Attachment II
ltr SHP-1097

GENERAL ATOMIC

GENERAL ATOMIC COMPANY
P. O. Box 81608
San Diego, CA 92138

GADR-55
ADDENDUM I
REVISION C

FINAL DESIGN REPORT FOR FORT ST. VRAIN FUEL SHIPPING CASK

Approved: Robert L. Moore

21 August 1979

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INTRODUCTION

Addendum 1 to GADR-55 provides the Safety Analysis for an alternate closure system for the model FSV-1 cask. This alternate closure system consists of the following major components:

Fuel Container Lid
Shipping Cask Cover
Impact Limiter

Associated with these major components are the seals, test ports, bolts, and retainers.

The alternate closure system is shown on General Atomic Company (GAC) Drawings GADR-55-2-1, GADR-55-2-2 and GADR-55-2-3. The detailed description and the supporting analysis is presented in the folloiwng sections of Addendum 1. These sections are numbered the same as the sections of GADR-55 and contain the additional analysis and description associated with the alternate closure system for the model FSV-1 cask. The alternate closure system is designed to satisfy the requirements of 10 CFR 71 as effective June 1978, except that the leakage rates and tests are designed to satisfy the requirements of ANS N14.5, "Leakage Tests on Packages for Shipment of Radioactive Materials", dated November 1974.

Reference throughout this report has been made to GAC manufacturing drawings designated as 90-H1501-XXX. These individual drawings are not a part of this report. Instead, GAC Drawings GADR-55-2-1, GADR-55-2-2 and GADR-55-2-3 have been included to provide the necessary design information.

f. Using the 17-1/2 ton overhead crane, move a reactor isolation valve from storage and position it on top of the fuel loading port. Use alignment gage for positioning.

g. Connect purge and control lines to reactor isolation valve and open valve.

h. Inflate reactor isolation valve seals.

i. Unfasten the 12 bolts in the spent fuel container lid.

j. Remove shipping plug and primary plug from container lid.

k. Install track and adapter guide onto shipping container lid. Engage the track on the two keys in the RIV.

l. Using the 170 ton overhead crane, move the auxiliary transfer cask from storage position to the top of reactor isolation valve located on the fuel loading port.

m. Open the shutter of the valve of the auxiliary transfer cask and lower the auxiliary transfer cask grapple to engage track and adapter assembly for lifting the shipping container lid.

n. Raise the container lid into auxiliary transfer cask.

o. Close the reactor isolation valve.

p. With the purge connection on the reactor isolation valve, purge the auxiliary transfer cask and backfill with air.

q. Close auxiliary transfer cask shutter.

r. Move the auxiliary transfer cask to its storage position and bolt in place.

3. Placing the Spent Fuel Elements in the Shipping Cask.

a. Mount the fuel handling machine with 6 spent fuel elements to the RIV on the loading port.

b. Open the reactor isolation valve.

c. Evacuate fuel shipping cask through the reactor isolation valve and backfull with helium.

d. Open fuel handling machine cask valve.

e. Deposit 6 fuel elements into fuel shipping cask.

f. Close and seal the fuel handling machine cask valve and the reactor isolation valve.

g. Evacuate the reactor isolation valve interspace and backfill with air.

h. Remove the fuel handling machine to its storage position.

4. Installing the Container Lid.

a. Move the auxiliary transfer cask from its storage position and mount to the reactor isolation valve over the fuel loading port.

b. Evacuate the auxiliary transfer cask and backfill with helium.

c. Open the reactor isolation valve.

d. Lower and deposit the fuel shipping cask container lid.

e. Evacuate auxiliary transfer cask to 20 mm Hg and backfill with air.

f. Remove and store the auxiliary transfer cask.

g. Remove track and adapter assembly from the container lid.

h. Bolt down the container lid using twelve 1/2 inch bolts. Torque to 15 to 20 ft-lbs.

i. Install primary plug in the container lid.

j. Remove reactor isolation valve to its storage position.

5. Leakage Testing the Container Lid Seals.

a. Assembly verification testing. (Done before each use except when Step 5.b. is required.)

(1) Connect leakage test system with pressure gauge and shutoff valve to test port in container lid.

(2) Evacuate seal interspace to a pressure of 1 mm Hg. Close shutoff valve.

(3) Wait 2 minutes.* Maximum permissible pressure rise is 5.5 mm Hg (6.5 mm Hg on gauge).

*Test time is based on a total test cavity volume of 1 cubic inch (16.387 cm^3)

(4) If pressure rise is greater than the permissible rise, replace main flange and primary plug seals. Repeat Step 5.b.

b. Periodic verification testing (done prior to each third use or within 12 months prior to use or after each seal replacement).

(1) Connect leakage test system fitting with pressure gauge and shutoff valve to test port in container lid.

(2) Evacuate seal interspace to a pressure of 1 mm Hg. Close shutoff valve.

(3) Wait five minutes.* Maximum permissible pressure rise is 5.7 mm Hg. (6.7 mm Hg on gauge)

(4) If pressure rise is greater than the permissible rise, replace main flange and primary plug seals. Repeat Stem 5.b.

c. Disconnect leakage test system from vacuum source.

d. Open shutoff valve to vent seal interspace and remove leakage test system.

e. Install the shipping plug in the test port.

f. Remove seal adapter from top of cask.

*Test time is based on a total test cavity volume of 1 cubic inch (16.387 cm^3)

F. MAINTENANCE PROGRAM

The shipping cask with the fuel container, and all auxiliary equipment will be maintained to assure that all items are in proper operating condition. A checklist will be developed which will list each component which requires specific maintenance actions. The checklist will include the method of maintenance check to be used, the acceptance criteria for each, and the required maintenance frequency. Each checkpoint will require sign-off by the individual making the check. Space will be provided on the maintenance checklist to enter the equipment identification, supervisor's name, and the date maintenance is completed.

The maintenance checklist will also include all auxiliary equipment, such as the lifting yoke, tie-down assemblies, and trailer. Maintenance of the trailer will be carried out in accordance with standard industry-recommended procedures and schedules.

The cask operating procedure will contain steps requiring a review of the equipment maintenance program checklists to verify that all required maintenance and periodic testing has been accomplished.

G. LEAKAGE TESTING

In accordance with Regulatory Guide 7.4, the guidance contained in ANSI N14.5, "Leakage Tests on Packages for Shipment of Radioactive Materials", was used to establish the maximum permissible leakage rate and the minimum leakage test sensitivity.

1. The containment system assembly verification test will be conducted prior to each use (except when the periodic verification test is required) as follows:

Component	Verification
Fuel Container main flange double seal	(a) (b)
Fuel Container primary plug seal	(a) (b)

(a) Checklist verification of proper assembly.

(b) Leakage test by evacuating the seal interspace to a pressure of 1 mm Hg. Observe that pressure does not rise above 6.5 mm Hg in two minutes (maximum permissible leakage rate is 1×10^{-3} atm cm^3/sec).

2. The containment system periodic verification test will be conducted prior to each third use, within 12 months of any use and prior to any use following the replacement of any primary seals.

Component	Verification
Fuel Container main flange seal	(a) (b)
Fuel Container primary plug seal	(a) (b)

(a) Checklist verification of proper assembly

(b) Leakage test by evacuating the seal interspace to a pressure of 1 mm Hg. Observe tnat pressure does not rise above 6.7 mm Hg in five minutes (maximum permissible leakage rate is 4.12×10^{-4} atm cm^3/sec).

3. The shipping cask seals that are not part of the containment system will be tested as part of the annual maintenance procedure as follows:

   a. Pressurize the shipping cask cavity to 10 psig through the lower purge valve connection. Reinstall the purge valve cover and apply soap solution around the purge valve cover and the lower cavity access port cover. No leak indications permitted.

   b. Remove the shipping plug from the cask cover. Evacuate the seal interspace to a pressure of 1 mm Hg. Observe that pressure does not rise above 6.5 mm Hg in two minutes (maximum permissible leakage rate is 1×10^{-3} atm cm^3/sec).

4. Calculations for permissible leakage rate.

   The maximum permissible leakage rate and the minimum sensitivity of the leakage test were determined by using the guidance provided in ANSI N14.5, "Draft American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials".

   a. Containment: The FSV-1 cask with alternate closure system is assumed to be a Type B (U) package.

   b. Gaseous fission product inventory:

      (1) Normal conditions of transport: negligible quantity (Ref. 3).

      (2) Accident conditions of transport: Kr 85 470 curies (Ref. 3).

   c. Parameters:

      (1) A_2 value for Kr 85 = 1000 curies (Ref. 1).

      (2) R_N = package containment requirements for normal conditions of transport, curies per second (Ci/sec).

      $R_N = 2.78 \times 10^{-10}$ Ci/sec (Ref. 2)

(3) R_A = package containment requirements for accident conditions of transport, curies per second (Ci/sec).

$R_A = A_2 \times 1.65 \times 10^{-9}$ Ci/sec (Ref. 2).

(4) Fuel container net volume:

235×10^3 cm^3

(5) Volume of test port in container lid and the test equipment, V_p = 1.0 in.^{3} (16.387 cm^3)

d. Normal conditions of transport:

Since the inventory of gaseous fission products during normal conditions of transport is negligible, the accident condition will establish the permissible leakage rate.

e. Accident conditions of transport:

(1) L_A = permissible leakage rate, atm cm^3/sec

$$L_A = \frac{R_A}{C_A}$$

C_A = specific activity of containment medium

$$C_A = \frac{470 \text{ Ci}}{235 \times 10^3 \text{ cm}^3} = 2.0 \times 10^{-3} \text{ Ci/cm}^3$$

$$R_A = 1000 \times 1.65 \times 10^{-9} = 1.65 \times 10^{-6}$$

$$L_A = \frac{1.65 \times 10^{-6} \text{ Ci/sec}}{2.0 \times 10^{-3} \text{ Ci/cm}^3} = 8.25 \times 10^{-4} \text{ cm}^3/\text{sec}$$

f. Containment system periodic verification:

The periodic leakage test is required to have a sensitivity to detect leakage that is 1/2 of the permissible leakage.

$L_A = 8.25 \times 10^{-4}$ cm^3/sec

$1/2\ L_A = 4.12 \times 10^{-4}$ cm^3/sec

Thus a "pressure rise" test with a nominal sensitivity of 1×10^{-4} atm cm^3/sec was selected.

(1) Duration of leakage test:

Using a test volume of 16.387 cm^3, a starting pressure of 1 mm Hg and an ending pressure of 7.6 mm Hg (Ref. 2), the volume of inleakage, V_i is:

$$V_i = 16.387\ cm^3 \left[\frac{7.6}{760} - \frac{1}{760}\right] = 1.42 \times 10^{-1}\ cm^3$$

t = test time in seconds is:

$$t = \frac{1.42 \times 10^{-1}\ cm^3}{4.12 \times 10^{-4}\ cm^3/sec} = 344.7\ sec$$

The allowable rate of pressure rise is:

$$\frac{6.6\ mm\ Hg}{344.7\ sec} = .01915\ mm\ Hg/sec$$

The allowable pressure rise for a five minute test is:

$$.01915 \times 5 \times 60 = 5.7\ mm\ Hg$$

(2) Check of test sensitivity:

$$L_S = \frac{V_p\ T_S}{3600\ H}\left[\frac{P_2}{T_2} - \frac{P_1}{T_1}\right] \quad \text{(Ref. 2, Eq. B11)}$$

$$= \frac{16.387 \times 298}{3600 \times \frac{344.7}{3600}}\left[\frac{\frac{7.6}{760}}{298} - \frac{\frac{1}{760}}{298}\right]$$

$$L_S = 4.12 \times 10^{-4}\ atm\ cm^3/sec$$

g. Containment system assembly verification:

This test is used to verify that no gross seal defects exist prior to each shipment, therefore, a less sensitive test procedure is required. A test sensitivity of 1×10^{-3} atm cm^3/sec is assumed to provide a more reasonable test time although a 1×10^{-1} atm cm^3/sec test is allowed. (Ref. 2)

$$t = \frac{1.42 \times 10^{-1}\ cm^3}{1 \times 10^{-3}\ cm^3/sec} = 142\ seconds$$

The allowable rate of pressure rise is:

$$\frac{6.6\ mm\ Hg}{142\ sec} = .0465\ mm\ Hg/sec$$

The allowable pressure rise for a two-minute test is:

$$.0465 \times 2 \times 60 = 5.6\ mm\ Hg$$

SECTION I

Ref. 1. IAEA Safety Series, No. 6. 1973 revised.

2. ANSI N14.5. November 1974

3. GADR-55, Supplement A, page 9-5, 9-6 and 9-7.

The shipping cask closure is sealed to the cask body with a stainless steel/dual concentric silicon elastomer seal design similar to that used on the spent fuel container lid. A single test port is routed from the top of the closure to the innerspace between the concentric seals to allow for seal leak testing similar to that done on the container lid seal.

D. IMPACT LIMITER

An aluminum encased plywood impact limiter attaches to the top end of the cask and completely envelops the cask closure and container lid area. The impact limiter is designed to protect the cask closure area from both top end and side drops as well as drops through all intermediate angles. The limiter is made up of about 40 layers of 3/4 inch thick marine grade plywood and is encased in aluminum for weather protection and durability during handling. The impact limiter is clamped to the outer top end of the cask using a continuous mounting ring which is held to the impact limiter with six 1/2 inch diameter fasteners.

E. DRAWINGS

General Atomic Company: GADR-55-2-1, GADR-55-2-2, GADR-55-2-3.

A. DESIGN CRITERIA

The design criteria presented in Regulatory Guide 7.6 (Revision 1, March 1978) were used in the structural analysis of the cask cover and the container lid to verify that the Normal Conditions of Transport and the Hypothetical Accident Conditions of Appendicies A and B respectively, to 10 CFR Part 71 are satisfied.

TABLE V-1 presents a summary of the significant conditions, analytical values and allowables from the structural analysis.

TABLE V-1

Summary of Analysis Values for Normal Conditions of Transport and Hypothetical Accident Conditions

Ref.	Condition	Component	Stress	T(°F)	Analysis Value	Allowable	Pg
Reg. Guide 7.8 Para. C.1.c and C.3.c	15 psig 600°F (Design)	container lid housing	primary membrane	600	σ = 1,849 psi	Sm = 16,400 psi	5-22
			primary membrane + bending	600	σ = 9,688 psi	1.5Sm= 24,600 psi	5-22
			primary & secondary	600	σ = 9,688 psi	3Sm= 49,200 psi	5-22
			fatigue	600	n = 1,100 cycles	N = 10^6 cycles	5-22
NORMAL CONDITIONS OF TRANSPORT							
10 CFR 71 Appendix A Para. 1	130°F day	container lid top plate	bending	300	σ =22,296 psi	1.5Sm= 30,000 psi	5-26
		container lid top plate outer weld	primary	300	σ = 4,399 psi	Sm= 20,000 psi	5-27
		container lid top plate inner welds	shear	300	T =10,358 psi	0.6Sm= 12,000 psi	5-27
			primary	300	σ = 9,593 psi	Sm= 20,000 psi	5-28
			fatigue	300	n = 600 cycles	N= 60,000 cycles	5-28

TABLE V-1 (cont'd.)

Ref.	Condition	Component	Stress	T(°F)	Analysis Value	Allowable	Pg
10 CFR 71 Appendix A Para. 4	vibration	container lid	fatigue	300	σ = 1,450 psi	endurance limit = 25,400 psi	14-10
Para. 6	1 foot bottom drop	container lid housing	primary membrane	300	σ = 11,650 psi	Sm= 20,000 psi	5-68B
		container lid DU shielding	primary membrane	300	σ = 12,970 psi	$Sm=\frac{Su}{3}$= 19,700 psi	5-68B
		cask cover	primary membrane + bending	300	σ = 11,420 psi	$Sm=\frac{Su}{3}$= 46,700 psi	5-68B
			primary and secondary	300	σ = 11,420 psi	3Sm=Su=140,000 psi	5-68B
	1 foot side drop	container lid	bearing	300	σ = 3,255 psi	Sm= 20,000 psi	5-101C

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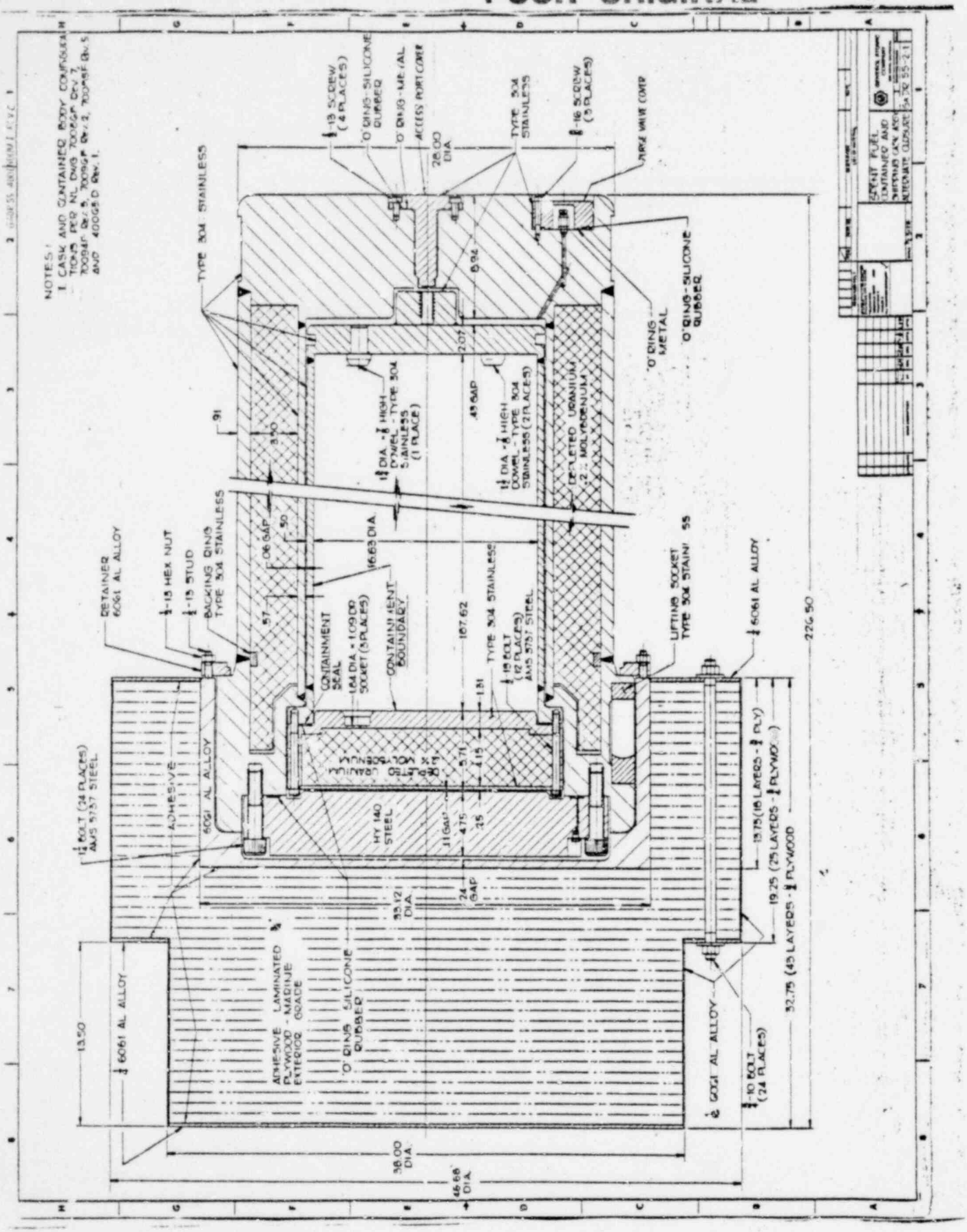
TABLE V-1 (Cont'd)

Ref.	Condition	Component	Stress	T(°F)	Analysis Value	Allowable	Pg
HYPOTHETICAL ACCIDENT							
10 CFR 71 Appendix B Para. 1	30' free drop bottom impact	container lid	primary membrane + bending	300	σ = 27,860 psi	Su= 66,000 psi	5-68
		cask cover	primary membrane + bending	300	σ = 38,970 psi	Su=140,000 psi	5-68
	30' free drop top impact	cask cover	primary membrane + bending	300	σ = 18,440 psi	Su=140,000 psi	5-106
Para. 2	puncture	cask cover	primary membrane + bending	300	σ = 137,400 psi	Su=140,000 psi	5-100
			puncture force	300	W = 2.5 x 10^6 lb.	P_s=8.06 x 10^6 lb	5-100 5-101
10 CFR 71 Appendix A and Appendix B	Normal and Hypothetical Accident	cask cover	extreme total stress intensity	300	σ = 155,900 psi	Sa=400,000 psi	Note (a)
		container lid	extreme total stress intensity	600	σ = 37,600 psi	Sa=650,000 psi	Note (b)

Notes:

(a) Extreme total stress intensity is composite of maximum stress (18,440 psi) from top impact plus maximum stress (137,400 psi) due to puncture.

(b) Extreme total stress intensity is composite of maximum stress (9,688 psi) due to design condition and maximum stress (27,860 psi) due to bottom impact.



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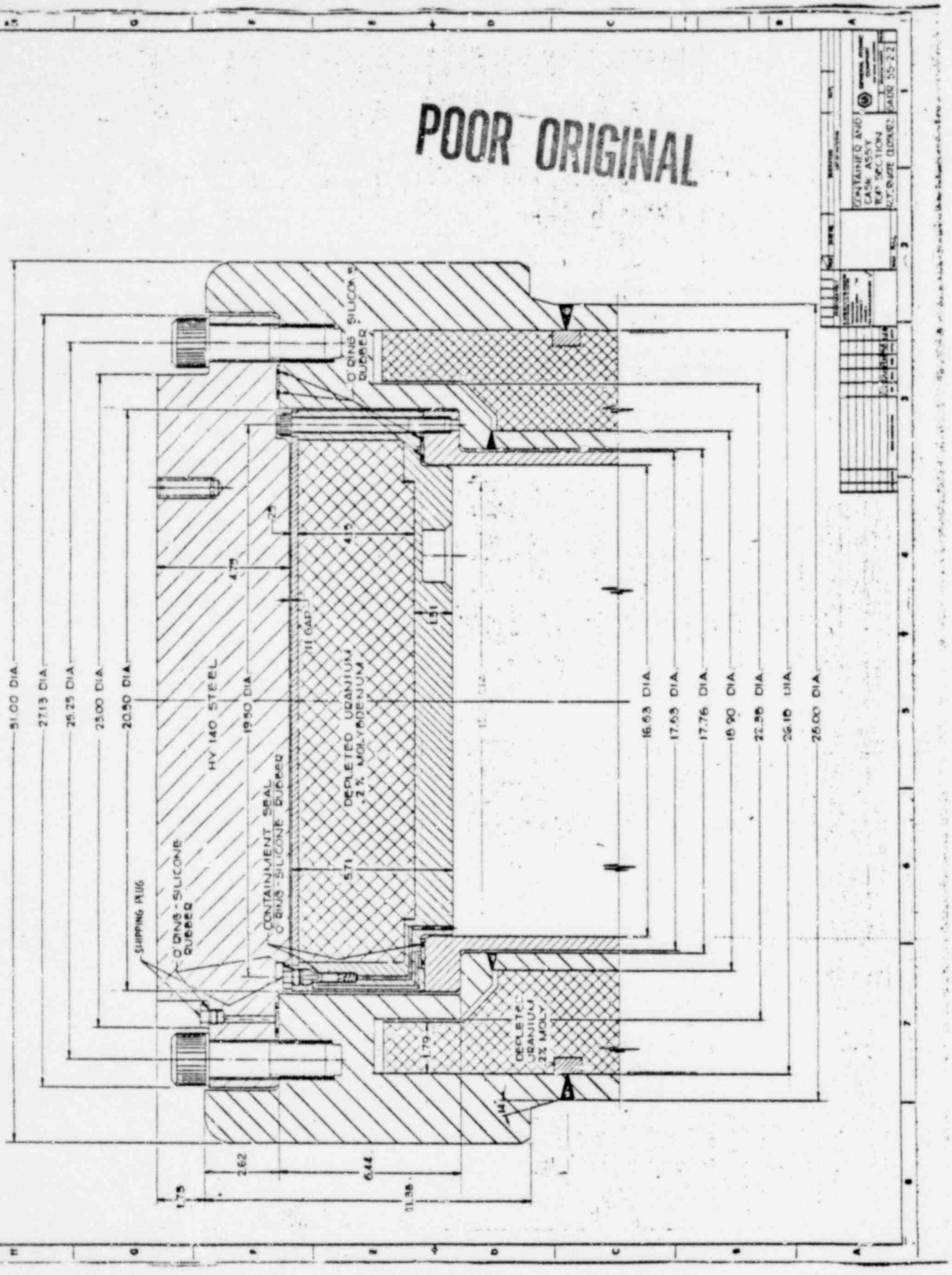
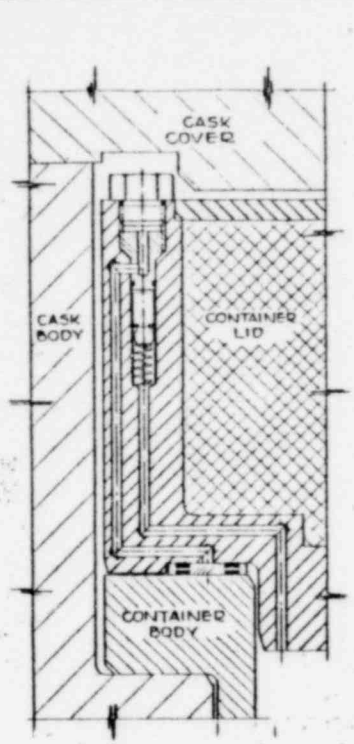
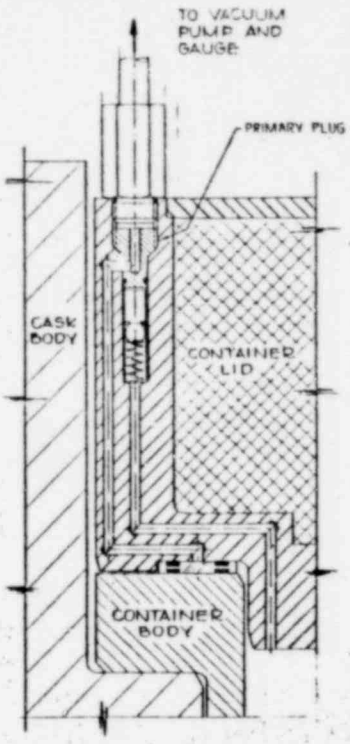
POOR ORIGINAL

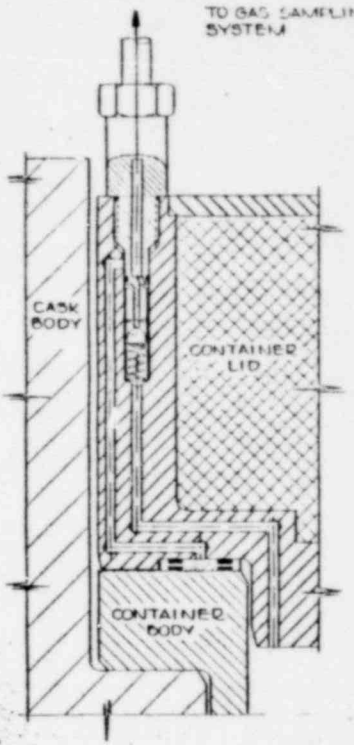




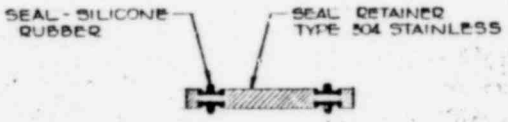
SHIPPING CONFIGURATION



SEAL TESTING CONFIGURATION



GAS SAMPLING CONFIGURATION



DETAIL - MAIN FLANGE SEAL FOR CONTAINER AND CASK
SCALE 4/1

POOR ORIGINAL

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