

71-9089

SAFETY ANALYSIS REPORT
FOR THE
HN-100S RADWASTE SHIPPING CASK
STD-R-02-012, REV. 0

referencing
10 CFR 71 Type "A" Packaging Regulations

Hittman Nuclear & Development Corporation
Columbia, Maryland 21045

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1. GENERAL INFORMATION

1.1 Introduction

The HNDC HN-100S radioactive waste shipping casks were constructed during the period 1972 to 1973. The casks have been in continuous service since construction and are used primarily to transport radioactive waste from nuclear power plants to licensed shallow land burial sites. The purpose of the following document is to provide the information and engineering analysis that demonstrates the performance capability and structural integrity of the HN-100S and its compliance with the requirements of 10 CFR 71.

1.2 Packaging Description

1.2.1 Packaging

The HN-100S Shipping Cask is a top-loading, shielded container designed specifically for the safe transport of Type "A" levels of radioactive waste materials between nuclear facilities and waste disposal sites. The radioactive materials can be packaged in a number of different type disposable containers; hence the model of the shipping cask when used with a specific set of internals are as follows:

<u>Model Number</u>	<u>Cask Internals</u>
HN-100S/170	One large disposable container
HN-100S/18	Eighteen 30 gallon drums
HN-100S/14	Fourteen 55 gallon drums
HN-100S/8	Eight 55 gallon drums
HN-100S/80	Two stackable disposable containers

The HN-100S Shipping Cask is a primary containment vessel for radioactive materials during transportation. It consists of a cask body, cask lid, and a shield plug. It is basically a top-opening right circular cylinder which is on its vertical axis. Its principal dimensions are 81.6 inches O.D. by 81.5 inches high with internal space of 75.6 inches I.D. by 74.5 inches high.

1.2.1.1 Cask Body

The cask body is a steel annulus in the form of a vertically-oriented, right circular cylinder closed on the bottom end. The side walls consist of a 1-1/2 inch inner steel shell and a 1-1/2 inch thick

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outer steel shell. The bottom is a 3 inch thick steel plate welded integrally to the internal steel body cylinder. The steel shells are connected by welding at the bottom of the cask and by welding to a concentric top flange designed to receive a Buna-N O-ring seal. Positive cask closure is provided by the O-ring seal and thirty 1-inch studs. Three lifting lugs are welded to both the top flange and the outer steel shell with all welds consistent with the "Cask Designers Guide." Tie-down is accomplished by four tie-down lugs welded to the cask body. There are three cask lifting lugs.

1.2.1.2 Cask Lid

The cask lid is a three inch thick steel plate 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. It has a Buna-N O-ring and uses 30 hold-down studs to provide cask closure. The cask lid also contains a "shield plug" at its center.

1.2.1.3 Shield Plug

The shield plug is a three inch thick, circular steel plate fabricated in a design similar to the cask lid including the Buna-N O-ring and sixteen hold-down studs to provide positive closure to the cask lid. The shield plug also has a lifting device located at its center to facilitate its handling.

1.2.1.4 Cask Closure

The shipping cask has two closure systems: (1) the cask lid is closed with 30 one-inch diameter bolts and a Buna-N O-ring seal, and (2) the shield plug is closed with 16 half-inch bolts and the same seal system used for the cask lid but smaller.

1.2.1.5 Cask Tie-Down System

The shipping cask tie-down system consists of two sets of two crossed tie-down cables (totaling four) and either shear blocks or shear ring (affixed to the vehicle load bed) designed to firmly position and safely hold the cask during transport.

1.2.1.6 Cask Internals

The cask internals consist of four separate configurations based on the types of containers to be housed: (1) one large disposable container, (2) eighteen 30 gallon drums (including two 9-drum pallets

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for material handling), (3) fourteen 55 gallon drums (including two 7-drum pallets), or (4) eight 55 gallon drums (including two 4-drum pallets). The containers include custom fabricated steel containers, steel drums, plastic containers and drums, high integrity containers, sealed containers constructed of other metals and materials, and racks to secure irradiated and contaminated components. All internal containers have integral leak-tight seals or closures, integral lift lugs and vertical symmetrical clearances. Drums are stacked in two tiers or levels, each on removable pallets designed to minimize interaction between drums. Shoring is not required for large containers and filled drum pallets designed to fit the cavity with minimal clearances.

1.2.2 Operational Features

The HNDC HN-100S radioactive waste shipping cask may include a number of required and optional accessories. These include: cavity drain plug, rain cover tie-downs, signs and mounting brackets, placards, mounting brackets, lid lift lug covers and security wires and security wire brackets.

1.2.3 Contents of Packaging

1.2.3.1 Type and Form of Material

The materials transported in the HNDC HN-100S cask will consist primarily of process waste and include bead ion exchange resin, powdered ion exchange resins, activated carbon, powdered carbon, diatomaceous earth, granular and fibrous filter media, filter sludge, blasting grit and crud, stabilized incinerator ash, irradiated and contaminated materials, filter cartridges and solidified liquids. The materials may be dewatered, solidified, absorbed or solids. The radioactive materials will be primarily by-product materials but may include source and transuranic materials in Type A quantities and greater than Type A quantities of low specific activity materials. Fissile materials in exempt quantities may be transported.

1.2.3.2 Maximum Quantity of Material Per Package

The maximum quantity of material that may be transported in the HNDC HN-100S cask will be:

- o Type A quantities.
- o Greater than Type A quantities of low specific activity radioactive materials.

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- o Materials and containers with weights not exceeding 17,000 pounds, and internal decay heat greater than 3 watts.
- o Cask, contents and container with weights not exceeding 43,000 pounds.
- o Activity levels not to exceed 200 mR per hour on the surface of the container or 10mR per hour at two meters from the side of the trailer.

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1.3 Appendix

The HNDC HN-100S radioactive waste shipping cask is constructed in accordance with Hittman Nuclear & Development Corporation Drawing Numbers:

C001-5-9128, Rev. 1 (1 Sheet)

C001-5-9129, Rev. 2 (1 Sheet)

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2. STRUCTURAL EVALUATION

This section identifies and describes the principal structural engineering design of the packaging, components and systems important to safety in compliance with the performance requirements of 10 CFR 71.

2.1 Structural Design

2.1.1 Discussion

The principal structural member of the HNDC HN-100S cask is the primary containment vessel or transport shield, as described in Section 1.2.1. The above components are identified on the drawing as noted in Appendix 1.3. A detailed discussion of the structural design and performance of these components will be provided below.

2.1.2 Design Criteria

The shield top and bottom are each constructed of a 3 inch thick steel plates. Cylindrical side walls have an equivalent skin of 3 inch steel consisting of two 1-1/2 inch thick plates.

2.2 Weights and Center of Gravity

The weight of the cask and liner (or payload) will not exceed 43,000 pounds. The cask weight is approximately 26,000 pounds. The center of gravity for the assembled package is located at the approximate geometric center of gravity.

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

Cask body	22,000 pounds
Closure lid	3,770 pounds
Shield plug	230 pounds
Total cask unloaded	26,000 pounds
HN-100S/170 Disposable container and waste	17,000 pounds
HN-100S-114 (14 drums of radwaste	13,000 pounds
HN-100S-118 (18 drums of radwaste	8,100 pounds

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2.3 Mechanical Properties of Materials

The following materials are used in the construction of the HN-100S cask:

Cask lift lugs and tie-down lugs - ASTM A515 Gr 70*:

$$\begin{aligned}F_{tu} &= 70,000 \text{ psi} \\F_{ty} &= 38,000 \text{ psi} \\F_{su} &= 42,000 \text{ psi (60\% } F_{tu}\text{)} \\F_{sy} &= 22,800 \text{ psi (60\% } F_{ty}\text{)} \\F_{brg} &= 55,000 \text{ psi}\end{aligned}$$

Lid lift lugs, shield plug lift lugs, and inner and outer shells ASTM A515 Grade 55*:

$$\begin{aligned}F_{tu} &= 55,000 \text{ psi} \\F_{ty} &= 30,000 \text{ psi} \\F_{su} &= 33,000 \text{ psi (60\% } F_{tu}\text{)} \\F_{sy} &= 18,000 \text{ psi (60\% } F_{ty}\text{)} \\F_{brg} &= 30,000 \text{ psi}\end{aligned}$$

*Values used are minimum required per ASTM standards

Lid studs meet requirements of ASTM A307 Gr A

($f_y = 60,000$ psi) or ASTM A320 Gr L7 or L43

($f_y = 105,000$ psi)

Weld shear strength is taken to be 15,600 psi.

2.4 General Standards for All Packages

This section demonstrates that the general standards for all packages are met.

2.4.1 Chemical and Galvanic Reaction

The materials from which the package is fabricated (steel) along with the contents of the package (disposable steel containers) will not cause significant chemical, galvanic, or other reaction.

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2.4.2 Positive Closure

Both types of drums (30 gallon and 55 gallon) and High Integrity Containers have positive closures. The large disposal containers will be permanently sealed with a container cap. All disposable containers are placed within the shipping cask which (itself) has positive closure for the cask lid to the body flange surface and also between the shield plug and the cask lid flange surface. Hence, there is no possibility of inadvertent opening of either the disposal containers or the shipping cask.

2.4.3 Lifting Devices

2.4.3.1 Shipping Cask

Three equally spaced lugs are welded to the upper steel flange and the outer steel shell of the cask body. The cask is lifted using these lugs, slings, and a suitable crane. The lifting lugs are designed to lift three times the weight of the cask with no stresses in excess of their yield stress. See the Appendix for analysis and details. (2.10.1)

2.4.3.2 Cask Lid

The lifting device for the cask lid consists of three equally spaced clevis pin lifting assemblies, attached to stiffener bars which are welded to the cask lid. These lifting devices will support three times the weight of the cask lid with no stresses in excess of their yield stress. See Appendix for analysis and details. (2.10.2)

2.4.3.3 Shield Plug

The lifting device for the shield plug consists of a single clevis pin assembly attached to a lug which is welded directly to the upper or outside of the steel plate which is the plug shield. This lifting device will support three times the weight of the shield plug with no stresses in excess of its yield stress. See Appendix for analysis and details. (2.10.3)

2.4.3.4 Lifting Lug Covers

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

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2.4.3.5 Ultimate Lug Failure

The lifting lugs are more than capable of supporting a load equal to three times the package weight. Should the lugs experience a load great enough to cause a failure, the lugs will shear out locally before any detrimental effects compromise the integrity of the package.

2.4.4 Tie-Down Devices

2.4.4.1 Tie-Down Forces

The tie-down devices consist of four ratchet binder and cable assemblies attached from the tie-down adapters on the cask to tie-down lugs on the trailer body. Additionally, shear blocks or a shear ring firmly position and hold the cask on the trailer bed. The tie-down lugs have been designed to allow the cask to withstand a vertical force of two times the weight of the cask, a transverse force of five times the weight of the cask, and a longitudinal force of ten times the weight of the cask with no resulting excessive stresses. See the Appendix for the analysis and details. (2.10.4)

2.4.4.2 Non-Tie-Down Devices

The four tie-down adaptors (or lugs) located on the cask periphery are covered when not in use with tie-down bars to prevent their use as lifting devices.

2.4.4.3 Tie-Down Device Failure

The four tie-down adaptors on the cask periphery have been designed so that loads transmitted by the tie-down cables under the worst conditions will neither damage the outer steel shell nor cause the tie-down adaptors to fail. The tie-down system analysis is shown in the Appendix. (2.10.4.4)

2.5 Standards for Type B and Large Quantity Packaging

This is not applicable to the HN-100S cask.

2.6 Normal Conditions of Transport

The HNDC HN-100S package has been designed and constructed, and the contents are so limited (as described in Section 1.2.3) that the performance requirements specified in 10 CFR 71.35 will be met when the package is subjected to the normal conditions of transport specified in Appendix A of 10 CFR 71. The ability of the HN-100S package

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to satisfactorily withstand the normal conditions of transport has been assessed as described below:

2.6.1 Heat

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

2.6.2 Cold

The steel materials selected for forgings, plate and bolting each retain structural integrity at temperatures down to -40° F.

2.6.3 Pressure

The HN-100S cask will withstand an internal pressure of 1/2 atmosphere (7.35 psi). This analysis is contained in Section 4 "Containment", specifically 4.2.1.

2.6.4 Vibration

The cask tie-downs firmly position the package as to minimize any vibrational effects. In addition, all cask external devices are firmly attached (either by welding or bolting) to the cask.

Specifically, the design closure consisting of the O-ring seal for both the cask lid and the shield plug closure are capable of withstanding higher temperatures and forces than the cask experiences during normal transport conditions. In a similar manner, the number of bolts and the strength of the bolting design for the closures assure that the bolts will not fail during normal transport.

2.6.5 Water Spray

Since the cask external is constructed of steel, this test is not required.

2.6.6 Free Drop

The cask has been analyzed to insure its structural adequacy to withstand a one-foot drop, striking any cask surface, onto a flat horizontal surface. The analysis is shown in Appendix 2.10.5.

2.6.7 Corner Drop

The specified condition is not applicable since the package weight is greater than 10,000 pounds.

2.6.8 Penetration

The impact of a vertical steel 1-1/4 inch diameter, 13 pound cylinder from a height of four feet will not puncture the cask outer steel shell. In addition, there is no externally mounted equipment on

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the cask, the damage of which due to this transport condition, would limit the cask structural adequacy or hinder its function.

2.6.9 Compression

This specified condition is not applicable since the package weight is greater than 10,000 pounds.

2.7 Hypothetical Accident Conditions

This section is not applicable to the HN-100S cask.

2.8 Special Form

This section is not applicable to the HN-100S cask.

2.9 Fuel Rods

This section is not applicable to the HN-100S cask.

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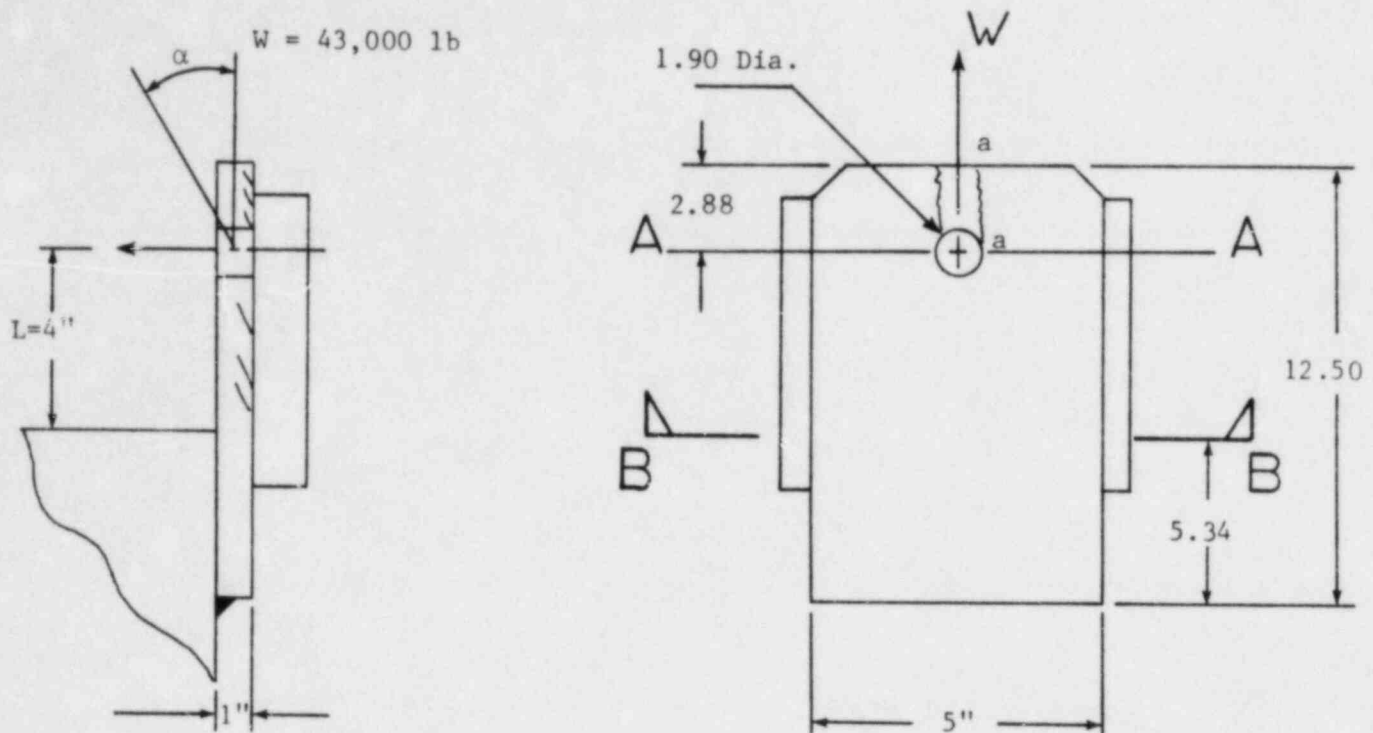
2.10 Appendix

- 2.10.1 Cask Lifting Lugs
- 2.10.2 Cask Lid Lifting Lugs
- 2.10.3 Shield Plug Lifting Device
- 2.10.4 Tie-Down Analysis
- 2.10.5 Free Drop Analysis

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2.10.1 Cask Lifting Lugs

Material: ASTM A515 GR 70 (Sy = 38,000 psi)



2.10.1.1 Tension Stress (across Plane A-A)

$$W = \frac{(\text{Load}) (3g)}{3 \text{ lugs}} = \frac{(43,000) (3)}{3} = 43,000 \text{ lb.}$$

$$\sigma_T = \frac{W}{A_1 - A_H + 2A_2} = \frac{43,000}{5(1) - 1.9(1) + 2(3)(.5)} = 7050 \text{ psi}$$

$$\text{Safety Factor} = \frac{S_v}{\sigma_T} = \frac{38,000}{7050} = 5.39$$

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2.10.1.2 Combined Stress (Section B-B)

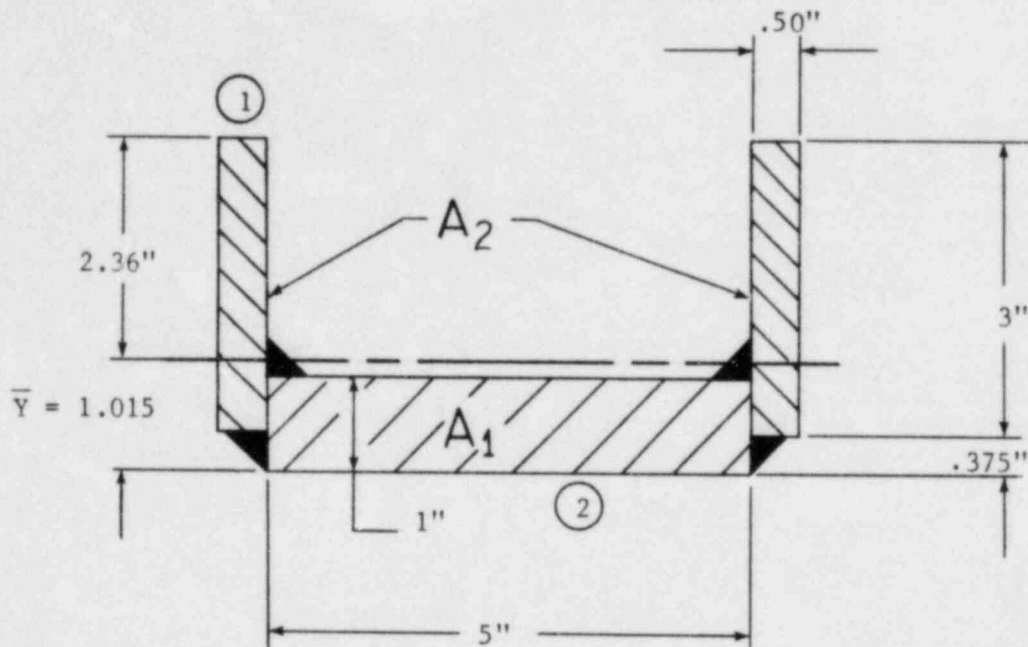
$$\sigma_{T1} = \sigma_1 + \sigma_2$$

σ_1 = tensile stress due to vertical load

$$\sigma_{T2} = \sigma_1 - \sigma_c$$

σ_2 = tensile stress due to bending

σ_c = compressive stress due to bending



$$A\bar{y} = A_1 y_1 + 2A_2 \bar{y}_2$$

$$8\bar{y} = 5(.5) + 2(3 \times .5)(1.875)$$

$$y = \frac{2.5 + 5.625}{8} = \frac{8.125}{8} = 1.015''$$

$$I_x = \frac{bh^3}{12} + Ad^2$$

$$I_{x1} = \frac{(5)(1.)^3}{12} + 5(1.015 - 0.5)^2 = 1.742 \text{ in}^4$$

$$I_{x2} = \frac{(1)(3)^3}{12} + 3(.86)^2 = 4.47 \text{ in}^4$$

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$$I_x = I_{x1} + I_{x2} = 6.21 \text{ in}^4$$

$$\sigma_1 = \frac{W}{A_1 + 2A_2} = \frac{43,000}{8} = 5380 \text{ psi}$$

$$\sigma = \frac{MC}{I} \quad \begin{array}{l} M = (W \tan \alpha) L = 43,000 (\tan 20^\circ) 4 \\ M = 62,600 \text{ lb-in} \end{array}$$

$$\sigma_2 = \frac{62,600 \times 2.36}{6.21} = 23,800 \text{ psi}$$

$$\sigma_c = \frac{62,600 \times 1.015}{6.21} = -10,230 \text{ psi (compression)}$$

$$\sigma_{T1} = \sigma_1 + \sigma_2 = 5380 + 23,800 = 29,200 \text{ psi}$$

$$\sigma_{T2} = \sigma_1 + \sigma_2 = 4563 - 10,230 = -5670 \text{ psi}$$

$$\text{Safety Factor } \frac{S_y}{\sigma_{T1}} = \frac{38,000}{29,200} = 1.30$$

NOTE: α is limited to 20° from centerline.

2.10.1.3 Shear due to bolt load (along Plane A-A)

$$\sigma_s = \frac{W}{A_s} = \frac{43,000}{2 \times 1 \times 2.4} = \frac{43,000}{4.8} = 8960 \text{ psi}$$

$$\text{Safety Factor} = \frac{S_{sy}}{\sigma_s} = \frac{22,800}{8960} = 2.54$$

2.10.1.4 Minimum Weld Length

Weld Assumptions

1. Weld Efficiency = .85
2. Allowable Shear Stress = 15,600 psi
3. Weld Fillet Strength (3/4" Fillet) = 7200 lb/in

Actual Weld Length: $(l_a) = 16.68 \text{ in.}$

$$\text{Required Weld Length: } (l_R) = \frac{43,000}{(7200) (.85)} = 7.03$$

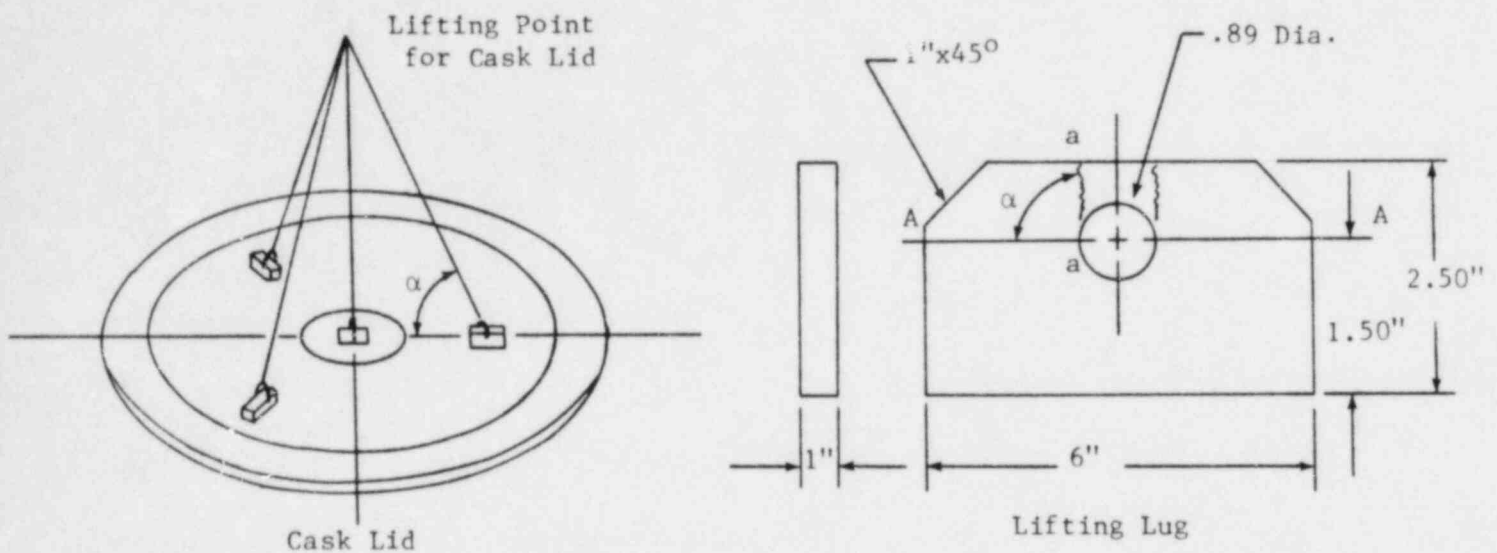
$$\text{Safety Factor} = \frac{16.68}{7.03} = 2.37$$

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2.10.2 Cask Lid Lifting Lugs

Three lifting joints have been provided in the cask lid to accommodate the lift sling attachment. Each of the lifting points is capable of lifting the entire weight of the lid.

Lid Weight = 4000 lb.



2.10.2.1 Shear due to bolt load (along Plane A-A)

- Assumptions:
- 1) $\alpha = 45^\circ$
 - 2) Shear along Plane A-A
(the actual area is greater)
 - 3) 3-g abrupt lift by 3 lugs will
be 4000 lb. per lug.

$$F = \sqrt{2} \quad W = \sqrt{2} (4000) = 5656 \text{ lb.}$$

$$A_s = (2) (1) (1) = 2 \text{ in}^2$$

$$\sigma_s = \frac{5656 \text{ lb}}{2 \text{ in}^2} = 2828 \text{ psi}$$

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Lug material is ASTM A515 GR 55 ($S_y = 30,000$ psi)

$$\text{Safety Factor} = \frac{S_y}{\sigma_s} = \frac{18,000}{2828} = 6.36$$

2.10.2.2 Tear Stress (across Plane A-A)

$$\sigma_t = \frac{W}{A} = \frac{4000}{(6-.89)(1)} = 782 \text{ psi}$$

$$\text{Safety Factor} = \frac{S_y}{\sigma_t} = \frac{30,000}{782} = 38$$

2.10.2.3 Lug Weld to Lid

A 1/2" Fillet Weld attaches the lug to the lid. The actual weld length (ℓ_a) = 14 in. and 4800 lb/in. of length is the safe load per linear inch of 1/2" weld.

$$\text{Lug Safe Load} = (4800 \text{ lb/in}) \times (14 \text{ in}) = 67,000 \text{ lb.}$$

$$67,000 \text{ lb.} \gg 4000 \text{ lb (weight of lid)}$$

The safe working load is much greater than the actual load (cask lid weight), hence the lug weld length is adequate.

2.10.2.4 Pin Bearing Strength

$$\sigma_{BR} = \frac{W}{Dt} = \frac{4000}{.75 \times 1.00} = 5333 \text{ psi}$$

$$\text{Safety Factor} = \frac{30,000}{5333} = 5.6$$

Where D = Pin Diameter
t = thickness of lug

2.10.3 Shield Plug Lifting Lug

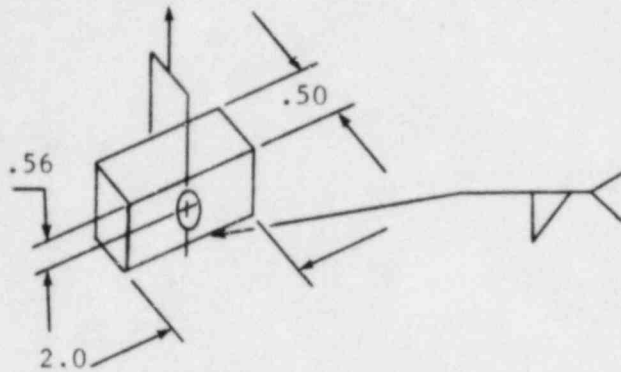
The shield plug lifting lug is a single clevis pin type assembly.

$$\text{Shield Plug Weight} = 230 \text{ lb}$$

$$3 \times 230 = 690 \text{ lb}$$

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The following analysis shows the adequacy of the connecting lug and the cover plate of the shield plug to support three (3) times the plug weight.



2.10.3.1 Shear due to bolt

$$690 / (2) (.33)(.5) = 2090 \text{ psi}$$

$$\text{Safety Factor} = 18,000 / 2090 = 8.6$$

2.10.3.2 Connecting Lug Bearing Stress

$$\sigma_{BR} = \frac{3W}{A} = \frac{3 \times 230 \text{ lb}}{(.5)(.45)} = 3067 \text{ psi}$$

$$\text{Safety Factor} = \frac{30,000}{3067} = 9.78$$

2.10.3.3 Required Weld Length

Assuming 2400 lb/in for 1/4" fillet weld

$$\text{The actual weld length} = (2 + 2 + .5 \times 2) = 5.0$$

The weld can support:

$$2400 \text{ lb/in} \times 5 = 12,000 \text{ lb.}$$

$$12,000 \text{ lb} > 690 \text{ lb.}$$

Hence there is adequate weld length

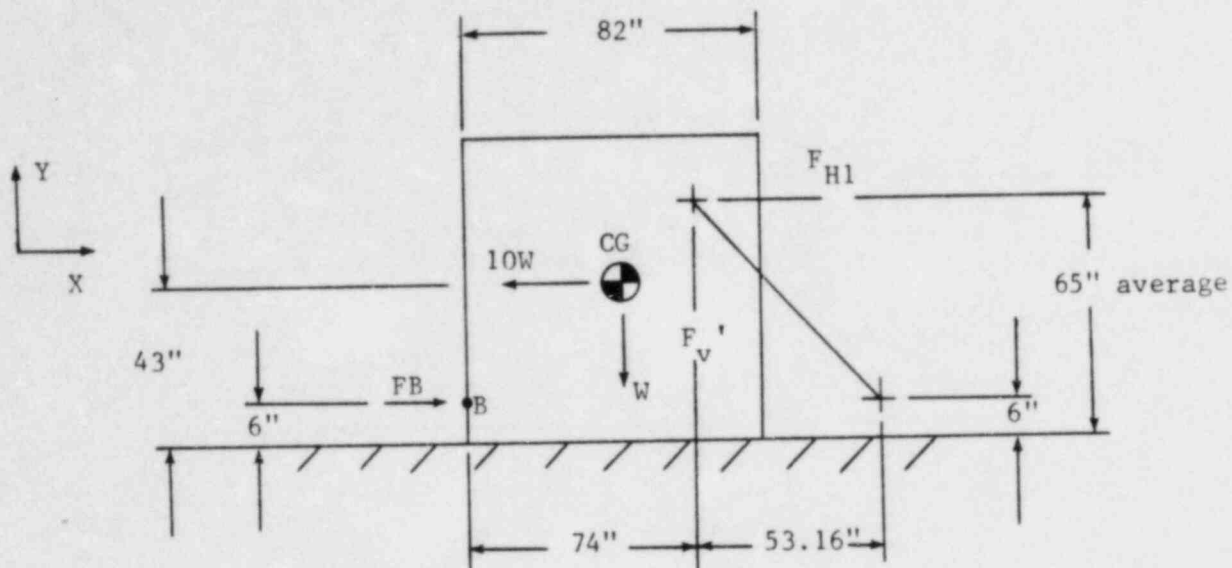
2.10.4 Tie-Down Analysis

2.10.4.1 Tie-Down Loads

The cask tie-downs consist of four (4) cable and turnbuckle assemblies and shear blocks or shear ring at the cask base which firmly position and hold the cask to the truck platform. The following analysis shows the ability of the cask tie-down lugs to withstand combined loads due to a 10g longitudinal, 5g transverse and 2g vertical loads.

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10g Longitudinal Load



$$\Sigma M_B = 0$$

$$10W (37) = W (41) + F_v' (74) + F_{H1} (59)$$

$$\frac{F_v'}{F_{H1}} = \frac{59}{53.16} = 1.11 \rightarrow F_v' = 1.11 F_{H1}$$

$$10 (43,000) (37) = 43,000 (41) + 1.11 F_{H1} (74) + F_{H1} (59)$$

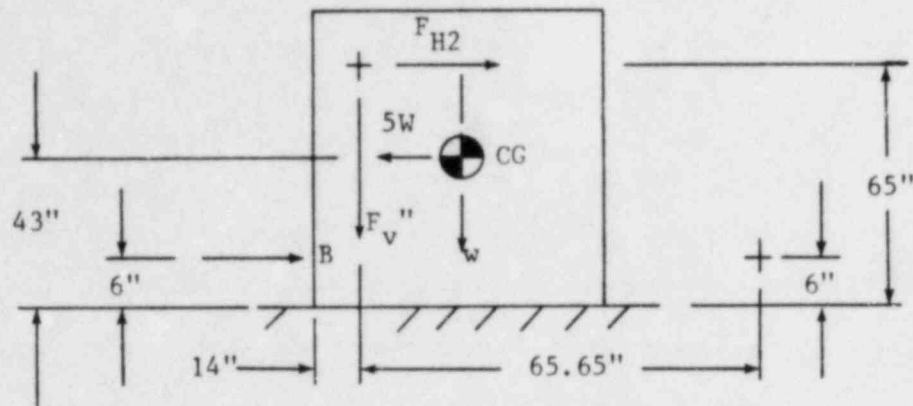
$$1.415 \times 10^7 = 141.14 F_{H1}$$

$$F_{H1} = 100,250 \text{ lb.}$$

$$F_v' = 1.11 F_{H1} = 111,260 \text{ lb.}$$

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5g Transverse Load



$$\sum M_B = 0$$

$$5W (37) = F_V'' (14) + F_{H2} (59) + W (41)$$

$$\frac{F_{H2}}{F_V''} = \frac{65.65}{59} = 1.11 \text{ therefore } F_{H2} = 1.11 F_V''$$

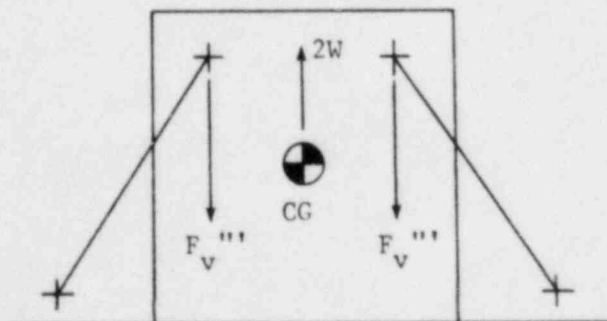
$$5 (43,000) (37) = F_V'' (14 + 65.49) + 41 (43,000)$$

$$6.19 \times 10^6 = 79.49 F_V''$$

$$F_V'' = 77,900 \text{ lb.}$$

$$F_{H2} = 86,500 \text{ lb.}$$

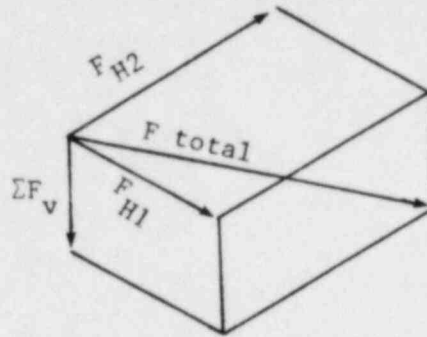
2g Vertical Load



$$4F_V''' = 2W \text{ therefore } F_V = .5W = .5(43,000) = 21,500 \text{ lb.}$$

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Combined Load on Each Lug



$$\Sigma F_v = F_v' + F_v'' + F_v''' = 111,260 + 77,900 + 21,500$$

$$F_v = 210,660 \text{ lb.}$$

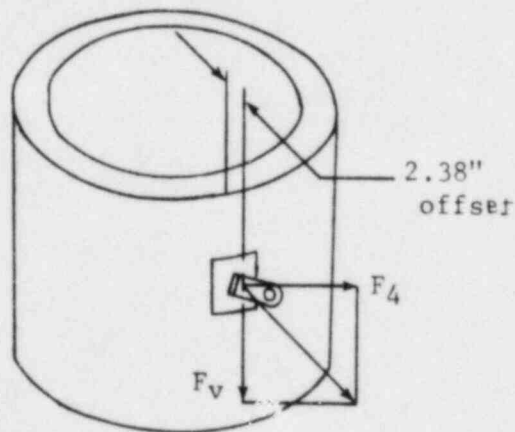
$$F_{\text{Total}} = \sqrt{F_{H1}^2 + F_{H2}^2 + F_v^2}$$

$$F_{\text{Total}} = \sqrt{(100,250)^2 + (86,500)^2 + (210,660)^2}$$

$$F_{\text{Total}} = 248,800$$

2.10.4.2 Analysis of Tie-Down Loads on Cask Shell

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



$$F_H = \sqrt{F_{H1}^2 + F_{H2}^2} = \sqrt{(100,250)^2 + (86,500)^2} = 132,410$$

$$F_v = 210,660 \text{ lb.}$$

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$$\begin{aligned}M_e &= \text{external longitudinal moment} \\M_c &= \text{external circumferential moment} \\M_e &= 2.38 \times F_H = 2.38 \times 132,000 = 315,135 \text{ in-lb.} \\M_c &= 2.38 \times F_v = 2.38 \times 210,660 = 501,370 \text{ in-lb.}\end{aligned}$$

The resulting longitudinal and circumferential moments in the cask cylinder outer steel shell are obtained from the external moments using the following formula: *

$$\begin{aligned}M_x &= .044 \frac{M_c}{aB} + .051 \frac{M_e}{aB} \\M_\phi &= .085 \frac{M_c}{aB} + .032 \frac{M_e}{aB}\end{aligned}$$

where: a = cask outer shell radius = 41"

$$B = \text{dimensionless ratio } \frac{c}{a} = \frac{6}{41} = .146$$

$$c = \text{mounting plate width} = \frac{12}{2} = 6"$$

$$N_x = 2.6 \frac{M_c}{a^2 B} + 1.37 \frac{M_e}{a^2 B}$$

$$N_\phi = 1.32 \frac{M_c}{a^2 B} + 3.4 \frac{M_e}{a^2 B}$$

Substituting into these equations yields:

$$M_x = \frac{.044 (315,135) + .051 (501,370)}{41 (.146)} = 6588 \text{ lb-in}$$

$$M_\phi = \frac{.085 (315,135) + .032 (501,370)}{41 (.146)} = 7155 \text{ lb-in}$$

$$N_x = \frac{2.6 (315,135) + 1.37 (501,370)}{(41)^2 (.146)} = 6137 \text{ lb-in}$$

$$N_\phi = \frac{1.32 (315,135) + 3.4 (501,370)}{(41)^2 (.146)} = 8640 \text{ lb-in}$$

*Bijlaard, P.P., "Stresses from Radial Loads and External Moments in Cylindrical Pressure Vessels", ASME, 1960.

PROPRIETARY DATA

The maximum longitudinal and circumferential stresses in the cask outer shell are:

$$\sigma_{x(\max)} = \frac{6M_x}{t^2} + \frac{N_x}{t} = \frac{6(6588)}{(1.5)^2} + \frac{6137}{1.5} = 21,660 \text{ psi}$$

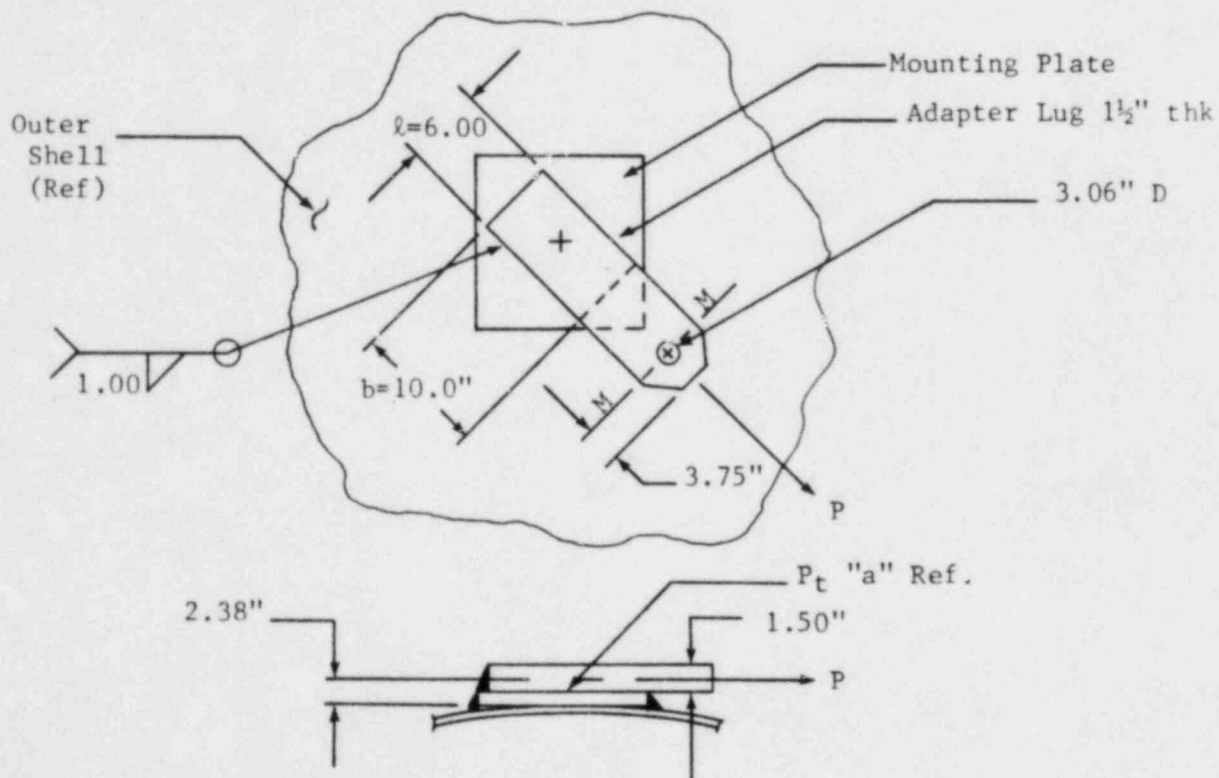
$$\text{Safety Factor} = \frac{30,000}{21,660} = 1.38$$

$$\sigma_{\phi(\max)} = \frac{6M_{\phi}}{t^2} + \frac{N_{\phi}}{t} = \frac{6(7155)}{(1.5)^2} + \frac{8640}{1.5} = 24,840 \text{ psi}$$

$$\text{Safety Factor} = \frac{30,000}{24,840} = 1.15$$

2.10.4.3 Analysis of Cask Tie-Down Adapter

The HN-100S Cask Tie-Down Adapter is analyzed for the maximum 10g, 5g and 2g combined loading condition.



PROPRIETARY DATA

Let $P = 248,800$ lb. (See Section 2.10.4.1)

The adapter is constructed of ASTM A515 GR70 Alloy Steel

$$\sigma_{ult} = 70,000 \text{ psi minimum}$$

Bearing stress in pin hole:

$$\sigma_{BR} = \frac{P}{Dt} = \frac{248,800}{3.06 \times 1.5} = 54,205 \text{ psi}$$

$$\text{Safety Factor} = \frac{70,000}{54,205} = 1.01$$

Tensile stress (in Plane M-M)

$$\sigma_T = \frac{248,800}{(6-3.06)1.5} = 56,417 \text{ psi}$$

$$\text{Safety Factor} = \frac{70,000}{56,417} = 1.24$$

Tear out in Pin Hole $(248,800)/(2)(1.5)(3.75) = 22,115$ psi

$$\text{Safety Factor} = \frac{33,000}{22,115} = 1.5$$

Weld Strength Analysis

Stresses in the adapter lug to the mounting plate are a result of the direct shear load.

$$\text{The direct shear stress } \sigma_s = \frac{248,800}{1 \times 7.07 \times 26}$$

$$\sigma_s = 13,533$$

The allowable shear stress is 15,600 psi

$$\text{Safety Factor} = \frac{15,600}{13,533} = 1.15$$

2.10.4.4 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 of the shell would be:

PROPRIETARY DATA

$$F = (248,800 \text{ lb.}) \left(\frac{55,000}{24,840} \right) = 550,885 \text{ lb.}$$

The lugs would fail due to a combination of bearing and tensile stresses. Based on ultimate strength of the lug, failure would occur with force if:

$$\text{Bearing: } (55,000 \text{ psi})(3.06 \text{ in})(1.5 \text{ in}) = 252,450 \text{ lb.}$$

$$\text{Tensile: } (70,000 \text{ psi})(6-3.06 \text{ in})(1.5) = 308,700 \text{ lb.}$$

Accordingly, a tensile failure of the lug will occur before the cask shell is damaged.

2.10.5 Free Drop Analysis

2.10.5.1 Corner Drop

The cask body must absorb the total kinetic energy. The kinetic energy to be absorbed by the cask body is:

$$E_k = mgh = (43,000 \text{ lb.})(12 \text{ in.}) = 516,000 \text{ in-lb.}$$

The volume of steel required to absorb this energy is:

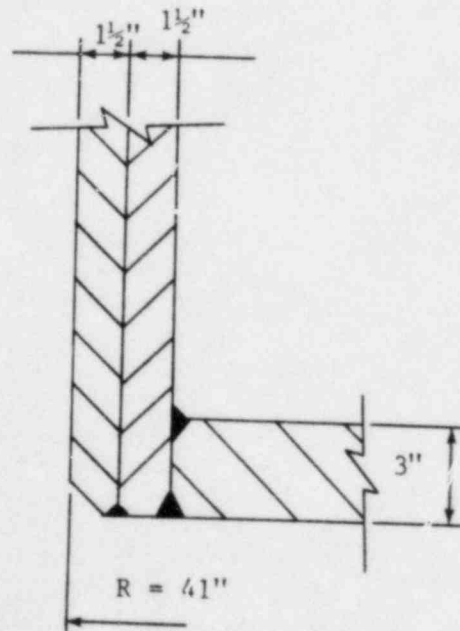
$$V_s = \frac{E_k}{S_y}$$

Material is ASTM A515 GR55 ($S_y = 30,000 \text{ psi}$)

$$V_s = \frac{516,000}{30,000} = 17.2 \text{ in}^3$$

Corner Impact

This configuration of the HN-100 cask corner is:

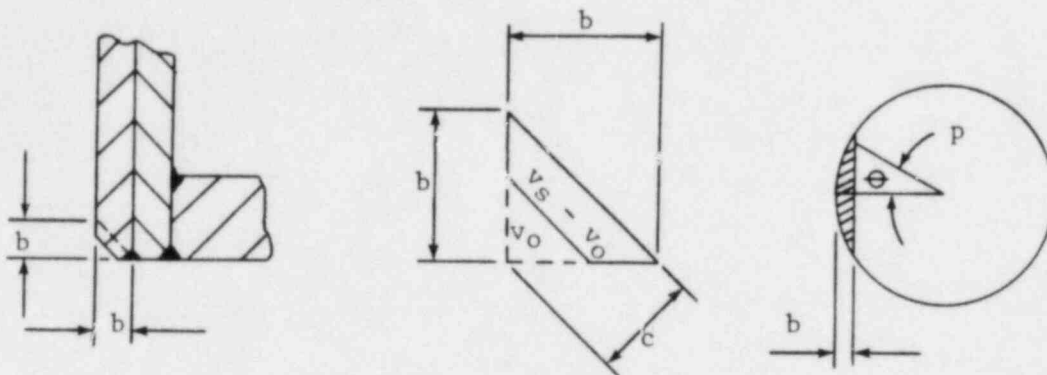


PROPRIETARY DATA

At an impact angle of 45° the steel corner will be deformed in the shape of an ungula and the volume of the deformation is determined by the following equation:

$$V_s = R^3 \left(\sin\theta - \frac{\sin^3\theta}{3} - \theta \cos\theta \right)$$

The angle $\phi = 16.4^\circ$ when the volume of the ungula is 17.3 in.^3



$$b = R (1 - \cos \theta)$$

$$b = 41 (1 - \cos 16.4^\circ) = 1.66 \text{ in.}$$

$$c = \frac{b}{\sqrt{2}} = 1.18 \text{ in.}$$

The effect on the cask body due to the corner impact event is shown on the above sketch.

The deceleration force exerted on the cask is calculated as the product of the maximum contact surface area and the yield strength of steel (30,000 psi). The area is:

$$A = \frac{\pi a^2}{2} - \left(xy + ab \sin^{-1} \frac{x}{a} \right), \text{ where } \theta = 45^\circ$$

PROPRIETARY DATA

$$\begin{aligned}R &= 41 \text{ in.} \\a &= R/\cos \theta = 41 \sqrt{2} = 58 \text{ in.} \\b &= R = 41 \text{ in.} \\h &= 1.66 \text{ in.} \\C &= R-h = 41 - 1.66 = 39.34 \text{ in.} \\y &= \sqrt{R^2 - C^2} = 11.55 \text{ in.} \\x &= C/\cos \theta = 39.34 \sqrt{2} = 55.63 \text{ in.}\end{aligned}$$

$$A = \frac{\pi(58)(41)}{2} - \left[(55.63)(11.55) + (58)(41) \sin^{-1} \left(\frac{55.63}{58} \right) \right]$$

$$A = 39.62 \text{ in}^2$$

$$\begin{aligned}\text{Deceleration Force} &= (39.62 \text{ in}^2) (30,000 \text{ psi}) \\&= 1,188,600 \text{ lb.}\end{aligned}$$

$$\text{Deceleration} = 1,188,600/43,000 = 27.6 \text{ g's.}$$

2.10.5.2 Cask Lid Loading-Top Corner Drop

The deceleration forces that will be generated during a top corner drop will be the same as those generated in a bottom corner drop. Since the weight and drop distance are the same, any difference will be due to the yield strength of the steel. Using minimum strength steel (30,000 psi) the 1.66 inch deformation from a corner drop will damage one or two studs at the point of impact but will not affect the integrity of the package.

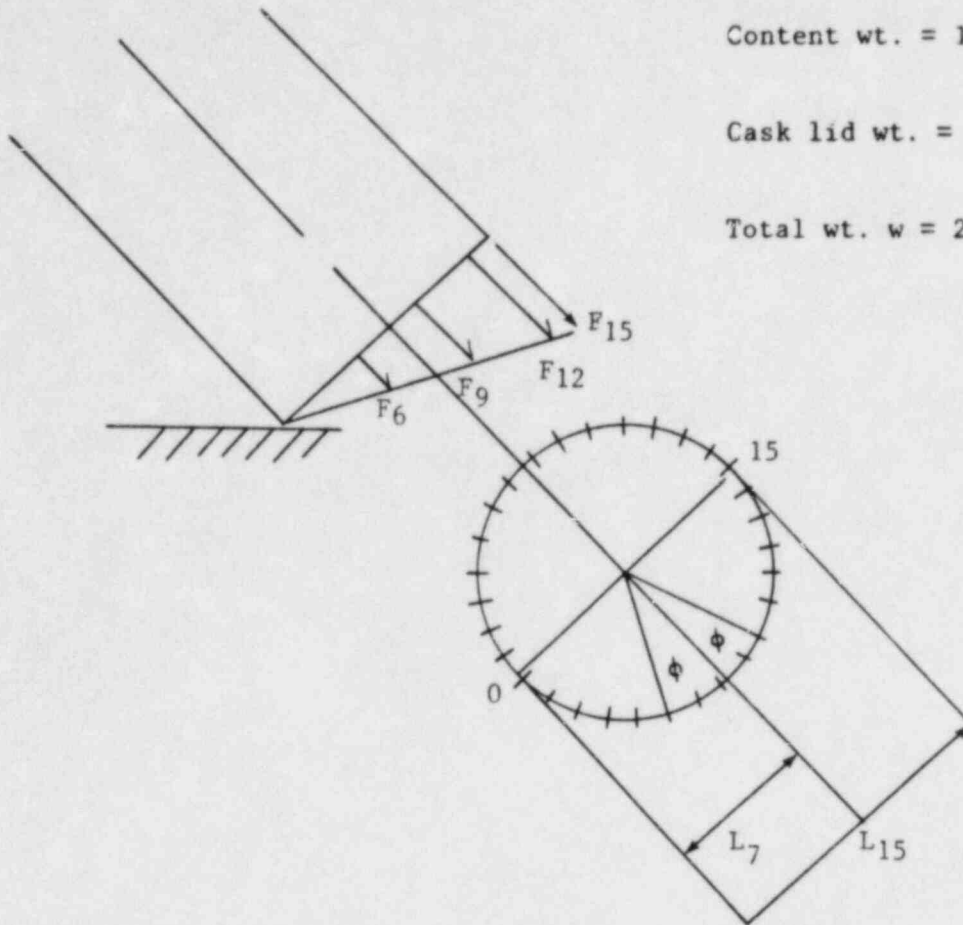
Impact at the upper corner of the cask will result in the cask contents pushing against the cask lid. The contents of the cask, it should be noted are positioned to limit actual movement to one (1) inch or less. The loading on the cask lid is realized in the studs. The studs stress is therefore equivalent to the inertia load of the contents and the inertia force of the lid itself. The following maximum weights of these constituents have been conservatively estimated. A deceleration force of 28 g's has been used in this analysis.

PROPRIETARY DATA

Content wt. = 17,000

Cask lid wt. = 4,000

Total wt. $w = 21,000$



Impact loading on cask lid closure studs.

The maximum loaded stud is that one furthest from the point of impact. The force acting on this bolt is designated at:

$F_{i5} = \text{Max. stud force}$

Taking the summation of moments about point "0."

Sum of stud load = $G (\text{Weight Lid} + \text{Contents}) \text{Cos } \phi \times R$

PROPRIETARY DATA

The maximum stud load, P_{15} , occurs in the single stud located at L_{15} . The load in the other studs (based on deflection with a rigid lid) will be:

$$L_i = \frac{L_i}{2R} \times P_{15}$$

The moment exerted by the studs can be expressed as:

$$M_i = L_i \times \frac{L_i}{2R} \times P_{15} + \frac{L_i^2}{2R} P_{15}$$

The sum of the stud moments will be:

$$2 \left[\frac{L_1^2 + L_2^2 + L_3^2 + L_4^2 + \dots + L_{14}^2}{2R} \right] P_{15} + \frac{(2R)^2}{2R} P_{15}$$

$$= [L_1^2 + L_2^2 + L_3^2 + L_4^2 + \dots + L_{14}^2 + 2R^2] \frac{P_{15}}{R}$$

$$= [20.37 R^2 + 2R^2] \frac{P_{15}}{R}$$

$$= 22.37 R P_{15} =$$

$$= (22.37 \times 41) P_{15} = 917 P_{15}$$

Where:

$$L_1 = R (1 - \sin 78^\circ) = 0.0218 R \quad L_1^2 = .00047 R^2$$

$$L_2 = R (1 - \sin 66^\circ) = 0.0865 R \quad L_2^2 = 0.0075 R^2$$

$$L_3 = R (1 - \sin 54^\circ) = 0.191 R \quad L_3^2 = 0.0365 R^2$$

$$L_4 = R (1 - \sin 42^\circ) = 0.3309 R \quad L_4^2 = 0.1095 R^2$$

PROPRIETARY DATA

$L_5 = R (1 - \sin 30^\circ) = 0.5 R$	$L_5^2 = 0.25 R^2$
$L_6 = R (1 - \sin 18^\circ) = 0.691 R$	$L_6^2 = 0.477 R^2$
$L_7 = R (1 - \sin 6^\circ) = 0.896 R$	$L_7^2 = 0.802 R^2$
$L_8 = R (1 + \sin 6^\circ) = 1.105 R$	$L_8^2 = 1.092 R^2$
$L_9 = R (1 + \sin 18^\circ) = 1.309 R$	$L_9^2 = 1.713 R^2$
$L_{10} = R (1 + \sin 30^\circ) = 1.5 R$	$L_{10}^2 = 2.25 R^2$
$L_{11} = R (1 + \sin 42^\circ) = 1.669 R$	$L_{11}^2 = 2.786 R^2$
$L_{12} = R (1 + \sin 54^\circ) = 1.809 R$	$L_{12}^2 = 3.272 R^2$
$L_{13} = R (1 + \sin 66^\circ) = 1.914 R$	$L_{13}^2 = 3.661 R^2$
$L_{14} = R (1 + \sin 78^\circ) = 1.978 R$	$L_{14}^2 = 3.913 R^2$
$L_{15} = R (1 + \sin 90^\circ) = 2R$	$L_{15}^2 = 4 R^2$
	$L_{1-14}^2 = 20.37 R^2$

Equating the stud moments to the moment exerted by the contents and cover:

$$917 P_{15} = (28)(21,000)(0.707)(41)$$

$$P_{15} = 18,590 \text{ lbs}$$

The head studs are one inch in diameter and are fabricated from either ASTM A320 Grade L7 or ASTM A307 Grade A. A307 is the worst case. The studs have a root diameter of 0.878 inches and an area of 0.606 in². The stress in the outer stud will be:

$$f = 18,590 \div 0.606 = 30,676 \text{ psi}$$

PROPRIETARY DATA

The yield strength of A307 steel is 60,000 psi. The safety factor for the studs are:

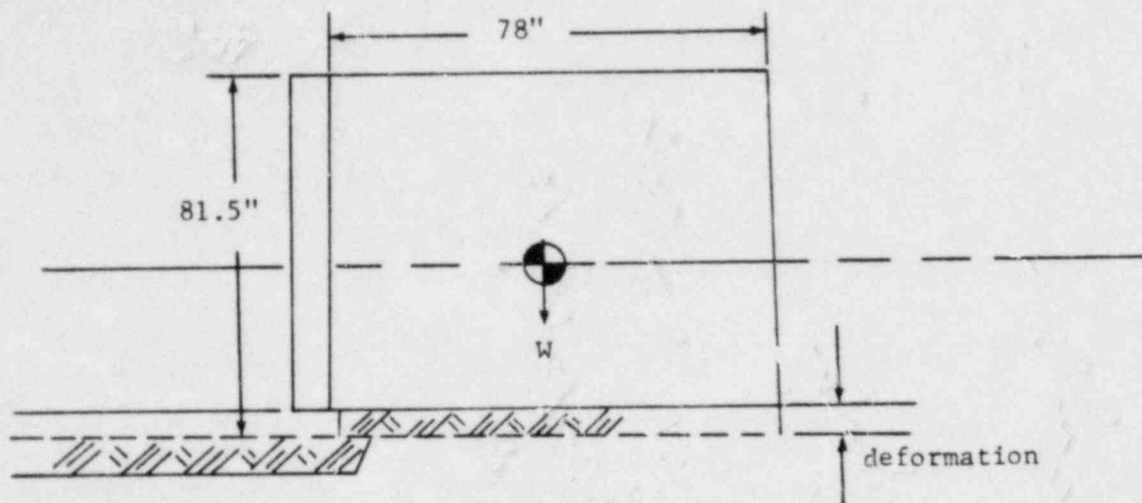
$$S.F. = (\text{yield}) = \frac{60,000}{30,676} = 1.95$$

The maximum elongation will occur at the bolt located in the L_{15} position. The maximum elongation will be:

$$e = \frac{Pl}{AE} = \frac{18,590 \times 4.75}{0.606 \times 29 \times 10^6} = 0.005 \text{ inches}$$

The elongation is a small fraction of the compression of the O ring seal.

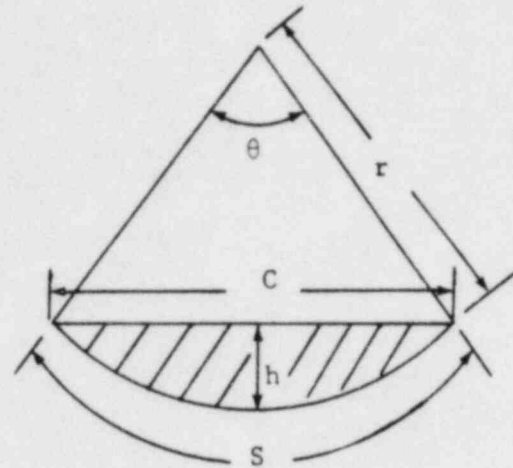
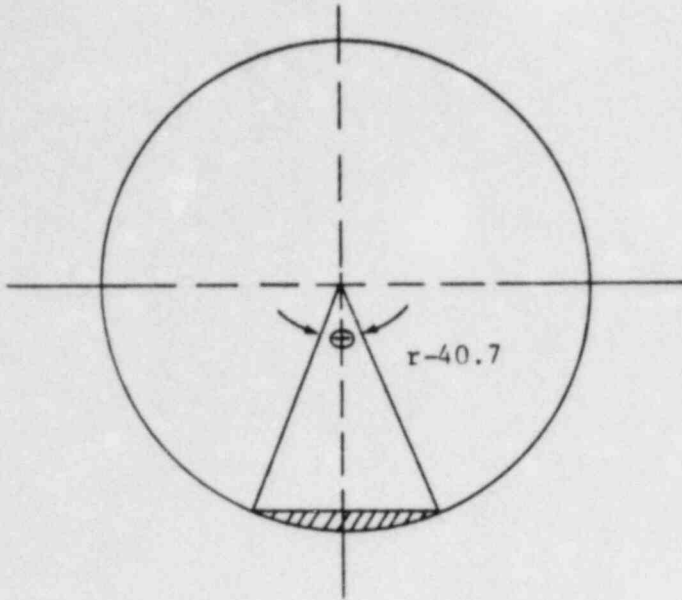
2.10.5.3 Side Drop



(Assumes side drop on entire side, not including flange, to determine maximum deceleration)

PROPRIETARY DATA

$$\text{Energy } (43,000 \text{ lb})(12) = 516,000 \text{ in-lb}$$



$$\text{Volume} = (516,000 \text{ in-lb}) / 30,000 \text{ psi} = 17.2 \text{ in}^3$$

$$\text{Area of segment} = 17.2 \text{ in}^3 / 78 \text{ in} = 0.22 \text{ in}^2$$

$$\text{Area} = \frac{1}{2} r^2 (\theta - \sin \theta)$$

$$\theta = 0.12 \text{ rad} = 6.87^\circ$$

$$V = \left[\frac{1}{2} (40.7)^2 (0.12 - \sin 6.87^\circ) \right] (78) = 18.6 \text{ in}^3 \text{ (558,000 in-lb)}$$

(108%)

$$h = r(1 - \cos \frac{1}{2} A) = 40.7 [1 - \cos (6.87/2)] = 0.0732 \text{ in}$$

$$0.0732 \text{ in} < 1.5 \text{ inch outer plate}$$

PROPRIETARY DATA

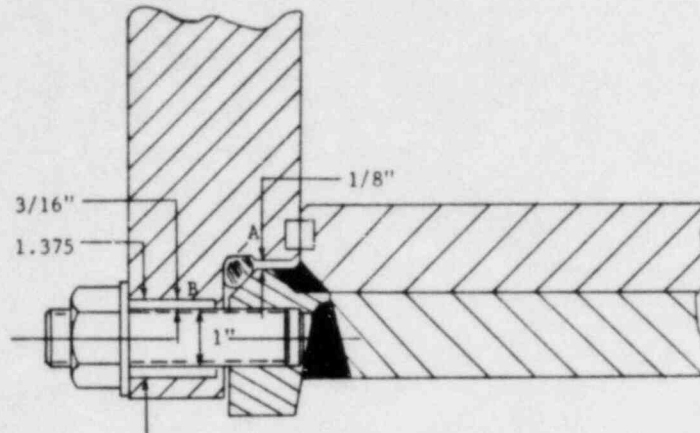
Surface area

$$C = 2\sqrt{h(d-h)} = 2\sqrt{(0.0732)(81.5 - 0.0732)} = 4.88 \text{ in}$$

$$\text{area} = (78)(4.88) = 380 \text{ in}^2$$

$$F = (380 \text{ in}^2)(30,000) = 11,425,760 \text{ lb}$$

$$11,425,760 \text{ lb}/43,000 = 265 \text{ g's}$$



The lid will contact at surface "A" before any major shear force is applied to the closure bolts. The lid will take the deceleration forces along the surface at "A" as bearing, and as shear along the plane of where the gasket corner intersects the lid.

The bearing force on the surface at "A."

$$(4000 \text{ lb})(265)/(81.5)(1.21) = 10,750 \text{ psi}$$

$$\text{S.F.} = 30,000/10,750 = 2.8$$

Shear

$$\text{Shear area of lid} = (77.5)^2(\pi/4) = 4,717 \text{ in}^2$$

$$\sigma_s = (4000)(265)/4,717 = 225 \text{ psi}$$

$$\text{S.F.} = 18,000/225 = 80$$

PROPRIETARY DATA

Shear of cask body at surface "A." (Assume only 1/2 of cask
body)

$$\sigma = (4000)(265)/(1/2)(\pi/4)(82.75^2 - 77.75^2)$$

$$\sigma = 3,363 \text{ psi}$$

$$\text{S.F.} = 18,000/3363 = 5.35$$

PROPRIETARY DATA

3. THERMAL EVALUATION

3.1 Discussion

The HN-100S cask 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:

<u>Isotope</u>	<u>Gamma Energy</u> mev	<u>Specific Activity</u> $\mu\text{Ci/ml}$ (1)	<u>Total Activity</u> Ci (2)
Cobalt-60	1.33	2.3	10.7
Cesium-137	0.66	12	56

(1) Based on cement solidified waste at 10 mR at six feet from cask.

(2) Based on 164 cubic feet of solidified material.

3.2 Summary of Thermal Properties of Materials

With the maximum amount of these materials that can be transported in the HN-100S cask, the heat generated by the waste will be as follows:

	<u>Heat Generation</u> (watts/curie)	<u>Total Activity</u> (curies)	<u>Total Heat</u> (Watts)	<u>Total Heat</u> (BTU/hr)
Cobalt	0.0154	10.7	0.165	0.561
Cesium	0.0048	56	0.27	0.92

PROPRIETARY DATA

The weight of waste per container will be about 13,000 pounds. Based on a specific heat of 0.156 BTU per degree F., 2028 BTU's or over 90 days with cesium would be required to heat the waste one degree Fahrenheit. Accordingly, the amount of heat generated by the waste is insignificant.

PROPRIETARY DATA

4. CONTAINMENT

4.1 Containment Boundary

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.

4.1.1 Containment Vessel

The cask is an upright circular cylinder composed of layers of structural steel. The cask wall consists of two 1-1/2 inch thick steel plate. The heavy steel flange connecting the annular steel shells at the top provides a seat for a Buna-N, or equivalent gasket seal used to provide a positive atmospheric isolation when the lid is bolted down by thirty (30) equally spaced 1-inch diameter studs. The shield plug is located in the center of the cask lid, has a Buna-N or equivalent gasket, and is bolted to the outer portion of the lid with sixteen (16) equally spaced 1/2 inch studs.

4.1.2 Containment Penetrations

The HN-100S has a drain with plug assembly the latter consisting of a lead filled 1-1/2 inch steel pipe and pipe plug. The drain port is located at the perimeter in the cask wall just above the cask's bottom plate. The penetration hole is angled laterally at 45° to prevent shine, should the plug be removed while waste is in the cask.

4.1.3 Seals and Welds

Both the primary lid and secondary shield plug are sealed by means of a Buna-N, or equivalent material "O"-ring.

4.1.4 Closure

The foregoing procedures for the primary lid require each stud to be tightened to 190 ft-lb to 210 ft-lb.

The equivalent tension (F) in each stud is:

$$F = T/Kd$$

where

T is the torque

d is the stud diameter, and

K is the torque coefficient (= 0.15)

PROPRIETARY DATA

Therefore,

$$F = (210 \text{ ft-lb})(12 \text{ in/ft})/(0.15)(1 \text{ in})$$

$$F = 16,800 \text{ lb/stud.}$$

The weight of the lid and shield plug is 4,000 lb.

Total force exerted on the gasket ring is:

$$(30)(16,800) + 4,000 = 508,000 \text{ lb}$$

$$\text{Area of "O" Ring} = (78 \text{ in}) (\pi)(5/8 \text{ in}) = 153.1 \text{ in}^2$$

Total pressure on gasket material

$$508,000/153.1 \text{ in}^2 = 3317 \text{ psi}$$

The torquing procedure values ensure that there is sufficient pressure on the gasket to seal the cask.

Similarly, the shield plug torquing requirement is 35 to 40 ft-lb.

$$F = (40 \text{ ft-lb})(12 \text{ in/ft})/(0.15)(0.5 \text{ in})$$

$$F = 6400 \text{ lb/stud.}$$

Weight of the shield plug is 500 lb. Total force on shield plug gasket is $(6400 \text{ lb})(16 \text{ studs}) + 230 = 102,630 \text{ lb}$.

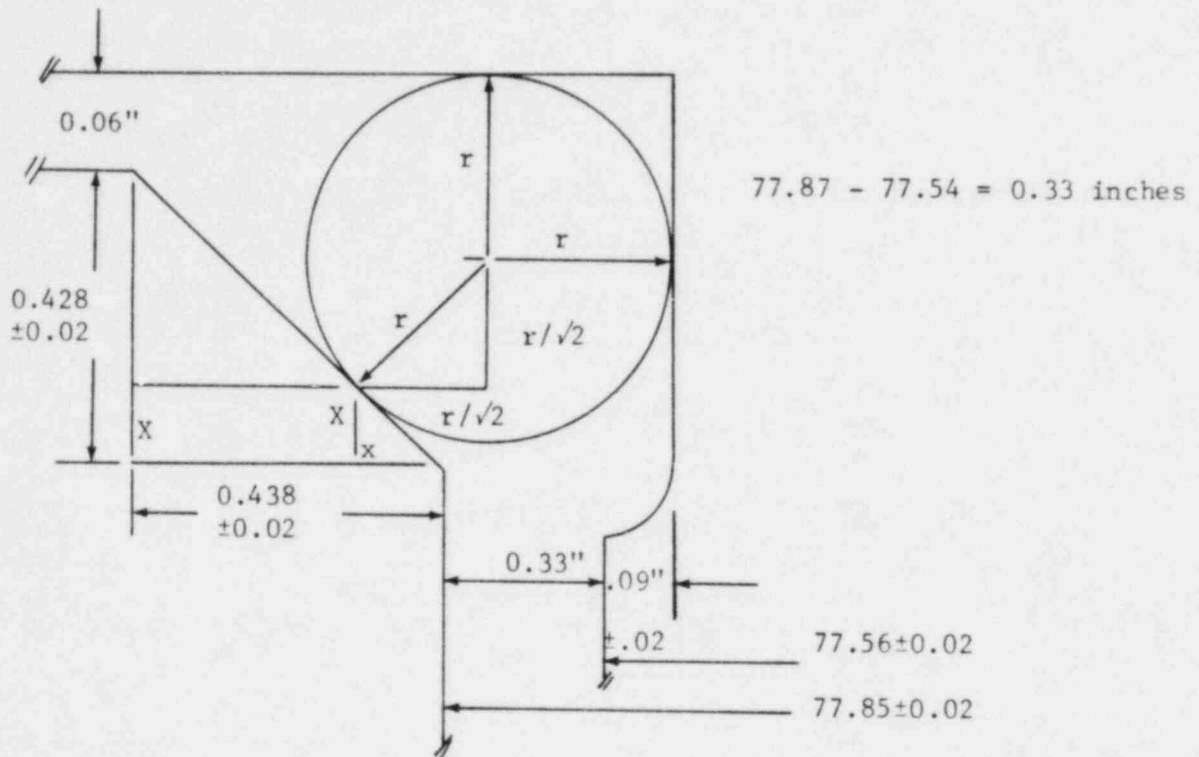
$$\text{Area of gasket} = (18.125)(\pi)(0.5) = 28.47 \text{ in}^2$$

$$\begin{aligned} \text{Pressure on gasket} &= 102,630/28.47 \\ &= 3604 \text{ psi} \end{aligned}$$

This is sufficient to maintain the gasket seal.

PROPRIETARY DATA

The previous analysis assumes the lids are properly centered and there is equal pressure over the circumference of the gasket. The minimum affect of the lid which would cause ununiform seating on the gasket would be the lesser of either the tolerance between stud and stud hole in lid or the O.D. of the lid and I.D. of the lid hole. The maximum opening on the primary lid is the difference in O.D. of the lid and I.D. of body, as shown below:



Using geometry, calculate the minimum value r can be and still have contact on the three surfaces.

$$\begin{aligned} r + r/\sqrt{2} &= 0.33 + 0.11 + x \\ r + r/\sqrt{2} &= 0.06 + 0.458 - x \\ \hline 2r + 2r/\sqrt{2} &= 0.958 \end{aligned}$$

$$r = 0.280 \text{ in}$$

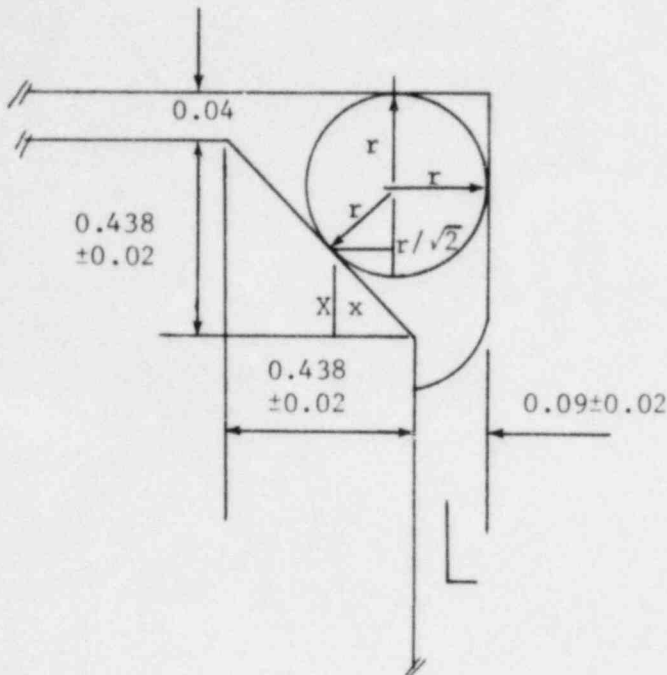
$$\text{diameter} = 0.561 \text{ in}$$

with a 5/8 inch diameter gasket, percent compression will be:

$$\frac{0.625 - 0.561}{0.625} = 10\%$$

PROPRIETARY DATA

Similarly, maximum compression on the "tight" side occurs when there is metal to metal contact between the I.D. of the cask and O.D. of the lid.



$$\begin{aligned} r + \sqrt{r} &= 0.07 + x \\ r + \sqrt{r} &= 0.04 + 0.418 - x \\ \hline 2r + 2\sqrt{r} &= 0.528 \end{aligned}$$

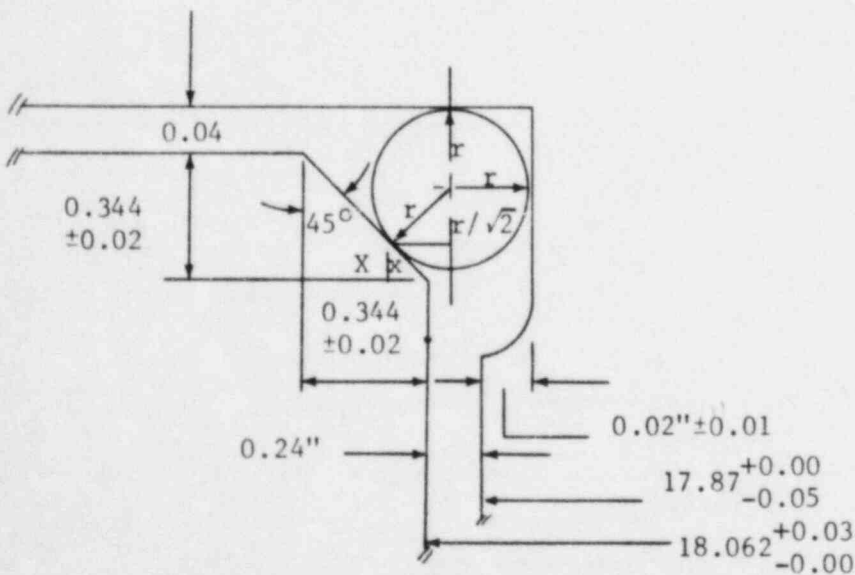
$$r = 0.1546 \text{ inches}$$

$$\text{diameter} = 0.3092 \text{ inches}$$

$$\text{Percent compression} = \frac{0.625 - 0.3092}{0.625} = 50\%$$

Secondary Lid (1/2 inch diameter O-ring)

Similarly, for the secondary lid for the maximum opening, stud tolerance is $0.208 < 0.225$.



$$18.092 - 17.82 = 0.272$$

$$(0.272/2) + (0.208/2) = 0.24$$

PROPRIETARY DATA

Using geometry -

$$\begin{aligned} r + r/\sqrt{2} &= 0.07 + 0.24 + x \\ r + r/\sqrt{2} &= 0.04 + 0.364 - x \\ \hline 2r + 2r/\sqrt{2} &= 0.714 \end{aligned}$$

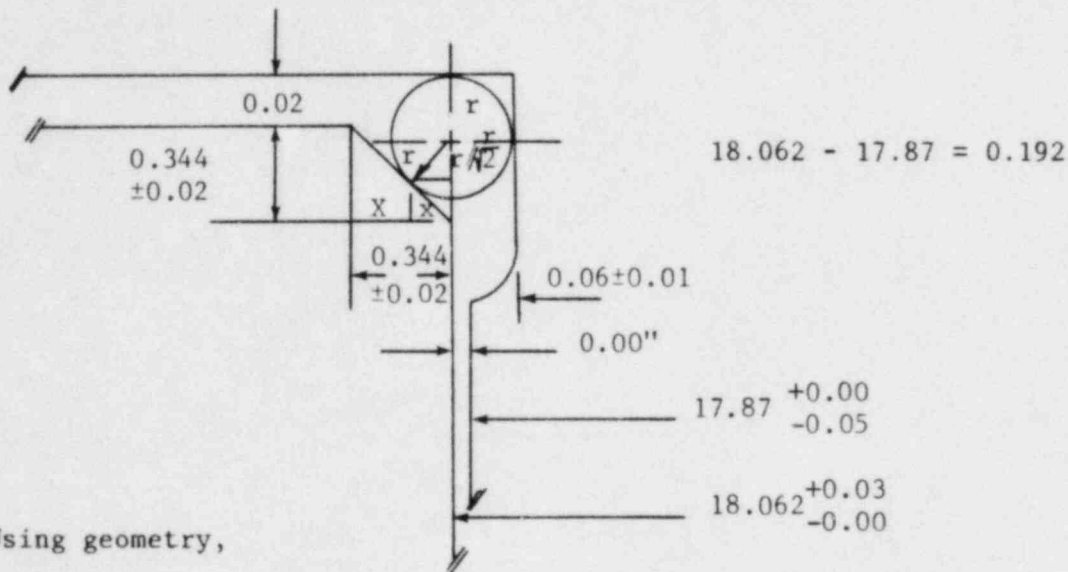
$$r = 0.209 \text{ inches}$$

$$d = 0.418 \text{ inches}$$

Using 1/2 inch diameter C-ring minimum compression is:

$$\frac{0.5 - 0.418}{.5} = 16\%$$

On the tight side, stud hole = 0.208 > 0.192, therefore, there will be metal to metal contact -



Using geometry,

$$\begin{aligned} r + r/\sqrt{2} &= 0.05 + x \\ r + r/\sqrt{2} &= 0.02 + 0.324 - x \\ \hline 2r + 2r/\sqrt{2} &= 0.394 \end{aligned}$$

$$r = 0.1153 \text{ inches}$$

$$d = 0.230 \text{ inches}$$

$$\text{compression} = \frac{0.5 - 0.230}{0.5} = 54\%$$

PROPRIETARY DATA

4.2 Requirements for Normal Conditions of Transport

4.2.1 Release of Radioactive Material

An internal pressure of 7.5 psig is the normal condition that may cause a release of radioactive material.

The force exerted on the primary lid from a 1/2 an atmosphere differential pressure is:

$$(7.5 \text{ lb/in}^2) (75.5 \text{ in})^2 (\pi/4) = 33,577 \text{ lb}$$

on a per stud basis,

$$33,577 \text{ lb}/30 \text{ studs} = 1120 \text{ lb/stud}$$

Add this force to the pre load,

$$1120 + 16,800 = 17,920 \text{ lb.}$$

$$\delta = \frac{PL}{AE} = \frac{(17,920 \text{ lb})(2.25 \text{ in})}{(.844)^2 (\pi/4) (29 \times 10^6)} = 0.0025 \text{ in}$$

This is very small and not enough to break the gasket seal and significantly reduce the package effectiveness.

Similarly, the shield plug experiences a force of

$$(7.5 \text{ lb/in}^2)(16.5 \text{ in})^2 (\pi/4) = 1605 \text{ lb}$$

On a per stud basis,

$$1605 \text{ lb}/16 \text{ studs} = 100.3 \text{ lb/bolt}$$

PROPRIETARY DATA

Added to the pre-load tension

$$100.3 + 6400 = 6500 \text{ lb/stud}$$

$$\begin{aligned}\delta &= PL/AE = (6500)(1.25)/(.4041)^2(\pi/4)(29 \times 10^6) \\ &= .0022 \text{ in}\end{aligned}$$

This distance is too small to break the seal and significantly reduce the package effectiveness.

4.2.2 Pressurization of Containment Vessel

Due to the nature of the waste contents, no vapors or gases could form to pressurize the vessel and significantly reduce the package effectiveness.

4.2.3 Coolant Contamination

The vessel contains no primary coolant, therefore this section is not applicable.

4.2.4 Coolant Loss

The vessel contains no primary coolant, therefore this section does not apply.

5. SHIELDING EVALUATION

5.1 Discussion and Results

The analysis was performed using the SPAN 4 computer code. This code, developed by the U.S. Atomic Energy Commission, is under limited distribution regulations, detailed descriptions of the code calculations are prohibited by the government.

5.2 Source Specification

The primary analytical parameter during the analysis was the Department of Transportation shipping limit of 10 MR/hr at a distance of two meters from the cask surface. Packaging conditions of both solidified waste and dewatered resin were considered. The allowable contents are shown both in terms of the specific activity of the waste form, and the surface radiation levels (for the large containers).

5.3 Model Specification

SPAN 4 calculates gamma-ray flux in rectangular, cylindrical and spherical geometries by integrating appropriate exponential kernals over a source distribution. The shield configuration is flexible -- a first-level shield mesh using any one of the three geometries is specified. Regions of this same geometry or of other geometries having their own (finer) meshes, may then be embedded between the first-level mesh lines defining second-level shield meshes. This process is telescopic -- third-level shield meshes may be embedded between second-level meshlines in turn. All meshes may have variable spacing. Sources may be located arbitrarily with respect to any shield mesh.

All kernals used assume exponential attenuation. By ray training, the straight-line distances between points in the source and close points are found to be used in calculating the attenuation. Integrals are evaluated by Gouss-Legendre or Lobatto quadrature. Accuracy is dependent on the accuracy of the library data and on the orders of quadrature used.

PROPRIETARY DATA

5.4 Shielding Evaluation

The graphs presented in Appendix 5.5 document the shielding capabilities of the HN-100 casks as analyzed by the SPAN 4 computer code. The specific activity is given in $\mu\text{Ci/ml}$; for ease of use the usage waste volume of the container is given below.

<u>Container</u>	<u>Usable Volume (cf)</u>	<u>Maximum Dewatered Resin Prior to Solidification (cf)</u>
HN-100-S	136	116.5
Drum	7.3	----

PROPRIETARY DATA

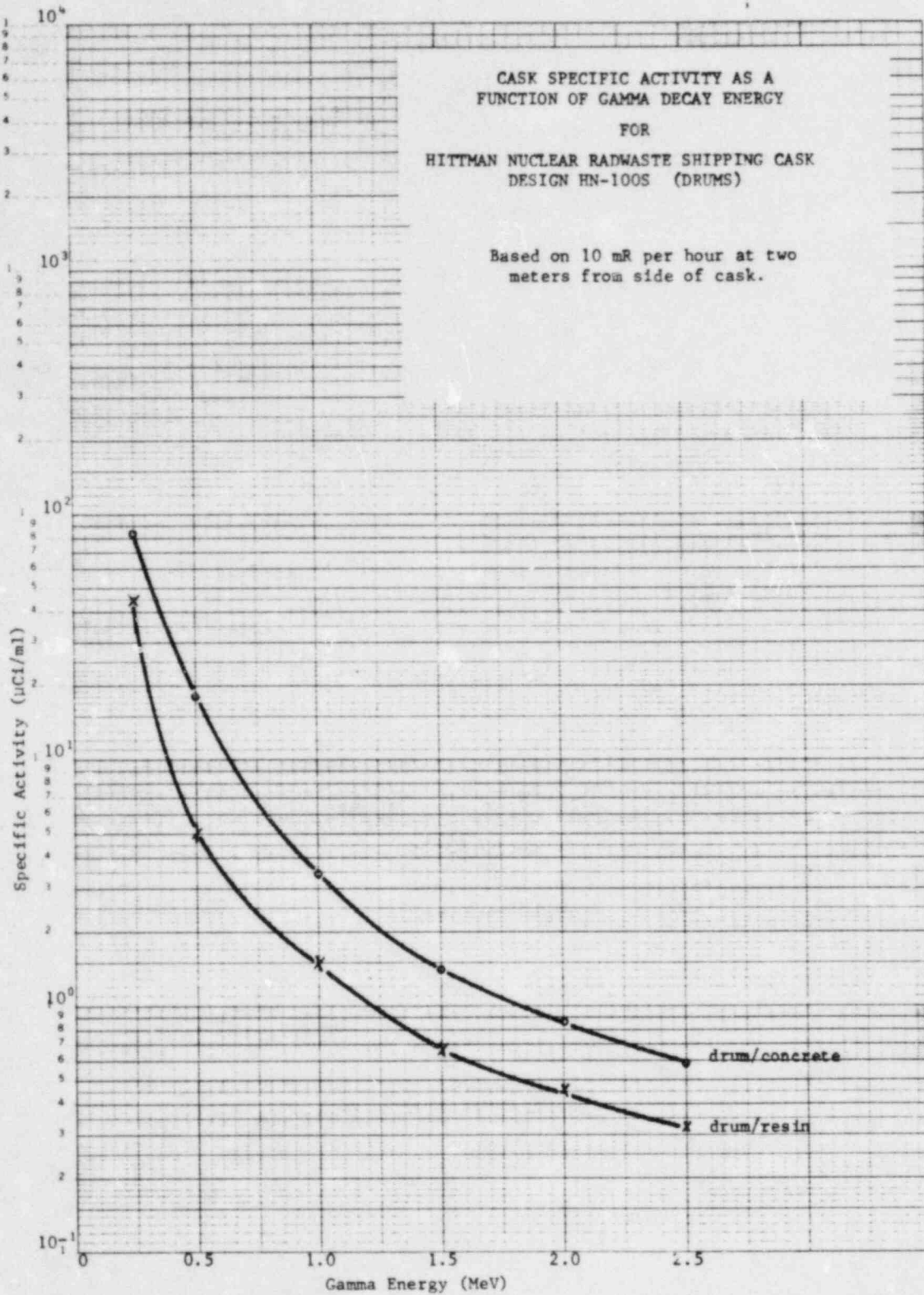
5.5 Appendix

Shielding Capabilities

- 5.5.1 Cask Specific Activity as a Function of Gamma Decay Energy for Hittman Nuclear Radwaste Shipping Cask, Design HN-100S.
- 5.5.2 Dose Rate at Side of Bare Liner as a Function of Gamma Energy for Hittman Nuclear Radwaste Shipping Liner, Design HN-100S.
- 5.5.3 Cask Specific Activity as a Function of Gamma Decay Energy for Hittman Nuclear Radwaste Shipping Cask, Design HN-100S.

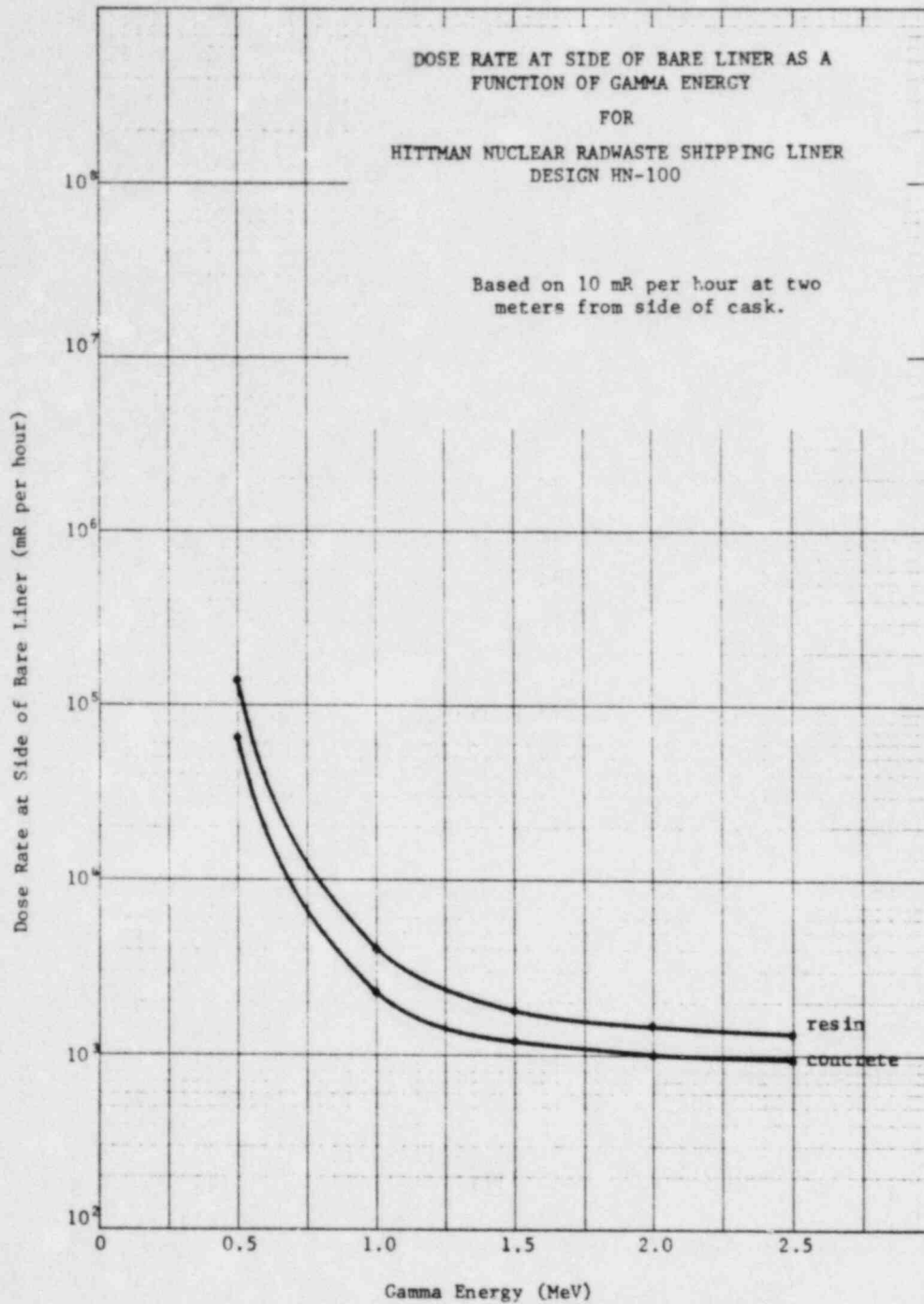
PROPRIETARY DATA

5.5.1



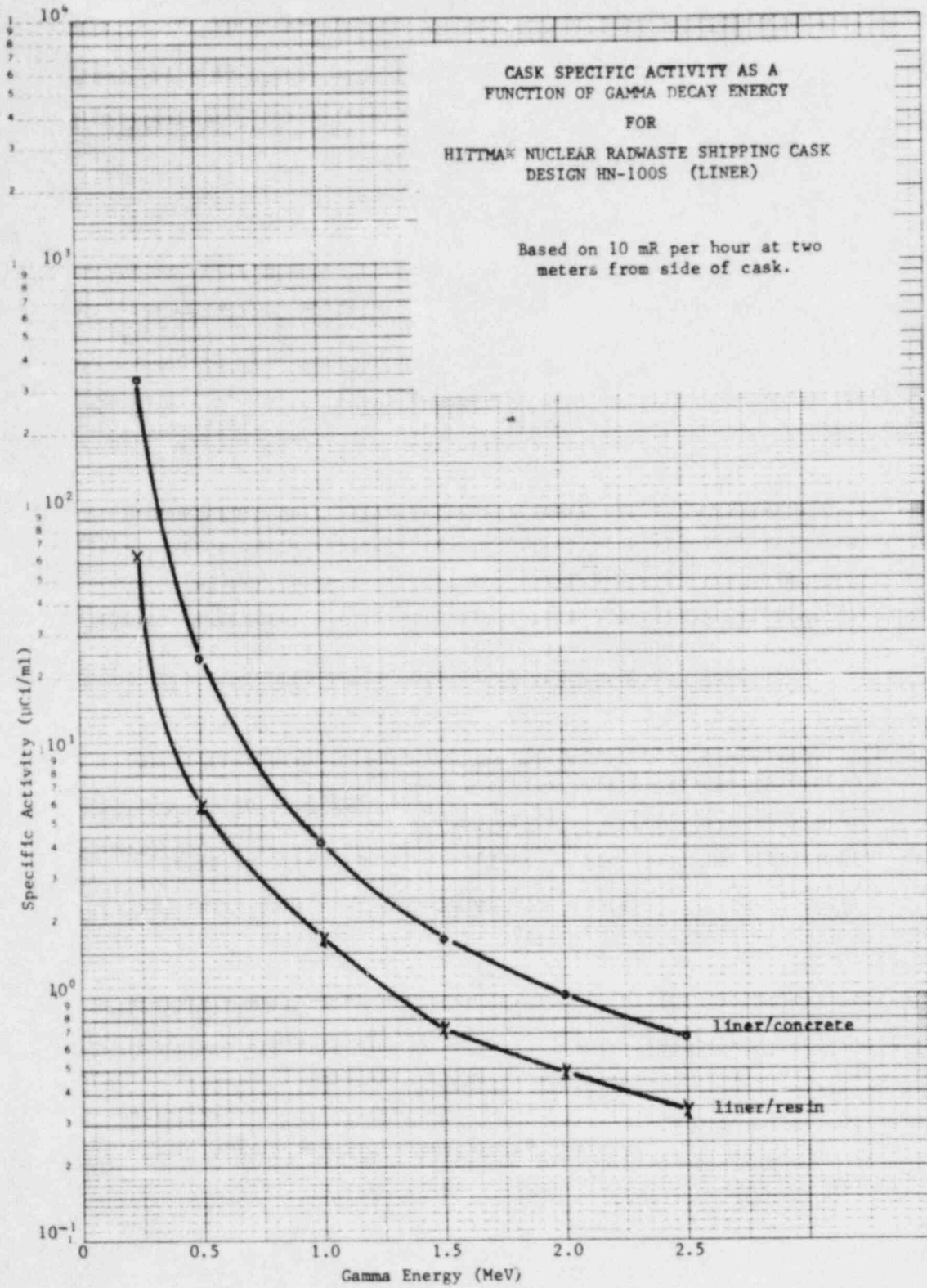
PROPRIETARY DATA

5.5.2



PROPRIETARY DATA

5.5.3



6. CRITICALITY EVALUATION

Not applicable.

PROPRIETARY DATA

7. OPERATING PROCEDURES

Customers that use the HN-100S casks are supplied a copy of the Rad Services Manual. This manual describes the services that will be supplied and contains a section on operating procedures. Included in this manual are the weight limitations, and type and quantity of licensed material limitations. The operating procedures describe the inspection of the trailer and cask upon arrival at the site, the opening, loading, closing procedures, and the forms that need to be filled out prior to the cask leaving the customer's site. An example is shown in Appendix A. This is all in accordance with Subpart D to 10 CFR 71.

Inspections performed under the operating procedure are done by the customer prior to loading. Inspection includes that cask has not been significantly damaged, closure of the package and any sealing gaskets are present and free of any defects, checking of the maximum loose and fixed contamination levels on the cask, and that the cask has been loaded and closed in accordance with written procedures. This is all in accordance with Section 71.54 of Title 10.

Radioactive Shipment Record describing the shipment and giving the information required by Section 71.62 of the Title 10 are required to be filled out in Triplicate. Prior to shipment, pertinent information from the Radioactive Shipment Record should be transmitted to Hittman and a copy should be mailed to Hittman as soon as possible after the shipment leaves the site. The other two copies accompany the shipment to the cosignee. An example is contained in Appendix 7.1.

7.1 Appendix

- 7.1.1 Radioactive Shipment Record
- 7.1.2 Cask Handling Procedure

7.1.1

See The Back Of This Form For The Instructions

HITTMAN NUCLEAR & DEVELOPMENT CORP. 9190 RED BRANCH ROAD - COLUMBIA, MARYLAND 21045 - 301/730-7804

Emergency Telephone (301) 659-9517

RADIOACTIVE SHIPMENT RECORD

Page _____ Of _____

Package Identification (1) _____ Unit No (2) _____ Date (3) _____

Shipment Origin (4) _____ Shipment Destination (6) _____

Address (5) _____ Address (7) _____

Shipment No. (8) _____ Carrier (9) _____ Driver's Signature (10) _____

Material Description (11) _____

Total Number Of Containers (12)

Total Activity m(Ci) (13)

Table with 14 columns: Container Number (14), Volume (Cu Ft) (15), Weight (Lbs) (16), MREM/HR Surface (17), MREM/HR 6 FT. (18), Radionuclide (19), Time per Container (20), Activity m(Ci) (21), Transport Index (22), E.N.M. (Grams) (23), Source Number (24), Chemical Form (25), Physical Form (26), Label (27). Includes a 'TOTALS' row at the bottom.

THE APPLICABLE ROUTINE DETERMINATIONS REQUIRED BY 10 CFR 71.54 HAVE BEEN PERFORMED AND ARE ACCEPTABLE

(28) DATE AUTHORIZED SIGNATURE TITLE

SURVEY DATA SURFACE (29) MREM/HR 6 FT. (30) MREM/HR CAB (31) MREM/HR

(32) INSTRUMENT USED: Manufacturer Model Serial Number

(33) LOOSE CONTAMINATION DPM/100CM²

(34) INSTRUMENT USED: Manufacturer Model Serial Number

(35) DATE SURVEYOR'S SIGNATURE TITLE

THIS IS TO CERTIFY THAT THE ABOVE-NAMED MATERIALS ARE PROPERLY CLASSIFIED, DESCRIBED, PACKAGED, MARKED, AND LABELED, AND ARE IN PROPER CONDITION FOR TRANSPORTATION, ACCORDING TO THE APPLICABLE REGULATIONS OF THE DEPARTMENT OF TRANSPORTATION.

(36) DATE AUTHORIZED SIGNATURE TITLE

THIS SHIPMENT IS TO BE MAINTAINED AS AN EXCLUSIVE USE SHIPMENT INSTRUCTIONS FOR MAINTENANCE OF EXCLUSIVE USE SHIPMENT CONTROLS THIS SHIPMENT IS TO BE MAINTAINED AS AN EXCLUSIVE USE SHIPMENT LOADING MUST BE PERFORMED BY A SINGLE CONSIGNOR HAVING THE EXCLUSIVE USE OF THE VEHICLE UNLOADING MUST BE DONE BY THE CONSIGNEE AND ONLY AT THE DESIGNATED DESTINATION REPOSITIONING OR MOVEMENT OF ANY LOADED MATERIAL WITHOUT THE WRITTEN PERMISSION OF THE CONSIGNOR OR HITTMAN NUCLEAR & DEVELOPMENT CORPORATION IS PROHIBITED.

BURIAL SITE COPY

7.1.2

PROJECT COVER SHEET

Document Title

CASK HANDLING PROCEDURE

Project Document Number

HNDC-0-001-1, Rev. 3

for

HN100S and HN100 Series 1

Shielded Transport Cask

Hittman Nuclear & Development Corporation
9190 Red Branch Road
Columbia, Maryland 21045

Ref: Std. Doc. N/A Rev.

I. PURPOSE

The purpose of this procedure is to provide instructions for loading/unloading the HN100 Series 1 and HN100S radioactive waste shipping casks.

II. RESPONSIBILITY

It is the responsibility of the user of a United States Nuclear Regulatory Commission (USNRC) certified package (cask) to assure the following:

- 1) He has the Certificate of Compliance for the cask and all referenced documents.
- 2) He is a registered user of the certified cask.
- 3) Under his Quality Assurance Program, the cask is inspected to verify its compliance with the terms and conditions of the Certificate of Compliance.
- 4) The cask is loaded and closed in accordance with an appropriate written procedure.
- 5) The cask is loaded in accordance with the Certificate of Compliance.
- 6) The shipment meets all the Department of Transportation, U.S. Nuclear Regulatory Commission, Burial Site Disposal Criteria and Burial Site License requirements.

NOTE: If there is a problem meeting any of the above requirements, immediately notify the regional HNDC Operations Office.

III. PROCEDURE

1.0 When ordering the cask, assure the following:

- 1.1 Waste to be shipped in the cask is either Low Specific Activity [49 CFR 173.389(c)] or Type A quantities of Normal or Special Form [49 CFR 173.389(d), 49 CFR 173.389(g) and 49 CFR 173.389(1)].
- 1.2 Burial site disposal criteria and/or licenses and current copies of 10 CFR and 49 CFR are in your possession.
- 1.3 Waste is packaged or will be packaged in an acceptable manner in accordance with the Department of Transportation (49 CFR), U.S. Nuclear Regulatory Commission (10 CFR), and the applicable burial site requirements (burial site Disposal Criteria and/or Licenses).

- 1.4 Certificate of Compliance USA/9086/A for the HN100 Series 1 or USA/9089/A for the HN100S and all referenced documents are in your possession and your site is a registered user of the cask.
- 1.5 Your site has an approved U.S. Nuclear Regulatory Commission Quality Assurance Program in accordance with 10 CFR 71.51.

NOTE: If there is a problem assuring any of the above, immediately notify the regional HNDC Operations Office.

2.0 Receipt Inspection

- 2.1 Survey the empty cask and the vehicle to determine the maximum loose and fixed contamination levels.

External loose contamination levels should be less than 2,200 DPM/ 100 cm² Beta-Gamma and less than 220 DPM/100 cm² Alpha.

Fixed contamination levels should be less than 0.5 mrem/hr.

NOTE: Fixed contamination greater than 0.5 mrem/hr but less than 50 mrem/hr require the cask to have a Yellow II label. Under such conditions the empty cask must be a Radioactive Shipment and be accompanied by properly completed Radioactive Shipment Records.

NOTE: If cask is received with contamination levels in excess of those above immediately notify the regional HNDC Operations Office.

2.2 Inspect Tiedowns

- 2.2.1 Inspect tiedown lugs and shackles on cask and trailer for cracks and wear which would affect their strength.
- 2.2.2 Inspect tiedown cables to assure they are not loose, or damaged (frayed, crimped, etc.).
- 2.2.3 Inspect tiedown ratchets/turnbuckles to assure they are in proper working condition.

NOTE: If there is a problem with any of the items inspected, immediately notify the regional HNDC Operations Office.

2.3 Inspect Cask

- 2.3.1 If cask is equipped with raincover, remove raincover and inspect cask lid holddown nuts to assure all 30-1" nuts are present and undamaged.

- 2.3.2 Check to assure that cask lid (primary lid and shield plug) lifting lug covers are with the cask.
- 2.3.3 Remove cask lid in accordance with step 4.1.
- 2.3.4 Inspect primary lid holddown studs for damage.
- 2.3.5 Inspect primary lid gasket for cracks or tears which would affect proper sealing.

NOTE: Cask must be properly sealed prior to shipment.

- 2.3.6 Inspect interior of cask for standing water.

NOTE: Water must be removed prior to shipment.

- 2.3.7 Inspect interior of cask for obstructions to loading.
- 2.3.8 Inspect interior of cask for defects which might affect the cask integrity or shielding afforded by cask.
- 2.3.9 Inspect the shield plug holddown nuts to assure they are all present and not damaged.
- 2.3.10 Inspect the shield plug gasket if opened (or if the security seal is broken).

- 2.3.10.1 If the shield plug gasket inspection is necessary, remove the shield plug from the primary cask lid in accordance with steps 4.2.3.6, 4.2.3.7 and 4.2.3.8.

- 2.3.10.2 Inspect the shield plug holddown studs for damage.

- 2.3.10.3 Inspect the shield plug gasket for cracks or tears which would affect proper sealing.

NOTE: Cask must be properly sealed prior to shipment.

- 2.3.11 If loading drums, install shield plug (if removed) onto primary lid in accordance with steps 4.2.3.11, 4.2.3.12 and 4.2.3.13 and proceed to step 4.2.1 or 4.2.2.
- 2.3.12 If loading preloaded liners, install shield plug (if removed) onto primary lid in accordance with steps 4.2.3.11, 4.2.3.12 and 4.2.3.13 and proceed to step 4.2.4.

- 2.3.13 If loading waste into liner inside cask, proceed to step 4.2.3 (omitting steps 4.2.3.6, 4.2.3.7 and 4.2.3.8 if shield plug was removed).

NOTE: If there is a problem with any of the items inspected above, immediately notify the regional HNDC Operations Office.

3.0 Removal of Cask from trailer

NOTE: If it is necessary to remove cask from trailer proceed as follows:

- 3.1 Loosen ratchet binders/turnbuckles as necessary to remove pins from shackles at cask end of tiedown system.
- 3.2 Remove pins from shackles.
- 3.3 Loosen cask shear blocks or shear ring as necessary.
- 3.4 Using the (3) cask lift lugs and suitable rigging lift cask off trailer and place cask in proper position for loading.

Cask Weight - HN 100 Series 1 - 35,500 lbs.
 HN 100 S - 26,000

NOTE: Do not use cask lid lifting lugs to lift the cask.

4.0 Loading Cask

- 4.1 Remove the primary full diameter cask lid as follows:
 - 4.1.1 If cask is equipped with a raincover, and it has not been removed, remove the raincover from the cask.
 - 4.1.2 Disconnect the cask lid from the cask by removing the 30-1" holddown nuts.
 - 4.1.3 Remove the three (3) cask lid lifting lug covers.
 - 4.1.4 Using the three lifting lugs to accommodate suitable rigging and exercising caution in the handling of the cask lid due to possible contamination of the underside of the lid, remove the cask lid.

Lid Weight HN100 Series 1 - 6,000 lbs
 HN100S - 3,770 lbs

4.2 Loading can be accomplished by one of the following methods:

- 4.2.1 In cask loading of seven (7) drum pallets.

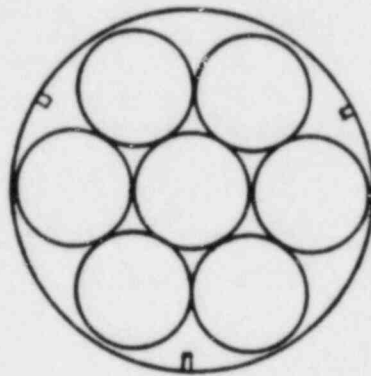
NOTE: Review Pre-release Checklist (Attachment 1) or similar site document and shipping papers to assure that inspections required on checklist or site document are performed during the cask loading process as necessary and that the information required on the shipping papers is determined as necessary.

- 4.2.1.1 Using the slings provided and exercising caution in the handling of the pallet due to possible contamination, remove the top pallet from the cask.

Pallet Weight - 750 lbs

- 4.2.1.2 Exercising caution to avoid placing drums on the pallet lift slings, load seven (7) drums on the pallet in the cask.

Maximum Drum Weight - 800 lbs



SKETCH 1

NOTE: For maximum shielding, load higher decay rate drums in the center position and the positions toward the front and rear of the trailer.

- 4.2.1.3 Place the top pallet back into the cask.

Pallet Weight - 750 lbs

- 4.2.1.4 Exercising caution to avoid placing drums on the pallet lift slings, load seven (7) drums on the pallet in the cask (see Sketch 1).

4.2.1.5 Proceed to Step 4.2.5.

4.2.2 Loading the seven (7) drum pallets outside the cask.

NOTE: Review Pre-release Checklist (Attachment 1) or similar site document and the shipping papers to assure that inspections required on the checklist or site document are performed during the cask loading process as necessary and that information required on the shipping papers is determined as necessary.

4.2.2.1 Using slings provided and exercising caution in the handling of the pallet due to possible contamination, remove both the pallets from the cask.

Pallet Weight - 750 lbs

4.2.2.2 Load seven (7) drums onto each pallet (see Sketch 3).

Maximum Drum Weight - 800 lbs

4.2.2.3 Lift one of the loaded pallets and place it inside the cask. For maximum shielding, assure proper orientation of pallet (see Note 2 of Sketch 1).

Maximum Loaded Pallet Weight - 6,400 lbs

4.2.2.4 Lift the other loaded pallet and place it inside the cask on the top of the first pallet. For maximum shielding, assure proper orientation of pallet (see Note 2 of Sketch 1).

Maximum Loaded Pallet Weight - 6,400 lbs

4.2.2.5 Assure easy access to the pallet lifting slings for removal of pallet at burial site.

4.2.2.6 Proceed to Step 4.2.5.

4.2.3 In cask loading of liner

NOTE: Review Pre-release Checklist (Attachment 1) or similar site document and shipping papers to assure that inspections required on checklist or site document are performed during the cask loading

process as necessary and that the information required on the shipping papers is determined as necessary.

4.2.3.1 If necessary remove cask from trailer in accordance with steps 3.1 through 3.4.

4.2.3.2 Using the slings provided, place liner in the cask.

Empty Liner Weight - 2,900 lbs

4.2.3.3 Except for close fitting contents, shoring shall be placed between secondary containers and the cask cavity.

4.2.3.4 Using the three (3) lifting lugs on the cask lid to accommodate suitable rigging lift and place cask lid on cask using alignment pins or lid alignment marks to assure proper positioning.

Lid Weight - HN100 Series 1 - 6,000 lbs
HN100S - 3,700 lbs

4.2.3.5 Secure the cask lid to the cask as follows:

4.2.3.5.1 Install the 30-1" holddown nuts.

4.2.3.5.2 Tighten the holddown nuts in accordance with Torquing Procedure HNDC-0-1001 as appropriate.

4.2.3.6 Remove shield plug holddown nuts.

4.2.3.7 Remove the shield plug lifting lug cover.

4.2.3.8 Exercising caution due to possible contamination of the underside of the shield plug, remove the shield plug.

Shield Plug Weight -
HN100 Series 1 - 500 lbs
HN100S - 230 lbs

4.2.3.9 Load the waste into the liner through the shield plug opening.

4.2.3.10 Install the liner lid, plugs or caps onto the liner.

- 4.2.3.11 Place the shield plug on the cask using the shield plug guide pins or lid alignment marks for proper positioning.

NOTE: Care should be taken to avoid damage to the gasket.

Lid Weight - HN100 Series 1 - 500 lbs
HN100S - 230 lbs

- 4.2.3.12 Secure shield plug as follows:

4.2.3.12.1 Install the 16-1/2" shield plug holddown nuts.

4.2.3.12.2 Tighten the shield plug holddown nuts in accordance with Torquing Procedure HNDC-0-1001 as appropriate.

- 4.2.3.13 Install the shield plug lifting lug cover.

- 4.2.3.14 If cask is equipped with raincover and the cask was not removed from trailer, install raincover.

- 4.2.3.15 Proceed to Step 5.0 of this procedure if cask was removed from trailer. Otherwise proceed to Step 6.0.

- 4.2.4 Loading preloaded liner.

NOTE: Review Pre-release Checklist (Attachment 1) or similar site document and the shipping papers to assure that inspections required on the checklist or site document are performed during the cask loading process as necessary and that information required on the shipping papers is determined as necessary.

- 4.2.4.1 If necessary, remove cask from trailer in accordance with Step 3.1 through 3.4.

- 4.2.4.2 Assure lid, plugs or caps are installed on liner.

- 4.2.4.3 Using the lifting slings provided, place liner into the cask.

Full Liner Weight -
HN100 Series 1 - 14,500 lbs. maximum
HN100S - 17,000 lbs maximum

4.2.4.4 Except for close fitting contents, shoring shall be placed between secondary containers and the cask cavity.

4.2.5 Install the primary full diameter cask lid as follows:

4.2.5.1 Using the three (3) lifting lugs on the cask lid to accommodate suitable rigging, lift the cask lid and place it on the cask using the alignment pins or lid alignment marks for proper positioning.

Lid Weight - HN100 Series 1 - 6,000 lbs
HN100S - 3,770 lbs

4.2.5.2 Secure the cask lid in accordance with Step 4.2.3.5.

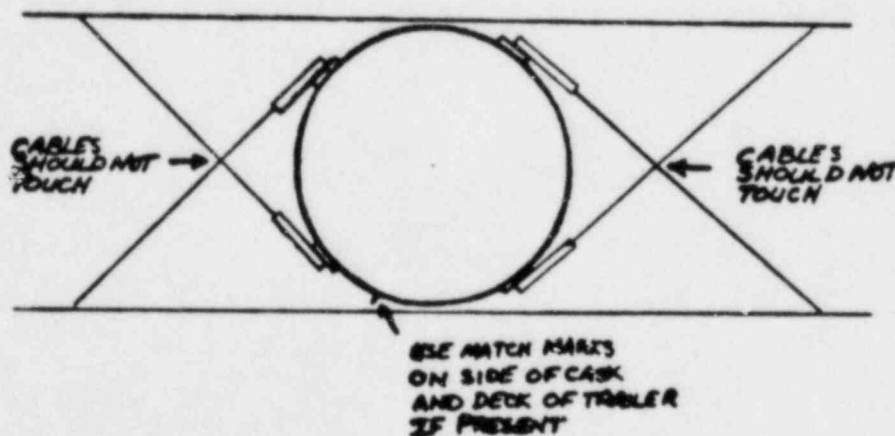
4.2.5.3 Install tamper-proof seals.

4.2.5.4 If cask is equipped with raincover, install raincover.

5.0 If cask was removed from trailer, proceed as follows:

5.1 Using the three (3) cask lift lugs and suitable rigging lift cask and place cask in proper position on trailer. See Sketch 2 for proper orientation.

Loaded Cask Weight -
HN100 Series 1 - 50,000 lbs
HN100S - 43,000 lbs



SKETCH 2

5.2 Install shackles through the end of the tiedown cables and attach to cask tiedown lugs by screwing pin through shackle and hole in lug.

- 5.3 Tighten the cask shear blocks or shear ring to secure the cask in position.
 - 5.4 Tighten ratch binders/turnbuckles as necessary to secure cask on trailer.
 - 5.5 If cask is equipped with raincover, install raincover.
 - 6.0 Prepare cask and vehicle for shipment as follows:
 - 6.1 Perform Radiation surveys of cask and vehicle and complete the necessary shipping papers, certifications, and Pre-release Checklist (Attachment 1) or site equivalent.
 - 6.2 Placard vehicle and label cask as necessary.
 - 7.0 Unloading Cask
 - 7.1 Survey the cask and trailer in accordance with applicable site requirements.
 - 7.2 Remove cask lid in accordance with Step 4.1 of this procedure.
 - 7.3 Exercising caution due to possibly high dose rate, connect slings from liner or pallet to a suitable lifting device.

Maximum liner weight - 17,000 lbs
Maximum pallet weight - 6,400 lbs
 - 7.4 Exercising caution due to possible high dose rate, lift liner or pallet clear of the cask and place in disposal area.
- NOTE: Care should be taken to avoid damage to lid gasket.
- 7.5 Repeat Steps 7.3 and 7.4 for second pallet.
 - 7.6 Place empty pallets back inside the cask unless instructed otherwise by HNDC.
 - 7.7 Install cask lid in accordance with Step 4.2.5 of this procedure.
 - 7.8 Survey the cask and trailer for release in accordance with applicable site requirements.

PRE-RELEASE CHECKLIST

Date _____
Shipment No. _____
Transport Co. _____
Time of Arrival at Site _____
Time of Departure from Site _____

- | | <u>Initial</u> |
|--|----------------|
| 1. Inner Container(s) Sealed | _____ |
| 2. Inner Container(s) Secured in Place | _____ |
| 3. All gaskets and gasket sealing surfaces inspected and free of defects | _____ |
| 4. Cask Lid and/or Shield Plug Closure Bolts Torqued/Ratchet Binders Tightened | _____ |
| 5. Tamper-proof Seal Inspected | _____ |
| 6. Lift Lugs Covers Installed | _____ |
| 7. Cask Tiedowns Inspected | _____ |
| 8. Cask Properly Labeled | _____ |
| 9. Vehicle Properly Placarded | _____ |
| 10. Surveys Completed and Recorded | _____ |
| 11. Shipping Papers Properly Filled Out and Signed | _____ |

Signature _____

Title _____

Date _____

PROPRIETARY DATA

8. ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

8.1 Acceptance Tests

Materials are specified under the ASTM and ASME codes. Welder qualifications and weld procedures are in accordance with ASME or AWS Codes. Non-destructive testing of specified welds includes visual, liquid penetrant, or magnetic particle as described in the ASTM Code.

The HN-100S casks were pressure tested when originally fabricated to verify the adequacy of the seals and cask when subjected to an internal pressure.

8.2 Maintenance Program

Cask maintenance and repair is controlled by the Quality Assurance Program. The casks undergo a routine technical inspection at least once every four months. These inspections involve checking cask for contamination, damage to interior or exterior, gaskets, studs, signs and placards, shielding and tiedowns. These inspections are covered by Cask Maintenance and Repair procedures. An example is shown in Appendix 8.3.

8.3 Appendix

8.3.1 Cask Maintenance and Repair Procedure

No.	Rev.	Date	Title:
HNDC-O-001	1	1/14/83	Cask Maintenance & Repair

1.0 PURPOSE

This procedure describes the administrative controls to be exercised over the periodic maintenance and repair of radwaste shipping packages.

2.0 GENERAL

2.1 The administrative controls described herein shall apply to the following maintenance activities:

- a) periodic maintenance and parts replacement required by the package approval and/or necessary to maintain the package in a mechanically safe and sound condition in conformance with the package approval;
- b) repair of nonconforming package structures, components, parts or appurtenances as necessary to return those items to a condition in conformance with the package approval.

2.2 The requirements of this procedure do not apply to routine inspections of packages required prior to shipment of radioactive material.

2.3 Primary responsibility for implementing the requirements set forth in this procedure rests with the Maintenance Supervisor.

2.4 The Maintenance Supervisor shall be responsible for the assignment and supervision of individuals, including contractor personnel, performing package maintenance activities required and controlled in accordance with this procedure.

2.5 The Maintenance Supervisor shall insure that the individuals assigned maintenance duties are familiar with operations involved and with the requirements of the package approval.

3.0 PERIODIC MAINTENANCE PROGRAM

3.1 The periodic maintenance program shall include the following main elements:

- a) routine inspection of the package at the disposal site after unloading;
- b) routine maintenance on a scheduled basis either at HNDC's headquarters or in the field.

No.	Rev.	Date	Title:
HNDC-O-001	1	1/14/83	Cask Maintenance & Repair

3.2 Routine Inspections (Disposal Site)

3.2.1 Routine inspections at the disposal site are not required but should be performed to ensure the early identification of problems.

3.2.2 Responsibility for routine inspections at the disposal site shall rest with HNDC personnel assigned to the site.

3.2.3 The Maintenance Supervisor shall be responsible for communicating to the HNDC personnel assigned to the site the inspections to be performed. This communication may be verbal, written or both as deemed appropriate by the Maintenance Supervisor.

3.2.4 HNDC personnel assigned to the site shall report any conditions which could constitute a nonconformance with the package approval immediately to the Maintenance Supervisor who in turn shall be responsible for initiating a Corrective Action Memo (CAM), if appropriate, in accordance with Section 16 of HNDC-C-200.

3.3 Routine Scheduled Maintenance

3.3.1 Routine scheduled maintenance includes those maintenance activities performed for the purpose of verifying a package's conformance with package approval requirements and to ensure that the package will continue to conform to those requirements during the period of use prior to the next scheduled maintenance.

3.3.2 Routine scheduled maintenance should include as a minimum, the following maintenance activities:

- a) visual inspections and measurements of package structure, components, parts and appurtenances for wear, damage and conformance to package approval requirements;
- b) adjustments and realignments;
- c) replacement of worn or defective parts, including gaskets, o-rings, studs, nuts, binders, signs, canvas covers, tie down cables, cable clamps, lifting lugs, tiedown lugs, shield plug studs, chains, impact skirt, etc.

3.3.3 The Maintenance Supervisor shall be responsible

No.	Rev.	Date	Title:
HNDC-0-001	1	1/14/83	Cask Maintenance & Repair

for preparing written instructions and/or checklists for the performance of routine scheduled maintenance.

3.3.4 These instructions and/or checklists may be generic in nature or specific to a particular package or package type. Where measurements or tests are required to determine the conformance of the package or part thereof with the package approval specific acceptance or rejection criteria must be included in the written instructions and/or checklists along with specific requirements for calibration or calibration checks of measuring and test equipment to be used.

3.3.5 The Maintenance Supervisor shall be solely responsible for the preparation, use and control of the written instructions and checklists delineating requirements for routine scheduled maintenance.

3.3.6 Each package shall receive routine scheduled maintenance at least once every four (4) months. Should the Maintenance Supervisor be unable to perform the required routine scheduled maintenance during the four (4) month period (e.g., because of a package being out of service), he shall file a memo in the routine scheduled maintenance log detailing the circumstances for the delay. A copy of the memo shall be forwarded to the Director, Operations and the QA Manager.

3.3.7 The Maintenance Supervisor shall be responsible for scheduling routine scheduled maintenance for each package.

3.3.8 Routine scheduled maintenance may be performed either at HNDC's headquarters or in the field as determined appropriate by the Maintenance Supervisor.

3.3.9 The Maintenance Supervisor shall maintain a log of all routine scheduled maintenance work done on each package. The log shall include the following information, as a minimum:

- (a) Unique log entry number for work identification purposes
- (b) Package identification
- (c) Date(s) maintenance performed and location
- (d) Names of individuals involved
- (e) Tag numbers for materials and parts issued from the QA-controlled storage area and used for package maintenance.
- (f) Summary description of work performed (reference may

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be made to instructions or checklists used)

g) summary description of package condition as found during routine scheduled maintenance, including non-conformances identified. If any Corrective Action Memos (CAMs) were issued as a result of conditions found adverse to quality these should also be listed.

3.3.10 The Maintenance Supervisor shall be responsible for keeping the Regional Operations Managers aware of schedule requirements for routine scheduled maintenance.

3.3.11 The Regional Operations Manager shall be responsible for the timely notification of the Maintenance Supervisor of the availability of each package for routine scheduled maintenance.

4.0 REPAIR PROGRAM

4.1 Repairs to packages required as a result of accidents or other incidents causing damage, or as a result of improper maintenance, use or operation of the package shall be reported, documented and controlled in accordance with the requirements of Section 16, "Corrective Action", of HNDC-C-200.

4.2 The Maintenance Supervisor shall in all cases be the "Action Designee" identified on the Corrective Action Memo (CAM) form for repair activities required in order to correct a defect or other nonconforming condition.

4.3 The Maintenance Supervisor shall determine on a case by case basis the need for special maintenance procedures for performing the repairs. Such procedures may be written on the CAM form and/or attached to it. The format and content of such procedures shall be at the discretion of the Maintenance Supervisor except that where measurements or tests are required to determine the conformance of the package or part thereof with the package approval specific acceptance or rejection criteria must be included in the written procedures along with specific requirements for calibration or calibration checks of measuring and test equipment to be used.

4.4 The CAM form and attachments thereto shall serve as the log of package repair activities. The information described in Article 3.3.9, items (b) through (f) shall be included on the CAM.

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4.5 Individuals identifying a need for package repair shall report such conditions in accordance with the requirements of Section 16 of HNDC-C-200.

4.6 The Maintenance Supervisor shall be responsible for initiating a CAM when conditions requiring repair are identified during routine scheduled maintenance and/or when such conditions are reported to him verbally by either HNDC or user personnel.

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FCUF _____ PDR
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WM _____ I&E REF.
WMUR _____ SAFEGUARDS _____
FCTC OTHER _____

DESCRIPTION:

Application for
renewal

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