3.5 Hypothetical Accident Thermal Evaluation

For purposes of analyzing the CNS-3-55 Cask's performance during the hypothetical thermal accident, a transient thermal analysis was conducted. Conditions and assumptions for this investigation included:

1. All the conditions and assumptions named in Section 3.4, Items 1 through 8.
2. The hypothetical fire was modelled as a black body pure radiation source, at 1425°F. 10 CFR Part 71, Appendix B, states that modelling shall be that of a "Standard" fire, in which, "the heat input to the package is not less than that which would result from exposure of the whole package to a radiation environment of 1475°F for 30 minutes with an emissivity coefficient of 0.9, assuming the surfaces of the package have an absorption coefficient of 0.8." Thus, the exterior surface of the package is assumed to possess an emissivity and absorptivity of 0.8. The emissive power of the hypothetical accident source is assumed equivalent to a grey body with an emissivity of 0.9 at a temperature of 1475°F. This is equivalent to a black body source with a temperature of 1474.71°F.

$$T_o = [\varepsilon_o (T_o)^4]^{1/4}$$
$$T_o = [(0.9)(1475 + 459)^4]^{1/4} - 459$$
$$T_o = 1424.71^oF.$$

As part of the initial starting conditions, the cask is allowed to reach steady state conditions under thermal input from solar insolation, and decay heat. When this is achieved, the hypothetical fire is inputted as a purely radiative thermal load onto the external surface of the cask.

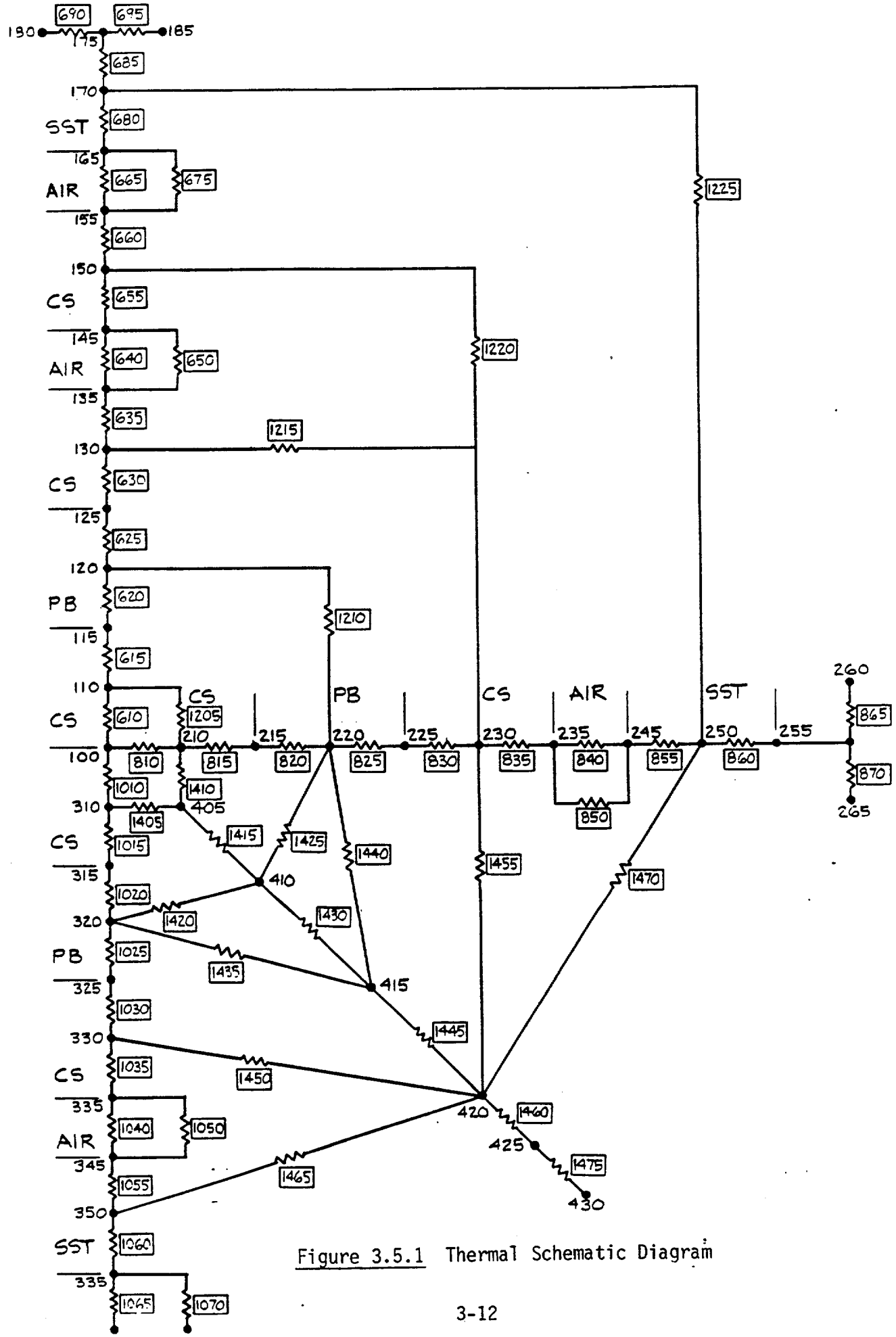


Figure 3.5.1 Thermal Schematic Diagram

It should be noted that because the cask equilibriates into a steady state mode, (under thermal loadings from solar insolation and decay heat), the initial starting temperatures for various regimes of the cask are higher than the outside ambient air temperature (100°F for the transient thermal analysis). For instance the core cavity temperature is 130°F at the beginning of the run, and it rapidly rises after the radiative fire input is imposed on the cask.

3.5.1 Thermal Model

The CNS-3-55 Cask thermal system was modelled by representation of each thermal regime within the cask, in a network of nodes (thermal resistors) and conductances (thermal capacitances). A schematic diagram of this network is shown, as Figure 3.5.1. Node 100 represents the interior cavity of the cask. The lower vertical axis represents the bottom of the cask. The upper vertical axis of the diagram represents the top of the cask; and the horizontal axis represents the cylindrical side shell of the cask. All other axes and connections represent interconnections between side and top or side and bottom. In addition, the two silicone O-ring seals were included in the nodal network; in order that the temperature history of these important items could be seen. These are included in the network as nodes 410, 415 and conductances 1430 and 1445.

3.5.1.1 Computer Program for Modeling Cask Thermal Performance

The MITAS-II computer program is a general purpose thermal analysis package which solves lumped parameter (i.e., resistor - capacitor) network representations of thermal systems. It utilizes a finite difference algorithm, and iterative techniques to solve the heat flow equations.

Primarily a packaged software program, MITAS requires the user to input information concerning the thermal network connections, and program execution constants. Both steady state and transient analyses may be conducted. The user may select a variety of output modes, including temperatures at nodal points, or a summary of heat flows into and out of any node (QMAP). This is quite useful in analyzing a complex network. For transient analysis, time-varying quantities can be shown over incremental values of time. For example, in the case of the hypothetical thermal accident, a complete analysis of the particular thermal state of the cask (including specified components/layers within) was made every fifteen minutes from the time the fire started. A graphical representation of this may be found in Figures 3.5.2 and 3.5.3. These correlate with the numbers given in Section 3.1.2. Once again, note that the start point of these plots is at 130°F, even though the ambient outside air temperature was specified as 100°F. This was because the system was allowed to come up to steady state conditions (due to insolation and decay heats) before the fire thermal load was inputted to the system.

Conduction is the main internal heat transfer mechanism within the cask. The main equation governing this is:

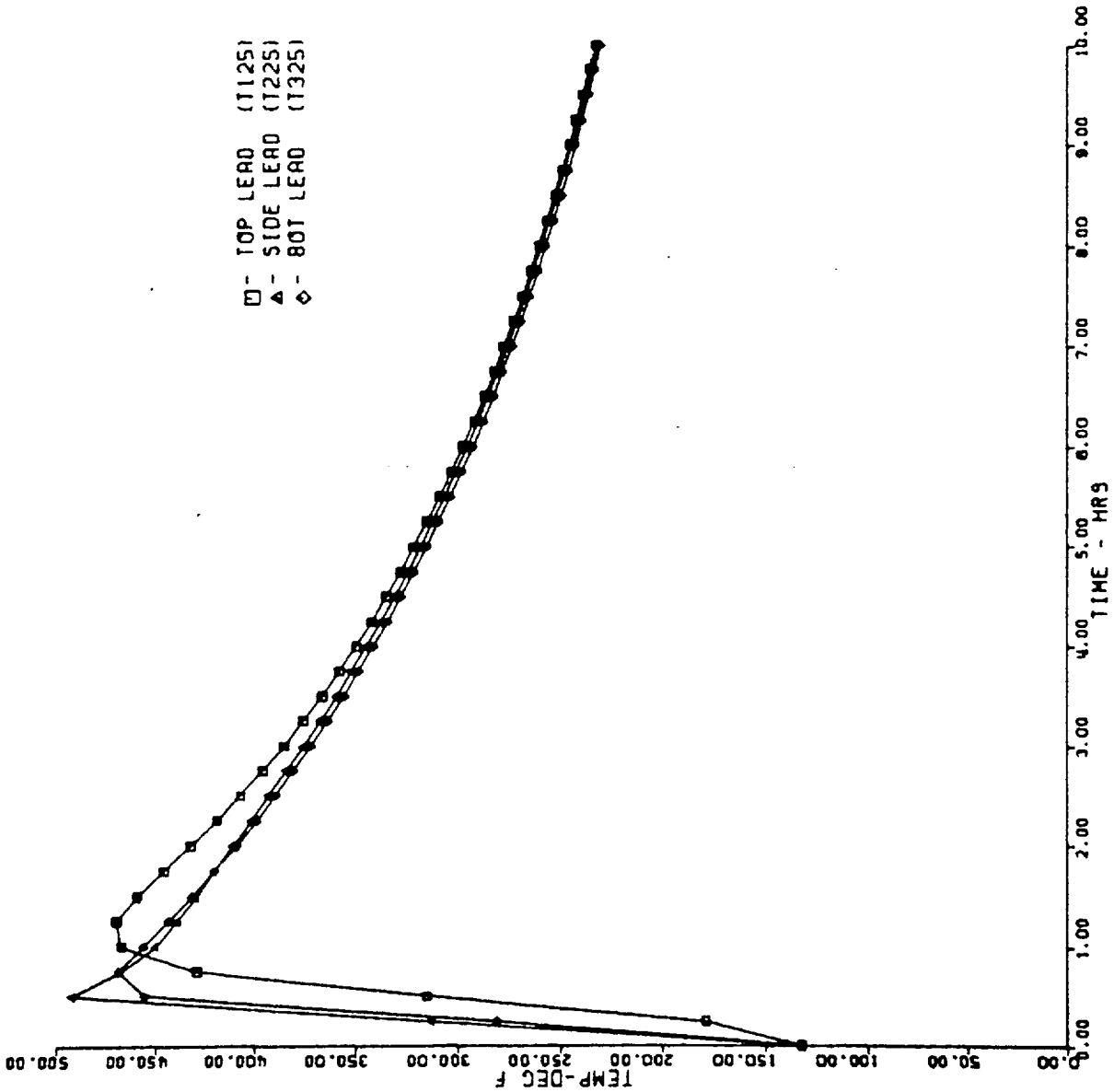


FIGURE 3.5.2 Time/Temperature Plots - Lead Hypothetical Accident

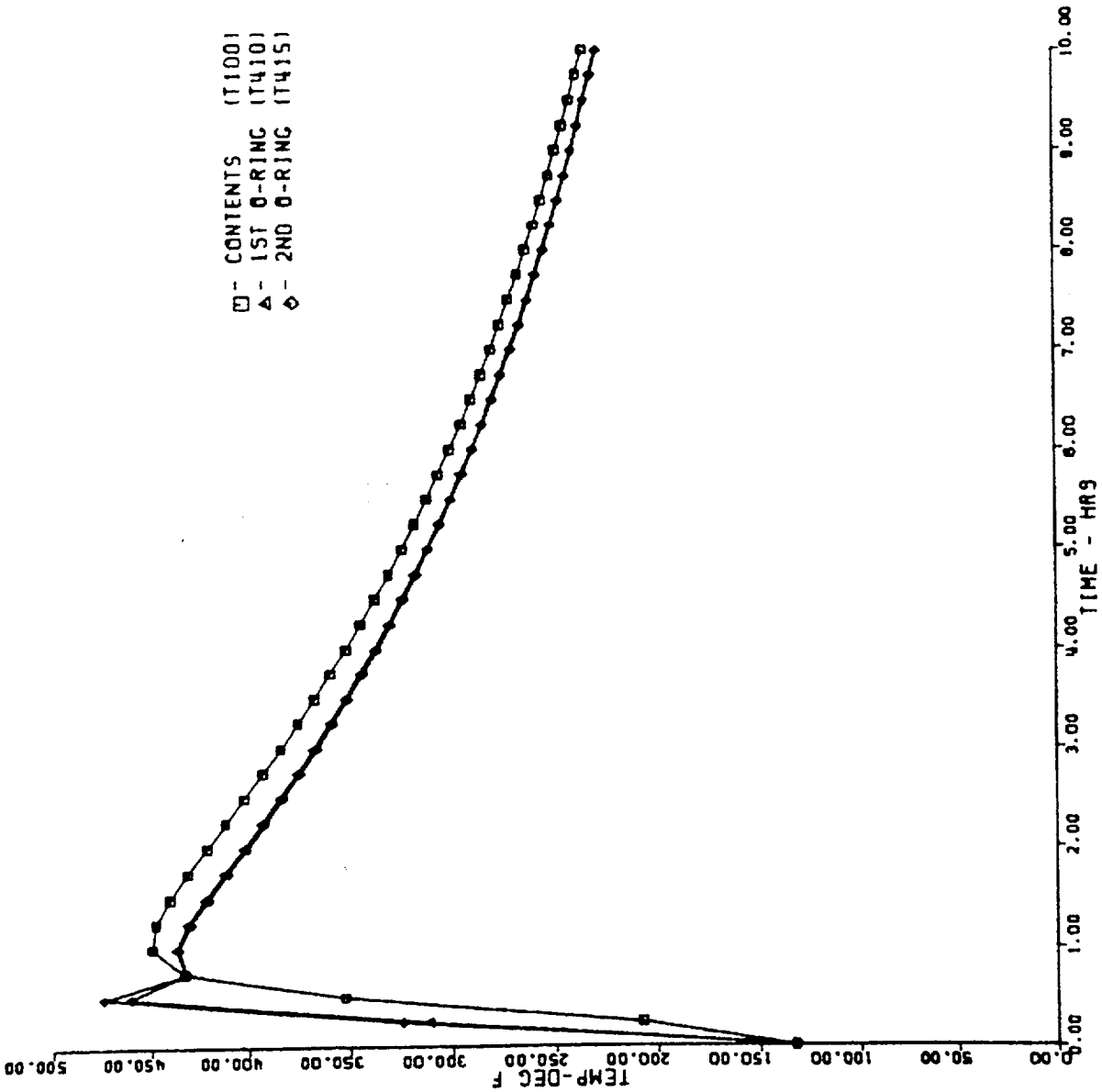


FIGURE 3.5.3 Time/Temperature Plots - Contents and Seals - Hypothetical Accident

3.5.1.1 Computer Program for Modeling ... (continued)

$$Q = \frac{KA}{L}$$

Where:

Q = Heat flow, Btu/hr.

K = Thermal conductivity of material, Btu/hr.-ft.-^{o}F

A = Cross-sectional area (perpendicular to direction of heat flow), ft.^{2}

L = Length (or thickness), ft.

For the computer program input, a normal layer has "A" equal to the area exposed to incoming heat, and "L" as thickness. In the case of interconnections between top and sides, or sides and bottom, "A" was the effective heat transfer area, however, "L" was calculated differently. "L" was the sum of the distance radially, from the centroid of the enclosed cask volume to a mid-point of the material at hand; and the vertical distance from the same centroid to the mid-point of the corresponding material in the top (or bottom). This produces a fairly large conduction length "L", which tends to make the total "Q" smaller. This is conservative, for the cask as a whole, since this assumes almost all heat flowing into (or out of) the cask, goes through the sides, top, or bottom and there is no contributing effect due to interconnections.

3.5.2 Package Conditions and Environment

The discussions of damage resulting from the free drop or puncture tests in 2.7.1.5 and 2.7.2.1 summarize only localized, minor damage to the cask. No damage indicated would reduce the effectiveness of the package performance in the thermal accident.

3.5.3 Package Temperatures

o Hypothetical Thermal Accident Conditions

Temperatures, ^{o}F, Maximum *

Inner Cavity: 449

Lead Shield: 492

First O-ring: 461

Second O-ring: 474

* Includes heating due to solar insolation.

3.5.4 Maximum Internal Pressures

When the cask undergoes the hypothetical thermal accident, the internal pressure will increase, due to volumetric expansion of air with heating; and also due to steam produced from water in the air itself.

The CNS 3-55 cask has an internal volume of 68.3 cubic feet. It is is assumed that 60% of the internal volume is occupied by the payload, a net internal air volume of 27.3 cubic feet is obtained.

(1) Air Expansion Pressure Calculation

Assume air to behave as a perfect gas. For a perfect gas, PV = MRT.

Where:

lbf = pounds force

lbm = pounds mass

P = Pressure, $lbf/ft.^2$

V = Volume, $ft.^3$

M = Mass of Gas, lbm

R = Universal gas constant, normalized to $\frac{ft.\text{-}lbf}{lbm\ ^{o}R}$

T = Temperature, ^{o}R

lbm of air, taken into net volume of cask, upon loading:

$$M = \frac{PV}{RT} = \frac{(14.7)(144)(27.3)}{(53.3)(70 + 460)} = 2.04 \text{ lbm of air.}$$

The internal cavity of the cask reaches a maximum temperature of $449^{o}F$, during the hypothetical thermal accident.

3.5.4 Maximum Internal Pressure (continued)

Internal pressure of air, during 449°F maximum temperature:

$$P = \frac{MRT}{V} = \frac{(2.04)(53.3)(449 + 460)}{27.3} = 3620 \text{ lbf/ft.}^2$$

$$= 25.2 \text{ psia}$$

It is realized that air does not behave entirely as a perfect gas (it will have a certain amount of water present as vapor), however, for the relatively low pressures and temperatures here, it is a reasonably fair assumption.

Note that for the preceding analysis, the amount of volume occupied by the payload has a relatively minor effect on the final outcome of the pressure calculation. If there is no payload inside the cask, more lbm of air are taken in initially, however, there is a larger volume to expand into. To illustrate this, the calculations are worked for two extreme situations:

No Payload in Cask	Payload Occupies 90% of Cask Internal Volume
M = 5.11 lbm Air	M = 0.51 lbm Air
P = 25.2 psia	P = 25.2 psia

2. Pressure increase due to production of steam due to water vapor in air.

Since the cask will be in a water pool upon loading, assume air inside to have a wet-bulb temperature of 70°F. From the psychometric chart, this is found to correspond to 0.016 lbm water/lbm of dry air. Picking the example of no payload within the cask as "Worst Case" (maximum pounds of air taken in):

3.5.4 Maximum Internal Pressures (continued)

$$5.11 \text{ lbm air} \times \frac{0.016 \text{ lbm water}}{\text{lbm air}} = 0.081 \text{ lbm water}$$

However, the loading process implies that there will be water still clinging to the inside surfaces of the cask and payload. In order to account for this, the above figure will be multiplied by <u>five</u>:

.081 lbm water x 5 = .405 lbm water assumed inside of cask

Specific volume of water vapor, which will turn to super-heated steam at 449°F:

$$V = \frac{\text{Volume}}{\text{lbm}} = \frac{68.3 \text{ ft.}^3}{0.405 \text{ lbm}} = 170.75 \text{ ft.}^3/\text{lbm}$$

For T = 449°F
V = 170.75 ft.^{3}/lbm

This corresponds to super-heated steam with a pressure of 4.27 psia (from steam tables).
Pressures with payload volumes of 0%, 60% and 90%:

	0%	60%	90%
Air	5.11 lbm	2.04 lbm	.51 lbm
Water	.405 lbm *	.16 lbm *	.041 lbm *
V	170.75 ft.^{3}/lbm	167.3 ft.^{3}/lbm	176.4 ft.^{3}/lbm
P	4.27 psia	4.3 psia	4.3 psia

* Includes 5 x factor.

In addition to the factor of 5 in figuring the amount of water present, this analysis is conservative since 70°F (wet-bulb) air was assumed. In the actual wet loading temperature situation, the water temperature (and overall cask temperature) would probably be 40 - 50°F; air at this temperature would have a significantly lower amount of water in it, when compared with 70°F air.

3.5.4 Maximum Internal Pressures (continued)

3. Internal Pressures - Summary

Pressure, air expansion -	25.1 psia
Pressure, residual water - turning to steam	4.2 psia
TOTAL	29.3 psia

29.4 psia = 14.6 psig.

3.5.5 Maximum Thermal Stresses

The maximum thermal stresses from the hypothetical accidental fire are evaluated in Section 2.7.3.

3.5.6 Evaluation of Package Performance for Hypothetical Accident Thermal Conditions

The results of the thermal accident analysis demonstrate that the package including seals will survive the thermal accident, since maximum predicted temperatures are consistent with the allowables for all materials.

3.5.6.1 Performance Evaluation of Cask Closure Seals

The temperature of the two silicone rubber seals on the primary cover was determined in order to assess the effect of the hypothetical fire on their ability to maintain a seal. The two silicone rubber seals are situated more than 4 inches in from the periphery of the cask. In this location they are thermally isolated from the end by several steel plates and a lead layer.

3.5.6.1 Performance Evaluation of Closure Seals (continued)

The following estimate of seal life is based on the maximum temperatures in Figure 3.5.3 for the second O-ring.

A curve relating temperature limits of the seal material with exposure time is taken from manufacturer literature (Parker Seal Company - Seal Compound Manual). (Reference Appendix 3.6.1.) At a maximum temperature of 474°F, the silicone seal has a seal life of approximately 40 hours at this temperature.

3.5.6.2 Performance Evaluation of Cask Drain and Vent

The thermal performance of the drain vent valve and vent plug (in center of cask top) will be adequate when subjected to fire test conditions. The drain line will be sealed with a vent valve designed to relieve at a pressure of 25 psig. (Reference Appendix 3.6.3.)

The vent assembly in the center of the cask top consists of a lead filled steel plug insert in the vent opening and a 1-1/2 inch thick plate bolted to the top to secure the plug insert. A flat gasket of Tauril packing material by Anchor Packing Company will be used to seal the vent plate to the cask body. This super service gasket is intended for super heat and high pressures with continuous temperatures to 800°F. This material will provide a satisfactory seal under the fire test conditions. (Reference Appendix 3.6.2.)

3.6 Appendix

3.6.1 "Seal Life at Temperature" Parker Seal Company - Seal Compound Manual, Figure 6-4.

3.6.2 Anchor Sheet Packing for Gaskets "Tauril" Super Service Sheet Packing.

3.6.3 Circle Seal Relief Valves, 500 Series, Popoff, Inline, 5-150 psi.

3.6.4 "Abstract - MITAS-II-NOS-FIN Version, Thermal Analysis System.

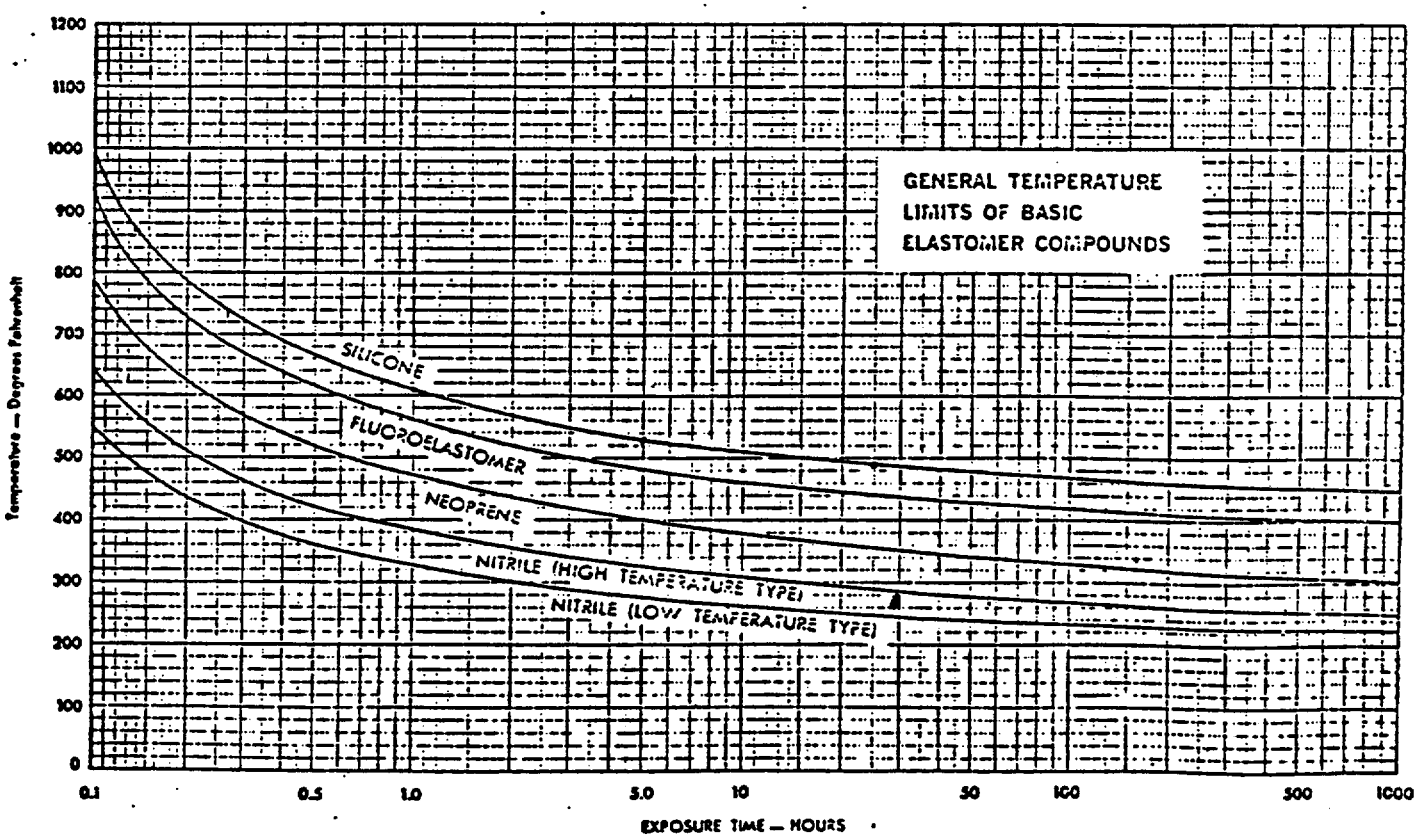
TIME

With the introduction of . _ Seal Compound Manual, Parker is introducing the fourth dimension in sealing: TIME. The other three dimensions—Media, Pressure, and Temperature—have been discussed previously.

Heretofore temperature limits, both high and low, have been published at conventional short term test temperatures. These have little bearing on the actual long term service of the seal in either static or dynamic applications. A comparison of the temperature limits of individual compounds in this Manual with previous Parker literature will reveal that the upper temperature limit has been lowered on some compounds and the lower temperature limit raised on many more. The narrower temperature range does not imply that the materials are no longer as good as formerly indicated, but rather, that high temperature values based on continuous seal reliability for 1,000 hours are being recommended. As il' trated by the graph (Fig. 6-4), short term or intermitten. .ervice at higher temperatures can be handled by these materials.

For example, an industrial Nitrile (Buna N) compound, N219-7, is recommended to only 250°F, yet it has been known to seal satisfactorily for five minutes at 1000° F (538°C) and at 300°F (149°C) for 300 hours. Therefore, when the application requires a temperature higher than that recommended in the compound and media tables, check the temperature curve to determine if the total accumulated time at high temperature is within the maximum allowable limit.

The sealing ability of a compound deteriorates with total accumulated time at temperature. The curve shows the safe, cumulative time at a given temperature for specific compounds used as static seals. For dynamic seal applications, use temperatures 25°F (14°C) below the high temperature ratings of all compounds.



This chart is intended only as a rough guide. It cannot be used for precise predictions of seal life. Results will vary with compound and fluid medium.

Figure 6-4 Seal Life at Temperature

APPENDIX 3.6.2

Anchor Sheet Packing for Gaskets

Every Material—Every Construction

The Anchor line of sheet packing comprises every material and construction suitable for the making of gaskets. To meet the sealing requirements of every fluid, every gas at temperatures from cryogenic to superheat; with working pressures to the highest employed by any industry, necessitates an unlimited variety of sheet formulations and constructions. It is logical that Anchor, whose business is devoted exclusively to supplying products for every packing and sealing requirement of all industry, should offer this unlimited range of sheet packing. Every item listed has proved itself under the severest conditions imposed by the service for which it was designed. You buy direct from Anchor—strategically nationally located branches are manned by packing experts who are always ready to assist users in selecting the most efficient packing, with economy for their particular service needs

"TAURIL"

REG. U. S. PAT. OFF.

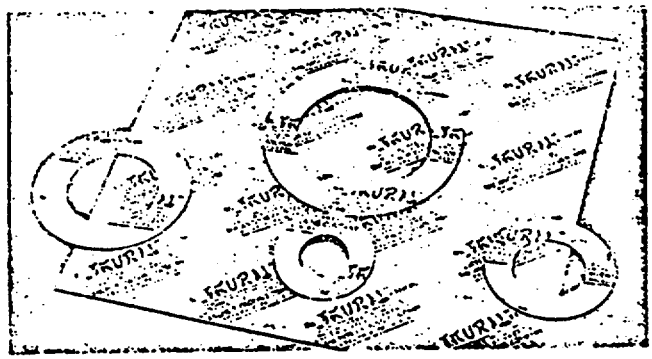
SUPER SERVICE SHEET PACKING

for High Pressures and Temperatures

Description: This top quality sheet is approved by the Underwriters Laboratories and meets ASTM Specification 1161-A. Tauril is made from long fiber asbestos, thoroughly impregnated with (SBR) binder, pressure bonded and vulcanized into a dense sheet of uniform thickness and surface finish. Special processing produces a strong, tough gasket material preferred by engineers for its long life and superior resistance to superheat and high pressures

Uses: For temperatures to 800° F.

Sizes: Sheets 50" x 50"; 50" x 150"; in thicknesses of 1/64", 1/32", 1/16", 3/32" and 1/8"



TARGET

REG. U. S. PAT. OFF.

FOR SEVERE SERVICE

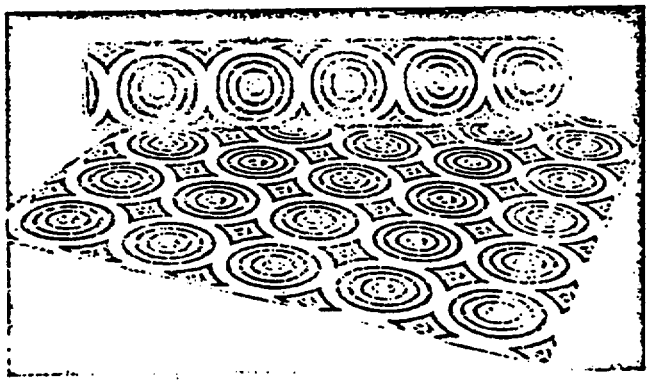
Description: This compressed asbestos fiber sheet, bonded with Buna N (NBR) is approved by the Underwriters Laboratories; meets the following specifications: MIL G 12803A; ASTM 1170 P1141A; AMS 3232. A heat-resisting synthetic impregnation provides immunity to the action of oil and many petroleum solvents. Gaskets made from Target withstand the severest conditions imposed on a compressed gasket

Uses: For chemical and acid services where oil or solvents might be harmful to gaskets containing natural rubber; against fuels, oils, refrigerants, aromatics. Temperatures: −80° F. to +800° F.

Sizes: 50" x 50"; 60" x 60"; 50" x 150"; 60" x 120"; thicknesses 1/64", 1/32", 1/16", 3/32", 1/8"

Approximate Weights per 50" x 50" Sheet

1/64"—2-1/2 pounds • 1/32"—5 pounds • 1/16"—10 pounds
3/32"—15 pounds • 1/8"—20 pounds



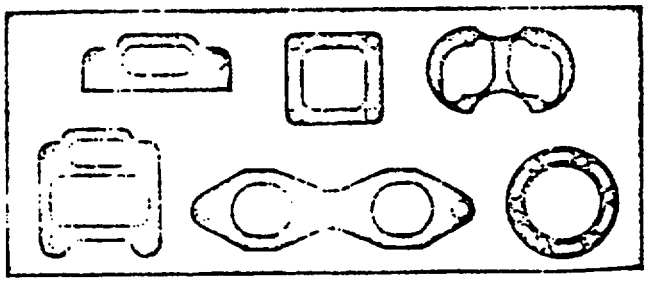
TWICOM

Compressed Asbestos, SBR Binder

Description: Compressed asbestos, SBR binder, with close-mesh, steel wire gauze reinforcement, graphited both sides. Available on special order only

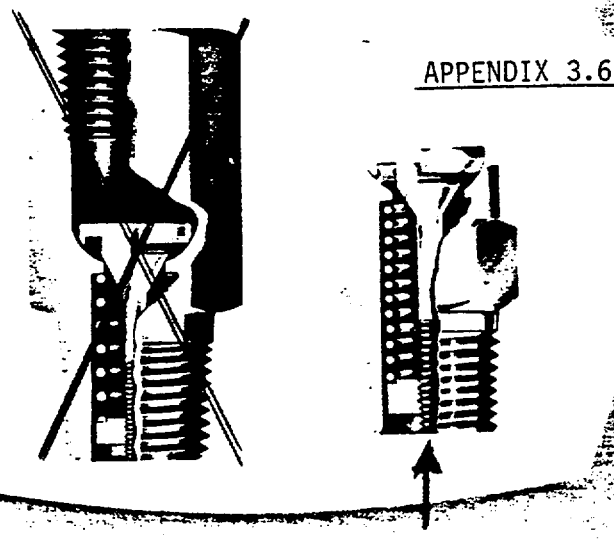
Uses: For rugged service gaskets, any purpose

Sizes: 1/64", 1/32", and 1/8" thick; sheets, 59" x 40" and 59" x 80"



Tauril, Target and Twicom Gaskets are available in any size and shape to your drawings

APPENDIX 3.6.3



CIRCLE SEAL

precision valves

RELIEF VALVES

500 Series

Popoff, inline

.5-150 PSI

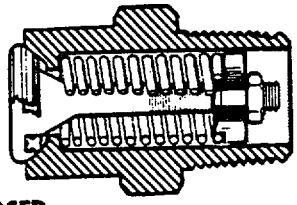
Wherever perfect sealing is required, the proven reliability of CIRCLE SEAL precision valves provides the one complete answer: a combination of absolute leak proof sealing when closed and virtually maintenance-free operation.

PURPOSE: To provide small, lightweight, reliable relief valves which are bubble tight at normal operating pressures, crack accurately and repeatedly at preset pressure to pass adequate flow with minimum pressure rise.

OPERATING CHARACTERISTICS:

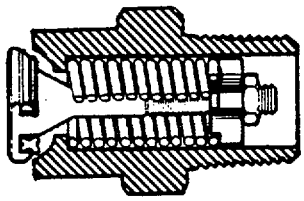
- **ZERO LEAKAGE** to 95-98% of cracking pressure.
- **INCREASED SEALING EFFICIENCY** as pressure increases. Resilient "Q" ring seal is forced against metal seat as pressure increases up to set cracking pressure.
- **CRACKING PRESSURE ACCURACY** — Valves can be preset to required cracking pressure.
- **WIDE RANGE** of cracking pressures, without sacrificing flow characteristics, provided through interchangeable springs and simple adjustment. (See replacement springs and adjusting information.)
- **TAMPER-PROOF ADJUSTMENT** — Adjustable only from inlet side for safety against tampering. Permits precise setting for the most exacting system requirements.
- **STICKING ELIMINATED** — Poppet head provides metal seat on low pressure side of seal, limits squeeze on resilient seal ring. Prevents water and dirt from entering valve.
- **LONG, MAINTENANCE-FREE SERVICE** — Parts will not wear out in normal service. Overhaul, if necessary, is quickly made by replacing resilient seal.

HOW IT WORKS



CLOSED

Resilient seal design prevents leakage. Sealing efficiency *increases* with increased pressure up to cracking pressure. Metal to metal seat on low pressure side supports spring load, prevents sticking.



OPEN

When system pressure overcomes spring force poppet opens momentarily exposing variable orifice between poppet and body to pass increasing flow with minimum pressure rise without blowdown.

RESEALING

Resilient seal automatically establishes line of contact with spherical seat. Seal provides dead tight reseal very close to cracking pressure.

CIRCLE SEAL PRODUCTS
Division Circle Seal Corporation
POST OFFICE BOX 3666
ANAHEIM • CALIFORNIA • 92803

Printed in U.S.A.
Representatives in Principal Cities
Form 6S-2145 6/73

CIRCLE SEAL

precision valves

RELIEF VALVES 500 Series

Popoff, inline .5-150 PSI

SERVICE RECOMMENDATIONS

MODEL NUMBER	O-RING MATERIAL	OPERATING TEMPERATURE	SUITABLE FOR
~~559~~	~~Buna N~~	~~−40° to +250°F~~	~~General Purpose, Air, Acetylene, Ammonia, Freon 12, Hydrogen, Inert Gases~~
533	Neoprene	−40° to +250°F	Oxygen, Helium, Air, Hydrogen Carbon Dioxide, Nitrogen, Acetylene
~~562~~	~~Ethylene Propylene~~	~~−65° to +300°F~~	~~Skydrol, Air, Steam~~
~~532~~	~~Viton~~	~~−20° to +400°F~~	~~Aromatic Fuels, Synthetic Oils, Solvents, Carbon Tetrachloride, Toluene, Trichloroethylene. Steam.~~
~~524~~	~~Silicone~~	~~−70° to +450°F~~	~~Air, Chlorinated Transformer Oil, Oxygen~~
520	Teflon	−100° to +450°F	Chemically inert, suitable for nearly all fluids. Not available for cracking pressures below 2.5 PSI.

TECHNICAL DATA

MATERIAL: Body and internal parts — bar stock

SPRING: Stainless steel 302 or 17-7PH

RESILIENT SEAL: See service recommendations

OPERATING PRESSURE: 0-200 PSI

CRACKING PRESSURE: .5-150 PSI
Higher cracking pressures available — please check with factory.

ADJUSTMENT: ±50% of nominal. Adjustment is on inlet side, and cannot be tampered with after valve is installed.

CRACKING PRESSURE ACCURACY: Operating tolerance for cracking pressure is 5%. Initial crack may be slightly higher than cracking pressure tolerance.

RESEAT AND RESEAL: See Cracking Pressure-Reseal Chart for characteristics of each seal.

D Prefixed Model Number denotes DEFLECTOR CAP. These models are supplied with a cap which diverts high pressure blasts from personnel and instruments. Serves as a rain and dust shield. Increases flow capacity and facilitates manual override.

THE D500 MODEL WITH DEFLECTOR CAP IS AVAILABLE ONLY IN THE DISCHARGE TO ATMOSPHERE VERSION OF THE VALVE. NOT RECOMMENDED FOR CRACKING PRESSURES BELOW 2 PSI.

HOW TO ORDER

Part Number Designation

D520T-6M-25

D559A-6MP-10

- VARIATION IDENTIFICATION
- BASIC MODEL NUMBER
- MATERIAL
- END CONNECTIONS — INLET/OUTLET
- CRACKING PRESSURE

(cracking pressure is defined as 5 cc/min. with gas)

Note: Valves are preset at factory. Pressure at which valves will crack in normal service, nominal cracking pressure ±5%. SEE CRACKING PRESSURE-RESEAL CHART.

MATERIAL

A Aluminum
B Brass
T Stainless, 303
T_1 Stainless, 316

CONNECTIONS

(size in ⅛")
M Male pipe
P Female pipe

NOMINAL CRACKING PRESSURE INFORMATION

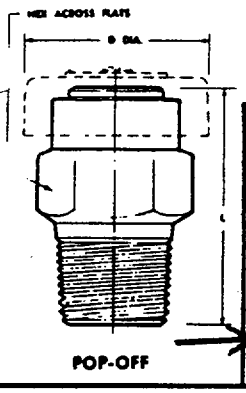
NOMINAL C.P.	RANGE	RESEAL DEAD TIGHT % OF C.P. @ ROOM TEMP.
1	0.5-2.4	50-70%
4	2.5-5.9	70-85%
10	6.0-13.9	88%
20	14-28	90%
50	29-72	92%
100	73-150	94%

* FACTORY SET @ 25 PSI

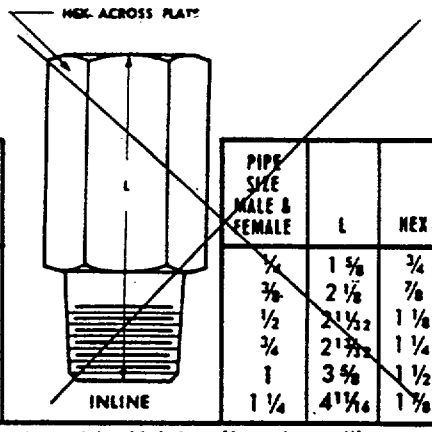
CIRCLE SEAL PRODUCTS
Division of Circle Seal Corporation
POST OFFICE BOX 3666
ANAHEIM • CALIFORNIA • 92803

Printed in U.S.A.
Representatives in Principal Cities

DIMENSIONS



PIPE SIZE MALE	L	HEX	D DIA.
1/8	1	1/2	.62
1/4	1 3/16	5/8	.89
3/8	1 1/4	3/4	1.20
1/2	1 3/4	1	1.44
3/4	2 1/16	1 1/8	1.87
1	1 1/2	2 13/16	1.87



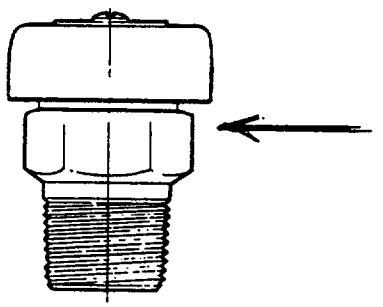
PIPE SIZE MALE & FEMALE	L	HEX.
1/4	1 5/8	3/4
3/8	2 1/8	7/8
1/2	2 11/32	1 1/8
3/4	2 13/32	1 1/4
1	3 5/8	1 1/2
1 1/4	4 11/16	1 7/8

Complete part number must include Cracking Pressure — denoted by ** below. If exact presetting not required, use appropriate Nominal C.P. followed by word (Nominal).

MATERIAL AND STYLE		SIZE	MODEL NUMBER 559	533	532	524
ALUMINUM	POPOFF	1/8	559A-1M-**	533A-1M-**	532A-1M-**	524A-1M-**
		1/4	559A-2M-**	533A-2M-**	532A-2M-**	524A-2M-**
		3/8	559A-3M-**	533A-3M-**	532A-3M-**	524A-3M-**
		1/2	559A-4M-**	533A-4M-**	532A-4M-**	524A-4M-**
		3/4	559A-6M-**	533A-6M-**	532A-6M-**	524A-6M-**
		1	559A-8M-**	533A-8M-**	532A-8M-**	524A-8M-**
	INLINE	1/4	559A-2MP-**	533A-2MP-**	532A-2MP-**	524A-2MP-**
BRASS	POPOFF	1/8	559B-1M-**	533B-1M-**	532B-1M-**	524B-1M-**
		1/4	559B-2M-**	533B-2M-**	532B-2M-**	524B-2M-**
		3/8	559B-3M-**	533B-3M-**	532B-3M-**	524B-3M-**
		1/2	559B-4M-**	533B-4M-**	532B-4M-**	524B-4M-**
		3/4	559B-6M-**	533B-6M-**	532B-6M-**	524B-6M-**
		1	559B-8M-**	533B-8M-**	532B-8M-**	524B-8M-**
	INLINE	1/4	559B-2MP-**	533B-2MP-**	532B-2MP-**	524B-2MP-**
		3/8	559B-3MP-**	533B-3MP-**	532B-3MP-**	524B-3MP-**
		1/2	559B-4MP-**	533B-4MP-**	532B-4MP-**	524B-4MP-**
		3/4	559B-6MP-**	533B-6MP-**	532B-6MP-**	524B-6MP-**
		1	559B-8MP-**	533B-8MP-**	532B-8MP-**	524B-8MP-**
		1 1/4	559B-10MP-**	533B-10MP-**	532B-10MP-**	524B-10MP-**
303 S.S.	POPOFF	1/8	559T-1M-**	533T-1M-**	532T-1M-**	524T-1M-**
		1/4	559T-2M-**	533T-2M-**	532T-2M-**	524T-2M-**
		3/8	559T-3M-**	533T-3M-**	532T-3M-**	524T-3M-**
		1/2	559T-4M-**	533T-4M-**	532T-4M-**	524T-4M-**
		3/4	559T-6M-**	533T-6M-**	532T-6M-**	524T-6M-**
		1	559T-8M-**	533T-8M-**	532T-8M-**	524T-8M-**
	INLINE	1/4	559T-2MP-**	533T-2MP-**	532T-2MP-**	524T-2MP-**
		1/2	559T-4MP-**	533T-4MP-**	532T-4MP-**	524T-4MP-**
		3/4	559T-6MP-**	533T-6MP-**	532T-6MP-**	524T-6MP-**
316 S.S.	POPOFF	1/4	559T1-2M-**	533T1-2M-**	532T1-2M-**	524T1-2M-**
		1/2	559T1-4M-**	533T1-4M-**	532T1-4M-**	524T1-4M-**
		3/4	559T1-6M-**	533T1-6M-**	532T1-6M-**	524T1-6M-**
		1	559T1-8M-**	533T1-8M-**	532T1-8M-**	524T1-8M-**
	INLINE	1/4	559T1-2MP-**	533T1-2MP-**	532T1-2MP-**	524T1-2MP-**

MATERIAL AND STYLE	SIZE	MODEL NUMBER D559	D532
ALUMINUM	1/4	D559A-1M-**	D532A-1M-**
	1/4	D559A-2M-**	D532A-2M-**
	3/8	D559A-3M-**	D532A-3M-**
	1/2	D559A-4M-**	D532A-4M-**
	3/4	D559A-6M-**	D532A-6M-**
BRASS	1/4	D559B-1M-**	D532B-1M-**
	1/4	D559B-2M-**	D532B-2M-**
	3/8	D559B-3M-**	D532B-3M-**
	1/2	D559B-4M-**	D532B-4M-**
	3/4	D559B-6M-**	D532B-6M-**

For ASME code valve currently available in 1/4 inch size in either aluminum or brass, add ASME after valve number.



REPLACEMENT SPRINGS*

RANGE	1M/2MP	2M/3MP	3M/4MP	4M/6MP	6M
0.5-2.5	10182-1	10262-1	10362-1	10462-1	10662-1
2.0-6.0	10182-4	10262-4	10362-4	10462-4	10662-4
.0-15.0	10182-10	10262-10	10362-10	10462-10	10662-10
-30	10182-20	10262-20	10362-20	10462-20	10662-20
-75	10182-50	10262-50	10362-50	10462-50	10662-50
0-150	10182-100PH	10262-100PH	10362-100PH	10462-100PH	10662-100PH

* Springs for each valve size are interchangeable. The Cracking Pressure range can be changed by replacing the spring with one covering the desired range.

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APPENDIX 3.6.4

ABSTRACT

The Martin Marietta Interactive Thermal Analysis System, MITAS-II-NOS-FTN Version, is a general software system designed to solve, primarily, lumped parameter, i.e., resistor-capacitor (R-C), network representations of thermal systems. With due attention to thermal peculiarities of library routines and appropriate units, MITAS-II is fully capable of solving lumped-parameter representations of any physical problem described by diffusion-type equations using finite-difference, thermal analogue methods. In addition, MITAS-II can be used as a general purpose program with utilization of its array and constant capability along with library or user subroutines by simply ignoring the network definition inputs.

MITAS-II is an extensively updated version of MITAS-I and CINDA-3G thermal analyzer programs. It can be used to solve small or large problems with "floating" core memory requirements and significant user input logic capabilities. Maximum network size is 4,000 nodal areas, 16,000 unique conductors and 1,024 input arrays. MITAS-II also has extensive edit and restart capabilities for extended or parametric case runs.

This MITAS-II version has been converted to Fortran Extended and operates using the NOS operating system.

4.0 CONTAINMENT

4.1 Containment Boundary

4.1.1 Containment Vessel

The cask inner liner shell is considered to be the package containment vessel, together with the closure (lid) seals and closure bolts. This shell consists of a right circular cylinder of 36 inches inner diameter and 111.125 in. inner height. This shell is fabricated of 0.250 inch thick carbon steel clad with 20% T-304 stainless steel on the inner (cavity) side.

At the closed (top) end of the cask, the cylindrical shell is welded to a circular end plate 0.50 inch thick of carbon steel clad with 20% T-304 stainless steel on the inner (cavity) side.

At the closure (bottom) end of the cask, the cylindrical sheel is welded to a 1.250 inch thick T-304 stainless steel ring plate, which forms the sealing surface for the two O-ring seals in the closure (lid) assembly.

The facing flange plate of the closure (lid) assembly is a 1.00 inch thick T-304 stainless steel ring plate with two O-ring grooves holding two 0.375 inch diameter O-rings. The stepped, inner surface of the closure assembly is made up of a 0.50 inch thick ring welded to a 0.625 inch thick circular plate, both of T-304 stainless steel.

The closure assembly is attached to the cask body by (12) 1.50 inch diameter bolts equally spaced around the facing flange plate.

4.1.2 Containment Penetrations

There are two vent/drain penetrations of the containment vessel. A cask vent hole made up of a 1.25 inch, Schedule 40, stainless steel pipe penetrates the center of the closed end of the cask. The pipe inner end is welded to the 0.50 inch cavity liner plate and to a 0.75 inch plate back-up ring. The pipe outer end is welded to the two inner layers of 0.50 inch and 0.625 inch steel plates of the outer shell.

The vent hole is closed by a 6.00 inch long, lead-filled, 1.00 inch Schedule 40 pipe welded to a 1.50 inch thick by 7.375 inch. O.D. cover plate. This stainless steel cover plate is sealed with a 1/8 inch thick sheet gasket. The vent hole plug assembly is fastened to the outer shell of the cask with four 0.50 inch by 2.00 inch long bolts.

The cask closure (lid) assembly contains a drain pipe leading from the drain sump, consisting of a 0.75 inch, Schedule 40 stainless steel pipe welded to the 0.250 inch stainless steel drain sump liner plate. The drain pipe then leads out through the side of the lower outside ring of the closure assembly, penetrating through this outside 0.50 inch plate. The end of this drain pipe is closed by a 0.750 inch threaded relief valve.

4.1.3 Welds and Seals

The containment vessel components are all joined by full penetration groove welds and fillet welds, all designed and fabricated to ASME Code procedures by code qualified welders.

The closure (lid) assembly includes two 0.375 inch diameter O-rings of silicone contained in two separate grooves providing a double seal for the cask opening. The closure assembly drain pipe is sealed by a 0.750 inch NPTF threaded relief valve.

4.1.3 (continued)

The closed end of the cask vent plug assembly contains a 1/8-inch thick gasket of Anchor "Tauril" sheet packing to provide the seal for the vent plug assembly.

4.1.4 Closure

The cask closure assembly has a tapered sidewall penetrating into the inside diameter of the cask cavity which centers the closure with a close fit with less clearance than the closure bolts-to-bolt hole clearances.

The closure assembly is secured to the cask body assembly by (12) 1.50-inch diameter bolts, equally spaced, around the assembly flange and the cask retaining flange. These bolts are fabricated of AISI-4140 chrome-moly steel, 160,000 pounds U.T.S. These bolts are torqued to 75 ft./lbs. (lubricated). Eight bolts are threaded 1-1/2- 8 UNC and four bolts, 1-1/2- 6 UN.

4.2 Requirements for Normal Conditions of Transport

4.2.1 Release of Radioactive Material

The CNS 3-55 cask is designed to assure no release of radioactive material in excess of limits prescribed in the NRC Regulatory Guide 7.4, "Leakage Tests on Packages for the Shipment of Radioactive Materials."

Table 4.2.1 shows the radiological limitations on a releasable medium that could transport radioactivity through leaks, if any exist, in the containment system. Appendix 4.4 summarizes the derivation of the limits given in the table. Provided these limits are not exceeded, compliance of the CNS 3-55 package with the requirements of NRC Regulatory Guide 7.4 is assured. In accordance with Regulatory Position, Paragraph C of this

guide, compliance with the requirements of 10 CFR 71 for "no release of radioactive material from the containment vessel" is demonstrated.

Table 4.2.1

LIMITATIONS ON RELEASABLE CASK CONTENTS

Content Description	Surface Contamination Limits (dpm per 100 cm^2)
Known Radionuclides	$A^*_2/N^{**} \times 1.02 \times 10^7$
Mixture of Unknown Radionuclides (no alpha emitters)	$\frac{4.08 \times 10^6}{N}$
Mixture of Unknown Radionuclides (including alpha)	$\frac{2.04 \times 10^4}{N}$

*A_2 Value in curies as specified in 10 CFR Part 71, Appendix A.
**N = Total number of square meters of surface area for cask contents.

4.2.2 Pressurization of Containment Vessel

Section 3.4 identifies normal condition temperatures and pressures within the containment vessel. The predicted pressure value assumes a sufficient quantity of free water is present, thus, all prssure calculations are based upon the properties of saturated water. These conservative predictions or pressure and associated temperatures are used to evaluate integrity of the CNS 3-55 package. None of these conditions reduce the effectiveness of the package containment.

4.2.3 Coolant Contamination

Not applicable. There are no coolants involved in the CNS 3-55 Cask.

4.2.4 Coolant Loss

Not applicable. See 4.2.3 above.

4.3 Containment Requirements for the Hypothetical Accident Conditions

Section 2.7.5 covers accident condition damages to the CNS 3-55. Although the cask structure remains intact, it is stated that the O-ring closure seal will probably leak gases due to localized deformation of the closure flange. Based on such a risk of a release under accident conditions, no integrity will be assumed for the containment of the releasable portion of the cask contents. Table 4.3.1 gives the limits that must be complied with. These limits assure that no more than the tabulated value of material can be released from the containment. This complies with the NRC Regulatory Guide 7.4 limit of A_2 per week for a B(u) type package.

-Continued on Following Page-

Table 4.3.1

LIMITATIONS ON CASK CONTENTS CONTAMINATION ASSUMED AVAILABLE FOR RELEASE UNDER ACCIDENT CONDITIONS

Content Description	Surface Contamination Limits (dpm per 100 cm^2)
Known Radionuclides	$A^*_2/N^{**} \times 2.22 \times 10^9$
Mixture of Unknown Radionuclides (no alpha emitters)	$\frac{8.88 \times 10^8}{N}$
Mixture of Unknown Radionuclides (including alpha)	$\frac{4.44 \times 10^6}{N}$

4.4 APPENDIX - Normal and Accident Radioactive Material Release Limits for the CNS 3-55 Cask

Figures 4.2.1 and 4.3.1 define limits for cask contents surface contamination to assure no more activity be released than defined in Paragraph 5.3.2 of ANSI Standard N14.5-1977. For the CNS 3-55 package the medium is assumed to be a small quantity of residual water in the vapor phase along with the air inside the cask cavity.

A soap bubble leak test as outlined in Paragraph A3.3 of Appendix A of the ANSI Standard is used to verify a maximum leakage rate of 10^{-3} cm^3/sec (ANSI N14.5, Table A1).

Normal Transport Limits

Using the calculational methods from ANSI Standard N14.5-1977,

$$L_N = \frac{R_N}{C_N}$$

where: L_N = Permissible leakage rate, cm^3/sec

R_N = Regulatory Limit (Table 1 of ANSI N14.5)

C_N = Activity of Medium

$$L_N = 2 \times 10^{-3} \frac{atm\text{-}cm^3}{sec}$$

$$R_N = (2.78 \times 10^{-10}) \times A_2 \quad Ci/sec$$

Therefore,

$$C_N = \frac{R_N}{L_N} = \frac{(2.78 \times 10^{-10}) \times A_2}{1 \times 10^{-3}} \frac{Ci}{cm^3} =$$

$$(1.39 \times 10^{-1})(A_2) \frac{Ci}{m^3}$$

As the volume of the CNS 3-55 cask is 55 ft^3 = 1.65 m^3, the total releasable material limit for the 3-55 is:

$$(1.65)(2.78 \times 10^{-1})(A_2) = (0.46)(A_2) \text{ Ci.}$$

Regulation 10 CFR Part 71, Appendix A.II gives values of A_2 for unknown nuclide mixtures with or without alpha emitters as 0.002 Ci and 0.4 Ci respectively.

Therefore, the CNS 3-55 cask can carry a releasable 0.18 Ci of mixed unknown nuclides with no alpha emitters and 0.0009 with alpha emitters and be in compliance with NRC Regulatory Guide 7.4. These amounts have been converted to surface contamination limits and listed in Table 4.2.1. The surface limits were derived as follows:

From the above calculation,

Releasable activity = 0.46 A_2 Ci

Converting Ci to dpm, (disintegrations per minute)

$$A_2 \times 0.46 \text{ Ci} \times 1000 \frac{\text{mCi}}{\text{Ci}} \times 2.22 \times 10^9 \frac{\text{dpm}}{\text{mCi}} =$$

$$A_2 \times 1.02 \times 10^{12} \text{dpm}$$

This will be spread over N meters of contents surface area. As contamination limits are normally expressed in dpm/100 cm^2, the total surface contamination can be expressed as:

$$\frac{A_2 \times 1.02 \times 10^{10} \frac{\text{dpm}}{100 \text{ cm}^2} \times \text{m}^2}{\text{Nm}^2} =$$

$$\frac{A_2}{N} \times 1.02 \times 10^{10} \frac{\text{dpm}}{100 \text{ cm}^2}$$

Accident Condition Limits

From ANSI N14.5 and 10 CFR Part 71.51, Type B packages must limit releases under accident conditions of transport to one A_2 value per week. This amounts to 0.4 Ci/week for a mixture of unknown nuclides with no alpha emitters and 0.002 Ci/week for mixtures with alpha emitters. As the integrity of gasket seals is not verifiable under accident conditions and a quantitative leakage rate is not available, it is assumed that the total surface contamination quantity will be released within the one week period after the accident.

The allowable surface contamination limits in dpm per 100 cm^2 are given in Table 4.3.1. The table was generated as follows:

$$\frac{A_2 \text{ Ci}}{\text{week}} \times 1000 \frac{\text{mCi}}{\text{Ci}} \times 2.22 \times 10^9 \frac{\text{dpm}}{\text{mCi}} =$$

$$\frac{A_2}{N} \times 2.22 \times 10^{12} \frac{\text{dpm}}{\text{week}}$$

Again, the activity will be spread over N meters of contents surface area. As contamination limits are normally expressed in dpm/100 cm^2, the total surface contamination can be expressed as:

$$\frac{A_2 \times 2.22 \times 10^{10} \frac{\text{dpm}}{100 \text{ cm}^2} \times \text{m}^2}{\text{Nm}^2} =$$

$$\frac{A_2}{N} \times 2.22 \times 10^{10} \frac{\text{dpm}}{100 \text{ cm}^2}$$

5.0 SHIELDING EVALUATION

5.1 Discussion and Results

5.1.1 Operating Design

This cask will be operated such that the contents in the cask will not create a dose rate exceeding 200 mrem./hr. on the cask surface, or 10 mrem./hr. at six feet from the cask surface.

The package shielding must be sufficient to satisfy the condition of 10 CFR Part 71, paragraph 71.36(a)(1) for the hypothetical accident conditions. Any shielding loss resulting from the 30 foot drop or the fire transient will not increase the external dose rate to more than 1000 mrem./hr. at 3 feet from the external surface of the cask.

5.1.2 Shielding Design Features

The cask side wall shielding consists of the outer 0.50 inch thick stainless steel shell, the inner 0.50 carbon steel concentric shell surrounding 6.0 inches thickness of lead and an inner containment shell wall of 0.250 inch thick stainless clad carbon steel. Total material shield thickness is 1.25 inches of steel and 6.0 inches of lead.

The closed end of the cask body shielding consists of an outside layer of 1.50 inch thick stainless steel, a second layer of 0.625 inch thick stainless steel and an inner third layer of 0.50 inch thick stainless steel and carbon steel. A lead shield thickness of 5.25 inches and an inner containment liner thickness of 0.50 inch of stainless clad carbon steel completes the closed end cask shielding. Total material shield thickness of the closed end of the cask is 3.125 inches of steel and 5.25 inches of lead.

5.1.2 Shielding Design Features (continued)

The closure end of the cask shielding consists of an assembly made in a stepped configuration. The outer surface is a 0.375 inch thick stainless steel plate covering an inner 1.25 inch thick carbon steel plate. The internal lead shield thickness is 6 inches maximum. The cavity side of the closure assembly is a 0.625 inch thick stainless steel plate. Total material shield thickness of the closure assembly is 2.25 inches of steel and 6 inches of lead.

To compensate for the lead slump condition referenced in the hypothetical accident analysis following the 30 foot drop on the closed end of the cask (see Section 2.7.1.1.1), a shield ring is installed and bolted to the inner cavity side of the closure assembly (Reference Drawing No. C-111-D-0001, Rev.-.) The shield ring consists of a ring of lead 3.5 inches thick by 4.375 inches high enclosed in 0.750 inch thick stainless steel forming a shield ring 34.50 inches O.D. by 24.50 inches I.D. by 6.0 inches high.

5.1.3 Shielding Design Evaluation

The shielding evaluation model demonstrates that the cask will meet all the requirements for normal transport conditions for the contents to be carried in the cask. The summary of results from the hypothetical accident drop conditions (Section 2.7.1.5) indicates no significant loss of shielding. The lead slump void resulting from the 30 foot drop on the closed end of the cask is shielded by the internal shield ring assembly mounted on the cask closure assembly. Possible gap streaming from this area is also addressed fully in this section below and found to be negligible and within the limits specified under 10 CFR Part 71 for hypothetical accident conditions.

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 *						
Gamma	37	120	200	1.0	6.6	7.3
Neutron **	5.1	5.1	5.1	0.21	0.21	0.21
Total	42.1	125.1	205.1	1.21	6.81	7.51
HYPOTHETICAL ACCIDENT CONDITIONS *						
Gamma	5900	120	940	25	6.6	32.3
Neutron	5.1	5.1	5.1	0.21	0.21	0.21
Total	5905.1	125.1	945.1	25.21	6.81	32.51
10 CFR Part 71 Limit				1000	1000	1000

* See Section 5.1.4 below.
** See Appendix 5.6 for calculations for typical Sb-Be dose.

5.1.4 Maximum Dose Rate Calculations

Table 5.1 gives both normal and accident condition dose rates for a typical loading of the cask. The following assumptions were used to develop the values given in the table.

Normal Conditions

- The source is modeled as a point source which can exist on any interior cask surface. This is very conservative, as the source is considered to be in contact with all inner cask surfaces at the same time.

5.1.4 (continued)

Accident Conditions

- o A dose increase is caused by a 4.1 inch lead slump at the closure end (bottom) of the cask.
- o The dose increase at 3 feet from the side of the cask is also seen at 3 feet from the closure end of the cask.
- o The surface dose rate of 5,900 mr./hr. assumes the point source, which creates the 200 mr./hr. normal surface limit, is at the nearest possible location to the streaming path. A value of h = 7.25 inches is used in recalculating doses according to Section 5.4.3 of this S.A.R.
- o The surface dose through the streaming path of 5,900 mr./hr. is seen as 740 mr./hr. at the closure surface end due to an increased path length of 6.75 inches to reach that surface. To obtain this, a value of h = 14 inches was used in the streaming equation (Section 5.4.3).

5.2 Source Specification

5.2.1 Gamma Source

The cask is to handle non-fuel bearing components only or solid and solidified by-product material. Gamma radiation sources are a variety of isotopes; such as Co-58, Co-60, Zr-95, Ag-110, Sb-124 and/or Na-24. The major gamma radiation source will be Co-60 from stainless steel components to be handled. Since source geometry will vary considerably for this container, the conservative approach to shield design shall be for the analysis to be based upon a point source (shape and volume factors are not taken into account).

5.2.2 Neutron Source

Depleted neutron sources will be shipped. To ensure the limits of Section 5.1.1 are not exceeded, analysis

5.2.2 Neutron Source (continued)

supplemented by measurement will be performed. For the most part, depleted Sb-Be sources will be transported. Appendix 5.6 shows that even when transporting the maximum amount of Sb-124 permitted, the predicted dose rate is well below the limits outlined in Section 5.1.1.

5.3 Model Specification

5.3.1 Description of the Radial and Axial Shielding Configuration

Dimensions of the radial and axial shielding material models are shown in Figure 5.3.1. They are based on drawing number MOD-139-1.

5.3.2 Description of Lead Slump Configuration

Dimensions of the streaming gap model are shown on Figures 5.3.2.1 and 5.3.2.2. The drawing represents a 4.1 inch lead slump which may occur as the result of a 30 foot accidental cask drop. A lead shielding ring is used to limit the streaming from this lead gap.

FIGURE WITHHELD UNDER 10 CFR 2.390

* The S.S. 304 Liner is not included in the models

FIGURE WITHHELD UNDER 10 CFR 2.390

SKETCH 5.3.2.1

FIGURE WITHHELD UNDER 10 CFR 2.390

SKETCH 5.3.2.2

5.3.3 Shield Regional Densities

The mass densities for each material are shown in the table below.

TABLE 5.3 SHIELD REGIONAL DENSITIES

MATERIAL	ELEMENT	DENSITY (g/cc)
Carbon Steel	Fe	7.86
304 Stainless Steel	Cr	1.502
	Fe	5.612
	Ni	0.79
Lead	Pb	11.34

5.4 Shielding Evaluation

5.4.1 Radial Model

The gamma radiation sources that correspond to regulatory dose rate limits for the cask in a radial direction were calculated assuming a point source. This gives the most conservative approach and allows for the wide variety of source geometries that could be encountered transporting irradiated non-fuel components. The dose model used for this calculation is shown in Figure 5.3.1.

The point source is determined as follows:

$$\phi_\gamma = KB \frac{S_o}{4\pi a^2} e^{-b_1} \qquad (1)$$

where, ϕ_γ = Photon Flux, $\frac{\gamma}{cm^2\text{-sec}}$

K = Flux to dose conversion = $2.3\times10^{-6} \frac{R/hr.}{\phi_\gamma}$ for Co-60 (2)

S_o = Equivalent source, $\frac{\gamma}{sec}$

$b_1 = \Sigma_i \mu_i t_i$

B = Buildup factor

a = Distance from source to dose point, cm

5.4.1 Radial Model (continued)

Through the side of the cask, the following values are used:

Lead: $t = 6$ in. $= 15.2$ cm, $\mu/\rho = 0.0600$

$\mu = 0.684\ cm^{-1}$ (3)

Steel: $t = 1.25$ in. $= 3.18$ cm., $\mu/\rho = 0.0515$

$\mu = 0.415\ cm^{-1}$

Giving:

$b_1 = 10.9$

The buildup factor is taken for iron to represent the laminated shield. (4)

$B = 16$

Two dose rates will be considered:

$D_1 = 10$ mr/hr, where $a = 7.25$ in. $= 72$ in. $= 201$ cm

which gives, $S_o = 7.48 \times 10^{12} \frac{\gamma}{sec}$

and,

$D_2 = 200$ mr/hr, where $a = 7.25$ in. $= 18.4$ cm

which gives, $S_o = 1.25 \times 10^{12} \frac{\gamma}{sec}$

The dose rates at the cask surface and at 3 and 6 feet from the surface are shown in Figure 5.4.1 for various source strengths.

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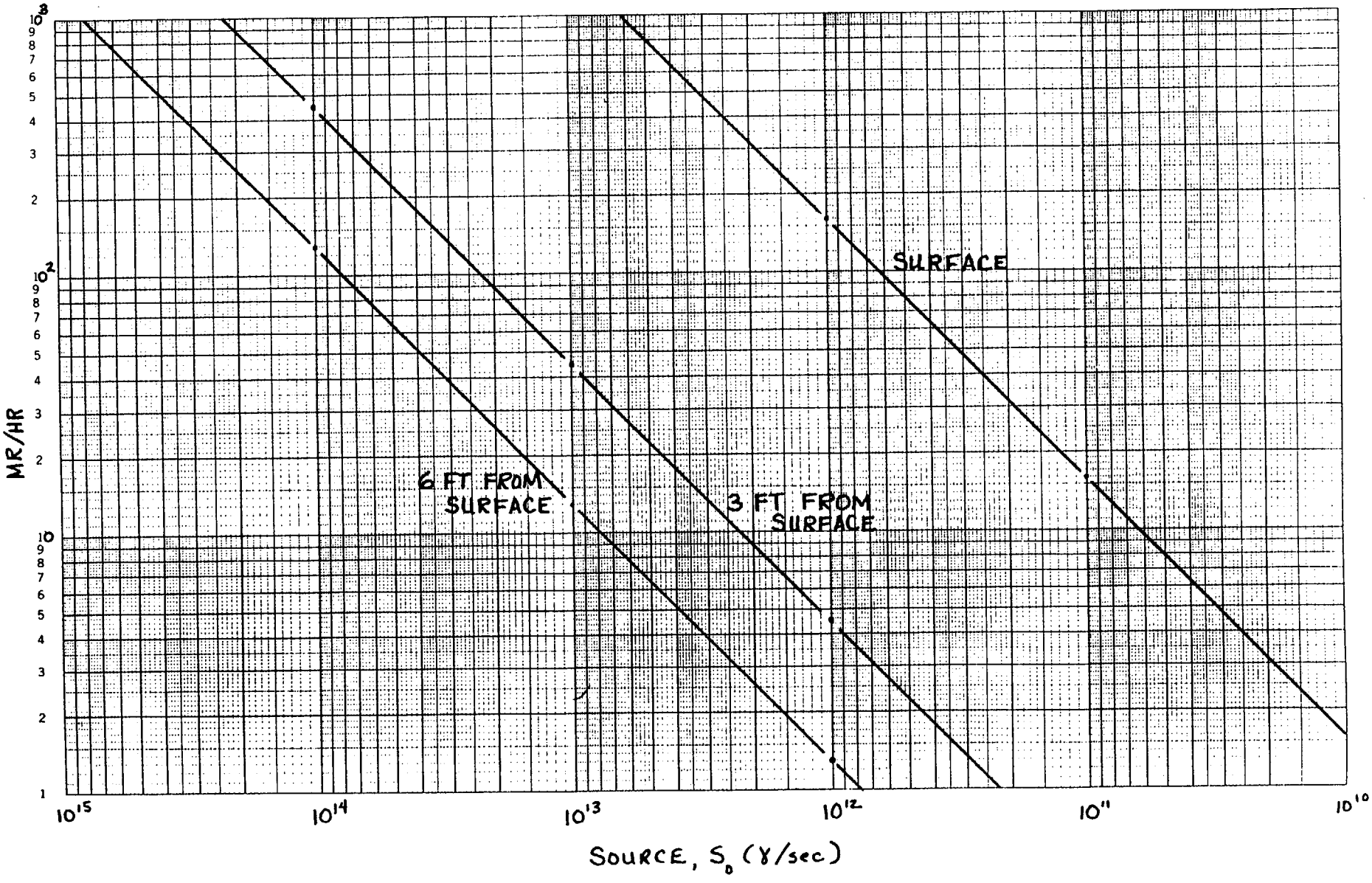

FIGURE 5.4.1 SIDE OF CASK

5.4.2 Axial Model

The gamma radiation sources that correspond to regulatory dose rate limits for the cask in an axial direction were calculated assuming a point source. This gives the most conservative approach and allows for the wide variety of source geometries that could be encountered transporting irradiated non-fuel components. The dose model used for this calculation is shown in Figure 5.3.1.

The point source is determined as follows:

$$\phi_\gamma = KB \frac{S_o}{4\pi a^2} e^{-b_1} \qquad (1)$$

where, ϕ_γ = Photon Flux, $\frac{\gamma}{cm^2\text{-sec}}$

K = Flux to dose conversion = $2.3\times10^{-6} \frac{R/hr}{\phi_\gamma}$ for Co-60 (2)

S_o = Equivalent Source, $\frac{\gamma}{sec}$

$b_1 = \Sigma_i \mu_i t_i$

B = Buildup Factor

a = Distance from source to dose point, cm.

Through the top of the cask, the following values are used: (3)

Lead: t = 5.25 in. = 13.3 cm, μ/ρ = 0.0600

μ = 0.684 cm^{-1}

Steel: t = 2.75 in. = 6.99 cm, μ/ρ = 0.0515

μ = 0.415 cm^{-1}

Giving:

b_1 = 9.10 + 2.90 = 12.0

The buildup factor is taken for iron to represent the laminated shield. (4)

B = 18

5.4.2 Axial Model (continued)

Two dose rates will be considered:

D_1 = 10mr/hr, where a = 8 in. + 72 in. = 203 cm
which gives, $S_o = 2.04 \times 10^{13} \frac{\gamma}{sec}$
and,

D_2 = 200 mr/hr, where a = 8 in. = 20.3 cm
which gives, $S_o = 4.07 \times 10^{12} \frac{\gamma}{sec}$

The dose rates at the closed end and at 3 and 6 feet from the surface are shown in Figure 5.4.2.1 for various source strengths.

Through the bottom (closure) of the cask, the following values are used: (3)

Lead: $t = 6$ in. = 15.2 cm, $\mu/\rho = 0.0600$
$\mu = 0.684\ cm^{-1}$
Steel: $t = 2\text{-}1/4$ in. = 5.72 cm, $\mu/\rho = 0.0515$
$\mu = 0.415\ cm^{-1}$

Giving:

$b_1 = 10.4 + 2.37 = 12.8$

The buildup factor is taken for iron to represent the laminated shield. (4)

$B = 19$

Two dose rates will be considered:

D_1 = 10 mr/hr, where a = 8.25 in. + 72 in. = 204 cm
which gives, $S_o = 4.34 \times 10^{13} \frac{\gamma}{sec}$
and,

D_2 = 200 mr/hr, where a = 8.25 in. = 21.0 cm
which gives, $S_o = 9.19 \times 10^{12} \frac{\gamma}{sec}$

5.4.2 (continued)

The dose rates of the closure end of the cask at the surface and at 3 and 6 feet from the surface are shown in Figure 5.4.2.2 for various source strengths.

VERNON McMILLAN, INC., ELIZABETH, N.J. 07208 No. 19-1350 (R 2470-L-5) Log 3 x 5 • Made in U.S.A.

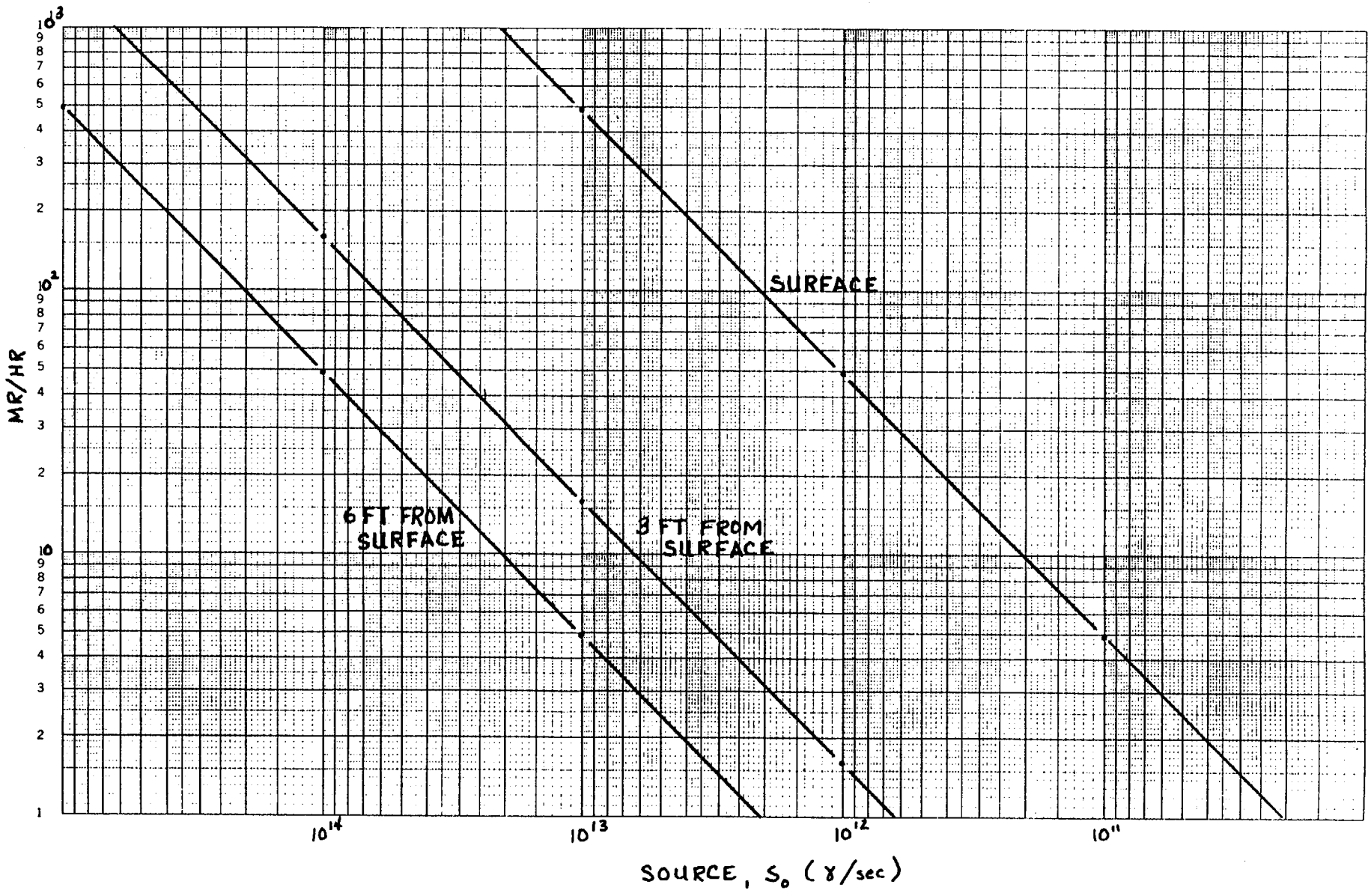

FIGURE 5.4.2.1 CLOSED END OF CASK

VERSAGRAPH ELIZABETH, N.J. 07208 No 19-1350 (R 2470 L-5) Log 3 x 5 • Made in U.S.A.

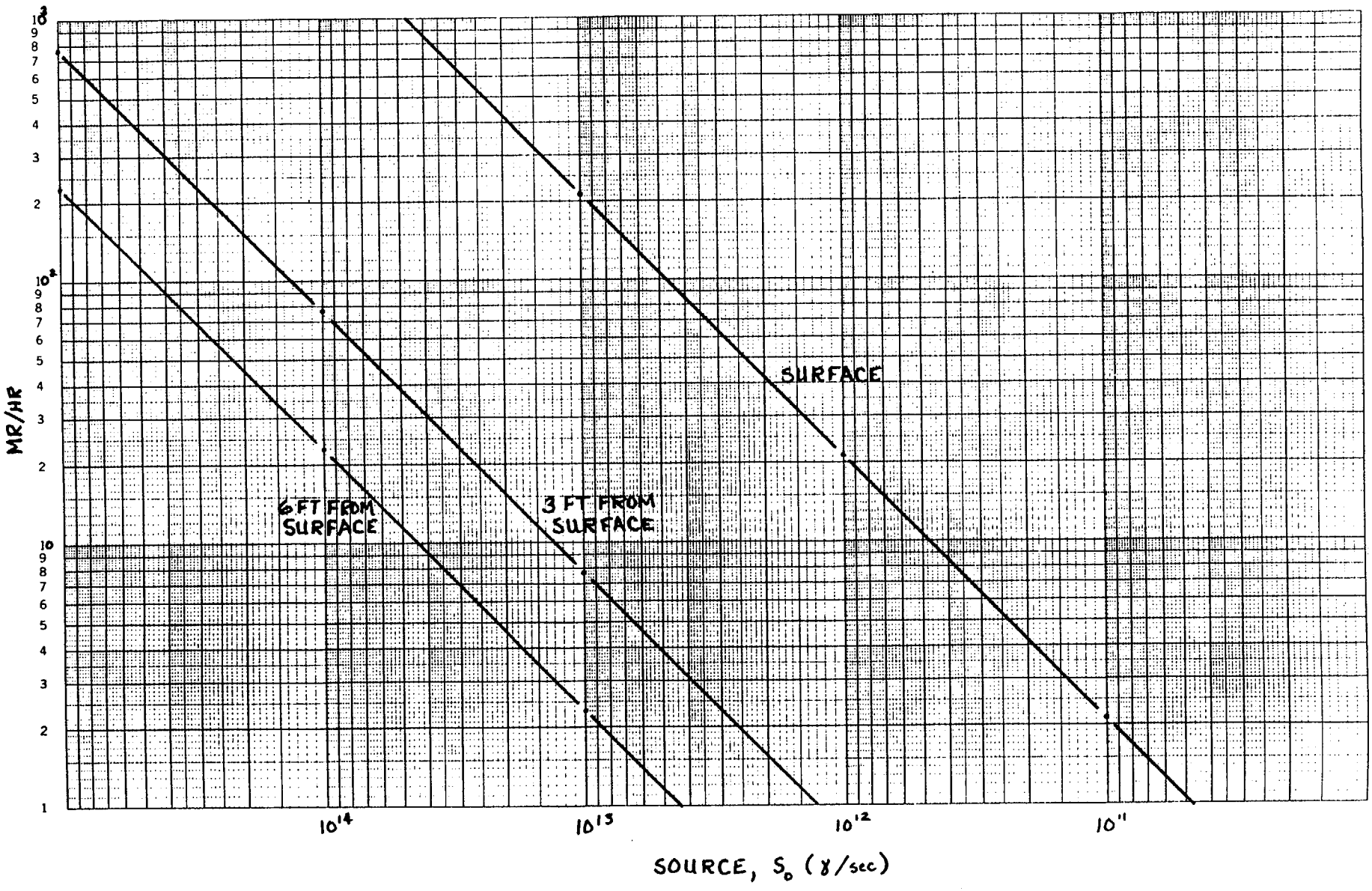

FIGURE 5.4.2.2 CLOSURE END OF CASK

5.4.3 Radiation Streaming with Lead Slump

The cask shielding must be able to limit the dose rate to 1000 mr/hr at three feet in the accident case. The limiting surface dose rate of 200 mr/hr will result in a dose rate at three feet of about 1.0 mr/hr (Table 5.1). Thus an increase in dose rate by a factor of 1000 = $\left(\frac{1000 \text{ mr./hr.}}{1.0 \text{ mr./hr.}}\right)$ would be required to result in the limiting value of 1000 mr/hr. It is seen in the following that the local dose rate three feet from the side of the cask may increase by a factor of 25 because of the additional scattering component through a void created by lead slumping in a drop on the top of the cask.

The lead slump calculated in Section 2 is 4.1 inches. The base plate inserts into the cavity a distance of 1.5 inches beyond the end of the lead. The lead shield annulus will completely cover the voided area to prevent direct streaming as shown in Figure 5.3.2.2.

"Radiation Leakage from Narrow Gaps in Shields" (Reference Appendix 5.5.1) presents the following equation for streaming from a gap.

$$D/D_0 = C_3 WdA/h^3$$

The gap is 4.1 inches so $w = \frac{4.1}{12} = 0.34$ feet. The distance from the point of scatter to the deflector (3 feet from the cask) varies from 3.0 feet plus the cask wall thickness (7.25 inches) to 3.0 feet plus the wall thickness plus the cask cavity diameter.

Using the smallest values for conservatism,

$$h = 3.0 \text{ feet} + \frac{7.25}{12} \text{ feet} = 3.6 \text{ feet}$$

and,

$$dA = \frac{\pi(21.5^2 - 18^2)}{144} = 3.02 \text{ ft.}^2$$ (See Figure 5.3.2.2).

5.4.3 Radiation Streaming with Lead Slump (continued)

The scattering angle, as shown in Figure 5.3.2.2 will be 60° or greater. A value of 60° will be used for conservatism.

From Figure 5 of Appendix 5.5.

$$C_3(60^o) = 1.5\times10^{-2}$$

then,

$$D/D_o < \frac{1.5\times10^{-2} \times 0.34 \text{ ft.} \times 3.02 \text{ ft.}}{(3.6 \text{ ft.})^3}$$

$$D/D_o < \underline{\underline{3\times10^{-4}}}$$

Thus, the streaming from the gap is less than 3×10^{-4} of the unshielded dose rate.

The initial dose rate D_o is right at the inner gap. No reduction is allowed for the distance from the source to the inner edge of the gap. This allows additional conservatism in this analysis.

The shielding reduction afforded by 6 inches of lead and 1.25 inches of steel at a distance 3 feet from the cask surface is:

$$D/D_o \simeq \frac{r_1^2}{r_2^2} Be^{-b_1}$$

where, B = Buildup factor

$b_1 = \Sigma_i \mu_i t_i$
r_1 = 7.25 in.
r_2 = 36 in.

Using the following values, (3)

Lead: = 0.684 cm^{-1}, t = 6 in. = 15.2 cm

Steel: = 0.415 cm^{-1}, t = 1.25 in. = 3.18 cm

b_1 is calculated to be 10.9.

5.4.3 Radiation Streaming with Lead Slump (continued)

The buildup factor for steel is used to represent the laminated shield.

$$B = 16. \quad (4)$$

This gives a reduction factor of

$$D/D_o = \left(\frac{7.25^2}{36^2}\right)16e^{-10.9} = \underline{\underline{1.2\text{x}10^{-5}}}$$

The shielding effectiveness of the laminated shield is $1.2\text{x}10^{-5}$ and that of the gap is $3\text{x}10^{-4}$. This means that the dose rate from streaming through the gap at 3 feet from the cask is about 25 times the dose rate at 3 feet from the cask through the shield.

As the dose rate at 3 feet from the side of the cask for a surface dose rate of 200 mr./hr., which occurs on the closure end, is 1.0 mr./hr. (see Table 5.1) the radiation dose from streaming through the void should be about 25 times this or 25 mr./hr. This complies with the accident dose limit of 1 r./hr. at 3 feet. It is also assumed that this 25 mr./hr. streaming level is present above the closure end of the cask and is therefore added to the 7.3 mr./hr. radiation level at 3 feet from the closure surface. This gives a total accident dose rate of 32.3 mr./hr. (See Table 5.1).

5.5 Appendix

5.5.1 References

1. Reactor Shielding Design Manual, Theodore Rockwell III, D. Van Nostrand Co., Inc., Princeton, N.J. 1956 - page 347.

2. IBID, page 19.

3. IBID, page 447.

4. Radiological Health Handbook, U.S. Department of Health, Education, and Welfare, January 1970.

5.5.2 "Radiation Leakage from Narrow Gaps in Shields", page 566, 573 and 584, 4th Proceedings of the International Symposium on Packaging and Transportation of Radioactive Materials, September 22 - 27, 1974.

CONF-740901-P2
DISTRIBUTION CATEGORY UC-71

APPENDIX 5.5.2

4TH PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM ON PACKAGING AND TRANSPORTATION OF RADIOACTIVE MATERIALS

September 22-27, 1974
Miami Beach, Florida

sponsored by

UNION CARBIDE CORPORATION NUCLEAR DIVISION
AND THE
U.S. ATOMIC ENERGY COMMISSION

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RADIATION LEAKAGE FROM NARROW GAPS IN SHIELDS

R. Haworth R. A. C. Liquorish

C. B. G. Taylor

ABSTRACT

Clearance gaps around plugs and other movable components can be a significant source of radiation leakage from large casks. There is however a lack of quantitative information on which a designer can base his choice of clearance dimension.

The factors underlying this problem are discussed, and expressions based on a single-scatter approximation are derived for some typical geometries. Calculated data is presented for iron, lead and uranium shields, for Co60 and Cs137 gamma radiation.

Experiments to check the expressions are described. It is shown that the accuracy of this method is sufficient for dealing with practical problems.

INTRODUCTION

One of the problems to be solved by the designer of a large cask is the choice of clearance dimensions for any plugs, slides or shafts that pass through the shielding. Generous clearances simplify manufacture, minimize cost, and make for easy operation. Tight clearances may mean trouble, the more so as a high level of radiation accelerates corrosion and destroys lubricants, and nuclear heating in the cask can cause differential expansion. Clearances should be made as large as radiation leakage will allow, but how to decide how much is permissible? The designer needs data from which to estimate the radiation penalty associated with each choice of clearance.

Clearance gaps are seldom directly in line with the radiation source, so scattered radiation must be taken into account. Although the shielding literature has many references to scattering it does not

and for $\theta \rightarrow 90^{o}$,

$$\left.\frac{dC}{d\theta}\right|_{90^{o}} = -\frac{N_e.K(E_1,\theta_s)}{\mu_2} . \qquad (10)$$

Consider now Fig 6c, which shows scattered radiation leaving a shield through a narrow gap of width w, the point of scatter being distant h from the outside of the shield. As θ decreases from $\theta = \pi/2$, at grazing emergence, C rises from zero at $\theta = \pi/2$ to $C = N_e.K(E_1,\theta_s).w/(\mu_2 h)$ at $\theta = w/h$ radians. Substituting in (7) gives

$$D = \frac{N_e.K(E_1,\theta_s).w.dA.D_o}{\mu_2 h^3} \qquad (11)$$

for which we can write

$$D = C_3.\frac{w.dA.D_o}{h^3} \qquad (12)$$

where C_3 is another dimensionless factor referring to each shield material, energy of incident radiation, and angle of scatter. It is plotted in Fig 5.

In Fig 6c the exposure rate is not constant across the gap, being zero in line with the scattering surface and rising to D at the facing surface. In the case shown in Fig 6d the contributions from the two faces are complementary in this respect and the exposure rate is constant across the width of the gap, being equal to $D = C_3.w.dA.D_o/h^3$ throughout.

EXPERIMENT

Instrumentation

We used X-ray film to map leakage fields in experimental conditions, supplementing it in some cases with radiation monitors of various types. For all film measurements a 16 mm lucite filter was used to absorb recoil electrons knocked out of the shield by scattered photons. Without this precaution an exposure rate figure up to three times that due to the gamma radiation may be recorded.

LEAKAGE RADIATION DUE TO SCATTER AT FLAT GAP.

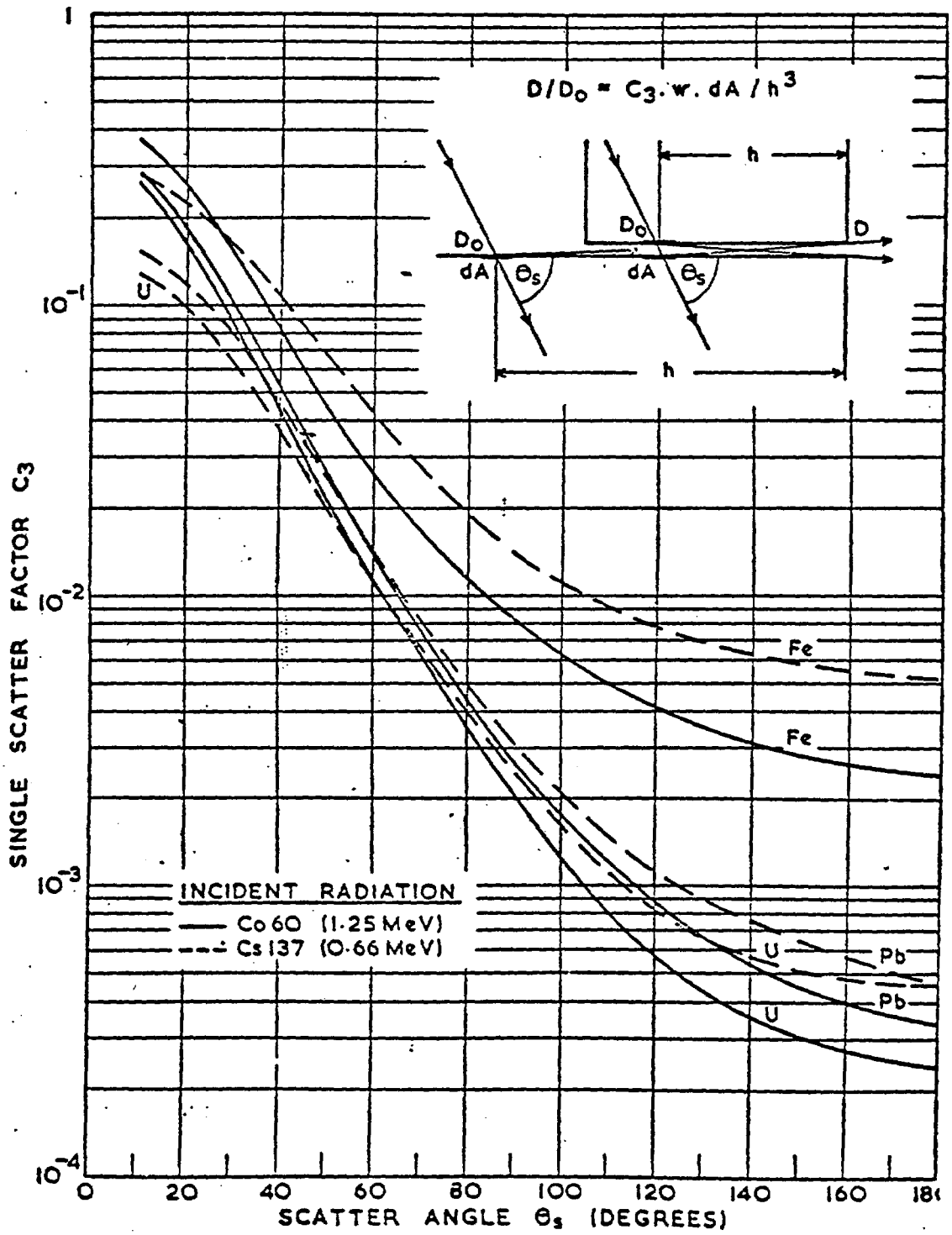

Fig. 5 Single scatter factor C_3, for grazing diffuse reflection from flat surface or leakage into narrow plane gap.

5.6 Appendix

5.6.1 References

1. Reactor Shielding Design Manual, Theodore Rockwell III, D. Van Nostrand Co., Inc., Princeton, NJ 1956, pp. 360, 385.
2. Radiological Health Handbook, US Department of Health, Education and Welfare, January 1970, page 193.

5.6.2 Dose Rate Analysis for Typical Sb-Be Neutron Source

This analysis conservatively takes into account only the shielding effects of geometry, disregarding additional shielding due to the cask walls. In Section 4.4, the total releasable material limit is given as 0.46 (A_2) Ci. From 10 CFR 71, Appendix A, the value of A_2 for Sb-124 is 5 Ci. Therefore these calculations are based on a maximum source strength of 2.3 Ci.

A worst case is to assume all activity within one source touching the inside wall of the cask. Calculations are performed for the dose rate at the surface of the cask and also at a distance of 3 feet from the cask surface.

Reference 1 in Section 5.6.1, page 360 gives the following equations at a point P (see Figure 5.6.2) for the effect of geometry of a cylindrical source:

$$\phi = \frac{B\, S_v\, R_o^2}{2\,(a + z)}\, F(\theta, b_2)$$

$$\theta_1 = \theta_2 = \theta$$

$$b_2 = \mu_s z + \sum_i^n \mu_i\, t_i$$

where:

ϕ	=	Flux
B	=	Buildup factor
S_v	=	Volumetric source strength of neutrons
R_o	=	Radius of neutron source
a	=	Distance from source to dose point
z	=	Effective self attenuation distance

$$F(\theta, b_2) = \int_0^{\theta} e^{-b \sec \theta'} \, d\theta'$$

The length of each neutron source is 19.55 inches and its diameter is 0.70 inches. See Figure 5.6.3 for a view of the cask wall with the neutron source depiction.

<u>Dose Rate at the Surface of Cask</u>

$$z = \frac{0.700''}{2} = 0.350'' \quad \text{(max)}$$

$$z = 0'' \quad \text{(min)}$$

$$a_1 = 0$$

$$a_2 = 7.25''$$

$$\theta_1 = \arctan\left(\frac{9.775''}{0.35''}\right) = 87.95°$$

$$\theta_2 = \arctan\left(\frac{9.775''}{7.60''}\right) = 52.14°$$

To calculate the flux at the surface of the cask, the volumetric source strength of neutrons, S_v, must first be determined. The conversion from curies to neutrons per second is given by the neutron yield. Reference 2, Section 5.6.1 gives a value of the yield as 1.6×10^6 (n/sec)/Ci. The neutron source strength, S, is then:

$$S = (2.3\ Ci)\left(1.6 \times 10^6\ \frac{n/\text{sec}}{Ci}\right) = 3.68 \times 10^6\ n/\text{sec}$$

The volume under consideration is:

$$V = \pi R_o^2 l$$
$$= \pi (0.35\ in)^2 (19.55\ in) (2.54 \frac{cm}{in})^3$$
$$= 123.3\ cm^3$$

Therefore the volumetric source strength of neutrons is:

$$S_v = \frac{S}{V} = \frac{3.68x10^6\ n/sec}{123.3\ cm^3} = 2.99x10^4 \frac{n/sec}{cm^3}$$

It is conservative to assume the buildup factor, B, is 1.0 and the effective self attenuation distance, z, is 0.0 cm. Reference 1 in Section 5.6.1 gives the value of F(52.14°,0) = 0.86 . Substituting all of these values into the flux formula for the cask surface yields:

$$\phi_{cask\ surface} = \frac{B\ S_v\ R_o^2}{2(a + z)} F(\theta, b_2)$$

$$= \frac{(1.00)\left(2.99x10^4 \frac{n/sec}{cm^3}\right)(0.35in)^2 \left(2.54 \frac{cm}{in}\right)^2}{(2)(7.25\ in + 0.0\ in)\left(2.54 \frac{cm}{in}\right)} (0.86)$$

$$= 551.8 \frac{n/sec}{cm^2}$$

Linearly interpolating from 49 CFR 173.403 at E = 24 KeV yields a conversion factor of 108.0 n/(cm²•sec) ≡ 1 mR/hr. Therefore the dose rate at the cask surface due to a 2.3 Ci. Sb-124 source is:

$$Dose\ Rate = (\phi_{cask\ surface})(Conversion\ factor)$$
$$= \left(551.8 \frac{n/sec}{cm^2}\right)\left(\frac{1 \frac{mR}{hr}}{108.0 \frac{n}{cm^2 \cdot sec}}\right)$$
$$= 5.1 \frac{mR}{hr}\ at\ the\ cask\ surface$$

Dose Rate 3 Feet from the Cask

$$z = \frac{0.700''}{2} = 0.350'' \quad \text{(max)}$$

$$z = 0'' \quad \text{(min)}$$

$$a = \textit{Cask wall thickness} + 3 \textit{ Feet}$$
$$= 7.25'' + 36'' = 43.25''$$

$$\theta = \arctan\left(\frac{9.775''}{43.25 + 0.35''}\right) = 12.63°$$

Again a conservative assumption is a buildup factor, B, of 1.0 and an effective self attenuation distance, z, of 0.0 cm. Reference 1 in Section 5.6.1 gives the value of F(12.63°,0) = 0.21 . The value of the volumetric source strength of neutrons, S_v remains the same. Substituting all of these values into the flux formula for a distance of 3 feet from the cask surface yields:

$$\phi_{3\ ft\ dist.} = \frac{B\ S_v\ R_o^2}{2\,(a + z)}\ F(\theta, b_2)$$

$$= \frac{(1.00)\left(2.99x10^4 \frac{n/sec}{cm^3}\right)(0.35in)^2\left(2.54\frac{cm}{in}\right)^2}{(2)\,(43.25\ in + 0.0\ in)\left(2.54\frac{cm}{in}\right)}\ (0.21)$$

$$= 22.58\ \frac{n/sec}{cm^2}$$

The flux to dose conversion factor remains 108.0 n/(cm²•sec) ≡ 1 mR/hr. Therefore the dose rate at a distance 3 feet from the cask surface due to a 2.3 Ci. Sb-124 source is:

$$\textit{Dose Rate} = (\phi_{3\ ft\ dist.})\ (\textit{Conversion factor})$$

$$= \left(22.58\ \frac{n/sec}{cm^2}\right)\left(\frac{1\ \frac{mR}{hr}}{108.0\ \frac{n}{cm^2 \cdot sec}}\right)$$

$$= 0.21\ \frac{mR}{hr}\ \ 3 \textit{ feet from cask surface}$$

FIGURE WITHHELD UNDER 10 CFR 2.390

Figure 5.6.2 Effect of geometry of a cylindrical source

Figure 5.6.3 Cross sectional view of cask wall

6.0 CRITICALITY EVALUATION

Since the CNSI 3-55 Cask is not to be used for Fissile Class II shipments, this section is not applicable.

7.0 OPERATING PROCEDURES

7.1 Procedure for Loading the Package

NOTE: DETAILED LOADING AND UNLOADING PROCEDURES ARE GIVEN IN CNSI DOCUMENT TR-OP-019 "HANDLING PROCEDURE FOR CHEM-NUCLEAR SYSTEMS, INC. TRANSPORT CASK CNS-3-55, MODEL NUMBER LL-57-65, THE VANDENBURGH CASK., CERTIFICATE OF COMPLIANCE NO. 5805".

NOTE; WHEN DEPLETED NEUTRON SOURCES ARE TO BE LOADED IN THE CASK, ACTIVATION ANALYSIS MUST BE PERFORMED TO ENSURE SECTION 4 LIMITS ARE NOT EXCEEDED.

7.1.1 Remove the sunshade, if used, from the cask by removing the twelve (12) bolts that attach the sunshade frame to the trailer and sliding it forward, or lift it off using the auxiliary crane.

7.1.2 Prepare to remove the hold-down straps.

NOTE: THE HOLD-DOWN STRAPS MUST BE MATCH-MARKED TO THE CRADLE BEFORE REMOVAL.

7.1.2.1 Remove the eight (8) 1-1/2-inch by 5-inch bolts that secure each trap to the cradle. Retain the bolts for re-installation.

7.1.2.2 Match mark the hold-down straps as to left and right.

7.1.2.3 Attach a lifting sling to the lifting lug on the hold-down strap.

7.1.2.4 Attach the crane hook to the sling, if necessary.

7.1.2.5 Remove the hold-down strap and detach the lifting sling.

7.1.2.6 Remove the other hold-down strap.

7.1.3 Remove the 4 inch removable trunnions from the locker beneath the trailer and bolt them to the cask.

7.1.4 Remove the impact absorbers from the cask lifting trunnions by removing the four bolts from each impact absorber. Retain these bolts for re-installation.

7.1.5 Prepare to lift the cask in a horizontal position.

NOTE: AT LEAST 16 INCHES OF WOOD MUST BE PLACED BETWEEN THE CASK AND THE LOADING SURFACE.

7.1.5.1 Place the two (2) 1-1/4-inch stainless steel wire rope slings around the cask and attach them to the large crane hook.

NOTE: ONE SLING MUST BE POSITIONED AHEAD (TOWARD THE CASK BELL END) OF THE LIFTING TRUNNIONS, AND THE OTHER SLING MUST BE POSITIONED BEHIND (TOWARD THE CASK CLOSURE END) THE REMOVABLE TRUNNIONS. USE THE STAINLESS STEEL WIRE ROPE SLINGS PROVIDED.

7.1.5.2 Lift the cask in a horizontal position, lower it onto the wood blocks, and chock it so that it will not roll.

NOTE: POSITION THE CASK SO THAT THE SMALL CRANE HOOK IS ABOVE THE REMOVABLE TRUNNIONS AND THE LARGE CRANE HOOK IS ABOVE THE LIFTING TRUNNIONS. THE CASK MAY HAVE TO BE ROTATED 90° TO ACCOMPLISH THIS.

7.1.5.3 Remove the wire rope slings.

7.1.5.4 Remove the crane hook.

7.1.6 Prepare to remove the impact limiters from the end of the cask.

7.1.6.1 Remove the six (6) 3/4-inch bolts that secure the impact limiters to the bell section end of the cask.

7.1.6.2 Attach a lifting sling to the eyebolts on the impact limiter.

7.1.6.3 Attach a lifting sling to the auxiliary crane hook.

7.1.6.4 Slide off the impact limiter and detach the lifting sling.

7.1.6.5 Remove the six (6) nuts from the six (6) installation bolts on the base plate end of the cask. Slide the bolts out and retain them for re-installation.

7.1.6.6 Attach a lifting sling to the eyebolts on the impact limiter.

7.1.6.7 CAREFULLY remove the impact limiter by sliding it off.

7.1.6.8 Remove the six (6) reinforcing blocks and retain them for re-installation.

7.1.7 Prepare to upright the cask.

7.1.7.1 Attach the large crane hook to the lifting yoke.

7.1.7.2 Attach the lifting yoke to the cask lifting trunnions.

7.1.7.3 Place on wire rope sling around the closure end of the cask and attach the ends of the slings to the small crane hook.

NOTE: THE SLING MUST BE POSITIONED JUST BEHIND (TOWARD THE CASK CLOSURE END) THE REMOVABLE TRUNNIONS.

7.1.7.4 With the yoke on the large crane hook and the sling on the small crane hook, lift the cask horizontally 4 feet clear of the wood blocks.

7.1.7.5 Raise the yoke end of the cask (the cask bell section) until the cask is vertical. Do not move the small crane hook during this operation.

7.1.7.6 Lower the cask in vertical position onto wood blocks and remove the wire rope sling.

CAUTION: TREAT ALL BOLTS, DRAIN PLUGS, VENT PLUGS, AND WATER REMOVED AS CONTAMINATED.

7.1.8 Remove the cask drain plug relief valve and prepare to collect contaminated water, if necessary. Remove the cask vent plug at the top of the cask by removing the four (4) 3/4-inch bolts that hold it in place. Inspect gasket.

7.1.9 Remove the removable trunnions from the cask and retain them for re-installation.

7.1.10 Prepare to remove the cask base plate.

NOTE: COUNT THE NUMBER OF TURNS IT TAKES TO REMOVE THE (4) TAPERED LEAD-IN BOLTS AND RECORD THIS NUMBER FOR FUTURE REFERENCE.

7.1.10.1 Remove the eight (8) 1-1/2 inch bolts on the cask base plate and the four (4) tapered lead-in bolts from the flange.

7.1.10.2 Visually inspect the bolts for any structural defects such as cracks or unusual signs of distress. Replace bolt if threads or bolt head are damaged.

7.1.10.3 With the lifting yoke attached to the crane and the upper trunnions, raise the cask bell section clear of the base plate and set it aside on wood blocks. While the bell is being removed, check the cask interior for radiation fields (check that shield ring is in place on base closure plate).

NOTE: RADIOACTIVELY CONTAMINATED LIQUIDS MAY BE REMOVED BY USE OF AN ABSORBENT MATERIAL. REMOVAL OF ANY MATERIAL FROM INSIDE THE CASK SHALL BE PERFORMED UNDER THE SUPERVISION OF QUALIFIED HEALTH PHYSICS (HP) PERSONNEL WITH THE NECESSARY HP MONITORING AND RADIOLOGICAL HEALTH SAFETY PRECAUTIONS AND SAFEGUARDS.

7.1.10.4 Inspect the O-Ring seals and the guide pins on base plate, and the seals on vent plug for damage. The seals must be replaced with new seals if inspection shows any defects or at least every six (6) months, as required by Section 8.2.4.

NOTE: WHEN O-RINGS ARE REPLACED, LEAK TESTING IS REQUIRED AS SPECIFIED IN SECTION 8.2.2.1.

7.1.11 Place the cask bell section back on the base plate and fasten the bell section to the base plate with four tapered lead-in bolts on the flange. Tighten the bolts firmly but do not torque them down.

7.1.12 Prepare to place the cask into the pool.

7.1.12.1 SLOWLY lower the cask into the pool, allowing time for the cask to fill with water. Allow approximately 30 minutes for the cask to fill.

7.1.12.2 Locate the position of the yoke in two directions 90° apart. Mark these points on the side of the pool for repositioning of the crane.

7.1.12.3 Confirm that the markings for alignment of the cask base plate and the flange on the bell section are visible.

7.1.12.4 Using the remote tool, unbolt the four (4) 1-1/2-inch tapered lead-in bolts from the flange on the cask bell section.

7.1.12.5 Lift the cask bell section out of the pool and place it on wood blocks in the laydown area.

7.1.13 Load the liner or basket onto the cask base plate.

7.1.14 Prepare to lift the cask out of the pool.

7.1.14.1 Position the cask bell section in the exact location as when it was removed from the pool.

7.1.14.2 Lower the cask bell section into the pool, aligning the base plate with the bell section by using the guide pins and alignment marks.

7.1.14.3 To ensure exact alignment, watch with binoculars as the flange on the bell section makes contact with the base plate. If the bell and base plate are properly aligned, the four tapered lead-in bolts that are dangling from the flange will rise about one inch on contact. After alignment has been confirmed, rest the bell section on the base plate.

7.1.14.4 Secure the base plate to the cask by tightening the four (4) tapered lead-in bolts with the special tool. The bolts are in painted locations.

7.1.14.5 Lift the cask out of the pool so that the drain clears the pool surface and allow water to drain into the pool. This will require that the cask remains suspended over the pool for about 45 minutes.

7.1.15 Prepare to decontaminate the cask.

7.1.15.1 While the cask is suspended over the pool, hose it and the lifting device with demineralized water.

7.1.15.2 Move the cask to a laydown area that is equipped with a contaminated drain line and set it down in the vertical position on wood blocks.

7.1.15.3 Re-inspect vent plug gasket and install the cask vent plug. Torque bolts to 50 ft-lbs (± 5 ft-lbs) Attach anti-tamper seals to the vent plug bolts.

7.1.15.4 Apply pipe thread sealant to the drain plug relief valve and install and torque to 12 ft-lbs (± 1 ft-lb).

7.1.15.5 Scrub the cask with soapy water to decontaminate.

7.1.15.6 If the external surface of the cask is painted, visually inspect the painted surfaces for wear, deep scratches, chipping, etc. Repair as necessary, using CNSI Engineering repair procedures. Based on the condition of the coating, the entire surface may be covered with a single coating of nuclear grade epoxy paint.

7.1.16 Move the cask to the trailer bay using the large crane. Lower the cask onto wood blocks.

7.1.17 Replace the eight (8) 1-1/2-inch base plate bolts. Torque all 12 base plate bolts to a lubricated value of 75 ft-lbs (± 7 ft-lbs).

7.1.17.1 Prior to delivery of the package to a carrier for transport, the package containment cavity shall be leak tested. The sensitivity of the test shall be at least 1×10^{-1} atm cm^3/sec (STP) per Section 8.2.2.1.

(continued on page 7-7)

7.1.18 Re-Install the removable trunnions.

7.1.19 Prepare to return the cask to a horizontal position.

7.1.19.1 Attach a 1-1/4-inch wire rope sling around the removable trunnions and to the small crane hook.

7.1.19.2 Lift the cask with the yoke until the cask bottom is at least 4 feet clear of the floor.

7.1.19.3 Take up the slack with the small crane.

7.1.19.4 SLOWLY lower the upper end of the cask with the yoke until the cask is horizontal.

7.1.19.5 Lower the entire cask in a horizontal position onto wood blocks and chock it to prevent it from rolling.

7.1.20 Prepare to replace the impact limiters on the bell section end of the cask.

7.1.20.1 Attach a lifting sling to the eyebolts on the impact limiters.

7.1.20.2 Attach the crane hook to the lifting sling.

7.1.20.3 Position the impact limiter near the end of the cask.

7.1.20.4 Align the six (6) tabs on the impact limiter with the six (6) bolt holes on the sides of the cask.

7.1.20.5 Attach the six (6) 3/4-inch bolts that secure the impact limiter to the cask.

7.1.21 Prepare to replace the impact limiter on the base plate end of the cask.

7.1.21.1 Attach a lifting sling to the eyebolts on the impact limiter.

7.1.21.2 Attach the crane hook to the lifting sling.

7.1.21.3 Position the impact limiter near the end of the cask.

7.1.21.4 Place the six (6) 1-inch by 16-inch bolts through the sequentially numbered blocks, bolts facing the reverse direction, and attach the impact limiter loosely to the cask. Retain a spare bolt for next step in the procedure.

7.1.21.5 When the six (6) bolts and blocks are aligned, slide the impact limiter CAREFULLY into place, reverse the bolts one by one using the spare bolt, and place nuts on the bolts.

7.1.21.6 Tighten the nuts and attach wire seals to the impact limiter.

7.1.22 Prepare to replace the cask on the trailer.

7.1.22.1 Remove the cask lifting yoke from the cask lifting trunnions and the large crane hook.

7.1.22.2 Attach the two (2) wire rope slings around the cask and attach them to the large crane hook.

NOTE: ONE SLING MUST BE POSITIONED AHEAD (TOWARD THE CASK BELL END) OF THE LIFTING TRUNNIONS, AND THE OTHER SLING MUST BE POSITIONED BEHIND (TOWARD THE CASK CLOSURE END) OF THE REMOVABLE TRUNNIONS.

7.1.22.3 Raise the cask high enough to get the trailer under it.

7.1.22.4 Place the cask in the cradle.

7.1.22.5 Remove the wire rope slings and place them in the equipment box.

7.1.22.6 Remove the removable trunnions and place them in the equipment box.

7.1.23 Prepare to replace the hold-down straps.

7.1.23.1 Attach the lifting sling to the lifting lug on the hold-down strap.

7.1.23.2 Attach the crane hook to the lifting sling.

7.1.23.3 Position the match-marked strap on the cradle using the alignment marks.

7.1.23.4 Attach the eight (8) 1-1/2-inch by 5-inch bolts that secure the strap to the cradle.

7.1.23.5 Detach the lifting sling from the hold-down strap.

7.1.23.6 Replace the other hold-down strap following the same procedure.

7.1.24 Replace the lifting trunnion impact absorbers with four (4) bolts each.

7.1.25 Replace the sunshade, <u>if used</u>, by sliding it aft and attaching the twelve (12) bolts that secure the sunshade to the trailer.

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

7.1.26.1 That external lifting trunnions are properly covered or removed for transport.

7.1.26.2 That trailer placarding and cask labelling meet DOT Specifications 49 CFR 172.500 and NRC Specification 10 CFR 71.85(c).

7.1.26.3 The exterior radiation and contamination levels should meet the specification set forth in D.O.T. 49 CFR 173.441 and NRC 10 CFR 71.47 and 71.87. When depleted neutron sources are contained in the cask, perform measurement for neutrons. The measured radiation level should not exceed the following limits:

7.1.26.3.1 200 millirem/hour on the excessible external surface of the cask.

7.1.26.3.2 10 millirem/hour at any point two (2) meters from the vertical plane projected from the outer edges of the vehicle or conveyance.

7.1.26.3.3 2 millirem/hour in any normally occupied positions of the vehicle.

7.1.26.3.4 The removable radioactive contamination on the cask external surface is less than 22 dpm/cm^2 BETA-GAMMA, and 2.2 dpm/cm^2 ALPHA.

(continued on page 7-10)

7.1.26.4 That the impact limiters are sealed with anti-tamper seals.

7.1.26.5 That the drain plug relief valve has been installed using a pipe thread sealant and sealed with an anti-tamper seal.

7.1.26.6 That the vent plug assembly is sealed with anti-tamper seals.

7.2 Procedure for Unloading the Package

In addition to the following sequence of events for unloading a package, packages containing quantities of radioactive material in excess of Type "A" quantities specified in 10 CFR 20.205 (b) shall be received, monitored and handled by the licensee receiving the package in accordance with the requirements of 10 CFR 20.205 as applicable.

NOTE: Keep crane cables vertical at all times to prevent lateral movement of the cask.
The cask shall be replaced on the trailer in the exact orientation as it was received.

7.2.1 Remove the sunshade, if used, from the cask by removing the twelve (12) bolts that attach the sunshade frame to the trailer and sliding it forward or lift it off using the small crane.

7.2.2 Prepare to remove hold-down straps.

NOTE: THE HOLD-DOWN STRAPS MUST BE MATCH-MARKED TO THE CRADLE BEFORE REMOVAL.

7.2.2.1 Remove the seal wires and the eight (8) 1-1/2-inch by 5-inch bolts that secure each strap to the cradle. Retain the bolts for re-installation.

7.2.2.2 Match-mark the hold-down straps as to left and right.

7.2.2.3 Attach a lifting sling to the lifting lug on one hold-down strap.

7.2.2.4 Attach the crane hook to the sling, if necessary.

7.2.2.5 Remove the hold-down strap and detach the lifting sling.

7.2.2.6 Remove the other hold-down strap.

7.2.3 Remove the 4-inch removable trunnions from the locker beneath the trailer and bolt them to the cask, if necessary.

7.2.4 Remove the impact absorbers from the cask lifting trunnions by removing the four (4) bolts from each impact absorber. Retain these bolts for re-installation.

7.2.5 Prepare to lift the cask in a horizontal position.

7.2.5.1 Place the two (2) 1-1/2-inch stainless steel wire rope slings around the cask and attach them to the large crane hook, using two (2) 50-ton clevises.

NOTE: ONE SLING MUST BE POSITIONED AHEAD (TOWARD THE CASK BELL END) OF THE LIFTING TRUNNIONS, AND THE OTHER SLING MUST BE POSITIONED BEHIND (TOWARD THE CASK CLOSURE END) OF THE REMOVABLE TRUNNIONS. USE THE STAINLESS STEEL ROPE SLINGS PROVIDED.

7.2.5.2 Lifting the cask in a horizontal position, lower it onto wood blocks, and chock it so that it will not roll.

7.2.6 Prepare to remove the impact limiters from the ends of the cask.

7.2.6.1 Remove the six (6) 3/4-inch bolts that secure the impact limiters to the bell section end of the cask.

7.2.6.2 Attach a lifting sling to the eyebolts on the impact limiter.

7.2.6.3 Attach the lifting sling to the small crane hook.

7.2.6.4 Slide off the impact limiter and detach the lifting sling.

7.2.6.5 Remove the six (6) nuts from the six (6) installation bolts on the base plate end of the cask. Slide the bolts out and retain them for re-installation.

7.2.6.6 Attach a lifting sling to the eyebolts on the impact limiter.

7.2.6.7 CAREFULLY remove the impact limiter by sliding it off.

7.2.6.8 Remove the (6) reinforcing blocks and retain them for re-installation.

7.2.7 Prepare to remove the cask base plate.

7.2.7.1 Attach two (2) shackles to two (2) holes in the base plate where the shackles fit in.

7.2.7.2 Attach the lifting sling to the shackles.

7.2.7.3 Attach the lifting sling to the small crane.

7.2.7.4 Remove the eight (8) 1-1/2-inch bolts and the four (4) tapered lead-in bolts from the cask. Retain them for re-installation.

7.2.7.5 Reposition the cask so that the open end of the cask is over the disposal area of the trench.

7.2.7.6 Attach a cable around the lifting trunnions and to a piece of heavy equipment to prevent movement of the cask.

7.2.7.7 Remove the cask base plate and place it on or wrap it with absorbent material or plastic sheeting.

7.2.8 Prepare to remove the contents of the cask.

7.2.8.1 Attach a hook-cable assembly to the basket or liner.

7.2.8.2 Lead the throw-away cable assembly from the cask to a load-pulling winch or crane.

7.2.8.3 SLOWLY operate the puller so that the attached cable will pull the liner out of the cask. Continue movement until the liner clears the cask and is in burial position in the trench.

7.2.9 Reposition the cask onto the wood blocks.

7.2.10 Survey the interior of the cask for radiation/contamination levels. Decontaminate if acceptable levels are exceeded.

CAUTION: TREAT ANY LIQUID IN THE CASK OR USED IN THE DECONTAMINATION PROCESS AS CONTAMINATED.

7.2.11 Visually inspect the inside of the cask for damage, liquid accumulation, or plugged drains. Remove the liquid and clean any plugged drains or fittings. If the inside surfaces of the cask are damaged, remove the cask from service.

7.2.12 As required, clean the inside of the cask base plate, shield ring, the O-rings, and the seating surfaces. Replace any O-rings if inspection shows any defects or replace in accordance with Section 8.2.4. If O-ring replacement is required, cask must be subjected to leak testing as specified in Section 8.2.2.1.

7.2.13 Prepare to replace the base plate on the cask.

7.2.13.1 Lift the base plate into position using the small crane.

7.2.13.2 Replace the eight (8) 1-1/2-inch bolts and the four (4) tapered lead-in bolts to the base plate. Torque the eight (8) 1-1/2-inch bolts to a lubricated value of 75 ft.-lbs. ($\pm$ 7 ft.-lbs.).

7.2.14 Decontaminate the cask surfaces. Survey to confirm that the cask is free of contamination. (As per Step 7.1.26.3.4)

7.2.14.1 If the external surface of the cask is painted, visually inspect the painted surfaces for wear, deep scratches, chipping, etc. Repair as necessary, using CNSI Engineering repair procedures. Based on the condition of the coating, the entire surface may be covered with a single coating of nuclear grade epoxy paint.

(continued on page 7-14)

7.2.15 Prepare to replace the impact limiter on the base plate end of the cask.

7.2.15.1 Attach a lifting sling to the eyebolts on the impact limiter.

7.2.15.2 Attach the crane hook to the lifting sling.

7.2.15.3 Position the impact limiter near the end of the cask.

7.2.15.4 Place the six (6) 1-inch by 16-inch bolts through the sequentially numbered blocks, bolts facing in the reverse direction, and attach the impact limiter loosely to the cask. Retain a spare bolt for next step in the procedure.

7.2.15.5 When the six (6) bolts and blocks are aligned, slide the impact limiter CAREFULLY into place, reverse the bolts one by one using the spare bolt, and place nuts on the bolts.

7.2.15.6 Tighten the nuts and attach wire seals to the impact limiter.

7.2.16 Prepare to replace the cask on the trailer.

7.2.16.1 Attach the two (2) wire rope slings around the cask and attach them to the large crane hook, if necessary.

NOTE: ONE SLING MUST BE POSITIONED FORWARD OF THE LIFTING TRUNNIONS, AND THE OTHER SLING MUST BE POSITIONED AFT OF THE REMOVABLE TRUNNIONS.

7.2.16.2 Raise the cask high enough to get the trailer under it.

7.2.16.3 Place the cask in the cradle.

7.2.16.4 Remove the wire slings and store them inside the impact limiter on the cask.

7.2.16.5 Remove the removable trunnions and replace them in the equipment box.

7.2.17 Prepare to replace the hold-down straps.

7.2.17.1 Attach a lifting sling to the lifting lug on one hold-down strap.

7.2.17.2 Attach the crane hook to the lifting sling.

7.2.17.3 Position the match-marked strap on the cradle using the alignment marks.

7.2.17.4 Attach the eight (8) 1-1/2-inch by 5-inch bolts that secure the straps to the cradle.

7.2.17.5 Detach the lifting sling from the hold-down straps.

7.2.17.6 Replace the other hold-down strap following the same procedure.

7.2.18 Replace the trunnion impact absorbers with four (4) bolts each.

7.2.19 Replace the sunshade, if used, by sliding it aft and attaching the twelve (12) bolts that secure the sunshade to the trailer.

7.2.20 Before the cask leaves the facility, perform Step 7.3.

7.3 <u>Preparation of an Empty Package for Transport</u>

7.3.1 Verify from previous Unloading and Inspection Procedures check-off forms that package interior was decontaminated, clean and free of liquids; that cask interior surfaces were free of damage, shield ring properly in place, and seals and seal surfaces were checked and found acceptable. The requirements of 49 CFR 173.427 with respect to shipment of empty packages will be complied with.

7.3.2 Visual inspection of all external surfaces of cask, impact limiters, skid assembly and trailer shall be performed and any defects shall be repaired.

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

7.3.3.1 That external lifting trunnions are properly covered or removed for transport.

7.3.3.2 That trailer placarding and cask labelling meet DOT Specifications 49 CFR 172.500 and NRC Specifications 10 CFR 71.85.

7.3.3.3 That exterior radiation levels are as per Step 7.1.26.3.4.

7.3.3.4 That the impact limiters are sealed with anti-tamper seals.

7.3.3.5 That the drain plug relief valve is securely installed and sealed with a pipe thread sealant.

7.3.3.6 That the vent plug assembly is securely installed and sealed with an anti-tamper seal.

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

8.1 Acceptance Tests

Prior to first use of the package:

8.1.1 Visual Inspection

The entire package, both inside and out, shall be visually inspected to note any significant damage (such as cracks, broken welds, punctures, discontinuities, etc.). Cask finished surfaces shall be checked for finish. Seals and seal surfaces shall be examined for proper condition (as per Step 7.1.10.4). Bolts shall be examined for good condition and then put in place (as per Step 7.1.10.2). Exterior nameplates must be in place and legible.

8.1.2 Structural and Pressure Tests

Vent plug assembly shall be installed on the cask vent, a cask drain outlet valve installed and the cask pressurized to 4 psig with air and bubble testing of all closures in accordance with ANSI Standard N14.5. If seal leakage is detected, the seal will be replaced, the seal surfaces checked and reworked if necessary.

8.1.3 Leak Tests

An alternate hydrostatic test may be performed by placing the vent plug test adapter (LS-6000-4) assembly on the cask vent, attaching a 12 foot or longer length as required of tygon tubing to the vent. Remove the cask drain line plug and install drain valve. Attach water supply to the drain valve, Raise tubing 12 feet above cask. Introduce water into the cask until vent tubing is full. Close drain valve and remove water supply. Check all cask seals for leaks. Replace seals and rework seals surfaces if necessary.

8.1.4 Components Tests

There are no auxiliary components on the package requiring testing.

8.1.5 Tests for Shielding Integrity*

A grid layout shall be overlayed on the outside surfaces of the cask. A radioactive gamma source shall be placed within the cask and the outside surface scanned by suitable radiation detection equipment. An average count rate shall be determined by recording the radiation reading in mR/hr. or counts per minute at the intersection of grid points one foot square over the entire outside surface of the cask. In addition, each one-foot square grid shall be scanned and the highest radiation reading recorded.

Any area or defect which indicates a radiation reading over a square inch of surface area that exceeds twice the average radiation reading for the entire cask shall be repaired. There shall be no more than one defect of this magnitude in any one square foot grid.

8.1.6 Thermal Acceptance Test

No thermal acceptance test is to be performed on the cask package. Section 3.0, Thermal Evaluation, does not indicate any critical temperatures requiring test evaluation.

* Reference: This test procedure is copied from the original contract terms and supplemental agreement between Atcor, Inc. and P.X. Engineering Co., Everett, Mass. (cask fabricator) and certified by Arnold Green Testing Laboratories, Inc., Natick, Mass., dated 4/17/69.

8.2 Maintenance Program

Inspections and tests and the inspections noted in Section 7.0, Operating Procedures, provide for continued monitoring of the condition of the package. Damaged, failed, or even incipient failure will be promptly detected. Repair or replacement shall be made prior to transport (See Appendix 8.3).

8.2.1 Structural and Pressure Tests

Routine visual examinations will be performed to detect damage or defects significant to package condition. Exterior stencils, nameplates, and bolts will be verified in place. Drains, fittings, gaskets, and seals shall be tested to verify that they are not plugged or damaged. Tests for leak tightness of cask in accordance with Section 4.0, Appendix 4.4 shall be accomplished by one of the following methods:

8.2.1.1 Pressurizing cask interior to 4 psig and bubble testing all closures.

8.2.1.2 Hydrostatic test (optional).

8.2.1.2.1 Attach a 12 foot or longer length as required of tygon tubing to the vent. Open Vent.

8.2.1.2.2 Remove drain line plug and install drain valve. Attach water supply to drain valve.

8.2.1.2.3 Raise tubing 12 feet above cask.

8.2.1.2.4 Open drain valve. Introduce water into cask until vent tubing is full.

8.2.1.2.5 Close drain valve. Remove water supply.

8.2.1.2.6 Check cask for leaks. All O-rings must be maintained in accordance with Section 8.2.4.

8.2.1.2.7 Drain cask of all water by opening drain valve. (The water in cask may be contaminated and should be drained to contaminated drain.)

8.2.2 Leak Test

8.2.2.1 Prior to delivery of the package to a carrier for transport, the package containment cavity shall be leak tested. The sensitivity of the test shall be at least 1×10^{-1} ATM cm^3/SEC (STP).

8.2.2.2 The packaging containment cavity shall be leak tested initially and at least once every twelve (12) months. The sensitivity of the test shall be at least 1×10^{-3} ATM cm^3/SEC (STP).

8.2.3 Subsystem Maintenance

The cask does not have any subsystems.

8.2.4 Valves and Gaskets on Containment Vessel

8.2.4.1 All O-rings and gaskets must be replaced at least every six months, even if satisfactory condition is noted during the routine inspections which are made prior to each shipment. After replacement, leak testing is required as specified in 8.2.2.1 above.

8.2.4.2 Relief valve shall be bench tested annually to verify that relief will occur at set pressure of 25 +10% - 0% psig.

8.2.4.3 Pressure gage shall be tested to verify accuracy within 0.5 psi over range of 0 to 30 psig.

8.2.5 Shielding

No tests are required for shielding performance other than routine loaded surveys.

8.2.6 Thermal

No thermal tests are required.

8.2.7 Painted Cask Surface

If the cask is painted, the painted surface shall be thoroughly examined at periods not to exceed one (1) year and the general condition of the coating noted in the cask documentation. If the overall surface of the cask shows significant cracking, chipping, flaking or discoloration, the cask surface shall be sanded, decontaminated, and re-coated with at least two coats of nuclear grade epoxy paint.

(continued on page 8-5)

8.3 Appendix

8.3.1 Documentation

All operations, use and maintenance records for the VNDB Shipping Cask shall be maintained for a period of two years after their generation. All records relating to repair or rework of the cask shall be maintained for the life of the cask. These shall include but not be limited to material procurement documents, vendor material certification or certificates of compliance, inspections and test results.

8.3.2 Operation

The operation functions of the VNDB Cask will be examined at periods not to exceed one (1) year to verify the continued satisfactory performance of the cask. However, if the cask has been inactive for a period of greater than one year, these functions will be examined prior to next use. These functions include but shall not be limited to the following features:

8.3.2.1	Drain Valve
8.3.2.2	Pressure relief valve
8.3.2.3	Vent
8.3.2.4	Pressure gauge
8.3.2.5	Seals

Procedures shall be prepared and followed for each of these operation checks. The results shall be properly recorded and the records will become part of the cask documentation as indicated in Section 8.3.1.

8.3.3 Use

8.3.3.1 Prior to each use of the VNDB Cask a series of pre-use checks shall be made. The purpose of these checks is to prepare the cask for the ensuing shipment and to assure that there is no apparent damage or deficiency in the cask which occurred during prior use of storage. The pre-use checks as well as the loading operations shall follow prescribed procedures. The pre-use checks shall include but not be limited to:

8.3.3.1.1 Visual inspection
8.3.3.1.2 Inspection of seals

8.3.3.2 During the cask loading sequence, checks, inspection and measurements shall be made to assure that the cask is properly loaded and sealed.

These checks, inspections, and measurements shall include but not be limited to:

8.3.3.2.1 Health Physics surveys
8.3.3.2.2 Seals and valves checks
8.3.3.2.3 Cover closure checks
8.3.3.2.4 Pressure checks
8.3.3.2.5 Tie-down attachment checks
8.3.3.2.6 Review of decay heat determination
8.3.3.2.7 Dose rate measurements

8.3.4 Maintenance

A maintenance schedule shall be established to keep the cask in a full operable condition. Procedures shall be established which will indicate the routine inspections and maintenance steps which will be taken. The procedures will indicate the frequency of the maintenance operations and inspections and the corrective action which will be taken should damage or an inoperable component be detected.

8.3.5 Repair

Should repair to the VNDB Cask be required it shall be performed in such a way as to return the cask to an operating condition equal to or better than its original condition. Procedures will be established to assure that the repair to any portion of the cask will not reduce the operability of any other portion or component. The repair program shall include at a minimum the following efforts:

- Design Control and Review
- Materials Selection and Control
- Repair Fabrication Control
- Inspection Control
- Testing Control
- Documentation

8.3.5.1 Design Control and Review

If repair to the cask is indicated, CNSI Engineering will determine the manner in which the repair should be performed. Their decisions shall be submitted in writing to Quality Assurance for approval before implementation will be permitted. Approval of CNSI Engineering shall be documented and the Transportation Manager shall be responsible for preparing and implementing repair procedures.

8.3.5.2 Materials Selection and Control

All purchased materials and components shall be purchased according to appropriate specifications and requirements. Material certification or certificates of compliance shall be required of all materials and components. Upon receipt of the materials and/or components their compliance with the specifications or requirements shall be checked. They shall then be properly identified as suitable for use in the VNDB Cask. Any materials or

components which will be stored prior to use shall be stored in such a way that deterioration or damage will not occur during the storage.

8.3.5.3 Repair Control

All repair operations shall be done in accordance with the repair procedures established by CNSI Engineering. Where special processes or techniques such as welding or heat treating are specified they shall be performed by qualified technicians or operators and according to established codes and standards. The Quality Assurance Manager will be responsible for implementing the Quality Assurance Program prepared for this work.

8.3.5.4 Inspection Control

The repair work shall be inspected by knowledgeable inspectors at the inspection points indicated in the approved repair procedures. Work shall not proceed at any such inspection point until the inspections and tests have been made and approved by the inspector. The inspector shall be a person who is to perform the inspection and evaluate the results and who did not perform the work or is responsible for the operation.

All instruments used in all inspections shall be calibrated with standards traceable to the National Bureau of Standards or to a certified laboratory. The results of all inspections and tests will be fully documented and become part of the cask records.

Inspectors will be qualified in accordance with appropriate codes and standards.

Nonconforming, inoperative, or malfunctioning materials and equipment will be appropriately marked to prevent inadvertent use or reuse.

Such materials or equipment will be disposed of in a reasonable time after determination of faults for corrective action. (See 3.3.6.)

8.3.5.5 Testing Control

All tests of the repaired cask shall be made as required to show compliance with all requirements of the original cask. Tests such as shielding and pressure tests shall follow the test procedures established for the originally fabricated cask. Where no such test was previously made is deemed desirable on the repaired cask, testing procedures shall be established using current practices for cask testing as a guide. All test procedures and results shall be fully documented and become part of the cask records.

8.3.5.6 Documentation

All of the efforts involved in the cask repair shall be fully documented. This includes but is not limited to:

8.3.5.6.1 Repair procedures
8.3.5.6.2 Material purchase orders
8.3.5.6.3 Material certification
8.3.5.6.4 Material receipt inspection reports
8.3.5.6.5 Repair inspection reports
8.3.5.6.6 Test Procedures and results

All documentation shall become part of the permanent cask records.

8.3.6 Corrective Action Program

The CNSI corrective action program shall apply to the operating, use, maintenance and repair procedures for the cask for prompt detection and correction of conditions which might adversely affect the safety of the operation of the cask. In the event of adverse conditions such as deficiencies, deviations, defects, and non-conformance, the cause of such condition will be determined and corrective action will be taken to preclude its repetition. Identification, cause and corrective action for adverse conditions shall be fully documented and become part of the cask records.

9.0 DRAWINGS

LIST OF DRAWINGS FOR CNS 3-55 SHIPPING CASK

Drawing Number		Drawing Name
MOD-100	Rev. 12	Modification of VNDB Cask (LS-6000-1)
C-111-D-0001	Rev. -	3-55 Cask Shield Ring
C-111-E-0002	Rev. -	CNS 3-55 Lid Detail
MOD-139-1	Rev. K	VNDB Shipping and Storage Cask Engineering Reference Drawing
MOD-140	Rev. C	VNDB Shipping and Storage Cask Closure Detail
MOD-124	Rev. D	VNDB Skid Assembly
0999-D-07	Rev. G	Cask Shock Absorber Detail for Top Cover, Bottom & Trunnions
0999-C-08	Rev. G	Vent
C-110-D-5001	Rev. 1	Sunshade for CNS 3-55 Shipping Cask

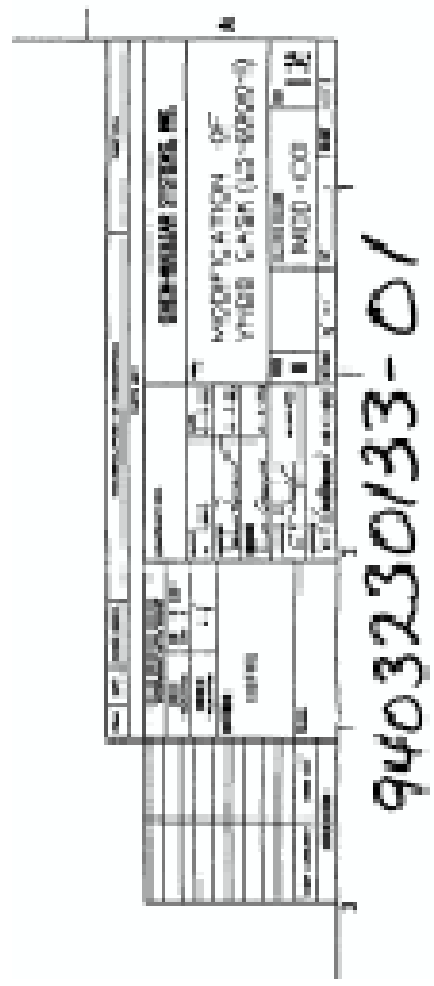

FIGURE WITHHELD UNDER 10 CFR 2.390

SHT 2 OF 5 | A

MODIFICATION INSTRUCTIONS:

1. DWG. NO. LS-6000-1 SHEET 1:

   REMOVE ITEM NO. 11. THIS ITEM TO BE FLUSH WITH ITEM NO. 1.

   DWG. NO. LS-6000-1 SHEET 2:

   REMOVE ITEM NOS. 12, 14, 15, 16, 18, 19, 22, AND 23.

   THESE ITEMS TO BE FLUSH WITH ITEM NO. 1.

2. DWG. NO. LS-6000-1 SHEET 2:

   ITEM NO. 13 TO BE CUT TO 4.50 DIM. REMOVE BURRS. (SEE DWG. NO. MOD-100 SHEET 1 VIEW "A" AND SECTION H-H.)

3. DWG. NO. LS-6000-1 SHEET 2:

   ITEM NO. 12 TO BE PLUG WELDED SEALED BOTH ENDS (TO BE FLUSH WITH ITEM NO. 1). (SEE DWG. NO. MOD-100 SHEET 1 SECTION F-F.)

4. DWG. NO. LS-6000-1 SHEET 2:

   (a) ADD ITEM NO. 104 LOCATE AND WELD PER DWG. NO. MOD-100 SHEET 1 SECTIONS D-D AND H-H. HOLES TO BE IN ALIGNMENT AFTER WELDING (TYPICAL 4 PLACES).

   (b) ADD ITEM NO. 106 LOCATE AND WELD PER DWG. NO. MOD-100 SHEET 1 SECTIONS D-D AND H-H. HOLES TO BE IN ALIGNMENT AFTER WELDING (TYPICAL 4 PLACES).

   (c) ADD ITEM NOS. 119 AND 104 LOCATE AND WELD PER DWG. NO. MOD-100 SHEET 1 SECTIONS C-C AND H-H. HOLES TO BE IN ALIGNMENT AFTER WELDING (TYPICAL 8 PLACES). ADD ITEM NO. 105 LOCATE AND WELD

REV. LET.	REVISIONS	BY	DATE	REV. LET.	REVISIONS	BY	DATE
A	WAS SHT 2 OF 4						

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505 KING AVE.
COLUMBUS 1, OHIO

TOLERANCE UNLESS OTHERWISE NOTED				NEXT ASSY.	NO REQ'D
FRAC ±	ANG. ±	DEC			
	DRAWN	CHECKED	PROJ. APP		
BY	Seibert				
DATE	5-11-68			SCALE	K-G
DIV.	748			—	—

TITLE: MODIFICATION INSTRUCTIONS VNDB CASK (LS-6000-1)

ACCT. NO. N 9954

DWG. NO. MOD-100 | 12

SHT 3-5 | A |

5. DWG. NO. MOD-100 SHEET 1:

(a) ADD ITEM NO. 125. LOCATE AND WELD PER DWG. NO. MOD-100 SHEET 1.

(b) ADD ITEM NO. 128 TO ITEM 125 USING FOUR 1-8 UNC x 1.88 LONG BOLTS.

REV LET	REVISIONS	BY	DATE	REV LET	REVISIONS	BY	DATE

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FRAC ±	ANG ±	DEC.	
	DRAWN	CHECKED	PROJ. APP
BY	Deitel		
DATE	6-4-68		
DIV.	748		

NEXT ASSY.	NO. REQ'D

TITLE
MODIFICATION INSTRUCTIONS
VNDB CASK (LS-6000-1)

SCALE	K-G	ACCT. NO.	DWG. NO.	
—	—	N 9954	MOD-100	12

SHEET 3 OF 5 SHEETS

PER DWG. NO. MOD-100 SHEET 1 SECTIONS C-C AND H-H. HOLES TO BE IN ALIGNMENT AFTER WELDING (TYPICAL 8 PLACES).

6. DWG. NO. LS-6000-1 SHEET 2:

DRILL SIX 0.75-DIA. HOLES ON AN 8.00-DIA. ON THE CENTER LINE OF ITEM NO. 13. DRILL THROUGH ITEM NO. 1 ONLY! PLUG WELD ITEM NO. 17 TO ITEM NO. 1 (TYPICAL 6 HOLES). TYPICAL 2 PLACES. (SEE DWG. NO. MOD-100 SHEET 1 VIEW "A" AND SECTION H-H .)

7. DWG. NO. LS-6000-1 SHEET 2:

ADD ITEM NOS. 101 AND 102 TO ITEM NO. 13 (2 PLACES). LOCATE AND WELD PER DWG. NO. MOD-100 SHEET 1 VIEW "A" AND SECTION H-H.

8. DWG. NO. LS-6000-1 SHEET 2:

ADD ITEM NOS. 107 AND 108, 2 REQUIRED EACH. LOCATE AND TACK WELD THESE ITEMS INTO POSITION PER DWG. NO. MOD-100 SHEET 1 VIEW "E" AND SECTIONS G-G AND H-H. MAKE ALL 0.50 FILLET WELDS FIRST. THEN MAKE THE 0.50 BEVEL "V" WELDS. FINISH WELDS AND MATCH FINISH DIRECTION (TYPICAL 4 PLACES).

9. DWG. NO. LS-6000-1 SHEET 1:

ADD ITEM NO. 116 TO ITEM NO. 3 (BASE PLATE) AND WELD PER DWG. NO. MOD-100 SHEET 1 SECTION H-H.

10. DWG. NO. LS-6000-1 SHEET 2:

(a) ADD ITEM NOS. 109 AND 114 TO ITEM NO. 3. POSITION THESE ITEMS AND WELD PER DWG. NO. MOD-100 SHEET 1 SECTION H-H.

REV LET	REVISIONS	BY	DATE	REV LET	REVISIONS	BY	DATE
A	WAS SHT 3 OF 4 SHTS.						

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TOLERANCE UNLESS OTHERWISE NOTED		
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DATE	5-17-68		
DIV.	748		

NEXT ASSY	NO REQ'D

TITLE
MODIFICATION INSTRUCTIONS
VNDB CASK (LS-6000-1)

SCALE	K-G	ACCT. NO.	DWG. NO.	
—	—	N 9954	MOD-100	12

(b) ADD ITEM NO. 110. LOCATE AND WELD PER DWG. NO. MOD-100 SHEET 1 SECTION H-H. NOTE: CAUTION MUST BE APPLIED AS TO INSURE PROPER ALIGNMENT BETWEEN ITEM NOS. 115, 111, 110, AND 114 (SECTION H-H).

(c) ADD ITEM NO. 115 TO ITEM NO. 111. POSITION ITEM NO. 115 WITH CAUTION TO INSURE PROPER ALIGNMENT WITH ITEM NOS. 110 AND 114. WELD PER DWG. NO. MOD-100 SHEET 1 SECTION H-H.

11. DWG. NO. LS-6000-1 SHEET 1:

ITEM NO. 120 REPLACES ITEM NO. 5 FOUR PLACES. SEE DWG. NO. MOD-100 SHEET 1 SECTIONS D-D AND H-H.

12. DWG. NO. LS-6000-1 SHEET 1:

ITEM NO. 121 REPLACES ITEM NO. 6 EIGHT PLACES. SEE DWG. NO. MOD-100 SHEET 1 SECTIONS C-C AND H-H.

13. DWG. NO. LS-6000-1 SHEET 1:

ITEM NO. 118 REPLACES ITEM NO. 15. SEE DWG. NO. MOD-100 SHEET 1 SECTION H-H.

14. DWG. NO. LS-6000-1 SHEET 1:

ITEM NO. 118 REPLACES ITEM NO. 13 (BOLTS). SEE DWG. NO. MOD-100 SHEET 1 SECTION H-H.

15. DWG. NO. LS-6000-1 SHEET 1:

ITEM NOS. 30, 17, 2, AND 14 NOT USED. (SEE DWG. NO. MOD-100 SHEET 1 SECTION H-H FOR REPLACEMENT ITEMS.)

16. DWG. NO. MOD-100 SHEET 1:

ADD ITEM NO. 122. LOCATE AND WELD PER SECTIONS H-H AND G-G.

REV. LET	REVISIONS	BY	DATE	REV. LET	REVISIONS	BY	DATE
A	WAS SHT 4 OF 4 SHTS						

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FRAC ±	ANG ±	DEC			
	DRAWN	CHECKED	PROJ. APP		
BY	Seibert				
DATE	5-17-68			SCALE —	K-G —
DIV.	748				

TITLE: MODIFICATION INSTRUCTIONS VNDB CASK (LS-6000-1)

ACCT. NO. N9954 | DWG. NO. MOD-100 | 12

FIGURE WITHHELD UNDER 10 CFR 2.390

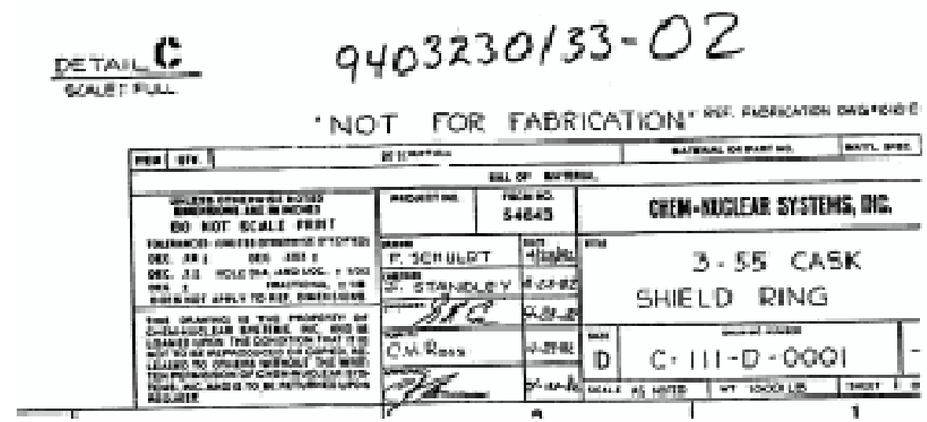

FIGURE WITHHELD UNDER 10 CFR 2.390

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FIGURE WITHHELD UNDER 10 CFR 2.390

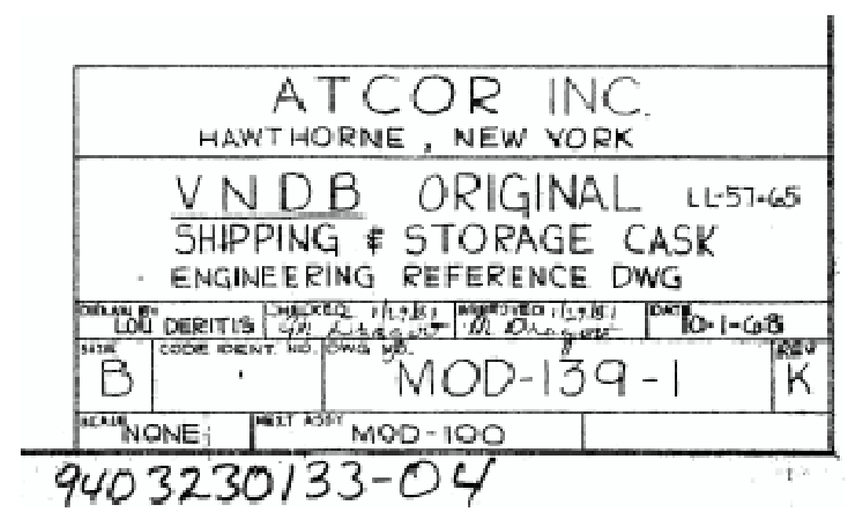

FIGURE WITHHELD UNDER 10 CFR 2.390

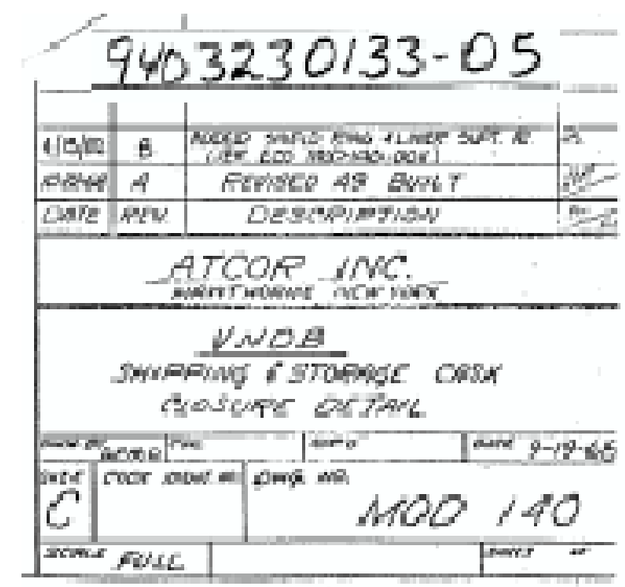

FIGURE WITHHELD UNDER 10 CFR 2.390

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FIGURE WITHHELD UNDER 10 CFR 2.390

FIGURE WITHHELD UNDER 10 CFR 2.390

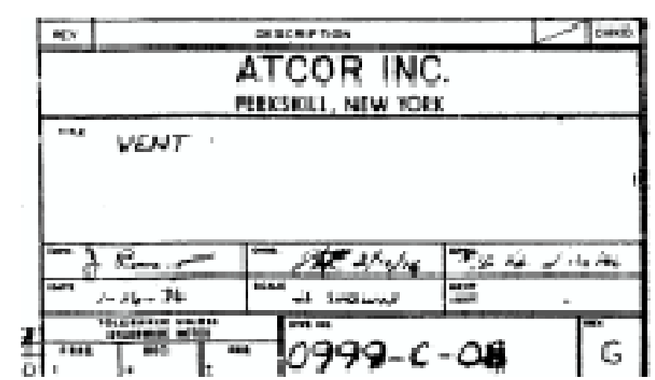

FIGURE WITHHELD UNDER 10 CFR 2.390

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FIGURE WITHHELD UNDER 10 CFR 2.390