CHEM—NUCLEAR SYSTEMS INC.
P.O. Box 1866 • Bellevue, Washington 98009 • (206) 827-0711

November 19, 1979

Mr. Charles E. MacDonald, Chief
Transportation Branch
Division of Fuel Cycle and
Material Safety
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Reference: Docket No. 71-6275

Dear Mr. MacDonald:

We respectfully submit our application for the renewal of Certificate of Compliance No. USA/6275/B( ). This submittal reflects a compilation and consolidation of a previously approved Safety Analysis report and all amendments in a format which is consistent with NRC Regulatory Guide 7.9. There have been no changes or additions to the SAR and the detailed calculations of prior submittals except for changes to the format as set forth in Regulatory Guide 7.9. Where required for clarity and readability, former handwritten analyses have been typed.

Our check in the amount of $150.00 is enclosed as required by Section 170.31(11-C) of 10CFR170.

Please contact this office if you have any questions on this renewal application.

Sincerely,

CHEM-NUCLEAR SYSTEMS, INC.

J. Stewart Corbett

J. Stewart Corbett
Manager, Licensing & Safety

JSC/mk

1599 263

cc: Louis E. Reynolds

14859

7912180095

Safety Analysis Report
For The
CNS 0-4 (LL-28-4) Cask

1599 264

Submitted By:

Chem-Nuclear Systems, Inc.
P.O. Box 1866
Bellevue, WA 98009

October 31, 1979

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for

CNS 0-4 Cask

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1. GENERAL INFORMATION

1.1 Introduction

This Safety Analysis Report (SAR) is submitted in support of Chem-Nuclear System's request for the renewal of Certificate of Compliance No. 6275 which authorized the transport of solid radioactive material.

The package is used primarily for the transport of solid radioactive wastes which are contained within secondary containers. Wastes consist of spent filters contained in sealed containers, irradiated solid metal items in secondary containers and up to 10,000 curies of cobalt-60 in special form contained in a secondary sealed container.

The analysis considers both normal and accident conditions. The results of the analysis demonstrate that the proposed mode of shipment of the filter elements satisfies the requirements established by the Department of Transportation. It is indicated that the cask and contents would maintain their integrity in a (30) foot fall and would also survive the puncture test. Dose rate levels on the surface of the cask will be negligible since the cask and source container together provide the equivalent shielding of twelve (12) inches of lead. Reductions of lead shielding thickness as a result of the postulated accident would still result in radiation levels several orders of magnitude below acceptable levels for the accident situation. The dissipation of decay heat poses no problem due to the minimal decay load

(0.765 BTU/hr.). The levels of activity and decay heat involved in this shipment are small in relation to cask capacities indicating a safe shipment.

1.2 Package Description

1.2.1 Packaging

The cask is a cylindrical lead-filled steel weldment weighing approximately fourteen (14) tons. An effective cavity of 15 inches diameter and 43½ inches in length is provided with a shielding equivalent of approximately 11.7 inches of lead. The outside diameter of the main body of the cask is 39-1/8 inches and the overall length is 67 inches.

The outer shell of the cask is fabricated from two concentric steel shells totaling 1 inch in thickness. The outer skin is made from 5/8 inch A516-Grade 60 steel and the inner skin is made from 3/8 inch thick type 304 stainless steel. The inner shell of the cask is fabricated of 1/4 inch thick type 304 stainless steel.

Three (3) removable lifting lugs spaced at 120° intervals, 6 inches below the top of the cask, are provided for cask handling. The cover of the cask is secured with twenty 3/4 inch bolts. The cask is secured to the mounting frame on the flat bed trailer with twelve 1-1/8 inch bolts (UTS = 125,000 psi). The frame is constructed of two twelve inch channels along the length of the flat bed trailer. Each channel is fastened to the trailer bed with twenty-nine (29) 1/2 inch bolts.

Cask

The CNS 0-4 (LL-28-4) cask (see "reference drawing") is a cylindrical lead-filled steel weldment weighing approximately fourteen (14) tons. The cask provides an effective cavity of 15 inches diameter by 40 inches long with 11.7 inches lead equivalent shielding. The outside diameter of the main body of the cask is 39-1/8 inches and the overall length is 67 inches.

The cask is constructed of two concentric steel shells welded at one end to an elliptical dished head within a flat base plate, with a lead-filled steel cover bolted to the other end. The space between the inner and outer steel shells is filled with lead.

The inner shell is fabricated of 1/4 inch thick type 304 stainless steel. The elliptical dished head is fabricated of 1/2 inch thick mild steel. The total thickness of the outer shell is one (1) inch which is made from 3/8 inch thick type 304 stainless steel (inner skin) and 5/8 inch thick A516-Grade 60 steel (outer skin). The thickness requirements of the outer shell were set by structural criteria based on a 40 inch drop on a 6 inch diameter piston.

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The removable cover consists of a lead-filled steel tapered plug, 20 inches nominal diameter by 12 inches thick, welded to a 32 inch diameter cover plate fabricated of 7/8 inch thick A 516-Grade 60 steel. The cask cover contains two concentric recesses of diameters 13-3/4 inches and 3-1/2 inches respectively. The larger recess has a depth of 2 inches while the smaller recess is 1-1/2 inches deep. The cover is secured to the main body of the cask by twenty 3/4 inch bolts. The cover is also equipped with three (3) removable eye bolts to facilitate handling.

The cask is equipped with three (3) removable lifting lugs placed 120 degrees apart and 6 inches below the top of the cask. The lifting lugs are designed to engage with the lifting lug support and each lifting lug is held in place by two 1/2 inch bolts. When the cask is prepared for transit, the three (3) lifting lugs and the three (3) cover eye bolts are detached from the respective functional locations and secured to the cask fins during transit.

During transport, the cask is secured to the cask skid by twelve (12) 1-1/8 inch - 12 bolts (UTS = 125,000 psi). The cask skid consists of two (2) parallel 12 inch channels which extend the length of the covered flat bed trailer. Each channel is bolted to the skid with twenty-nine (29) 1/2 inch bolts (UTS = 125,000 psi).

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Receptacles for containing the radioactive materials within the CNS 0-4 (LL-28-4) cask are steel liners which are designed to be leak tight. However, the transportation cask itself is taken as the primary containment. There are no external or internal structures supporting or protecting the radioactive material receptacle (liner). Normal close tolerances between the liner and liner cask walls eliminate the need for supports.

The loaded CNS 0-4 (LL-28-4) cask weighing about 15 tons will be bolted (with twelve 1-1/8" - 12 inch bolts; 125,000 UTS) to the two 12 inch channels forming the cask support structure on the trailer bed. Handling of the cask and loading onto the trailer will be performed using a crane with wire rope slings attached to the three lifting lugs on the cask. The lifting lugs will be removed from the cask and bolted to the gussets before shipping. The steel liners are designed to fit snugly within the cavity of the CNS 0-4 cask to restrict movement of the container within the cask during transport.

At burial site, the lid of the cask will be removed and the liner containing the radwaste will be withdrawn from the cask using the bail on the liner.

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1.2.2 Operational Features

Not applicable.

1.2.3 Contents of Packaging

1. Large quantities of radioactive material, special form, in the form of not more than 10,000 curies of encapsulated cobalt-60 sources, which meet the definition of "Special Form".

2. Type B quantities of radioactive material, n.o.s., in the form of spent filter elements containing cobalt-58 and cobalt-60.

3. Type B and large quantities of radioactive material, n.o.s., in solid form packaged in an inner container which meets the criteria of a specification 7A package which will then be placed in the cask. The following additional limitations will be placed on the inner package:

    a. The maximum contact dose rate on the specification 7A package will not exceed 10,000 Rem per hour;
    b. The maximum weight of inner package with contents shall not exceed 1,225 pounds; and
    c. The maximum allowed decay heat load will not exceed 575 BTU/HR (168 watts).

The physical form and chemical form of the radioactive constituents will be dry and basically inert. 1599 272

1.3 Appendix

Drawing No. 1000-B-0061

Drawing No. 1000-E-0040-0

Drawing No. 1000-E-0041-0

Drawing No. 1000-R-0043-0, Rev. F

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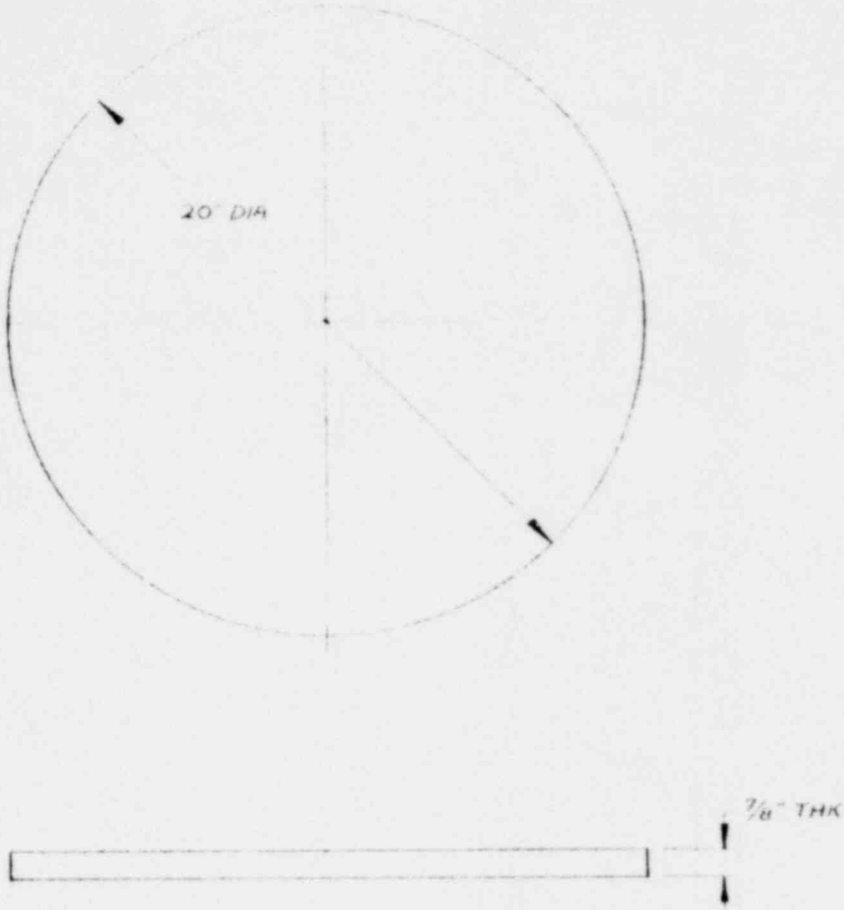
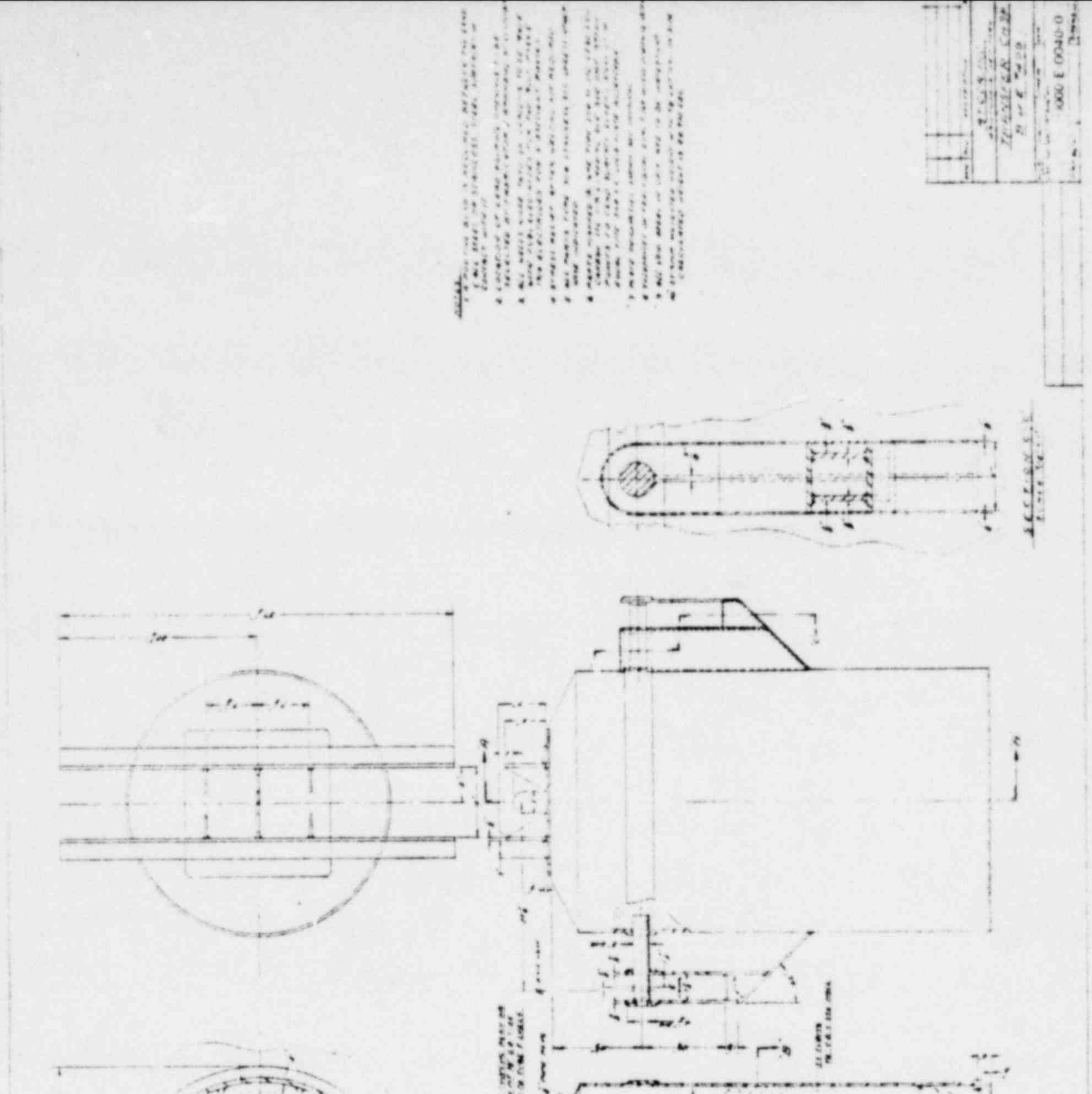


MAT'L.
STEEL PLATE ASTM A36

1599 274

ATCOR INC. ELMSFORD, NEW YORK		
TITLE SPACER PLATE SHIPPING CASK LL-28-4		
DWN	CHK	APP
DATE 4-29-70	SCALE 1/4" = 1"	NEXT ASSY 1000-R-0043
TOLERANCE UNLESS OTHERWISE NOTED FRAC. ± DEC. ± ANG ±	DWG NO. 1000-B-0061	REV.



POOR ORIGINAL

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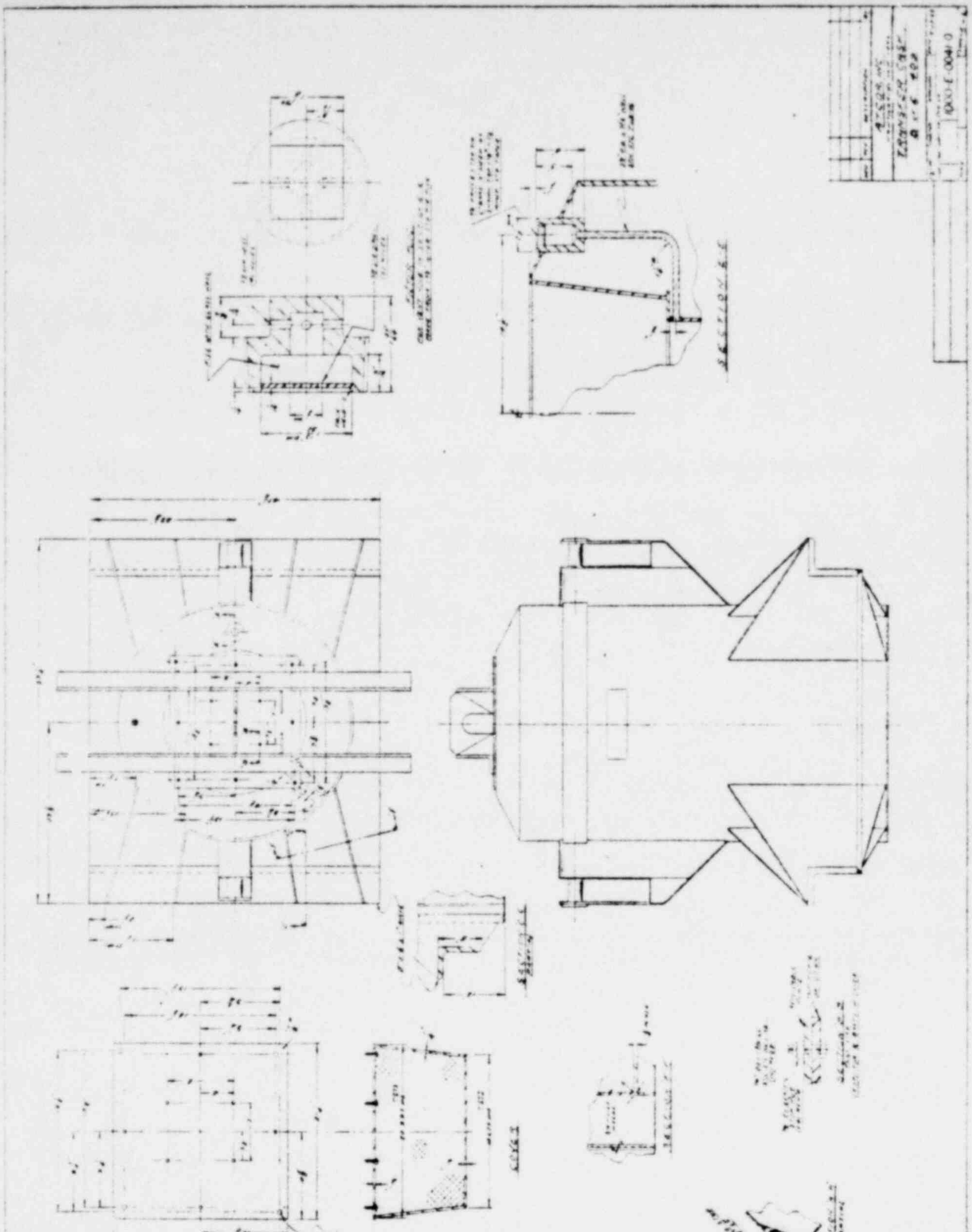

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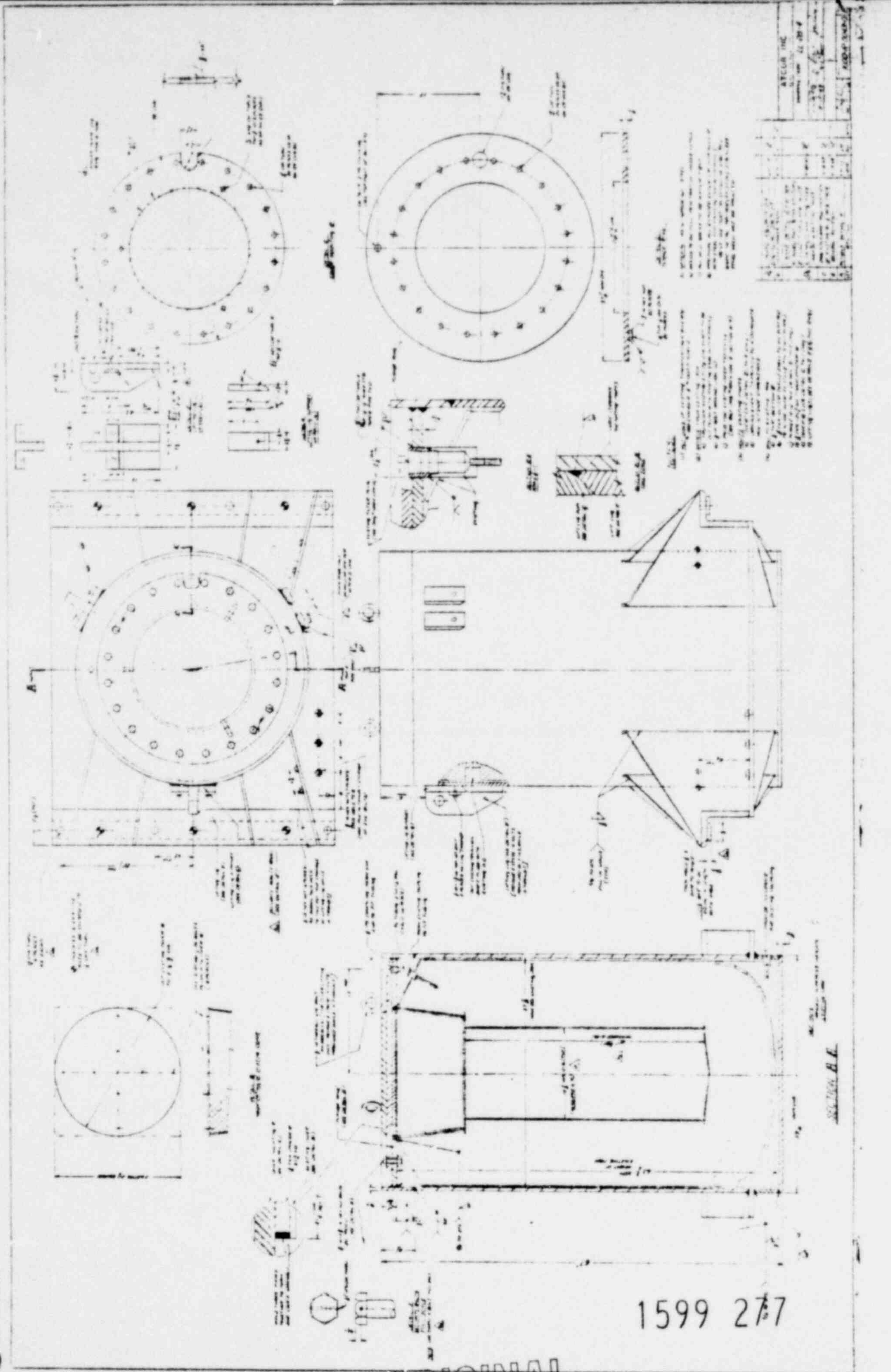
POOR ORIGINAL



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2. STRUCTURAL EVALUATION

2.1 Discussion

2.1.1 Design Criteria

In order to substantiate the structural integrity of the cask during the intended shipment, a complete and quite conservative analysis of the structural design has been performed and is included in this section of the report. The design loads specified in Department of Transportation regulations, 10 CFR 71 together with the design loads imposed during manufacture, have been considered. Moreover, conservative overlapping assumptions were made in order to simulate the "worst case" analysis. As a result of the calculations, it was found that critical cask dimensions are greater in all cases (hence greater strength) than required by the structural analysis.

A summary of the design analysis calculations and an analysis of a minimum liner within the CNS 0-4 cask is presented in Appendix 2.10. The detailed calculations are included in this section.

The various design loads specified by Nuclear Regulatory Commission regulations Section 10 CFR 71 are listed below.

1. 40 inch free drop on 6" cylinder.
2. External pressure of 25 psig.
3. 5 times the total cask weight on simply supported beam.

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4. Internal pressure 25 psig.
5. 30 foot free drop on side.
6. 30 foot free drop on end.
7. 30 foot free drop on corner.
8. Inside pressure on cover plate.
9. 92 g. on cover bolts.
10. 3 times the total cask weight on lifting lug.
11. 92 g. at neck of lid.
12. 10 g. forward, 5 g. sidewise, and 2 g. vertical on tie-down bolt.

2.2 Weights and Centers of Gravity

Gross Weight

1.	CNS 0-4 Cask	28,150 pounds
2.	Inner package with its contents	1,225 pounds
3.	Tractor and Trailer	32,900 pounds
	TOTAL	62,275 pounds

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2.3 General Standards for All Packages

2.3.1 Positive Closure

2.3.1.1 Cover Attaching Bolts

Utilizing the procedure outlined in ORNL-TM-2410 (page 27-31),

$$F_p + F_{oc} = W = 9,900 \text{ (from Section 2.6.3)}$$

$$F_W = 2N_g(W_1 + W_c) = 2N_g(1500 + 600) - 4200\ N_g$$

The deceleration g-number, N_g is,

$$N_g = \frac{H}{(L_{cg})_p} = \frac{30 \times 12}{4} = 90$$

The component along the axis during a corner drop is:

$$N_g = 90 \times \sin 30.72^{\circ} = 90 \times .511 = 46$$

Use $N_g = 46$

$$P_W = 4,200 \times 46 - 193,000$$

Use yield stress = 125,000 psi

The required total bolt area is:

$$A = \frac{9,900 + 193,000}{125,000} = \frac{202,900}{125,000} = 1.62 \text{ in}^2$$

Using 20 bolts as recommended by ORNL-TM-2410, (page 29), with an area for each bolt of:

$$A = \frac{1.62}{20} = 0.081 \text{ in}^2$$

The bolt actually used is 0.75" which has an area of 0.302 square inches, which compares favorably to the calculated A = .081 square inches.

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2.3.1.2 Shear Loading at Neck of Lid

Considering lead only, the strength of neck against the shearing off due to g-loading of a corner drop is:

$$N_g = \frac{\frac{\pi}{4} D_1{}^2 S_s}{W_e + W_c}$$

where D = diameter at the neck = 21 inches

S_s = shearing stress of lead

= 1,825 psi

$$N_g = \frac{0.7854 \times (21)^2 \times 1,825}{2,100} = 300$$

actual g-loading is 2 x 46 = 92

The resistance of cover bolting against shear is:

$$N_g = \frac{N \times \frac{\pi}{4} D_b{}^2 S_s}{W_1 + W_c}$$

$$= \frac{20 \times .302 \times 45,000}{2,100} = 130$$

Therefore, both the lid and the bolts have enough strength to resist the 92g. loading.

2.4 General Standards for all Packages

The general standards for all packaging specified in §71.31 are complied with as demonstrated in the following paragraphs.

2.4.1 Positive Closure

2.4.1.1 Cover Attaching Bolts:

Utilizing the procedure cutlined in ORNL-TM-2410 (page 27-31),

$F_p + F_{oc} = W = 9,900$ (from Section 2.6.3)

$F_W = 2N_g(W_1 = W_c) = 2N_g(1500 + 600) = 4200\ N_g$

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The deceleration g-number, N_g is:

$$N_g = \frac{H}{(L_{cg})_p} = \frac{30 \times 12}{4} = 90$$

The component along the axis during a corner drop is:

$$N_g = 90 \times \sin 30.72^o \times .511 = 46$$

Use $N_g = 46$

$$P_w = 4,200 \times 46 = 193,000$$

Use yield strcss = 125,000 psi

The required total bolt area is:

$$A = \frac{9,900 + 193,000}{125,000} = \frac{202,900}{125,000} = 1.62 \text{ in}^2$$

Using 20 bolts as recommended by ORNL-TM-2410, (page 29), with an area for each bolt of:

$$A = \frac{1.62}{20} = 0.081 \text{ in}^2$$

The bolt actually used is 0.75" which has an area of 0.302 square inches, which compares favorably to the calculated A - .081 square inches.

2.4.1.2 Shear Loading at Neck of Lid

Considering lead only, the strength of neck against the shearing off due to g-loading of a corner drop is:

$$N_g = \frac{\frac{\pi}{4} D_1{}^2 S_s}{W_e + W_c}$$

Where D = diameter at the neck = 21 inches

S_s = shearing stress of lead

= 1,825 psi

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$$N_g = \frac{0.7854 \times (21)^2 \times 1,825}{2,100} = 300$$

Actual g-loading is 2 x 46 = 92

The resistance of cover bolting against shear is:

$$N_g = \frac{N \times \frac{\pi}{4} D_b^2 S_s}{W_1 + W_c}$$

$$= \frac{20 \times .302 \times 45,000}{2,100} = 130$$

Therefore, both the lid and the bolts have enough strength to resist the 92 g. loading.

2.4.3 Lifting Devices

Strength of the lifting lug.

The total load when lifting is:

$$F = 3W = 3 \times 30,000 = 90,000 \text{ lb.}$$

Using three (3) detachable lifting lugs, each lug will take 30,000 lbs. With a 30 degree cable arrangement, the load in the direction of cable is:

$$F = \frac{30,000}{\cos 30^o} = 34,600 \text{ lb.}$$

The components of the load are 30,000 lb. in the axial direction and 17,300 lb. in the transverse direction.

The transverse component is bearing on the shell, with a bearing area of 1.5 x 6 - 9 square inches. Solution of this yields a bearing pressure of:

$$P = \frac{17,300}{9}$$ or 1,930 psi, which is insignificant.

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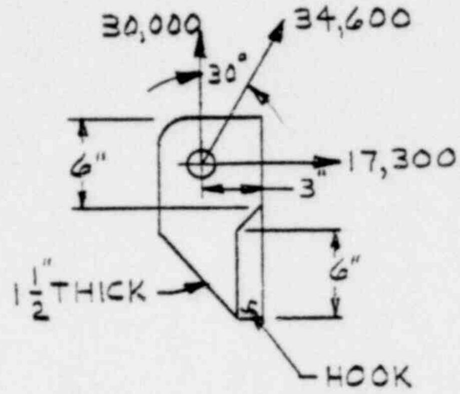
The local stress due to this loading may be estimated using Case 7 (page 300) from Roark's "Formulas for Stress and Strain":



$$\frac{R}{t} = \frac{19}{.625} = 30.4$$

$$\frac{A}{R^2} \quad \frac{9}{(19)^2} = 0.025$$

The local bending stress is approximately:

$$S_1 = \frac{0.9P}{t^2} = \frac{0.9 \times 17,300}{(1)^2} = 15,600 \text{ psi}$$

The local hoop stress is:

$$S_2 = \frac{8 \times P}{Rt} = \frac{8 \times 17,300}{19 \times 1} = 7,300 \text{ psi}$$

Both the calculated values are well below the yield stress of 30,000 psi. These estimations are based on a cask with the load concentrated at mid-span. If the load is distributed near the end support, the stresses are even less.

If the direct tension is considered at the lug, the cross sectional area required is:

$$A = \frac{34,600}{30,000} = 1.15 \text{ in}^2$$

In actuality, the minimum area provided is more than 4 square inches.

Shearing load on wells at the hook part produces a shearing stress which is:

$$S_{s1} = \frac{30,000}{(6+6)x.5} = 5,000 \text{ psi}$$

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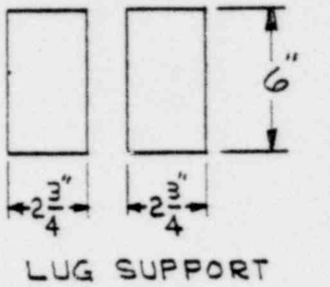
Shearing on the lug support is:



$$S_s 2 = \frac{30,000}{2 \times 2(6 \div 2.75) \times .5} = 1,720 \text{ psi}$$

Both are less than the allowable shearing stress (use half of the yield) = 15,000 psi.

The axial component will also introduce a bending of the support and hook:

On the support,

M = bending moment = 30,000 x 3.0 = 90,000 in-lbs.

The sectional modulus of the hook piece against bending is:

$$\frac{I}{C} = \frac{1}{7/2}\,\frac{1}{12} \quad 1.5(7)^3 - 0.5(6)^3 = 9.7$$

and the bending stress, $S = \frac{90,000}{9.7} = 9,300$ psi

With the yield stress of 30,000 psi, the factor of stress concentration that can be allowed is:

$$\frac{30,000}{9,300} = 3.22$$

During the lifting operation, the hook may have a tendency to escape. The escaping force would be:

$$F' = \frac{Fa}{b}$$

Acting on an inclined surface of slope 0, each of the forces F and F^1 can be resolved into two (2) components, one normal to the inclined surface, and the other parallel to it. Thus,

$$F_n = F \cos \Theta \qquad F'_n = F' \sin \Theta$$

$$F_p = F \sin \Theta \qquad F'_p = F' \cos \Theta$$

If Θ is too small, the hook may escape from engaging, the condition of no escape is:

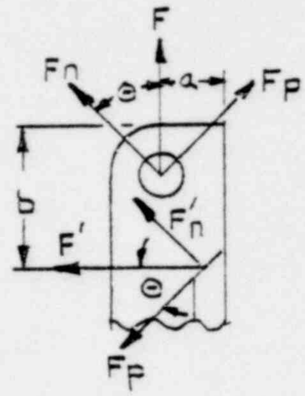
$$F'_{pl} < F_p + \mu(F_n + F'_n)$$

Where μ is the friction coefficient = 0.15

F' cos Θ is less than F sin Θ ÷ 0.15(F cos Θ ÷ F' sin Θ)

putting $F' = \frac{Fa}{b}$ into the above and simplifying, obtaining:

tan Θ is greater than $\frac{a - 0.15\ b}{b + 0.15\ a}$



with a = 3" and b = 7"

tan Θ is greater than $\frac{3 - 1.05}{7 + .45}$

Θ is greater than 14.7°

therefore, if Θ is greater than 14.7°, there will be no escaping. In this design, 45° slope is used. With,

F = 30,000 lb.

F' = 30,000 x 3/7 = 12,800 lb.

the escaping force is:

$F_e = F_p' = F'$ cos = 12,800 x 0.707 = 9,050 lb.

The retaining force against escaping is:

$F_r = F_p + 0.15\ (F_n + F_n')$ = 30,000 x 0.707 x 0.15(30,000 x .707 + 12,800 x .707)

= 21,200 + 4,500 = 25,700 lb.

25,700 is greater than 9,050; therefore, <u>no</u> <u>escape</u>.

The bending force on the hook tip, due to escaping force is:

$M = 12,500 \times \frac{1}{2} = 6,250$ in-lb.

The sectional modulus at the root of the hook tip is:

$\frac{I}{C} = 2\ \frac{1}{8}(2.75)(1)^{"} = 0.92$

Thus, $S = \frac{6,250}{0.92}$ = 6,800 psi, which is less than the 90,000 psi yield stress.

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The bearing stress at the hole has been estimated using Case 6 (page 320) of Roark's "Formulas for Stress and Strain":

$$\text{Max } S_c = 0.591 \sqrt{pE \frac{D_1 - D_2}{D_1 D_2}}$$

With free running fit, the difference between D_1 and D_2 is approximately 0.007". However, D_1-D_2 = 0.01" has been used in the following calculations:

$$\text{Max } S_c = 0.591 \sqrt{\frac{30,000}{1.5}\, 30 \times 10^6 \, \frac{0.01}{(1.625)^2}} = 28,000 \text{ psi}$$

Thus, the bearing stress is less than the 30,000 psi tensile yield, and the compressive yield is even higher.

2.4.4 Tiedown Devices

2.4.4.1 Strength of bolts on skid

These calculations are performed ignoring the strength contribution of other tie-down devices. According to the regulations, the load in the forward direction is:

moment M_1 = 10W x 32 = 10 x 30,000 x 32

= 9,600,000 in-lb.

The load in the sidewise direction is:

moment M_2 = 5W x 32 = 4,800,000 in-lb.

The load in the vertical direction is:

W_3 = 2W = 2 x 30,000 = 60,000 lb.

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Let F_1 F_2. . .F_6 are the induced force in the bolts as indicated in the diagram above. The moment balance gives:

$$M_1 = 2F_1' \times 53.25 + 2F_2 \times \frac{4}{5} \times 53.25 + 2F_3 \times \frac{3}{5}$$
$$\times 53.25 + 2F_4 \times \frac{2}{5} \times 53.25 + 2F_5 \times \frac{1}{5} \times 53.25$$

With identical size of bolts, the elongation of the bolts will have a relation as follows:

$$\frac{\Delta_2}{\Delta_1} = \frac{4}{5}, \Delta_2 = \frac{4}{5}\Delta_1$$
$$\Delta_3 = \frac{3}{5}\Delta_1$$
$$\Delta_4 = \frac{2}{5}\Delta_1$$
$$\Delta_5 = \frac{1}{5}\Delta_1$$
$$\Delta_6 = 0$$

Since $\Delta = \frac{FL}{AE} = CF$, where $C = \frac{L}{AE}$, a constant, then:

$$F_2 = \frac{4}{5}F_1 = 0.8F_1$$
$$F_3 = \frac{3}{5}F_1 = 0.6F_1$$
$$F_4 = \frac{2}{5}F_1 = 0.4F_1$$
$$F_5 = \frac{1}{5}F_1 = 0.2F_1$$
$$F_6 = 0$$

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Substitute the F's into the moment equation and rearrange, we have:

$$9,600,000 = 2 \times 53.25F_1 \ (1 + 0.8^2 + 0.6^2 + 0.4^2 + 0.2^2)$$

$$= 2 \times 53.25 \times 2.2F_1$$

Then: $$F_1 = \frac{9,600,000}{2 \times 53.25 \times 2.2}$$

$$= 41,000 \text{ lb.}$$

The bolt size is 1-1/8 inch-12 which gives a root area of 0.8118 inch^2. The stress due to the above load is:

$$S_1 = \frac{41,000}{0.8118} = 50,500 \text{ psi}$$

The stress on the bolt due to M_2 is:

$$S_2 = \frac{4,800,000}{6 \times 0.8118 \times 32} = 30,800 \text{ psi}$$

The stress due to W_3 is:

$$S_3 = \frac{60,000}{12 \times 0.8118} = 6,150 \text{ psi}$$

The total tensile stress is:

$$S_t = S_1 + S_2 + S_3$$

$$= 50,500 + 30,800 + 6,150$$

$$= 87,450 \text{ psi}$$

The shear load on the bolts is:

$$W_s = \sqrt{(10W)^2 + (5W)^2}$$

$$= 11.2 \times 30,000$$

$$= 336,000 \text{ lbs.}$$

The shearing stress on the bolts is:

$$S_s = \frac{336,000}{12 \times 0.8118} = 34,500 \text{ psi}$$

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The combined stress is:

$$S = \frac{1}{2} S_t + \sqrt{\left(\frac{S_t}{2}\right)^2 + {S_s}^2}$$

$$= \frac{1}{2} \times 87{,}450 + \sqrt{\left(\frac{87{,}450}{2}\right)^2 + (34{,}500)^2}$$

$$= 99{,}425 \text{ psi}$$

Comparing with the yield strength of the material, 105,000 psi, the bolt size is satisfactory.

2.4.4.2 <u>Strength of bolts securing cask supporting frame</u>

Same as the item above, we have:

$$9{,}600{,}000 = 2 \times 40 \times 12F_1 \quad 1 + \left(\frac{27}{28}\right)^2 + \left(\frac{2}{28}\right)^2 + \left(\frac{1}{28}\right)^2$$

$$= 2 \times 40 \times 12 \times 9.89F_1$$

Then: $$F_1 = \frac{9{,}600{,}000}{2 \times 35 \times 12 \times 9.89} = 1{,}160 \text{ lb.}$$

The bolt size is 1/2" which gives a root area of .1257 in^2.

The stress due to the above load is:

$$S_1 = \frac{1160}{.1257} = 9{,}100 \text{ psi}$$

The stress due to M_2 is:

$$S_2 = \frac{4{,}800{,}000}{29 \times .1257 \times 32} = 41{,}100 \text{ psi}$$

The stress due to W. is:

$$S_3 = \frac{60{,}000}{60 \times .1257} = 8{,}000 \text{ psi}$$

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The total tensile stress is:

$$S_t = S_1 + S_2 + S_3$$

$$= 9,100 + 41,100 + 8,000$$

$$= 58,200 \text{ psi}$$

The shear stress is:

$$S_s = \frac{336,000}{60 \times .1257} = 44,500 \text{ psi}$$

The combined stress is:

$$S = \frac{1}{2}S_t \div \sqrt{(\frac{S_t}{2}) + S_s}$$

$$= \frac{1}{2}(58,200) \div \sqrt{(\frac{56,200}{2})^2 + 44,500^2}$$

$$= 29,100 + 54,200$$

$$= 83,300 \text{ psi} < 105,000 \text{ psi}$$

The bolts are satisfactory.

2.5 Standards for Type B and Large Quantity Packaging

The standards for Type B and large quantity packaging, specified in §71.32 are complied with as demonstrated in the following paragraphs.

2.5.1 Load Resistance

Consider the Outer Shell as a simply supported beam bearing uniform load equal to 5 times the cask fully loaded weight.

If the cask is simply supported at the two ends, with a uniform load w lb/in, the stress may be determined from the following:

$$S = \frac{I}{(\frac{I}{C})} = \frac{I}{C} = \frac{M}{S}$$

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Where S = bending stress (psi)

I = bending movement (in-lbs)

C = distance of top (or bottom) fiber from neutral axis (inches)

Based on yield, S = 30,000 psi

for thin shells, $\frac{I}{C} = \frac{\pi}{4}D^2t$

$$M = \frac{wL^2}{8} = \frac{(wL)L}{8} = \frac{(5W)L}{8}$$

Substituting in the formula above:

$$\frac{\pi}{4}D^2t = \frac{(5W)L}{8 \times 30,000}$$

$$t = \frac{(5W)L}{\frac{\pi}{4}D^2 8 \times 30,000} = \frac{5 \times 30,000 \times 64}{.7854(38)^2\ 8 \times 30,000}$$

yielding t = .0353 inches, whereas the designed available thickness is t = 0.625 inches.

2.5.2 External Pressure

The Outer Shell of the cask must withstand an external pressure of 25 psig. The ASME Code, Section III (1965, p. 111), gives the allowable external pressure as:

$$P_a = \frac{4B}{3(\frac{Do}{t})}$$

B is determined from Figure 1-1100 by using two parameters $\frac{L}{Do}$ and $\frac{D}{t}$, on page 112 of the reference, Do = 38", L = 64" and t = 0.625".

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$$\frac{Do}{t} = \frac{38}{.625} = 61.$$

$$\frac{L}{Do} = \frac{64}{38} = 1.68$$

From Figure 1-1100 obtaining B = 14,500, then:

$$P_a = \frac{4 \times 14,500}{3 \times 61} = 317 \text{ psi}$$

Therefore, the proposed cask can be operated satisfactorily under an external pressure as high as 317 psi, far in excess of the required 25 psi.

2.6 Normal Conditions of Transport

The CNS 0-4 cask when subjected to the normal conditions of transport specified in Appendix A to 10 CFR Part 71, meets the standards specified in §71.35 of 10 CFR Part 71 as demonstrated in the following paragraphs.

2.6.1 Pressure

Top cover plate against inside pressure

Utilizing Equation 2 of the ASME Code, Section VIII (Page 19), the required thickness is given as:

$$t = d\sqrt{\frac{cp}{s} + 1.78\,\frac{Whg}{Sd^3}}$$

$W = 0.785\ G^2p + 2b \times 3.14\ Gmp$, (page 181)

use G = 30, b = 2, m = 2.5, p = 6, hg = 2, d = 30

$W = 0.785(30)^2 \times 6 + 2 \times 2 \times 3.14 \times 30 \times 2.5 \times 6$

W = 4240 + 5660

W = 9900

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$$t = 30\sqrt{\frac{0.3 \times 6}{18,750} + 1.78\frac{9,900 \times 2}{18,750(30)^3}}$$

$$t = (30)(.013)$$

$$t = 0.39"$$

If p = 25 psi is used, then:

$$t = 0.39\sqrt{\frac{25}{6}}$$

$$t = 0.8"$$

The available t = 0.875", as previously shown.

2.6.2 Internal Pressure

According to ASME Code Section VIII, Paragraph UG27 (page 10), the capability for internal pressure is:

$$P = \frac{SEt}{R + 0.6t}$$

Where S = maximum allowable stress (psi)

E = joint efficiency

t = shell thickness (inches)

R = inside radius of shell (inches)

For SA-516 Grade 60 material, the minimum tensile strength is 60,000 psi. 1/3 of this value, 20,000 psi, may be taken as allowable stress as ASME Code (Section III, page 118) specified. The joint efficiency E = 0.6 is a conservative value (ASME Code Section III, page 60). Substituting all the values in the above formula:

$$P = \frac{20,000 \times 0.6 \times .625}{18.375 + 0.6 \times .625}$$

$$= 400 \text{ psi}$$

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2.7 Hypothetical Accident Conditions

The CNS 0-4 cask when subjected to the hypothetical accident conditions as specified in Appendix B to 10 CFR 71 meets the standards specified in §71.36 of 10 CFR 71 as demonstrated in the following paragraphs.

2.7.1 Free Drop

2.7.1.1 End Drop

End deformation of lead shielding due to 30 foot drop on end.

Based on dynamic flow stresses, the energy is assumed to be absorbed by the deformation. Assuming a square end, the energy absorbed by steel is:

$$E_{st} = \pi D t_s (d) S_{st}$$

$$= \pi(38)\ .625(d)\ 60,000$$

$$= 4,480,000\ d$$

The energy absorbed by lead is:

$$E_{pb} = \frac{\pi}{4} D^2 (d) S_{pb}$$

$$= 0.7854(38)^2(d)5,000$$

$$= 5,670,000\ d$$

From the energy balance:

$$WH = E_{st} + E_{pb}$$

$$30,000 \times 360 = 4,480,000\ d + 5,630,000\ d = 10,160,000\ d$$

$$d = \frac{30,000 \times 360}{10,160,000} = 1.06''$$

This is for a flat end. Actually, the design has a conical top and ellipsoidal bottom. Since the deformation of the flat end is only about 1", the shielding thickness remaining after impact would not be less than 7", considering the geometrical configuration of the design.

2.7.1.2 Side Drop

The lead shielding must not undergo side deformation due to a 30 foot free drop on the side.

Figure 2.22 (page 51) of ORNL-TM-2410 provides that the half angle of the deformation arc can be determined from two parameters, as follows:

$$A = (\frac{R}{t_s} \frac{S_{pb}}{S_{st}} + s\frac{R}{L} \frac{t_e}{t_s} \text{ and,}$$

$$B = \frac{WH}{Rt_{st}LS_s}$$

Where: $R = \frac{38}{2} = 19$, $t_s = 0.625$ $t_e = 0.875$

$S_{pb} = 5,000$ $S_{st} = 60,000$

Then $A = (\frac{19}{.625} \frac{5,000}{60,000} + 2\frac{19}{64} \frac{.875}{.625}) = 2.55 + .83 = 3.38$

$$B = \frac{30,000 \times 360}{19 \times .625 \times 64 \times 60,000} = 0.236$$

From Figure 2.22, Θ is determined to be 26°. The thickness of shielding lost is:

$$d = R - R \cos \Theta = R (1 - \cos \Theta)$$

$$= 19 (1 - .899)$$

$$= (19) (.101)$$

$$= 1.9"$$

The actual thickness of the lead shielding is 10.8", as compared to the thickness lost of 1.9".

2.7.1.3 Corner Drop

Analysis of the corner deformation of the lead shielding due to a 30 foot free drop.

These calculations are performed considering the corner deformation to be at the top. From H. G. Clarke's test data presented in "Some Studies of Structural Response of Casks to Impact" (proceedings of the Second International Symposium on Packaging and Transportation of Radioactive Materials, October 14-18, 1968, pages 373-398), the dimensions of the test model and this prototype are compared in the following:

		Prototype	Model
Outside Diameter	D	38"	5"
Shell Thickness	t_s	0.825"	.05" .106" .173"
Lead Thickness	t_{pb}	10.8"	0.75"
Weight	W	30,000 lbs.	30 lbs.

The possible scaling factors are:

$$S_1 = \frac{D_p}{D_m} = 38/5 = 7.6$$

$$S_2 = \frac{(t_s)p}{(t_s)m} = \frac{.825}{.106} = 7.8$$

$$S_3 = \frac{(t_{pb})p}{(t_{pb})m} = \frac{11}{.75} = 14.7$$

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$$S_4 = \sqrt[3]{\frac{(W)p}{(W)m}} = \sqrt[3]{\frac{3,000}{30}} = 10$$

Using the smallest value, $S_1 = 7.6$, then the equivalent energy level for the model is:

$$E_m = \frac{30,000 \times 30}{(7.6)^3} = 2050 \text{ lb-ft}$$

Using Figure 6 of the referenced paper by H. G. Clarke,

$$\left(\frac{L_{cg}}{t_L}\right)_m = 0.72$$

$$(L_{cg})_m = 0.72(t_L)_m$$

$$= 0.72 \times .75 = 0.54$$

$$(L_{cg})_p = S_1(L_{cg})_m = 7.6 \times .54 = 4.1"$$

These calculations are based on a square corner. For a voided steel edge, some energy will be absorbed before the core is reached. Therefore, the actual deformation, starting from the core, would be less than 4".

2.7.1.4 <u>Oblique Drops</u>

An analysis of oblique drops is not required since the end, side and corner drops are more damaging to all systems and components.

2.7.1.5 <u>Summary of Results</u>

The following table provides a summary of the results of the 30 foot free drop analysis:

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Loading Condition	Calculated Valve	Actually Used	Remarks
30 ft. free drop on side	Deformation d = 1.9"	10.8"	
30 ft. free drop on flat end	Deformation d = 1.06"	8" min.	Remaining thickness of lead at least 7"
30 ft. free drop on corner	Deformation d = 4.1"	Available 10" min.	

2.7.2 Puncture

1) The Outer Shell of the cask must withstand puncture during a 40 inch, free drop onto a 6 inch diameter cylinder.

In accordance with ORNL-TM-2410 (page 12), the minimum shell thickness required to withstand the punching action without puncture is:

$$t = \left(\frac{W}{S}\right)^{.71}$$

Where W = total weight of cask and contents (lbs.)

S = ultimate tensile strength (psi)

t = Shell thickness (inches)

Performing the calculations using:

W = 30,000 lbs. and S = 60,000 psi, gives

$$t = \left(\frac{30,000}{60,000}\right)^{.71} = 0.61 \text{ inches}$$

The actual outside layer of 0.625 inches provides the required puncture resistance while the 3/8 inch steel inner layer of the outer shell provides an extra margin of safety.

2.7.3 Thermal

The thermal test follows the free drop and puncture tests. The analysis and results are shown in Section 3.5.

2.8 Special Form

The material meets the special form requirements given in Paragraph 71.4(o) when subjected to the applicable test conditions of Appendix D to 10 CFR Part 71.

2.8.1 Description

Large quantities of radioactive material, special form in the form of not more than 10,000 curies of encapsulated cobalt-60 sources which meet the definition of "special form" as prescribed in S173.389(g) of the DOT Regulations.

2.9 Fuel Rods

Not applicable.

2.10 Appendix

2.10.1 Analysis of a Minimum Liner

2.10.2 Summary of Structural Integrity Calculations

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2.10 APPENDIX

2.10.1 SUMMARY OF STRUCTURAL INTEGRITY CALCULATIONS

Structural Member	Item No.	Loading Condition	Calculated Value	Actually Used	Remarks
OUTER SHELL	1.	40" Free drop on 6" cylinder	thickness t=0.61"	t=0.625"	An extra safety margin is provided by the 3/8 steel inner layer of the cask outer shell.
	2.	External pressure of 25 Psig.	strength p=317psig	Max. Req'd p=25psig.	Based on t=0.625"
	3.	5 times the total cask wt. on simply supported beam	thickness t=0.0353"	t=0.625"	
	4.	Capability for Internal Pressure	p=400 psi		
OUTER SHELL & LEAD SHIELDING	5.	30 ft. free drop on side	Deformation d=1.9"	10.8"	
	6.	30 ft. free drop on flat end	Deformation d=1.06"	8" min.	Remaining thickness of lead at least 7".
	7.	30 ft. free drop on corner	Deformation d=4.1"	Available 10" min.	
COVER PLATE	8.	Inside pressure 25 psig.	Thickness t=0.8	t=0.875"	0.39" is required for 6 psig.

SUMMARY OF STRUCTURAL INTEGRITY CALCULATIONS

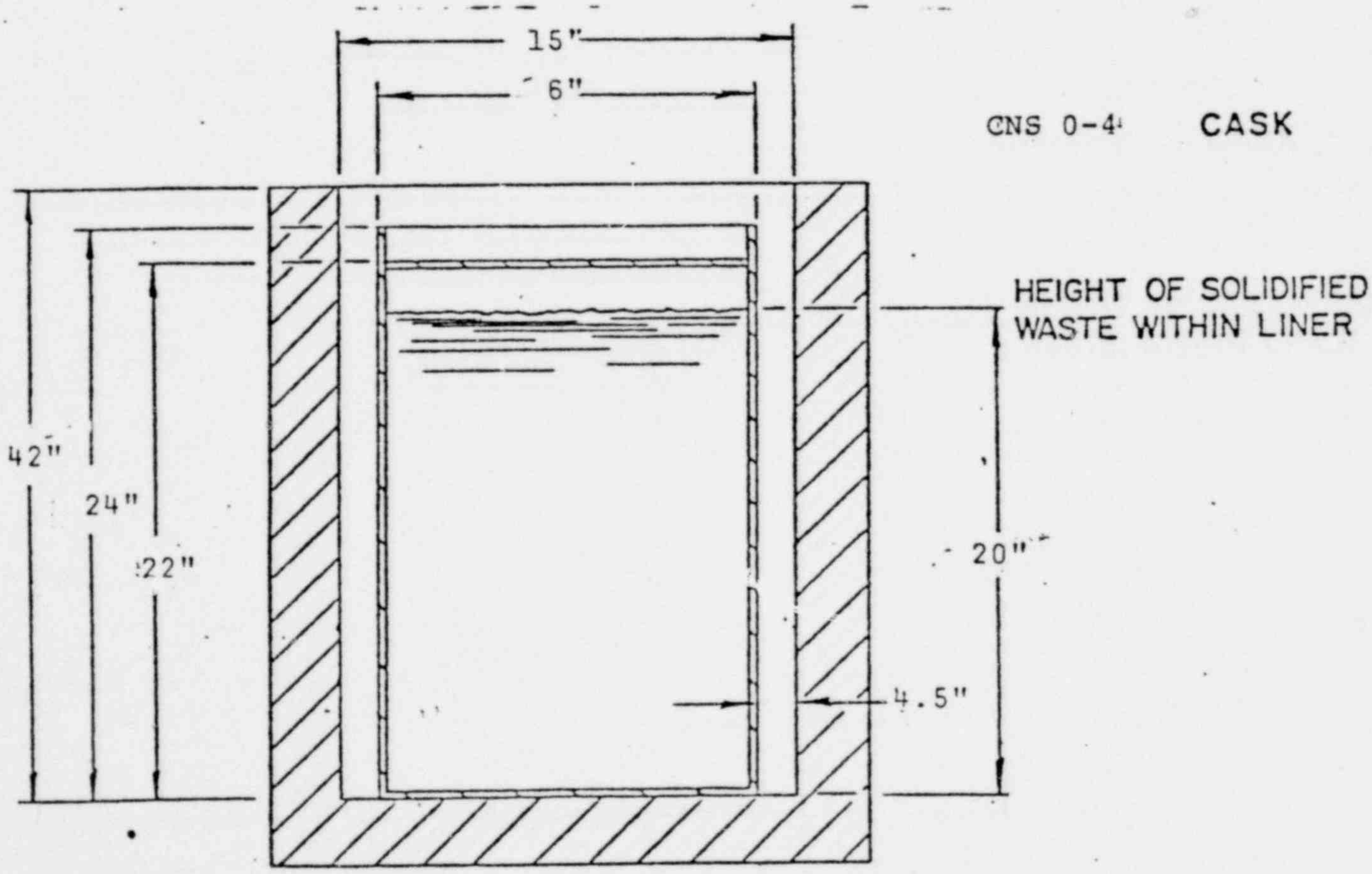
Page 2

Structural Member	Item No.	Loading Condition	Calculated Value	Actually Used	Remarks
COVER BOLTS	9	92 g. loading	area of each bolt=0.081 sq. inches	0.302 sq. inches	design is based on securing not strength
LIFTING LUG	10.	3 times the total weight based on yield	-	-	sufficient strength against the combined stress of tension and loading
LID	11.	92 g. at neck of lid	strength of lid neck-300g.	92 g.	considering lead only.
TIEDOWN BOLTS AT SKID	12.	10 g. forward, 5 g. sidewise, 2 g. vertical	bolt area 0.8118 sq. inches s=99,400psi	Yield Strength S_y=105,000psi	

2.10.2 ANALYSIS OF A MINIMUM LINER WITHIN THE CNS 0-4 CASK

The following analysis is provided to demonstrate that a liner, with a 6 in. diameter, 24 in. height, and a wall thickness of 14 ga minimun can withstand the accidental drop condition imposed on the CNS 0-4 cask loaded with the aforementioned liner. This will be established as a minimum requirement for the liner, so that any liner with a thicker wall, greater diameter or height, i.e. with less of a clearance within the cask cavity, will be acceptable for shipping waste in the CNS 0-4 cask.

Empty liner weight	-	100 lbs.
Contents weight	-	1100 lbs.
Filled Liner Weight	-	1200 lbs.



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(1) "g" Loading Acting on Cask Content

From basic mechanics of solids one can develop a formula for g loading based on the fact that from a fixed height drop, a defined speed is achieved, and from that speed at point of impact a deceleration to zero speed is effected by the deformation of the cask. The g loading will by definition of motion be the ratio of the force capable of causing the above deceleration to the weight of the falling body.

Also from basic mechanics, if two bodies are moving together at the same velocity, they exert zero force on each other. In this case the liner is moving with the same velocity as the cask, therefore the cask will not exert any force on its content, and therefore the liner will have to sustain its own g loading.

From basic motion

$v = (2Gh)^{\frac{1}{2}}$; $v = (2ad)^{\frac{1}{2}}$

where v = velocity of impact

G = gravitational acceleration

a = deceleration

h = drop height (360 in.)

d = stopping distance (1.9 in. from cask drop analysis)

therefore $a = Gh/d$

g loading = $F/W = ma/W = ma/mG = a/G = h/d$

$= 360/1.9 = 189.5$ (Let say 190)

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Density of Resin, Ro = 45#/ft^3

Pressure on Bottom of Liner = 45 x 20 x190 /1728 = 99 psi

Since the top and bottom weld of liner are identical, the following analysis will be applicable to both.

The Hoop Stress, generated within the liner is:

$$S = \frac{dP}{2t}$$

S = 6 x 99 /(2 x .075) = 3960 psi

This value is less than yield point for the liner material (AISI-1020 or equivalent, S_y = 40,000 PSI).

Actually, the above calculation is conservative, since the wall has stiffeners and the end plates act as stiffeners, therefore the full hoop stress can only be developed at a point between them. At this point, the internal pressure will be smaller, since the pressure diminishes linearly to zero at the top surface of the resin.

The weld configuration between the bottom plate and the shell generates a resultant force which will tend to shear the bottom plate from the shell, the force appearing as a shear stress on the weld. The shear stress is:

S_s = (6^2 x (Pi/4) x 99)/(6 x Pi x 2 x .075 x .707) = 1400 PS

This stress is below the limit of shear yield which is:

S_y = 0.6 x 40,000 = 24,000 PSI

Considering that the cask will land in the horizontal position, the height of the resin will be smaller than the liner diameter, which is 6. Consequently, all stresses will be less than the previously calculated stresses.

The liner will have an NPT type cap tested for 15 PSI pressure, or an alternate type of closure tested to the same pressure.

(4) Shift within Cask

The following analysis will determine the minimum criteria for a liner to withstand the motion within the CNS 0-4 cask. The dimensions of the liner will be no less than 6" in. diameter and 24" in height. Hence the clearance between the liner and the cask cavity is no more than 18" axially, or 4.5" radially. Since the liner and the cask are both cylindrical in shape, there is only three possible drop orientation realistically possible as follows:

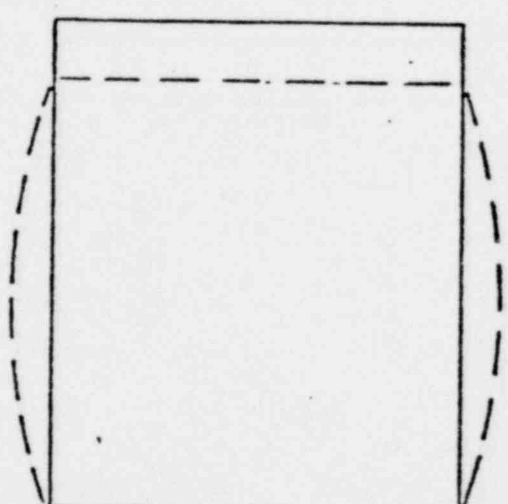
a. end drop (flat disk on flat disk)

b. side drop (circle within a circle)

c. corner drop (corner of cylinder within corner of a cylinder)

It may be argued that there is also a case of the liner corner drop on a flat surface of the cask cavity. But since this requires the cask to tilt clockwise while the liner tilt counterclockwise or vice versa, it is unlikely to happen. However since the liner is resting on the bottom of the cask, the clearance will not affect a bottom drop. In case of a side drop or an upside down drop, it is expected that the liner will travel the clearance space before the actual 30 ft. drop start. Therefore we can safely conclude that the two drops are not simultaneous.

a. End Drop



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(4) Cont.

C = Liner circumference

c = Elongation of liner circumference

F = Vertical load on liner

E = Modulus of elasticity (30×10^6 lb/in^2)

S = Yield Tensile Stress of AISI-1020 (40,000 PSI), UTS (69,000 PSI)

D = Diameter of liner (6 in.)

H = Height of liner (24 in.)

h = Shortening of liner height

d = Elongation of liner diameter

L = Circumference of vertical cross section

l = Elongation of L

Using Hooks Law

Maximum allowable Elongation of Circumference

c = CF/EA = CS/E = PiDS/E

Therefore d = DS/E

Reduction in height due to elongation in diameter.

$h = H - (Pi/4)D^2 H/((Pi/4) (D + d^2))$

$= H(1-D^2/(D+d)^2) = H(1-D^2/(D + DS/E)^2)$

$= H(1-1/(1 + S/E)^2) = 24 (1-1/(1 + 40000 / 30 \times 10^6)^2) = .072$ in

Maximum allowable load causing elongation

$P = hAE/H = AE(1-1/(1 + S/E)^2) = PiD\ tE(1-1/(1 + 69000 / 30 \times 10^6)^2)$

$= 84.8 \times 10^6(1-1/1.0046) = 388,299$ lb.

Accelerated load due to shift

1200 x 18/.072 = 300,000 lb.

The load does not exceed the ultimate load, therefore the liner will deform, but not tear.

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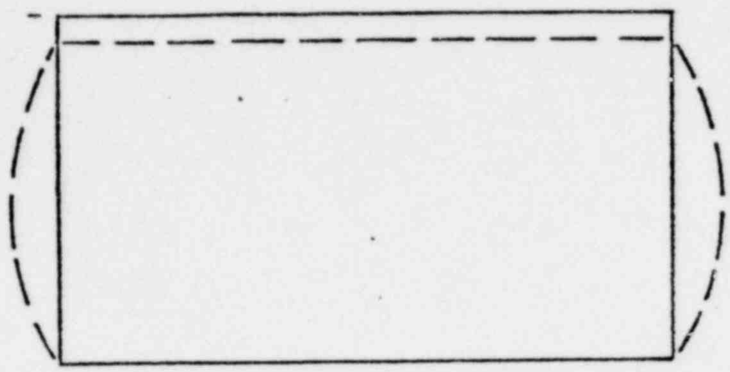
· (4) Cont.

b. Side Drop



Using Hook's Law

Maximum allowable circumferential elongation of vertical cross section:

$l = LF/EA = LS/E = 2(H + D)S/E$

$h = (l + 2d)/2 = l/2 + d$

$d = D - ((Pi/4)D^2H/((Pi/4)(H + h)))^{1/2}$

Or $1 - 2d/D + d^2/D^2 = H/(H + l/2 + d)$

$0 = -H + H + l/2 + d - 2Hd/D - ld/D - 2d^2/D + Hd^2/D^2 + ld^2/2D^2 + d^3/D^2$

$(1/D^2)d^3 + (H/D^2 + l/2D^2 - 2/D)d^2 + (1 - 2H/D - l/D)d + l/2 = 0$

$d^3 + (H + l/2 - 2D)d^2 + (D^2 - 2HD - lD)d + lD^2/2 = 0$

$H + l/2 - 2D = H + (H + D)S/E - 2D =$

$= 24 + (24 + 6)\ 40000/30 \times 10^6 - 2 \times 6$

$= 24 + .04 - 12 = 11.96$

$D^2 - 2HD - lD = 6^2 - 2 \times 24 \times 6 - 2 \times .04 \times 6 = 252.5$

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(4) b. Cont.

$D^2/2 = .04 \times 6^2 = 1.44$

Therefore $d^3 - 11.96\,d^2 - 252.5d + 1.44 = 0$

Since d is expected to be a small fraction, d^2 is even smaller, and d^3 is negligible compared to 252.5d. Therefore

$11.96d^2 + 252.5\,d - 1.44 = 0$

Or $d = (-126.3 \pm (126.3^2 + 11.96 \times 1.44)^{1/2})/11.96 =$

$= (-126.3 \pm (127.3)/11.96 = .084$ in.

Allowable load causing elongation d

$P = dAE/D = d\,2(D + H)tE/D =$

$= .084 \times 2(6 + 24).075 \times 30 \times 10^6/6$

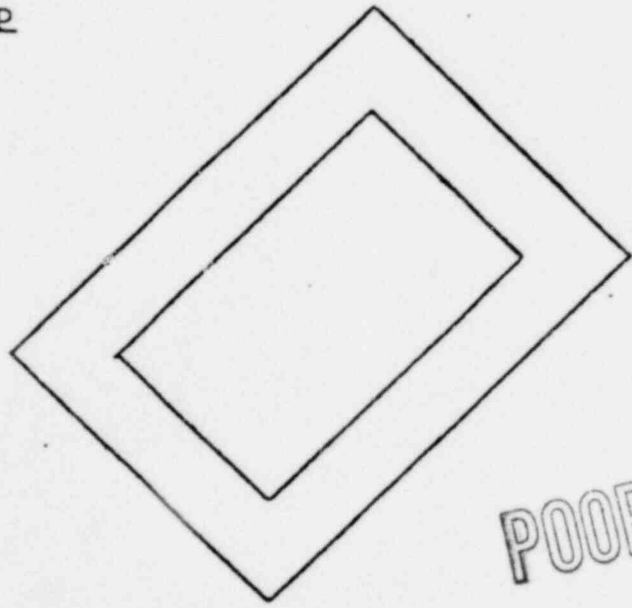
$= 1.89 \times 10^5$ lb.

Accelerated load due to shift

$1200 \times 4.5 / .084 = 64,285$ lb.

Therefore, the liner can withstand the drop within the cask cavity without exceeding its yield stress, i.e. without any permanent deformation.

c. Corner Drop



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(4) c. Cont.

A corner drop of the liner within the corner of the cask cavity will be a partial combination of the side and end drop, therefore the previous two cases are the most severe.

(5) Effect on Liner Containing Solidified Waste

Since the waste is in a solidified form, it will have no free water, and therefore will not be affected by either the heat or the pressure. And in terms of the weight analysis, the liner weight used was that of a liner full of solidified waste, so that for the case of the liner full of dewatered resin, is a less stringent case.

(6) Exception to Liner Dimension

In case of using a liner with a smaller diameter and/or a shorter height, wood shoring shall be required.

Wall thickness, weld size, closure and lifting lugs have to conform to the specification under any condition.

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3. THERMAL EVALUATION

3.1 Hypothetical Accident Thermal Evaluation

This analysis section considers the thermal response and other resultant effects of the CNS 0-4 cask when subjected to the thermal exposure special test described in 49 CFR 173.398. As defined, the fire test conditions are a radiant thermal source, having a temperature of 1475°F, and lasting for a period of 30 minutes. In addition, the standard fire is defined as having an effective source emissivity of 0.9, while the emissivity of the exposed cask surface is defined as 0.8.

Of primary interest is thermal response of the lead shield layer. The analysis included investigating the possibility of the lead melting. One representative case was examined, since the sides, top and bottom of the cask are nearly the same shielding design. A computer program was written to calculate temperatures at different locations within the cask for times during the fire (30 minutes) and times subsequent to the fire when cask temperatures stabilize and begin to fall. Calculated temperatures are presented in Figure 3.5.3. As seen in this figure, the maximum temperature of the lead was estimated to be less than 350°F, which is appreciably below the lead melting temperature of 621°F. This computation was made considering the internal surface was fully insulated and is, therefore, conservative. Since the cement encapsulating the filter is separated from the cask internal wall (where temperature is below 320°F) by an air gap, no deterioration of the cement is expected.

3.1.1 Analytical Model

The heat transfer model was considered to be composed of two steel layers and an inner thickness of lead. Between the steel, and at the interface between the lead and the steel, a 1/32" nominal air gap was used for each location. This gap thickness is felt to be on the low side and so provides a pessimistic thermal coupling between the shells when considering the thermal test conditions. The results and details of the analysis are presented in the following paragraphs. In conclusion, no lead melting is expected.

A computer code was written to calculate the thermal response of the cask to the special fire test. The code was based on the numerical method of Dusinberre for a one-dimensional transient.* Calculations were performed for the model of the CNS 0-4 cask shown in Figure 7-2.

Calculation of Surface Temperature

In finite difference form, a heat balance on the surface results in the following equation:

*William H. McAdams, Heat Transmission, Third Edition, McGraw-Hill Book Company, Inc., 1954, p. 44.

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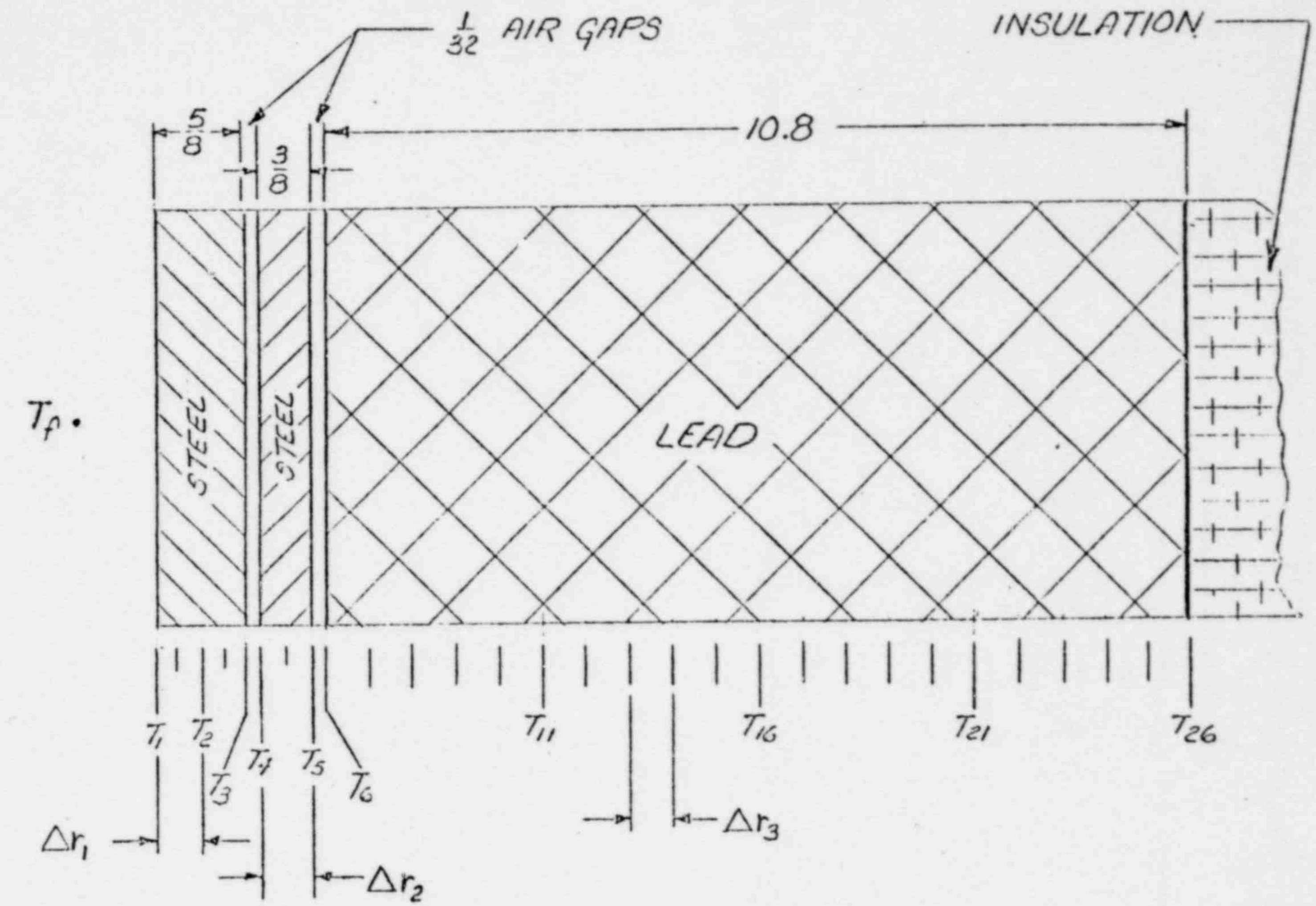

FIGURE 7-2 Calculational Model of CNS 0-4 Cask Used for Fire Test Calculation

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$$h_r(t_f - t_1) = \frac{K_s}{\Delta r}(t_1 - t_2) + \frac{\rho \Delta C_s}{2\Delta\tau}(t_1' - t_1)$$

The expression for the surface temperature, t_1', after a time increment of $\Delta\tau$ is obtained by rearranging the above equation, thus,

$$t_1' = \{2L_s t_f + (M_s - 2L_1 - 2)t_1 + 2t_2\} / M_s$$

Where $M_s = \Delta r^2/\alpha\Delta\tau$

$$L_s = \frac{h_r \Delta r}{K_s}$$

The surface coefficient for radioactive heat transfer is obtained from the expression

$$h_r = 0.173\, F_a \left\{ \left(\frac{t_f + 460}{100}\right)^4 - \left(\frac{t_1 + 460}{100}\right)^4 \right\}$$

Calculation of Interior Temperatures

The temperature response of the various cask layers is obtained from a finite difference form of the basic heat equation, namely,

$$\frac{t_i' - t_i}{\Delta\tau} = \alpha \left\{ \frac{t_{i+1} - 2t_i + t_{i-1}}{\Delta r^2} + \frac{1}{r_o - m\Delta r} \quad \frac{t_i - t_{i-1}}{\Delta r} \right.$$

The above equation is rearranged to a more useful form to calculate temperatures within cask layers after each time increment of $\Delta\tau$

$$t_i' = \frac{1}{M}\{t_{i+1} + (M - N - 2)t_i + (1 + N)t_{i-1}\}$$

Where $M = \frac{\Delta r^2}{\alpha\Delta\tau}$ $\qquad r_o$ = outside radius of region

$N = \frac{1}{\frac{r_o}{\Delta r} - m}$ $\qquad \Delta r$ = radial

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The above equation was used to calculate the temperatures (see Figure 7-2) t_2, t_5, t_7 through t_{25}.

Temperatures at Air Gaps

The temperatures on the inside and outside of air gaps after each time increment $\Delta\tau$ were calculated from finite difference equations developed using the same principles as above. For example t_5' and t_6' temperatures for the gap between the inner steel layer and the lead layer (see Figure 7-2) were calculated from the following equations:

$$t_5' = \frac{1}{M_s} \{2t_4 + (M_s - 2L_s - 2)t_5 + 2L_s t_6\}$$

and

$$t_6' = \frac{1}{M_1} \{2t_7 + (M_1 - 2L_1 - 2) t_6 + 2L_1 t_5\}$$

Heat transfer by radiation and conduction across the gap are included in the terms L_s and L_1.

For example:

$$L_1 = \frac{h_t \Delta r_1}{K_1}$$

Where

$$h_t = h_c + h_r$$

The radioactive coefficient h_r is calculated as in the section on the Surface Temperature while the following expression was used for the conduction term

$$h_c = \frac{K_{air}}{\Delta r_{gap}}$$

To a good approximation, the thermal conductivity of air, K_{air}, may be expressed as:

$$K_{air} = 0.0132 + 2.24 \times 10^{-5} \bar{t}_{gap}, \text{ Btu/hr ft } {}^{\circ}F$$

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Solution of Transient Temperature Equations

Solution of the transient temperature equation, requires that the following conditions be satisfied:

M is greater than 2 + N
M is greater than 2 + L

For the first steel layer, M = 2.5 was used. The duration of each time increment was determined to be:

$$\Delta\tau = \frac{\Delta r_s^{\,2}}{\alpha_s M_s} = \frac{\left(\frac{5}{16}\text{ inch X }\frac{1\text{ ft.}}{12\text{ in.}}\right)^2}{0.411\ \frac{ft^2}{hr}\text{ X } 2.5} = 0.000656\text{ hr}$$

For the half hour test, the total number of time intervals is

$$\frac{0.5\text{ hr}}{0.000656\text{ hr/increment}} = 760\text{ increments}$$

With the same time interval for lead:

$$M_1 = \frac{\Delta r_1^{\,2}}{\alpha_1 \Delta T} = \frac{\left(0.525\text{ inch X }\frac{1\text{ ft.}}{12\text{ inch}}\right)^2}{0.42\ \frac{ft^2}{hr}\text{ X } 0.000656\text{ hr}} = 6.92$$

The value of N and L are much smaller than unity so that the value of M for the steel (M= 2.5) and lead regions (M = 6.92) will satisfy the stated conditions and relating M, L, and N.

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Nomenclature for Fire Analysis Equations

C = Heat Capacity for Region, BTU/lb°F

F_a = Grey Body Factor $=1/(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2})$

h = Heat Transfer coefficient(Subscripts:r=radiation & c=conduction), BTU/hr ft^2 °F

k = Thermal conductivity for region, BTU/hr ft °F

L = $h\Delta r/k$ for material region(subscripts:s=steel & l=lead), dimensionless

M = $\Delta r^2/\alpha\ T$ for material region(subscripts:s=steel & l-lead), dimensionless

m = Index for annular nodes in each region (zero on outside radius of region)

N = $1/(\frac{r_o}{\Delta r} - m)$ for material region(subscripts:s=steel & l=lead), dimensionless.

r_o = outside (larger) radius of region, ft.

t_f = temperature of fire = 1475°F

t_i = Temperature at beginning of time increment at annular node i,°F

$\overline{t}$ = Average air gap temperature, °F

α = Thermal diffusivity of region material, ft^2/hr

$\Delta\tau$ = Duration of time interval, hr.

Δr = Thickness of annular node in material region

ε = Emissivity

ρ = Density of material in region

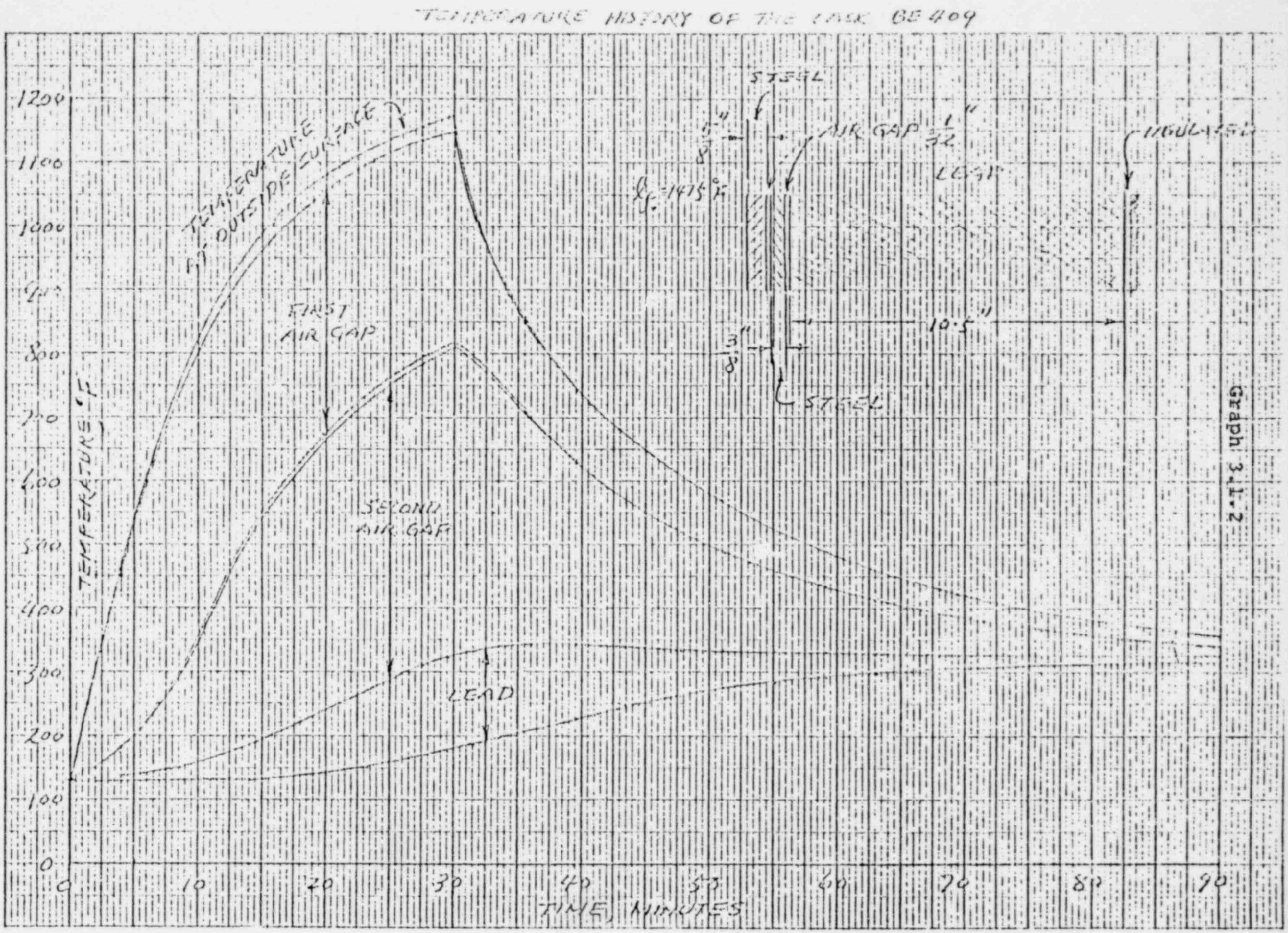
1599 317

3.1.2 Package Temperatures

Graph 3.1.2 shows the temperature response of the CNS 0-4 cask to a hypothetical fire.

1599 318

Graph 3.1.2



Graph 3.1.2 Temperature Response of CNS 0-4 Cask to Hypothetical Fire

4. CONTAINMENT

4.1 Release of Radioactive Material

There will be no release of radioactive material from the containment vessel since the vessel is structurally sound under normal and accident conditions as demonstrated in Sections 2 and 3.

4.2 Containment Requirements for the Hypothetical Accident Conditions

4.2.1 Fission Gas Products

Not applicable.

4.2.2 Release of Contents

There will be no release of radioactive materials under hypothetical accident conditions due to the structural integrity of the cask as demonstrated in Sections 2 and 3. There will be no gases and contaminated coolant released since there are no fission gas products and there is no coolant.

1599 320

5. SHIELDING EVALUATION

5.1 Discussion and Results

The maximum dose rate on the surface of the CNS 0-4 cask will occur on the top of the cask due to the reduced lead thickness in the cover. An equivalent lead thickness of 11.7 inches is provided by the body of the cask while the recesses in the cover of the cask (to provide clearance for the filter element) reduce the equivalent lead thickness to 8.1 inches.

Table 5.1

Summary of Maximum Dose Rates
(mR/hr)

	Package Surface			3 Feet From Surface of Package		
	Side	Top	Bottom	Side	Top	Bottom
Normal Conditions	The dose rate at the top of the cask, the maximum dose rate location, was calculated using the SDC* code to be 4.64×10^{-3} mr/hr. This dose rate is well below maximum permissible levels and will cause no radiation shielding problem under normal shipping conditions.					
Hypothetical Accident Conditions	Under accident conditions, the minimum shielding provided is 7 inches of lead. This shielding thickness would result in a dose rate on the surface of the cask similar to that through the top of the cask (10^{-2} mr/hr) which is well below the permissible level of 1000 mr/hr at 3 feet.					
10 CFR Part 71 Limit	----	----	----	1000	1000	1000

1599 321

5.2 Shielding Evaluation

The maximum dose rate on the surface of the CNS 0-4 cask will occur on the top of the cask due to the reduced lead thickness in the cover. An equivalent lead thickness of 11,7 inches is provided by the body of the cask while the recesses in the cover of the cask reduce the equivalent lead thickness to 8.1 inches. The dose rate at the top of the cask, the maximum dose rate location, was calculated using the SDC* code to be 4.64×10^{-3} mr/hr. This dose rate is well below maximum permissible levels and will cause no radiation shielding problem under normal shipping conditions.

Under accident conditions, the minimum shielding provided is 7 inches of lead. This shielding thickness would result in a dose rate on the surface of the cask similar to that through the top of the cask (10^{-2} mr/hr.) which is well below the permissible level of 1000 mr/hr. at 3 feet.

It is concluded that the CNS 0-4 cask provides more than adequate shielding.

*E. D. Arnold and B. F. Maskewitz, SDC, A Shielding Design Calculation Code for Fuel-Handling Facilities, ORNL-3041, March 1966.

1599 322

6. CRITICALITY EVALUATION

This section is not applicable since CNS 0-4 cask will not be used to transport fissile materials.

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7.0 OPERATING PROCEDURES

7.1 Procedures for Loading and Unloading the Package

Detailed loading and unloading procedures are given in Appendix 7.2, Procedure No. TR-OP-017, "Handling Procedure for Chem-Nuclear Systems, Inc. (CNSI) Transport Cask CNS 0-4, Model LL-28-4, C of C No. 6275".

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED

CNSI SAFETY REVIEW
BOARD APPROVAL
BY Brucell Johnson
DATE 11/15/79

REVISION STATUS

SHEET	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
REV.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
SHEET																	
REV.																	

PREPARED	DATE	
M C Terry	11-12-79	CHEM – NUCLEAR SYSTEMS, INC.
CHECKED L.B. Corbett	11-12-79	TITLE HANDLING PROCEDURE FOR CHEM-NUCLEAR SYSTEMS, INC. (CNSI) TRANSPORT CASK NUMBER CNS 0-4 (MODEL NUMBER LL-28-4) CERTIFICATE OF COMPLIANCE NUMBER 6275
ENGINEER W D Bridges	11-14-79	
QUALITY B. Simis	11/14/79	UNCONTROLLED COPY

APPROVED	CONTRACT NO.	DOCUMENT NO.	REV.	SHEET
R.H. Kinkade 11/14/79		TR-OP-017	-	1

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CNSQ 1001/8-78

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LIST OF FIGURES

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1.0 SCOPE

1.1 Purpose

This document establishes procedures for the routine handling, loading, and unloading of CNSI Transport Cask CNS 0-4, Model Number LL-28-4.

1.2 Applicability

This procedure applies to CNSI Transport Cask CNS 0-4, Model Number LL-28-4.

2.0 CASK DESCRIPTION

The CNS 0-4, Model Number LL-28-4 cask is a steel-encased, lead-shielded shipping cask (Figure 1). The cask body is a cylinder, 67 inches long by 39-1/8 inches in diameter, formed by two concentric steel shells whose annular region is filled with eleven inches of lead.

The outer shell is composed of two plates, one 3/8-inch stainless steel plate on the inside and a 5/8-inch thick mild steel plate on the outside. The 1/4-inch thick inner stainless steel shell has a 14 7/8-inch inside diameter and a 40-inch inside length. The base of the outer shell is welded to the bottom plates of the same construction, and the base of the inner shell is welded to a 1/4-inch circular plate. The cask lid is a flanged, recessed steel weldment having eleven inches of lead shielding. The cask lid is secured by twenty (20) 3/4-inch bolts.

Cask features include drain and vent couplings; removable lifting lugs, and removable lifting eyes for the lid.

CASK WEIGHTS (APPROXIMATE):

CASK LID WEIGHT	1,600	pounds
CASK WEIGHT (EMPTY, WITH LIDS INSTALLED)	28,150	pounds
MAXIMUM CASK PAYLOAD (INCLUDING SHORING)	1,850	pounds
MAXIMUM CASK WEIGHT (LOADED)	30,000	pounds

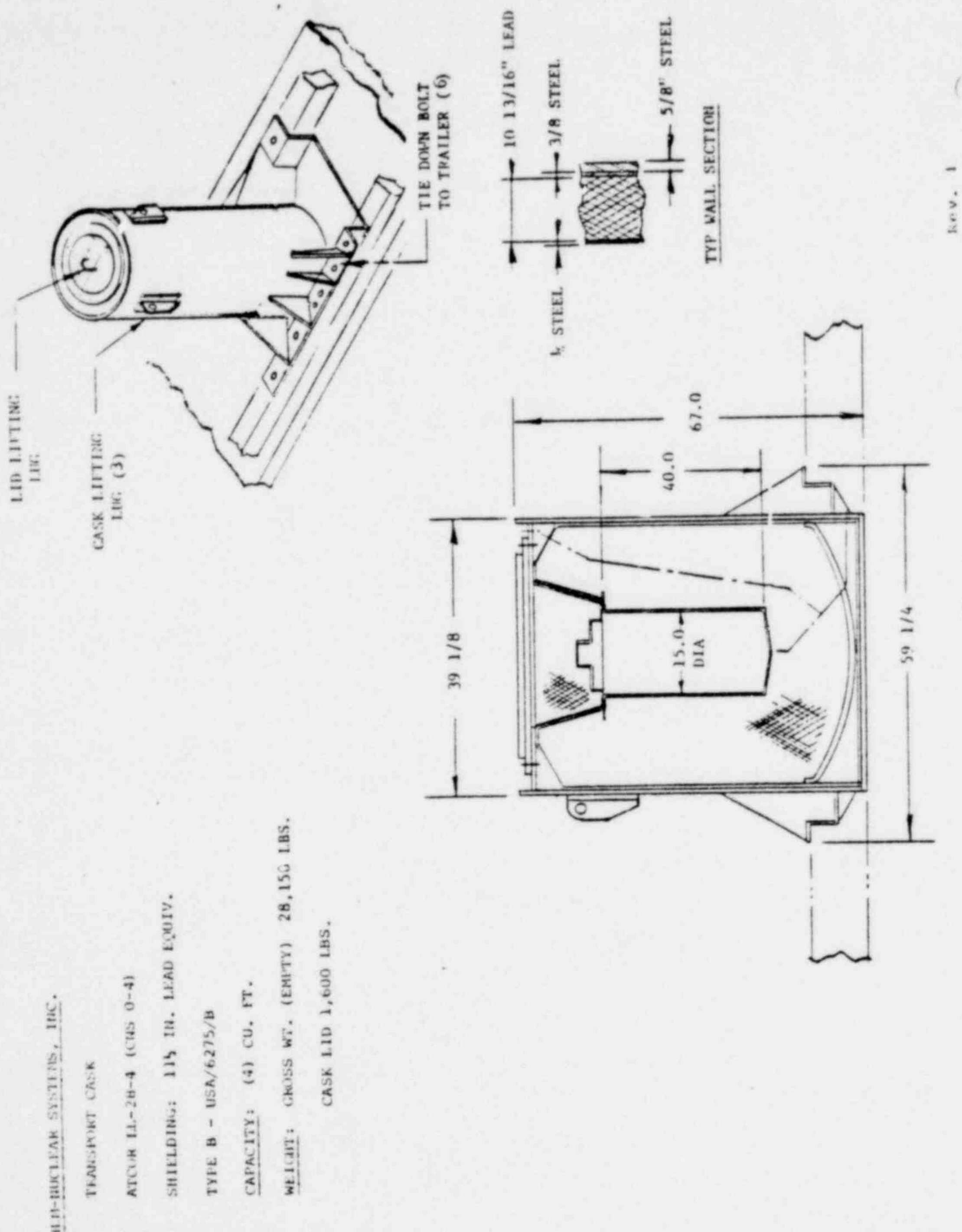
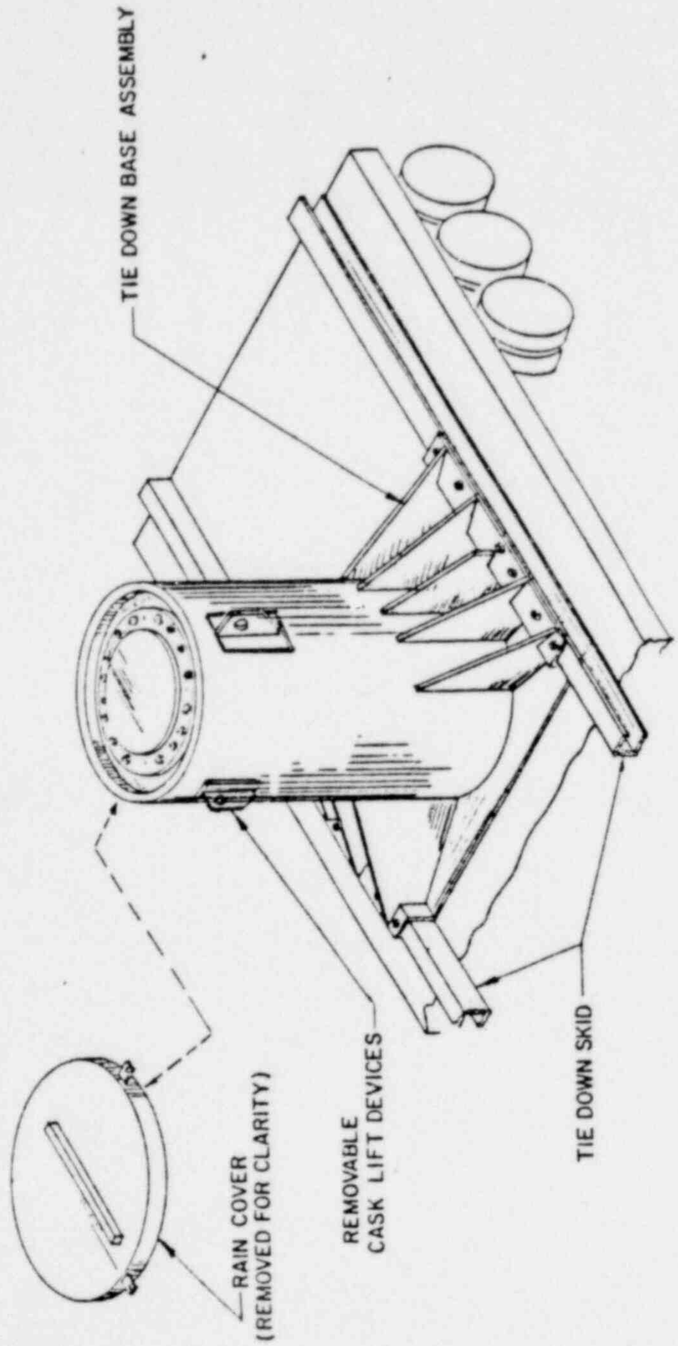


Figure 1. CNSI Transport Cask CNS 0-4, Model Number LL-28-4



LL-28-4
(CNS 0-4)

Rev. 1

DOCUMENT	REV.	SHEET
TR-OP-017	-	5

USER CHECKOFF SHEET

Date__________ Shipment Number__________ Waste Identification ______________

Operator(s)______________________________ HP Technician(s)______________________________

______________________________ ______________________________

______________________________ ______________________________

Shipper ______________________________ Driver______________________________

Time of arrival at Site ____________ Time of departure from site ____________

==

Please initial when item completed: Operator (O), Supervisor (S)

1. Disposable Liner Closure Devices Replaced __________(O) __________(S)
2. Gaskets Inspected __________(O) __________(S)
3. Lid bolts torqued __________(O) __________(S)
4. Cask sealed __________(O) __________(S)
5. Cask tiedowns inspected __________(O) __________(S)
6. Vehicle Placarded __________(O) __________(S)

Please fill in blank and initial: Operator (O), Health Physist (HP), Supervisor (S)

7. Cask Payload (including shoring) Max. __________ Actual __________
   __________(O) __________(S)
8. Decay heat-watts (if applicable) Max. __________ Actual __________
   __________(O) __________(S)
9. GAMMA = __________ at 6 ft. from tailer __________(HP) __________(S)
10. GAMMA = __________ at cask surface __________(HP) __________(S)
11. Smearable (d/m/100 cm^2) = __________. __________(HP) __________(S)

==

Health & Safety (H & S) - Please fill in blanks and initial.

GAMMA = __________ at 6 ft. from tailer __________(H&S)

GAMMA = __________ at cask surface __________(H&S)

12. Smearable (d/m/100 cm^2) = ______________________(H&S)

==

I hereby certify that the above statement is correct and the cask has been loaded and tested in accordance with approved procedures.

Operator(s) ______________________________

____

____

H & S Tech(s) ______________________________

____

____

Supervisor(s) ______________________________

____

____

Figure 2. User Check-off Sheet

3.0 REFERENCES

Code of Federal Regulations (CFR) Title 10, Part 71
Title 49, Part 172
Parts 173.389-173.398
Part 391

Federal Motor Carrier Safety Regulations Part 393.100

CNSI Transport Cask CNS 0-4, Model No. LL-28-4, Certificate of Compliance No. 6275

Atcor Drawings No. 1000-B-0061
1000-E-0040-0
1000-E-0041-0
1000-R-0043-0, Rev. F

4.0 REQUIREMENTS

4.1 Tools, Materials, and Equipment--At Shipper's Location

4.1.1 CNSI-furnished Items

- (a) CNS 0-4 (LL-28-4) cask and trailer
- (b) CNS 0-4 (LL-28-4) cask license and documentation
- (c) CNS 0-4 (LL-28-4) cask lid gaskets
- (d) CNS 0-4 (LL-28-4) cask disposable liners, as required

4.1.2 Shipper-furnished Items

- (a) Crane compatible with filled liner and cask lid
- (b) Lifting hardware
- (c) Tools
  - (1) 1 11/16" wrench for 1 1/8" bolts
  - (2) 1 1/8" wrench for 3/4" bolts
  - (3) Wrench for 1 3/4" bolts
  - (4) Gasket cement
  - (5) Proper size sockets
- (d) Lifting sling compatible with filled liner and cask lid
- (e) Acceptable bolt lubricant (Moly-Z, Neolube, or Anti-Seize)
- (f) Health physics (HP) instrumentation and support materials
- (g) Filling equipment for disposable liners

4.2 Tools, Materials, and Equipment--At Unloading Site

(a) Crane compatible with loaded pallet and cask lid

(b) Lifting and unloading hardware

(c) Tools

(1) 1 11/16" wrench for 1 1/8" bolts

(2) 1 1/8" wrench for 3/4" bolts

(3) Wrench for 1 3/4" bolts

(4) Gasket cement

(5) Proper size sockets

(d) Lifting sling compatible with filled liner and cask lid

(e) Acceptable bolt lubricant (Moly-Z, Neolube, or Anti-Seize)

(f) Health physics (HP) instrumentation and support materials

4.3 Prerequisites

Not applicable

4.4 Acceptance Criteria

Not applicable

5.0 HANDLING PRECAUTIONS

5.1 Treat the inside of the cask, the bottom of the cask lid, and any material removed as contaminated.

5.2 Lift the cask by using the three (3) lifting trunnions on the side of the cask. DO NOT lift the cask by the lifting eyes on the lid.

5.3 Survey the cask cavity for radiation and contamination levels after the cask contents have been removed. Decontaminate as required by the health physics technician after the contents have been removed.

5.4 Remove any liquid from the cask cavity. Treat this liquid as radioactive waste.

5.5 Visually inspect the cask for damage to the lid, lifting lugs or trunnions, lifting slings, or tie-downs.

5.6 When lowering a liner into the cask, be alert to the possibility of airborne contamination from the air escaping the cask.

5.7 Before the cask leaves the facility, the following shall be confirmed:

(a) That any external lifting lugs or trunnions are properly covered for transport.

(b) That the cask is secured to the trailer in accordance with Section 393.100 of the Federal Motor Carriers Safety Regulations and the Certificate of Compliance.

(c) That trailer placarding and cask labelling meet DOT Specifications (CFR Title 49, Part 172).

(d) That exterior radiation levels do not exceed 10 mR/hr at 6 feet and 2 mR/hr in the tractor cab, in accordance with 49 CFR 173.393 (j).

(e) That the outer package is sealed with anti-tamper seals.

(f) That the drain plug is securely installed and that a lead wire seal is attached.

6.0 LOADING PRECEDURE

6.1 Remove the rain cover by loosening the cables that attach the rain cover to the pallet and lifting off the rain cover.

6.2 Attach the cask lifting lugs, if necessary, by removing the three (3) lugs attached to the cask gusset and bolting them, with two (2) 1 3/4-inch bolts each, to the sides of the cask.

6.3 Prepare to remove the cask from the pallet, if necessary.

(a) Visually inspect the pallet and the cask for damage.

(b) Remove the twelve (12) 1 1/8-inch bolts holding the cask to the pallet, using a 1 11/16-inch wrench.

(c) Attach a three-point sling to the lifting lugs, inspect the rigging, and lift the cask to the loading area.

6.4 Attach the eyebolts, stored on the cask base, to the three (3) holes provided on the cask lid.

6.5 Prepare to load the cask.

NOTE: THIS CASK MAY BE DRY LOADED OR LOADED IN A FUEL POOL. IF YOU WILL NOT BE SUBMERGING THE CASK INTO A FUEL POOL, FOLLOW THE PROCEDURE FOR DRY LOADING, SECTION 6.5.2.

CAUTION: TREAT THE UNDERSIDE OF THE LID, THE SURFACES OF THE CASK, AND ANY BOLTS OR SEALS REMOVED AS CONTAMINATED.

KEEP CRANE CABLES VERTICAL AT ALL TIMES TO AVOID LATERAL MOVEMENT OF THE CASK.

6.5.1 Procedure for wet loading.

6.5.1.1 Prepare to remove the cask lid.

(a) Remove the twenty (20) 3/4-inch bolts from the cask lid.

(b) Attach a three-point sling to the three (3) eyebolts on the cask lid.

(c) Attach the crane hook to the lifting sling.

(d) Lift the lid straight up off the cask and place it on absorbent material or plastic sheeting.

CAUTION: BE ALERT THAT THE CASK LID GASKET MAY LIFT OFF WITH THE CASK LID.

(e) Remove the crane hook.

6.5.1.2 Prepare the cask for lowering into the pool.

NOTE: TREAT ANY LIQUID FROM THE DRAIN AS CONTAMINATED. IF THE CASK SLING IS TO BE DISCONNECTED FROM THE CRANE HOOK, CONFIRM THAT THE SLING HAS REMOTE CONNECTING/DISCONNECTING CAPABILITY.

(a) Remove the drain plug from the cask, clean the threads, and retain for re-installation.

(b) Open the filter vent on the cask lid.

(c) Attach the lifting sling to the three cask lifting lugs, if necessary.

(d) Attach the crane hook to the lifting sling.

(e) Lift the cask with the crane.

(f) Position the cask over the pool.

(g) Lower the cask into the pool to a sufficient depth to ensure safe operating conditions for all personnel.

(h) Detach the crane hook from the lifting sling, if necessary. Confirm that the cask is resting securely in the pool before disconnection.

6.5.1.3 Fill the liner, if necessary.

6.5.1.4 Load a filled liner into the cask, if necessary.

6.5.1.5 Prepare to replace the cask lid while the cask is in the pool.

(a) Visually inspect the lid gasket for cracks or tears. Replace the gasket if it is damaged. Inspect and clean the gasket seating surfaces.

(b) Attach the crane hook to the lid lifting sling.

(c) Position the lid over the cask by positioning the cut-out on the lid over the filter plug.

(d) Lower the lid onto the cask.

(e) Remove the crane hook and the lifting sling.

6.5.1.6 Prepare to remove the loaded cask from the pool.

(a) Attach the crane hook to the cask lifting sling.

(b) Lift the cask out of the pool. Allow the cask to remain over the pool until all of the liquid has drained out, approximately fifteen minutes.

NOTE: THE CASK MAY BE HOSED DOWN WHILE IT IS SUSPENDED OVER THE POOL.

(c) Replace the cask drain and vent plugs. Attach lead wire seals to the plugs and ensure that the drain plug does not leak.

(d) Move the cask to a level set-down area.

(e) Replace the twenty (20) 3/4-inch bolts on the cask lid. Torque to 160 ± 16 ft lb (120 ± 12 ft lb if lubricated).

(f) Decontaminate all external surfaces of the cask.

(g) Remove the crane hook, if necessary.

(h) Remove the lifting sling from the cask lid.

(i) Refer to Section 6.6.

6.5.2 Procedure for dry loading.

6.5.2.1 Prepare to remove the cask lid.

(a) Remove the twenty (20) 3/4-inch bolts from the cask lid.

(b) Attach a three-point sling to the three (3) eye-bolts on the cask lid.

(c) Attach the crane hook to the lifting sling.

(d) Lift the lid straight up off the cask and place it on absorbent material or plastic sheeting.

CAUTION: BE ALERT THAT THE CASK LID GASKET MAY LIFT OFF WITH THE CASK LID.

(e) Remove the crane hook.

6.5.2.2 Prepare to remove the liner from the cask, if necessary.

(a) Attach the crane hook to the bail on the liner.

(b) Lift the liner out of the cask and place it on absorbent material or plastic sheeting.

(c) Remove the crane hook.

6.5.2.3 Fill the liner, if necessary.

6.5.2.4 Prepare to load a filled liner into the cask, if necessary.

CAUTION: AS THE LINER IS LOWERED INTO THE CASK, AIR IN THE CASK WILL CUSHION AND SLOW THE LINER. BE ALERT TO THE POSSIBILITY OF AIRBORNE CONTAMINATION FROM THE AIR ESCAPING THE CASK DURING THIS PROCEDURE.

NOTE: CLEAN THE LINER BEFORE PLACING IT IN THE CASK. TREAT DEBRIS REMOVED AS CONTAMINATED.

(a) Attach the crane hook to the bail on the liner.

(b) Lower the liner straight into the cask.

(c) Remove the crane hook.

(d) Ensure that the liner lift bail swings clear to allow proper installation of the cask lid.

6.5.2.5 Prepare to replace the cask lid.

(a) Visually inspect the lid gasket for cracks or tears. Replace the gasket if it is damaged. Inspect and clean the gasket seating surfaces.

(b) Attach the lifting sling to the three (3) eyebolts on the cask lid.

(c) Attach the crane hook to the lifting sling.

NOTE: CLEAN THE BOTTOM SURFACE OF THE LID, TREATING ALL DEBRIS REMOVED AS CONTAMINATED.

(d) Position the lid over the cask by positioning the cut-out on the lid over the filter plug.

(e) Lower the lid onto the cask.

(f) Remove the crane hook and the lifting sling.

(g) Replace the twenty (20) 3/4-inch bolts on the cask lid. Torque to 160 ± 16 ft lb (120 ± 12 ft lb if lubricated).

6.6 Detach the eyebolts from the cask lid and replace them securely in the storage nuts on the cask base.

6.7 Prepare to replace the cask on the pallet, if necessary.

(a) Attach the three-legged lifting sling to the cask lifting lugs, if necessary.

(b) Attach the crane hook to the lifting sling.

(c) Place the cask on the pallet.

(d) Replace the twelve (12) 1 1/8-inch bolts that secure the cask to the pallet. Torque to 300 ± 30 ft lb (220 ± 22 ft lb if lubricated).

6.8 Detach the cask lifting lugs, if necessary, by unbolting the three (3) lugs and bolting them to the cask gusset.

6.9 Replace the rain cover and tighten the cables that attach the rain cover to the pallet.

6.10 Before the cask leaves the facility, the following shall be confirmed:

(a) That any external lifting lugs or trunnions are properly covered for transport.

(b) That the cask is secured to the trailer in accordance with Section 393.100 of the Federal Motor Carrier Safety Regulations and the Certificate of Compliance.

(c) That trailer placarding and cask labelling meet DOT Specifications (CFR Title 49, Part 172).

(d) That exterior radiation levels do not exceed 10 mR/hr at 6 feet and 2 mR/hr in the tractor cab, in accordance with 49 CFR 173.393 (j).

(e) That the outer package is sealed with anti-tamper seals.

(f) That the drain plug is securely installed and that a lead wire seal is attached.

7.0 UNLOADING PROCEDURE

NOTE: ALL PERSONS HANDLING A FILLED LINER SHALL OBSERVE ALL ESTABLISHED SITE RADIATION PROTECTION PROCEDURES.

7.1 Position the unloading crane at an optimum distance to facilitate off-loading and to minimize exposure.

7.2 Remove the rain cover by loosening the cables that attach the rain cover to the pallet and lifting off the rain cover.

7.3 Attach the eyebolts, stored on the cask base, to the three (3) holes provided on the cask lid.

7.4 Prepare to remove the cask lid.

<u>CAUTION:</u> TREAT THE UNDERSIDE OF THE LID, THE SURFACES OF THE CASK, AND ANY BOLTS OR SEALS REMOVED AS CONTAMINATED.

(a) Remove the twenty (20) 3/4-inch bolts from the cask lid.

(b) Attach a three-point sling to the three (3) eyebolts on the cask lid.

(c) Attach the crane hook to the lifting sling.

(d) Lift the lid straight up off the cask and place it on absorbent material or plastic sheeting.

<u>CAUTION:</u> BE ALERT THAT THE CASK LID GASKET MAY LIFT OFF WITH THE CASK LID.

(e) Remove the crane hook.

7.5 The health physics technician shall conduct a radiation and contamination survey to determine offloading precautions.

7.6 As the health physics technician directs, vacate all persons from the area except for the crane operator and a rigger. The rigger shall stand in clear view of the crane operator.

7.7 Prepare to remove the contents of the cask.

(a) Attach the crane hook to the bail on the liner.

(b) Lift the liner straight up out of the cask and allow any liquid to drip off.

(c) Place the liner in position for disposal or future handling.

(d) Detach the crane hook from the bail on the liner.

7.8 The health physics technician shall survey the interior of the cask for radiation and contamination levels. Decontaminate if acceptable levels are exceeded.

<u>CAUTION:</u> TREAT ANY LIQUID IN THE CASK OR USED IN THE DECONTAMINATION PROCESS AS CONTAMINATED.

7.9 Visually inspect the inside of the cask for damage or liquid accumulation. Remove any liquid. If the inside of the cask is damaged, remove the cask from service.

7.10 Place a new liner in the cask, if required.

NOTE: CLEAN THE LINER BEFORE PLACING IT IN THE CASK. TREAT DEBRIS REMOVED AS CONTAMINATED.

(a) Attach the crane hook to the bail on the liner.

(b) Carefully lower the liner into the cask and remove the crane hook. DO NOT damage the gasket seating surfaces, the sides of the cask, or inner walls.

(c) Ensure that the liner lift bail swings free to allow proper installation of the cask lid.

7.11 Prepare to replace the cask lid.

(a) Visually inspect the lid gasket for cracks or tears. Replace the gasket if it is damaged. Inspect and clean the gasket seating surfaces.

(b) Attach the lifting sling to the three (3) eyebolts on the cask lid.

(c) Attach the crane hook to the lifting sling.

NOTE: CLEAN THE BOTTOM SURFACE OF THE LID, TREATING ALL DEBRIS REMOVED AS CONTAMINATED.

(d) Position the lid over the cask by positioning the cut-out on the lid over the filter plug.

(e) Lower the lid onto the cask.

(f) Remove the crane hook and the lifting sling.

(g) Replace the twenty (20) 3/4-inch bolts on the cask lid. Torque to 160 $\pm$ 16 ft lb (120 $\pm$ 12 ft lb if lubricated).

7.12 Detach the eyebolts from the cask lid and replace them securely in the storage nuts on the cask base.

7.13 Replace the rain cover and tighten the cables that attach the rain cover to the pallet.

7.14 The health physics technician shall survey all exterior surfaces of the cask for contamination and radiation levels. Decontaminate, as required, to meet the limits set forth in Section 173.397 of CFR 49.

7.15 Before the cask leaves the facility, the following shall be confirmed:

(a) That any external lifting lugs or trunnions are properly covered for transport.

(b) That the cask is secured to the trailer in accordance with Section 393.100 of the Federal Motor Carrier Safety Regulations and the Certificate of Compliance.

(c) That trailer placarding and cask labelling meet DOT Specifications (CFR Title 49, Part 172).

(d) That exterior radiation levels do not exceed 10 mR/hr at 6 feet and 2 mR/hr in the tractor cab, in accordance with 49 CFR 173.393 (j).

(e) That the outer package is sealed with anti-tamper seals.

(f) That the drain plug is securely installed and that a lead wire seal is attached.

8.0 REPORTS AND RECORDS

The following reports shall accompany all loaded shipments:

(a) Radioactive Shipping Record (RSR)--prepared by the shipper's health physics department.

(b) Vehicle Radiation Survey--prepared by the shipper's health physics department.

(c) Bill of Lading--prepared and certified by the shipper.

(d) User Check-off Sheet--prepared and signed by the shipper.

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