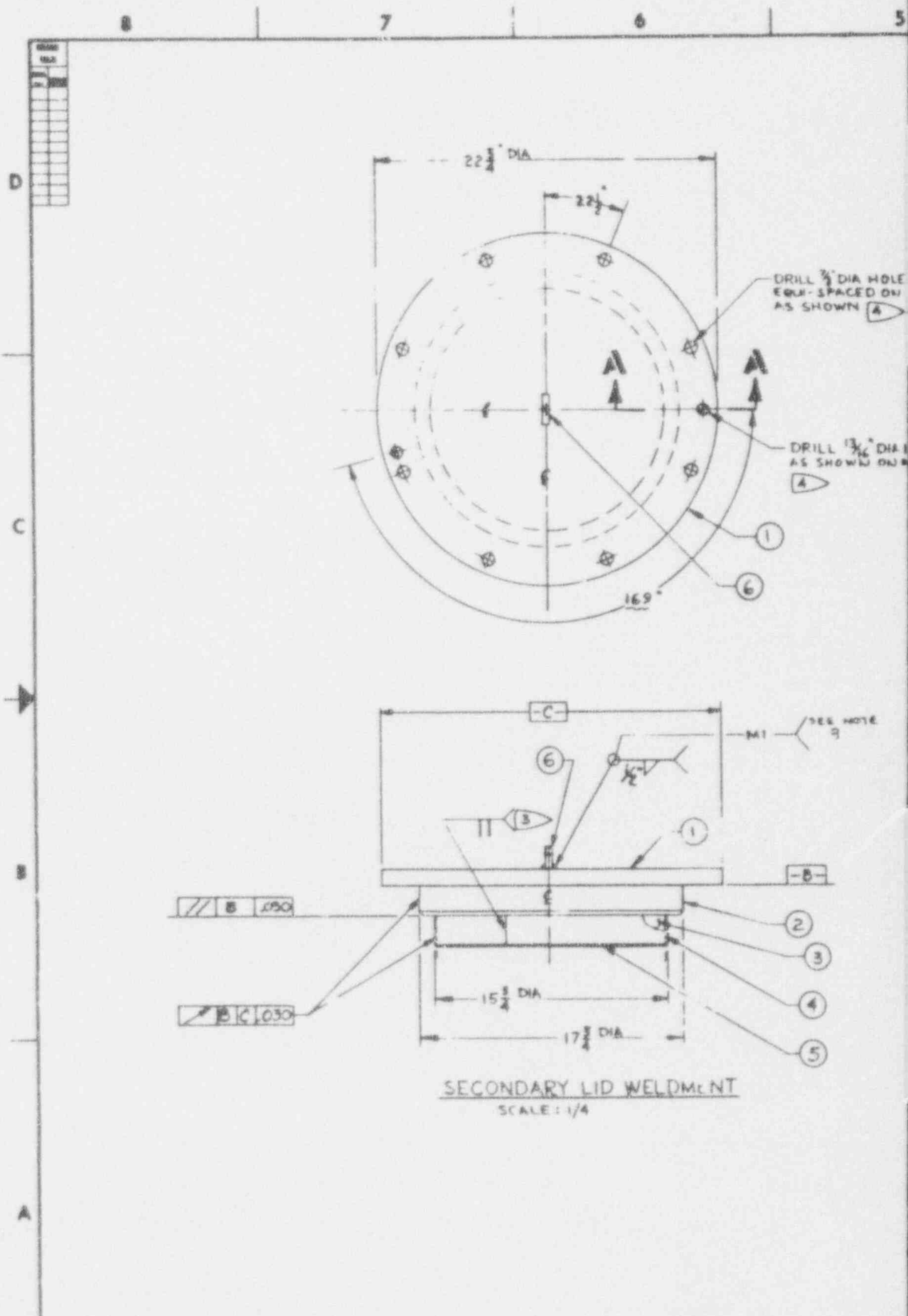
ITEM	QTY	DESCRIPTION	MATERIAL OR PART NO	MAT'L SPEC	WT

BILL OF MATERIAL

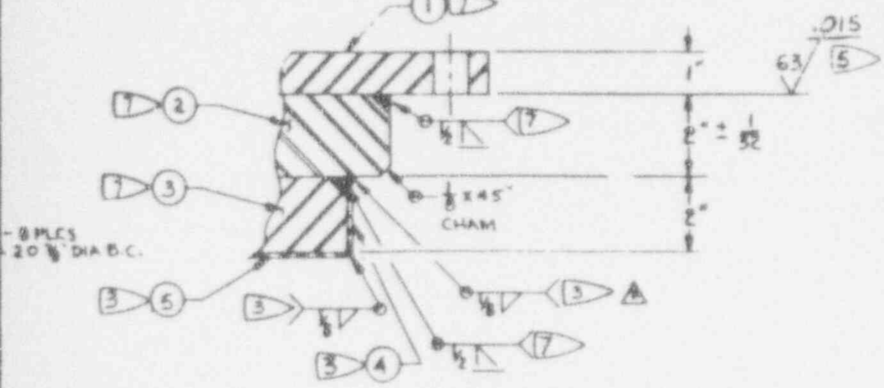
DO NOT SCALE PRINT

PROJECT NO	FSCM NO	
20548	84843	CHEM-NUCLEAR SYSTEMS, INC.
STEINER	2-28-85	PRIMARY LID WELDMENT 14-170 SERIES III CASK
SIZE	DRAWING NUMBER	REV
D	C-110-D-0018	C
SCALE NOTED		SHEET 2 OF 2

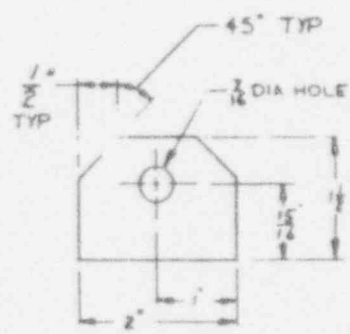
9307080157-06



22 3/4" DIA
22 1/2°
DRILL 3/4" DIA HOLE
EQUI-SPACED ON
AS SHOWN
DRILL 13/16" DIA
AS SHOWN ON
A
A
169°
C
B
-B-
SEE NOTE 9
15 3/4 DIA
17 3/4 DIA
.030
.030
SECONDARY LID WELDMENT
SCALE: 1/4



SECTION A-A
SCALE: 1/2



DETAIL ITEM 6
SCALE: 1/1

ZONE	LTR	DESCRIPTION	DATE	APPROVED
D3	A	ADD NOTE 7 CALLOUT TO ⅛" FILLET WELD SYMBOL		
2-3, 5-8	B	SEE ECO# C-110-D-0019-002; ADDED NOTE 8; ADDED (MT) TO LUG WELD SYMBOL		

SI APERTURE CARD

Also Available On Aperture Card

NOTES

1. BREAK ALL SHARP EDGES & REMOVE ALL BURRS.
2. WELDING SHALL BE PERFORMED BY WELDERS QUALIFIED PER ASME SECTION IX OR AWS SECTION D1.1.
3. SEAM WELDS SHALL BE GROUND FLUSH & SMOOTH. PLUG & FILLET WELDS SHALL BE PLACED & MADE IN SUCH A MANNER AS TO REDUCE WARPAGE TO THE ABSOLUTE MINIMUM.
4. HOLES TO BE MATCH DRILLED WITH CORRESPONDING HOLES IN PRIMARY LID DWG NO C-110-D-0018.
5. SURFACE FINISH TOL. ZONE IS FROM 18" I.D. TO 22⅝" O.D. SURFACE FINISH INDICATED IS PRIOR TO PAINTING.
6. SEE DRAWING No. C-110-D-0016 FOR ASSEMBLY.
7. EITHER WELDED OR ONE PIECE CONSTRUCTION, AT FABRICATOR'S OPTION.
8. ALL WELDS SHALL BE VISUALLY EXAMINED IN ACCORDANCE WITH ASME CODE, SECTION III, DIV 1, SUBSECTION NF, ARTICLE NF-5000 AND SECTION V, ARTICLE 9. IN ADDITION, ALL WELDS ON LIFTING LUGS SHALL BE MAGNETIC PARTICLE (MT) INSPECTED BEFORE AND AFTER 150% LOAD TEST IN ACCORDANCE WITH ASME CODE, SECTION III, DIV 1, SUBSECTION NF, ARTICLE NF-5000, AND SECTION V, ARTICLE 7.

ITEM	QTY	DESCRIPTION	MATERIAL OR PART NO	MAT'L SPEC
6	1	PLATE ⅜ THK	C.S.	ASTM A516 GR70
5	1	SHEET 12 GA	S.S. TYPE 304	ASTM A240
4	1	SHEET 12 GA	S.S. TYPE 304	ASTM A240
3	1	PLATE	C.S.	ASTM A516 GR70
2	1	PLATE	C.S.	ASTM A516 GR70
1	1	PLATE	C.S.	ASTM A516 GR70

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PROJECT NO 20548 | PROJ NO 54043

CHEM-NUCLEAR SYSTEMS, INC.

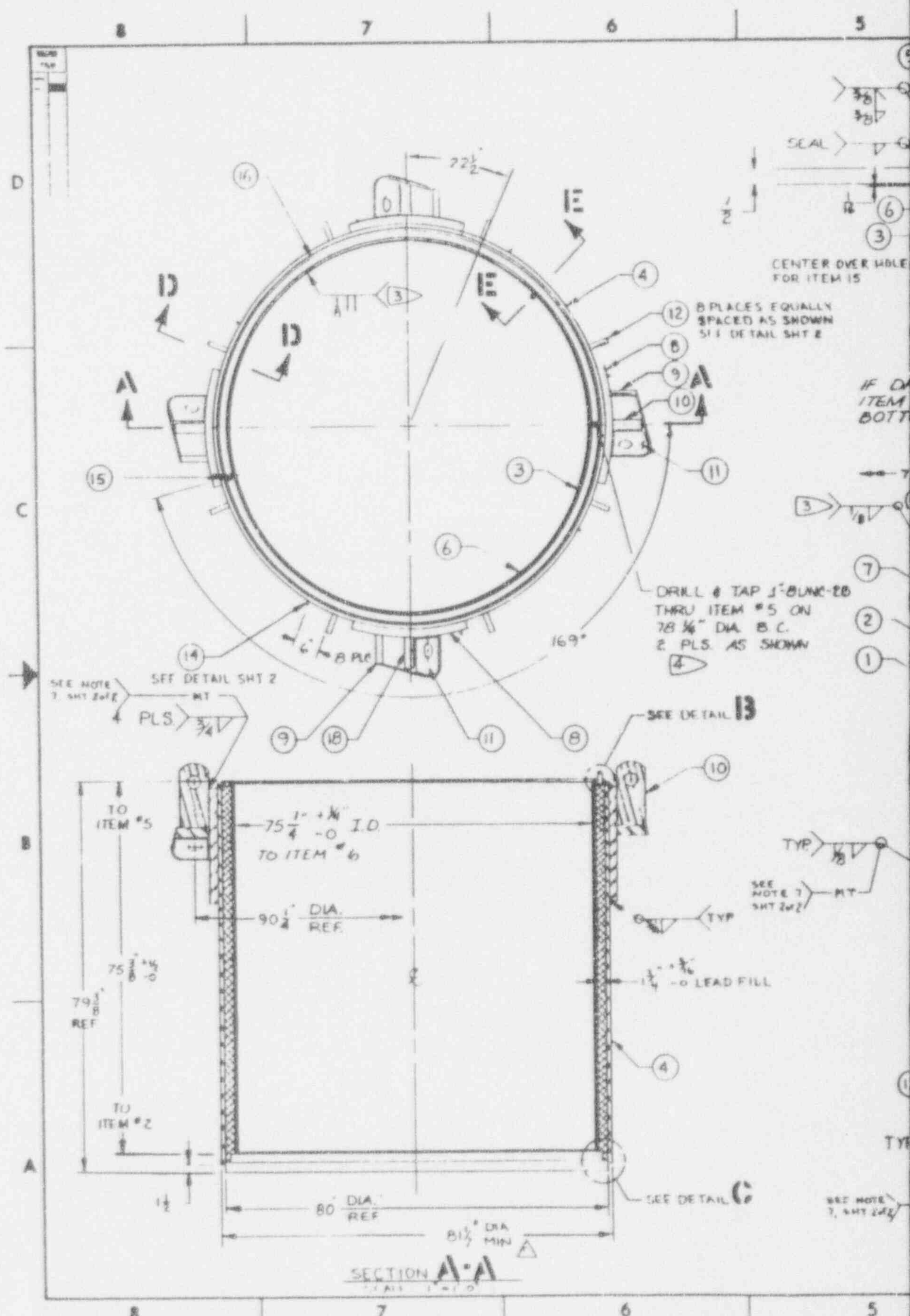
DRAWN: STEINER 3-3-83

TITLE: SECONDARY LID WELDMENT 14-170 SERIES III CASK

SIZE: D | DRAWING NUMBER: C-110-D-0019 | REV: B

SCALE: NOTED | SHEET 1 OF 1

9307080157-07



8
7
6
5
D
C
B
A
22 1/2°
E
D
A
4
12
8 PLACES EQUALLY SPACED AS SHOWN SEE DETAIL SHT 2
8
9
10
11
15
3
6
14
SEE DETAIL SHT 2
9
18
11
8
169°
DRILL & TAP 1"-8UNC-2B THRU ITEM #5 ON 78 1/4" DIA. B.C. 2 PLS. AS SHOWN
SEE NOTE 7, SHT 2 of 2
MT
4 PLS.
3/4
SEE DETAIL B
10
TO ITEM #5
75 1/4 +1/4 -0 I.D. TO ITEM #6
90 1/4 DIA. REF.
75 3/8 +1/4 -0
79 3/8 REF
TO ITEM #2
1 1/2
1 3/4 +1/16 -0 LEAD FILL
TYP
SEE DETAIL C
80 DIA. REF
81 1/2 DIA MIN
SECTION A-A
SEAL
CENTER OVER HOLES FOR ITEM 15
TYP
SEE NOTE 7 SHT 2 of 2
MT

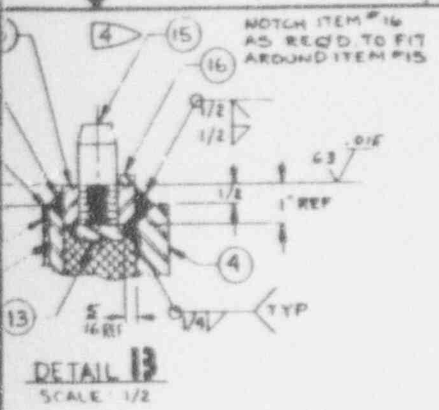
B	SEE ECO # C-110-D-0017-002 ADDED NOTE 6 & ADDED ... WELD NOTE TO LUGS. ...		

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
1 B	A	SEE ECO # C-110-D-0017-001		

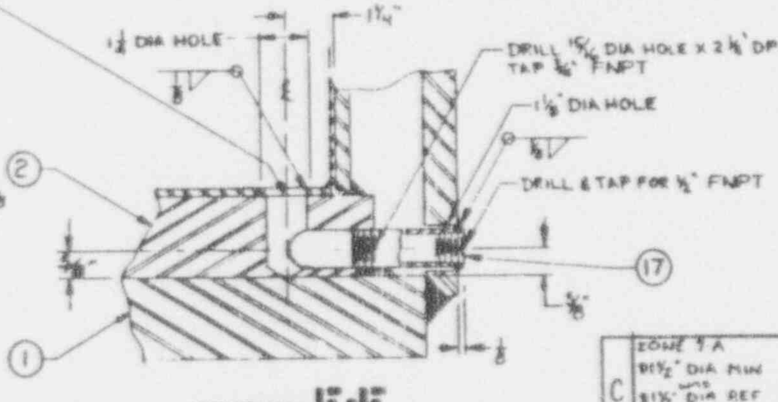
NOTES:

1. REMOVE ALL BURRS AND SHARP EDGES
2. WELDING SHALL BE PERFORMED BY WELDERS QUALIFIED PER ASME SECTION IX OR AWS SECTION D1.1.
3. SEAM WELDS SHALL BE GROUND FLUSH AND SMOOTH. PLUG AND FILLET WELDS SHALL BE PLACED AND MADE IN SUCH A MANNER AS TO REDUCE WARPAGE TO THE ABSOLUTE MINIMUM.
4. INDEX PIN (ITEM 15) HOLES SHALL BE MATCH DRILLED WITH CORRESPONDING HOLES ON PRIMARY LID DETAILS DWG NO. C-110-D-0018.
5. SEE DRAWING No. C-110-D-0016 FOR ASSEMBLY.
6. SEE SHEET 2 of 2 FOR ADDITIONAL WELDING INFO.



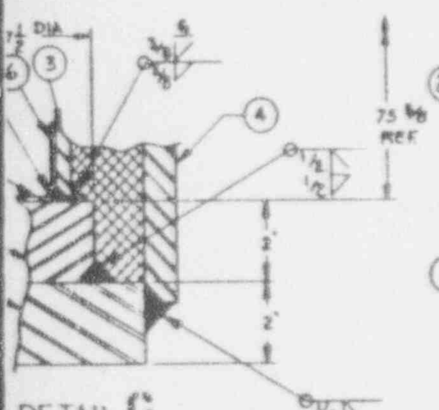
DETAIL B
SCALE 1/2

DRILL 1" DIA x 1 3/4" DP. DRILLED HOLE PIERCES THRU # 2, THEN SEAL WELD ... OF HOLE.

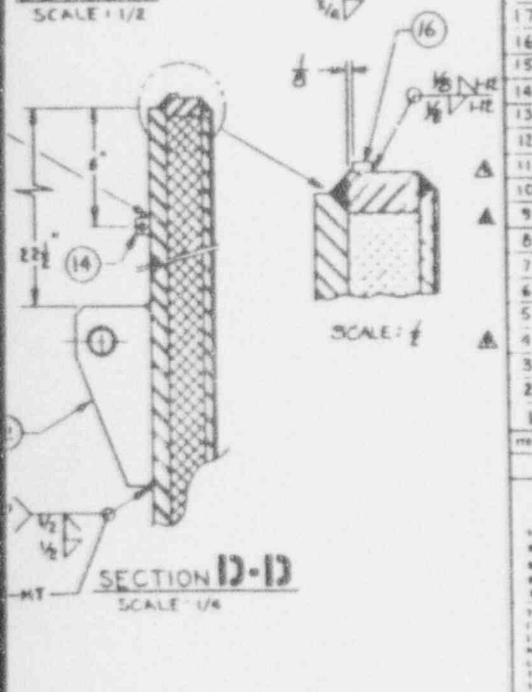


SECTION E-E
SCALE 1/2

C	ZONE 3 A Ø1½" DIA MIN Ø1½" DIA REF ECO # C-110-D-0017-003



DETAIL C
SCALE 1/2



SCALE: 1/2

SECTION D-D
SCALE 1/4

ITEM	QTY	DESCRIPTION	MATERIAL OR PART NO	MAT'L SPEC
19	A/R	LEAD	QQ-L-171e GRADE A OR C	
18	2	PLATE	C.S.	[illegible]
17	1	NIPPLE 3/4" MNPT x 3" LG. SCH 80	C.S.	A 53
16	1	PLATE 1/2" WIDE x 1/4" THK.	C.S.	ASTM A [illegible] OR EQUIVALENT
15	2	RD. BAR	S.S. TYPE 304	ASTM A276
14	8	STRIP	C.S.	[illegible]
13	2	PLATE 1 1/4 x 1 1/4 x 1/2 THK.	C.S.	[illegible]
12	8	PLATE	C.S.	[illegible]
11	8	PLATE	C.S.	[illegible]
10	2	PLATE	C.S.	[illegible]
9	4	PLATE	C.S.	[illegible]
8	4	PLATE	C.S.	[illegible]
7	1	SHEET 12 GA	S.S. TYPE 304	ASTM A 240
6	1	SHEET 12 GA	S.S. TYPE 304	ASTM A 240
5	1	PLATE, 1" THK.	C.S.	[illegible]
4	1	PLATE	C.S.	[illegible]
3	1	PLATE	C.S.	[illegible]
2	1	PLATE	C.S.	[illegible]
1	1	PLATE	C.S.	ASTM A516 GR 70

BILL OF MATERIAL

UNLESS OTHERWISE NOTED DIMENSIONS ARE IN INCHES
DO NOT SCALE PRINT

PROJECT NO 20548 | PROJ NO 84843

CHEM-NUCLEAR SYSTEMS, INC.

DRAWN STEINER 2-24-88

CASK WELDMENT
14-170 SERIES III CASK

SIZE D | DRAWING NUMBER C-110-D-0017 | REV C

SCALE NOTED | SHEET 1 OF 2

9307080157-08