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Consolidated Application for Approval of Packaging for Radioactive Material

Docket 71-9049

for

U.S. Nuclear Regulatory Commission
Transportation Certification Branch
Division of Fuel Cycle and Material Safety, NMSS
Washington, D.c. 20555

Prepared and Submitted by [signature]
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June 27, 1985

1.0 General Information

1.1 Introduction

The model GE-500 shielded shipping cask is designed for use as a type B package for radioactive material shipments.

1.2 Package Description

1.1.2 Packaging

The model GE-500 shipping cask basically consists of the cask, a base, and a protective jacket. It has a gross weight of 8100 lbs (the cask weights 6300 lbs). Reference drawing 106D3870 in Appendix 1.3 for a view of the complete package.

a) The Cask is 28 inches in diameter by 29-3/8 inches high. It is a lead filled stainless steel weldment. The outer shell is constructed of ¼ inch stainless steel plate, with a ½ inch bottom plate and a 1 inch top flange. The cavity is 7 inches in diameter by 7 inches deep. It is constructed of ¼ inch stainless steel plate. The cavity is shielded by 10 inches of lead on the sides and bottom, and 11 inches of lead on top.

The cavity is penetrated by a ½ inch O.D. x 0.065 inch wall stainless steel tube gravity drain line, running from the center of the cavity bottom to the side of the outer shell near the cask bottom. It is closed with either a fusible lead cored ½NPT hex head brass pipe plug, or a solid stainless steel plug.

NOTE: Advanced Medical Systems may, at its discretion, permanently close and seal the drain line for this container with no interference to its structural properties.

There are two diametrically opposed lifting ears welded to the side of the cask.

The cask lid is a lead filled flanged, stainless steel plug. It consists of two right cylinders of decreasing diameter, one 12 inches in diameter by 6-5/8 inches high, the other 9-3/8 inches in diameter by 4-3/8 inches high. A lifting loop, ½ inch in diameter, is located in the center of the lid top. The lid is held to the cask by six equally spaced 1 inch-8-UNC-2A steel bolts. Reference drawing 212E246 in Appendix 1.3 for a detailed view of the cask assembly. A silicone rubber gasket bonded to an aluminum back up plate provides a seal between the cask and its lid. Reference drawing 129D4690 in Appendix 1.3 for a detailed view of this seal.

b) The base is a hollow cylindrical steel weldment with a ½ inch square bottom plate on an I beam frame. Overall it is approximately 47½ inches square by 7 inches high. The cylindrical collar is 29-¼ inches in diameter by 3 inches high. It houses two sets of 1-¼ inch steel angles separated by a 5/16 inch steel mid plate. The cask rests on these angles.

There are two diametrically opposed tie blocks welded to the base, designed to accept the jacket attachment bolts. Reference drawing 106D3855 in Appendix 1.3 for a detailed view of the base assembly.

c) The protective jacket is a steel weldment, basically a right circular cylinder with open bottom and with a protruding box section diametrically across the top and vertically down the sides. It is double 5/16 inch wall construction, with a 1 inch air gap between walls. Overall it is 33-3/4 inches outside diameter, 40-3/4 inches wide by 38-7/8 inches high across the box section. A steel flange is welded to the outer wall of the open bottom.

There are four gussets welded to the flange and outer wall. There are two rectangular lifting loops located on the top of the box section at the corners. These loops are of welded construction. There are two tie down ears welded to the sides of the box section. These are diametrically opposed, 2 inch thick, with a 1-½ inch diameter hole.

The protective jacket is bolted through its flange to the base using six 2 inch bolts.

The jacket has slots along its bottom periphery and in the box section under the lifting loops to allow air circulation for cooling purposes. Reference drawing 706E790 in Appendix 1.3 for a detailed view of the jacket assembly.

1.2.2 Operational Features

Not applicable.

1.2.3 Contents of Packaging

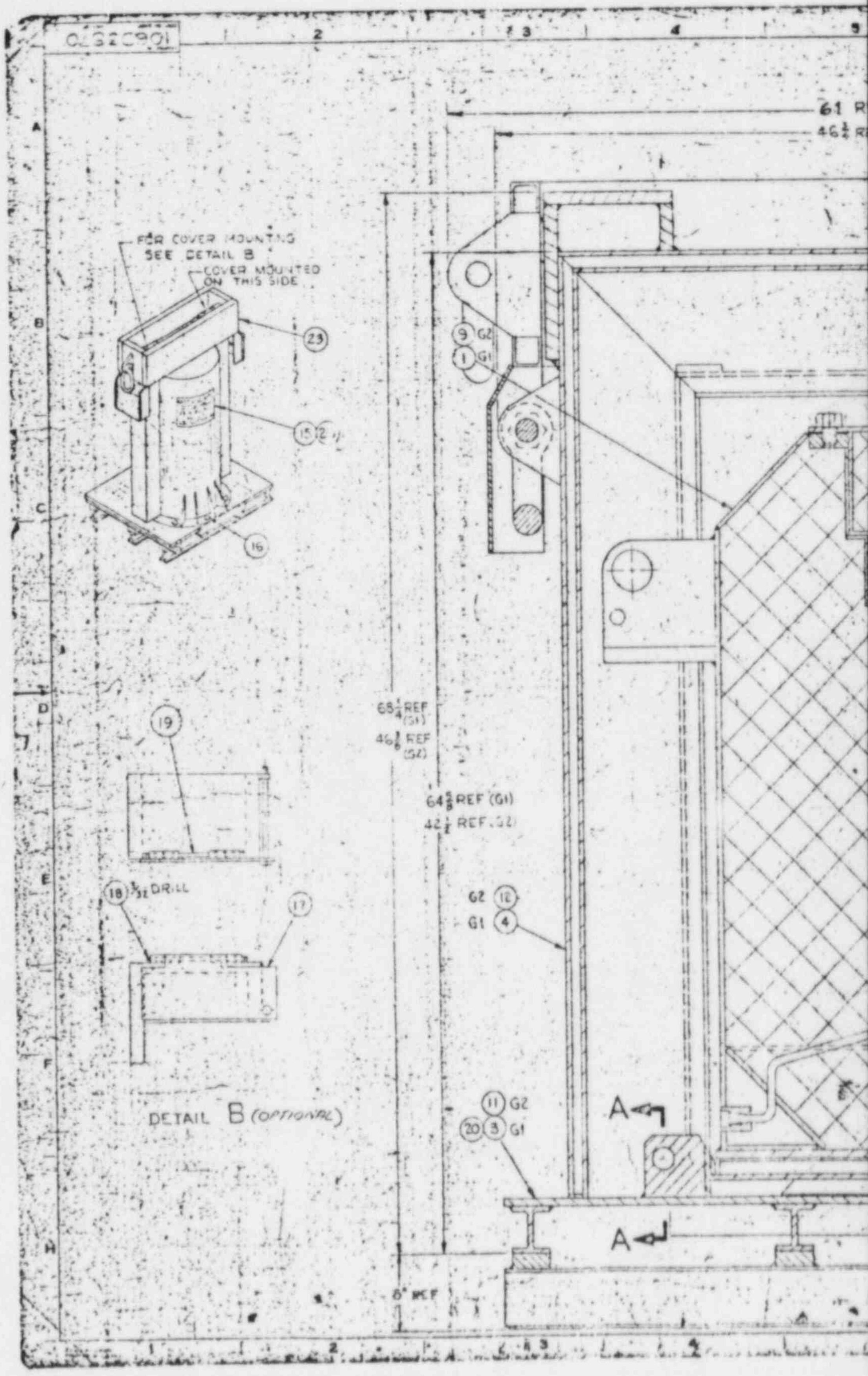
By product material meeting the requirements of special form, maximum decay heat load 780 watts.

1.3 Appendix

The following items may be found in this appendix:

Drawings

Originator	Number-Revision
GE	106D3870 - 11
GE	106D3855 - 4
GE	706E790 - 4
GE	212E246 - 7
GE	129D4690 - 1

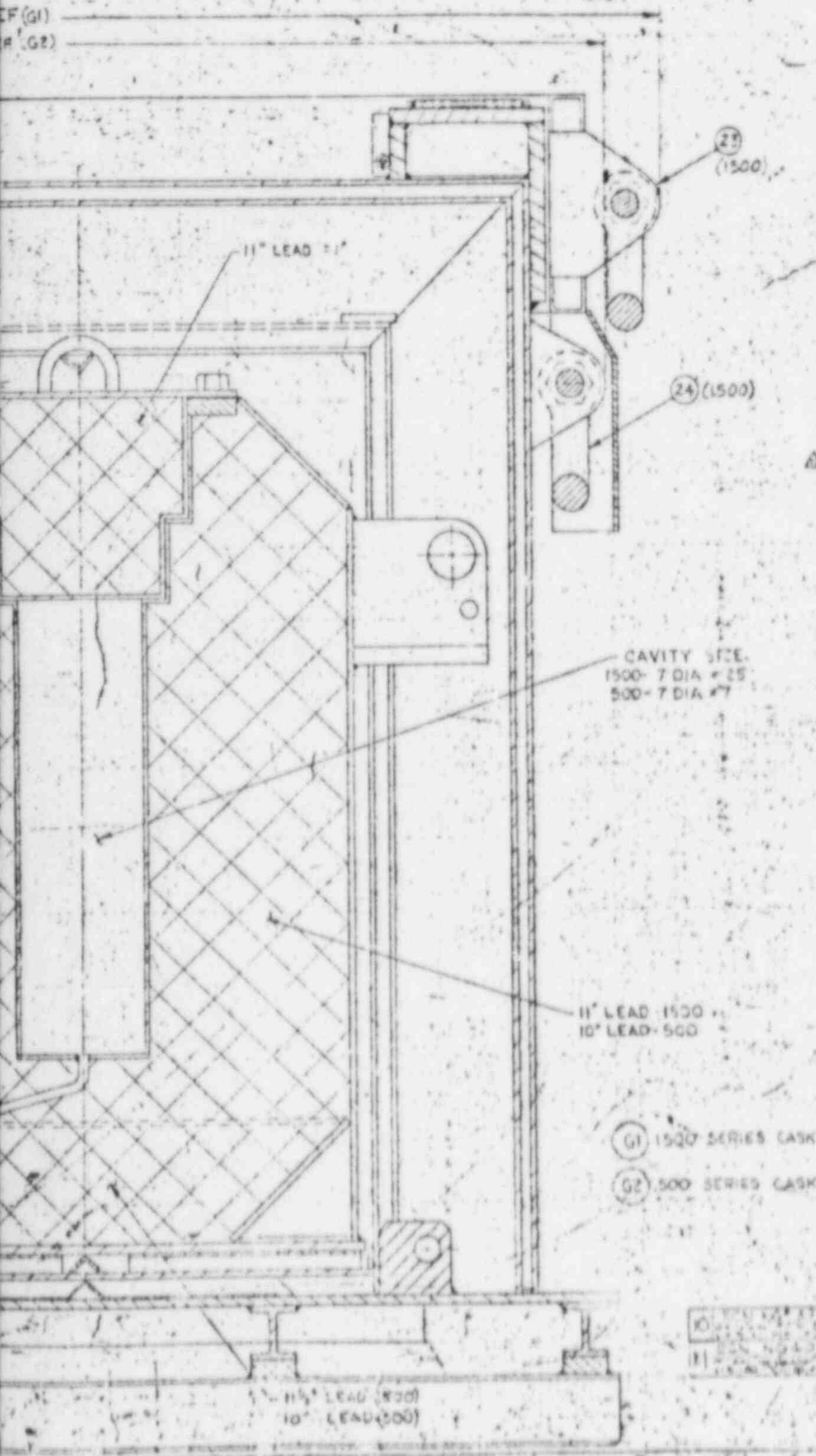


FOR COVER MOUNTING SEE DETAIL B
COVER MOUNTED ON THIS SIDE
23
15
16
19
18
17
DETAIL B (OPTIONAL)
61 R
9 G2
1 G1
68¾ REF (G1)
46⅞ REF (G2)
64⅜ REF (G1)
42⅞ REF (G2)
G2 12
G1 4
11 G2
20 3 G1
A
A
6" REF

GENERAL ELECTRIC 106D3870

MODEL 500 & MODEL 1500 TRANSPORT CONTAINER TOP ASSEMBLY

10603870

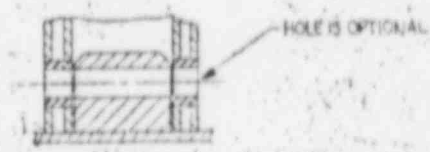


G4	G3	G2	G1	PC NO	NAME	DESCRIPTION
	[illegible]		1	1	CASK	[illegible]
	1	[illegible]	1	2	LID	[illegible]
[illegible]			1*	3	BASE	[illegible]
[illegible]	1		1	4	JACKET	[illegible]
[illegible]	[illegible]	2	2	5	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	6	LOCKWASHER	1 1/2 DIA STL
[illegible]	[illegible]	[illegible]	[illegible]	7	COTTER PIN	[illegible]
	5	3	3	8	WIRE	[illegible] STN STL
		1		9	CASK	[illegible]
	[illegible]	1	[illegible]	10	LID	[illegible]
		1		11	BASE	[illegible]
		1		12	JACKET	706E799G1
	6	6	6	13	BOLT	[illegible]
	6	6	6	14	LOCKWASHER	1" DIA STN STL
2	2	2	2	15	NAME PLATE	[illegible]
6	6	6	6	16	[illegible]	[illegible]
2	2	2	2*	17	COVER	[illegible]
4	4	4	4*	18	COTTER PIN	[illegible] DIA × [illegible] LG STL
2	2	2	2*	19	PIN	[illegible] STN STL
	1		1	20	BASE	[illegible]
2	2		4	21	[illegible]	[illegible]
1				22	CASK	[illegible]
			1	23*	TIE DOWN YOKE	[illegible]
			4	24	SHACKLE	12 TON NOM RATING
		2	2	25	NAME PLATE	[illegible]

* ALTERNATE PARTS

Also Available On Aperture Card

TI APERTURE CARD

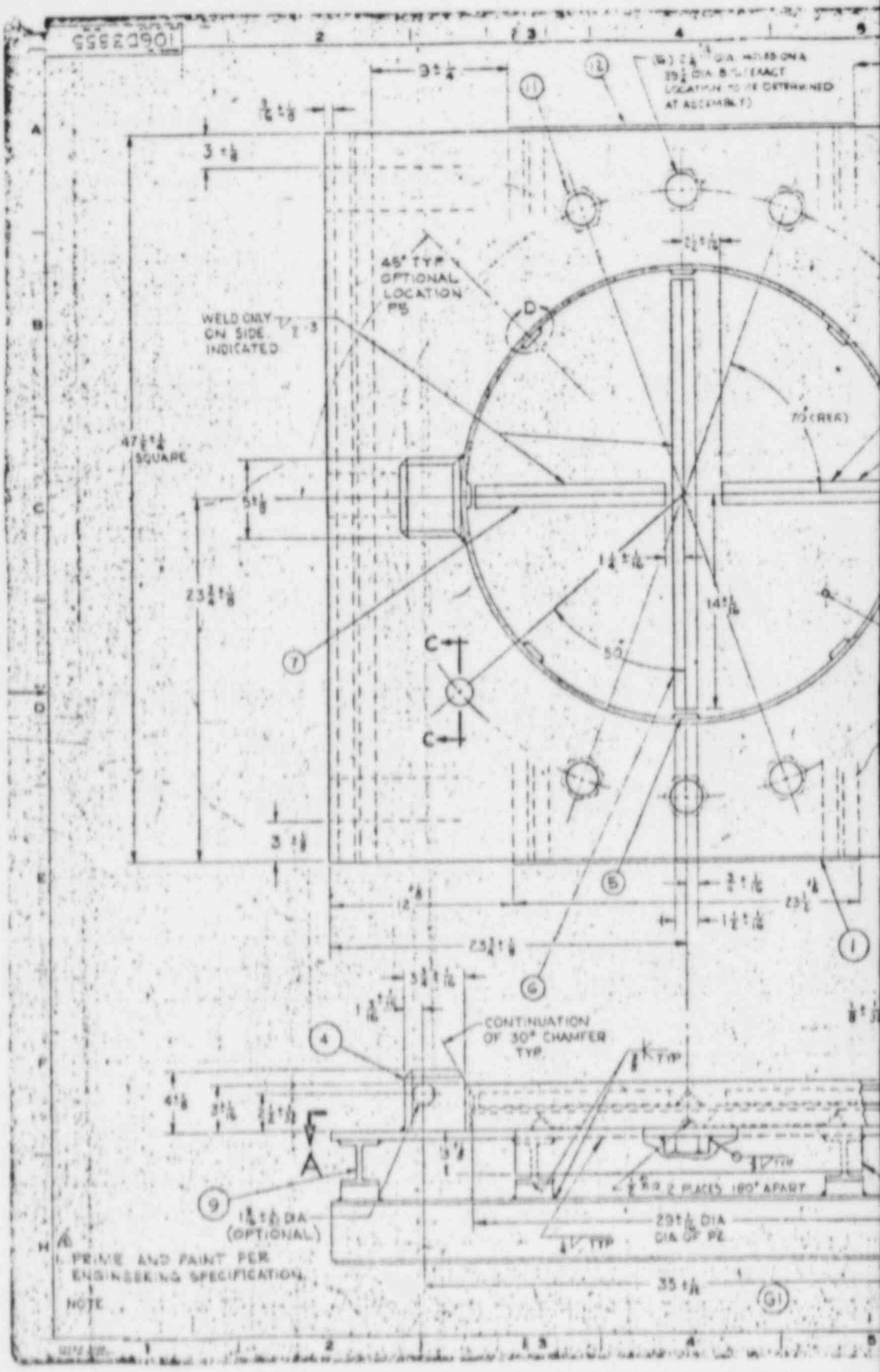


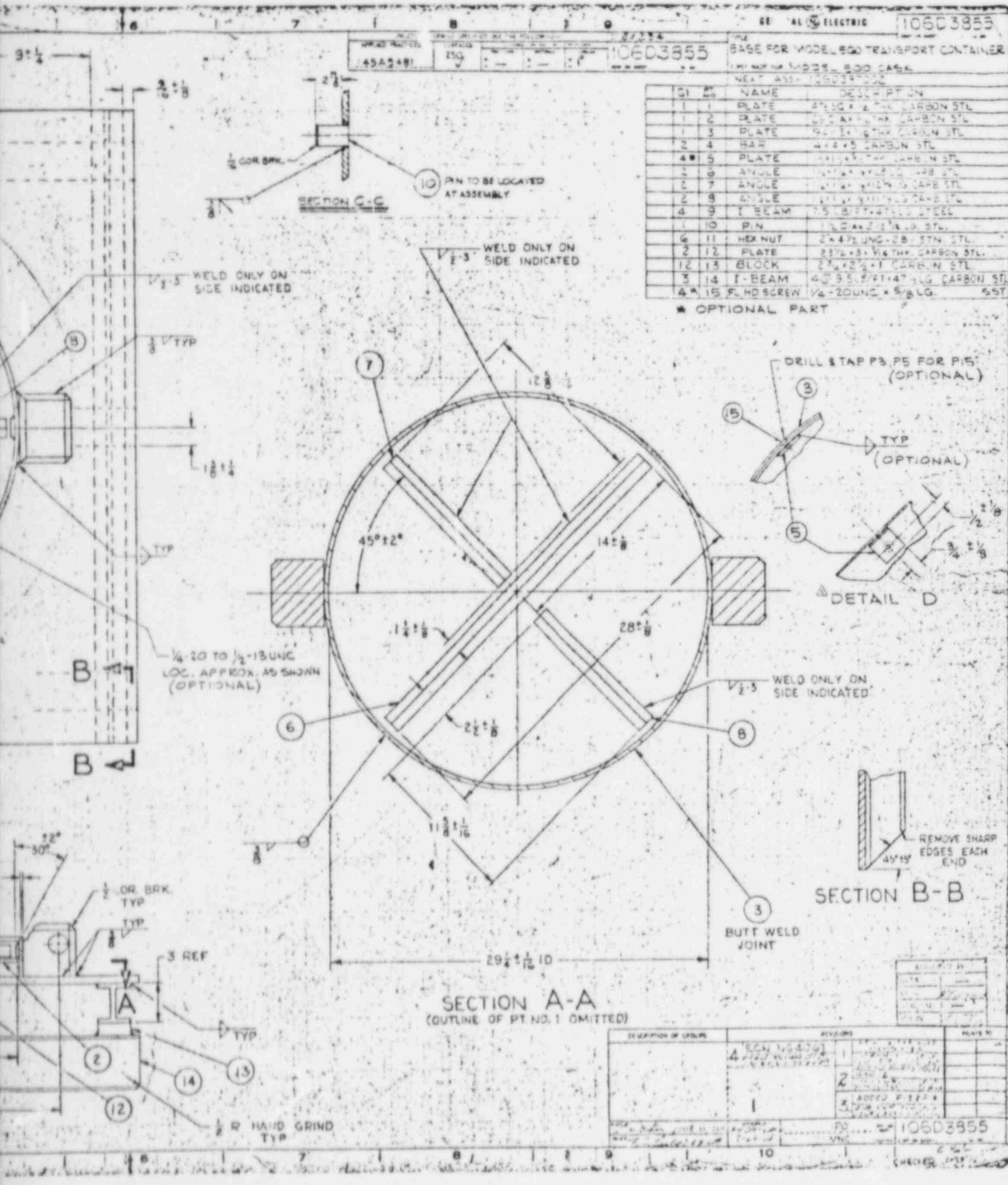
SECTION A-A

8507180585-01

Also Available On Aperture Card

TI APERTURE CARD





QT	PT NO	NAME	DESCRIPTION
1	1	PLATE	4" LG x 1/2 THK CARBON STL
1	2	PLATE	[illegible] THK CARBON STL
1	3	PLATE	[illegible] THK CARBON STL
2	4	BAR	4 x 4 x 5 CARBON STL
4*	5	PLATE	[illegible] THK CARBON STL
2	6	ANGLE	[illegible] CARB STL
2	7	ANGLE	[illegible] CARB STL
2	8	ANGLE	[illegible] CARB STL
4	9	I BEAM	7.5 LB/FT x 47 LG STEEL
1	10	PIN	[illegible] LG STL
6	11	HEX NUT	2 x 4 1/2 UNC-2B STN STL
2	12	PLATE	23 1/2 x 3 x 1/16 THK CARBON STL
12	13	BLOCK	2 3/4 x 2 1/2 x 1 CARBON STL
3	14	I-BEAM	4 @ 9.5 LB/FT x 47 LG CARBON STL
4*	15	FL HD SCREW	1/4-20UNC x 5/8 LG SST

* OPTIONAL PART

8507180585-02

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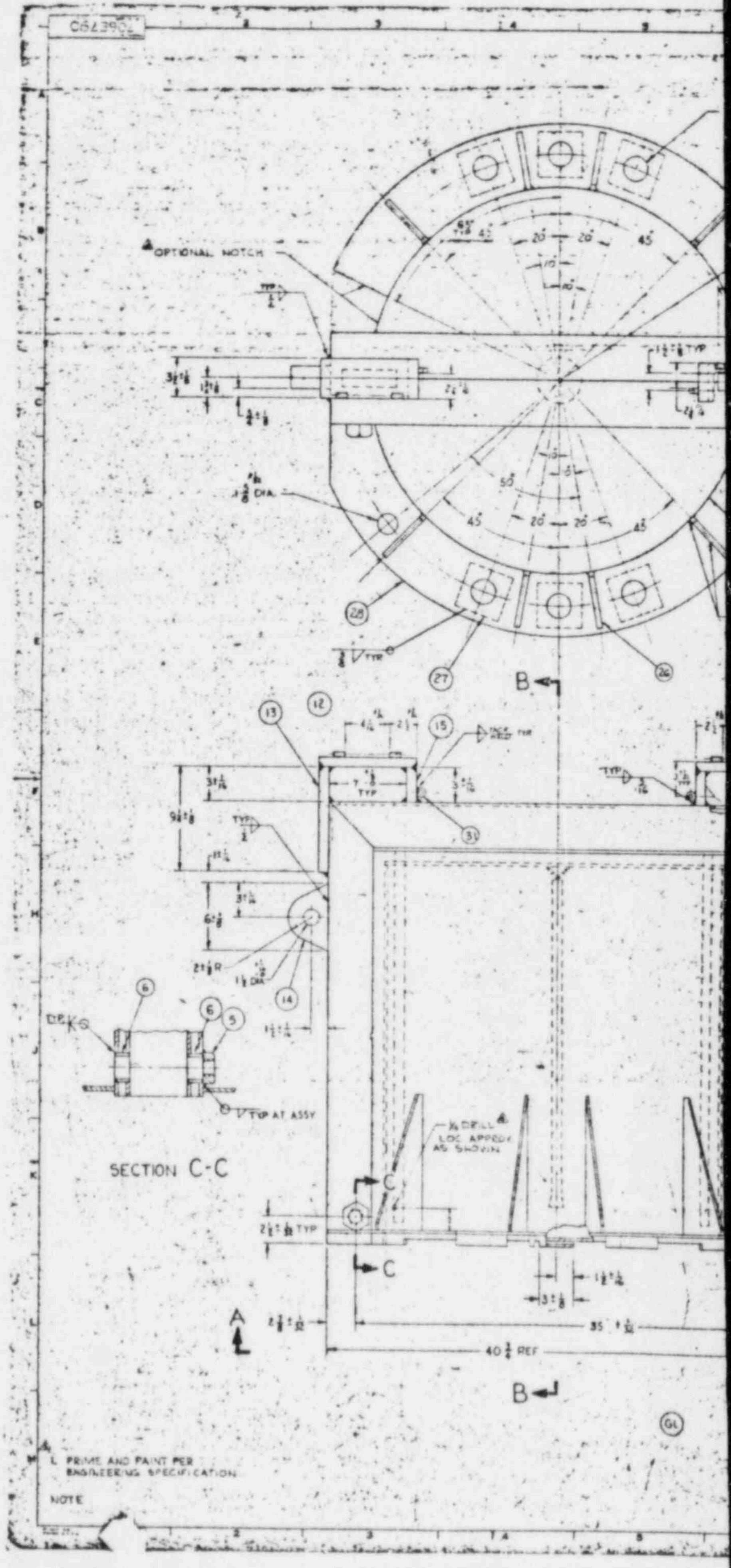
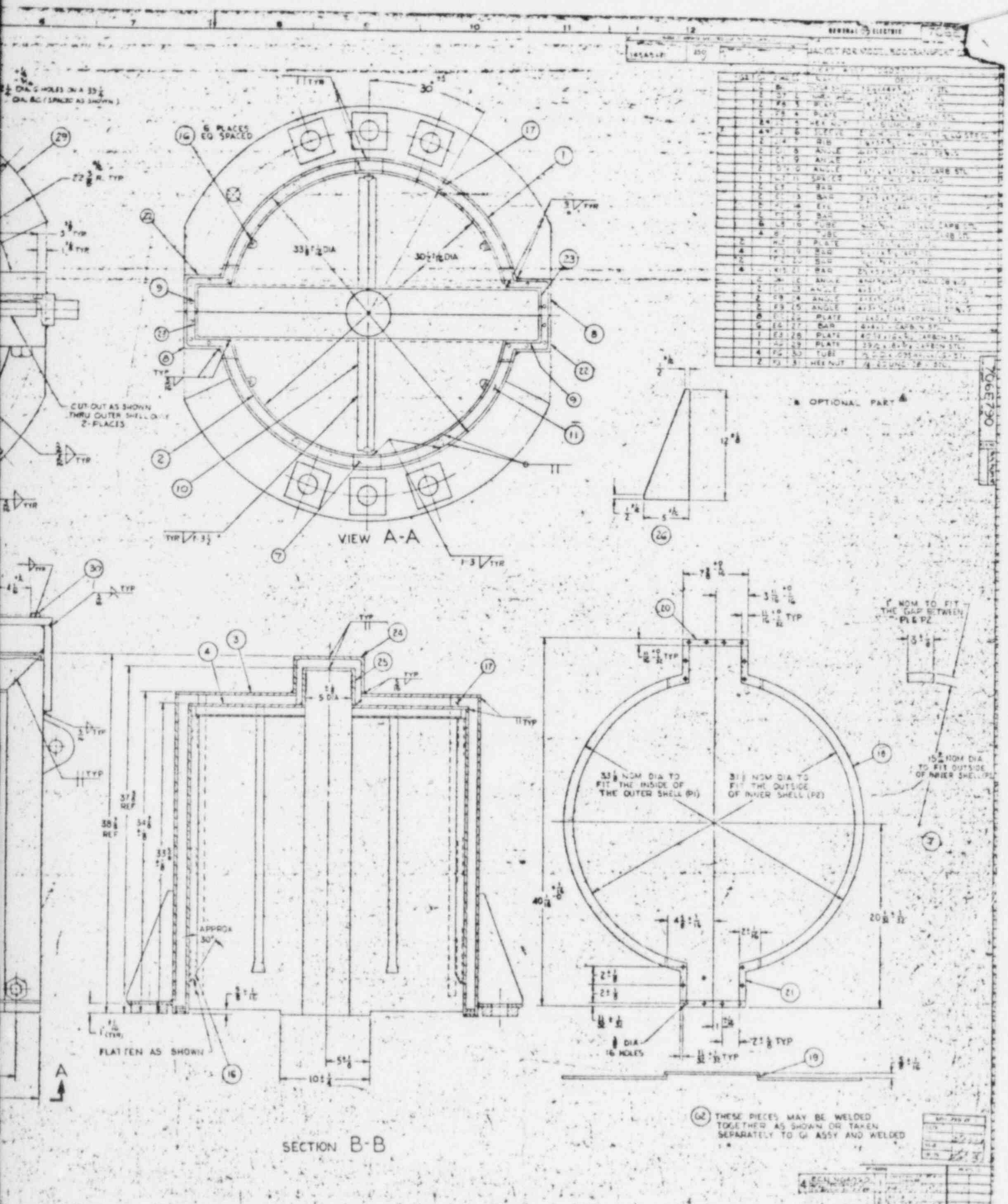
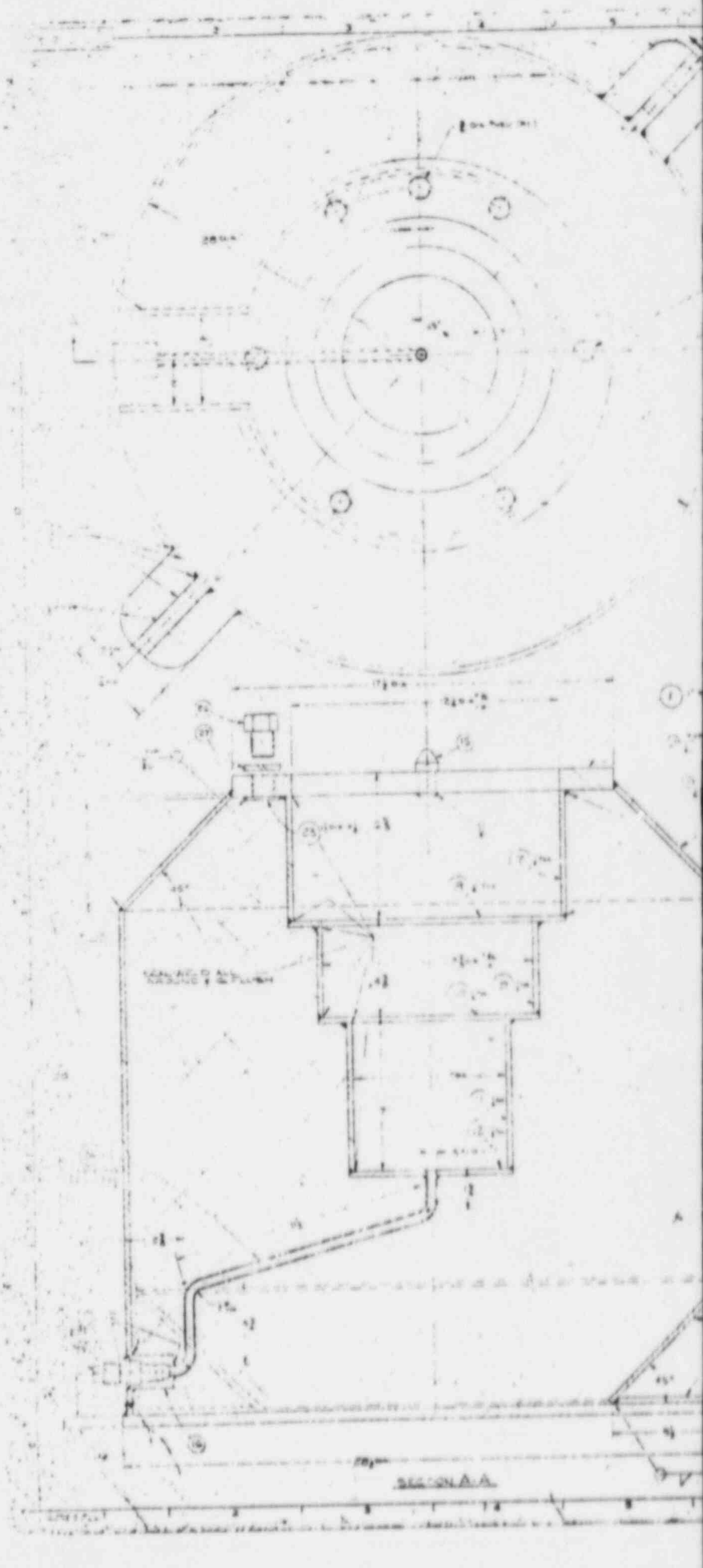
Aperture Card

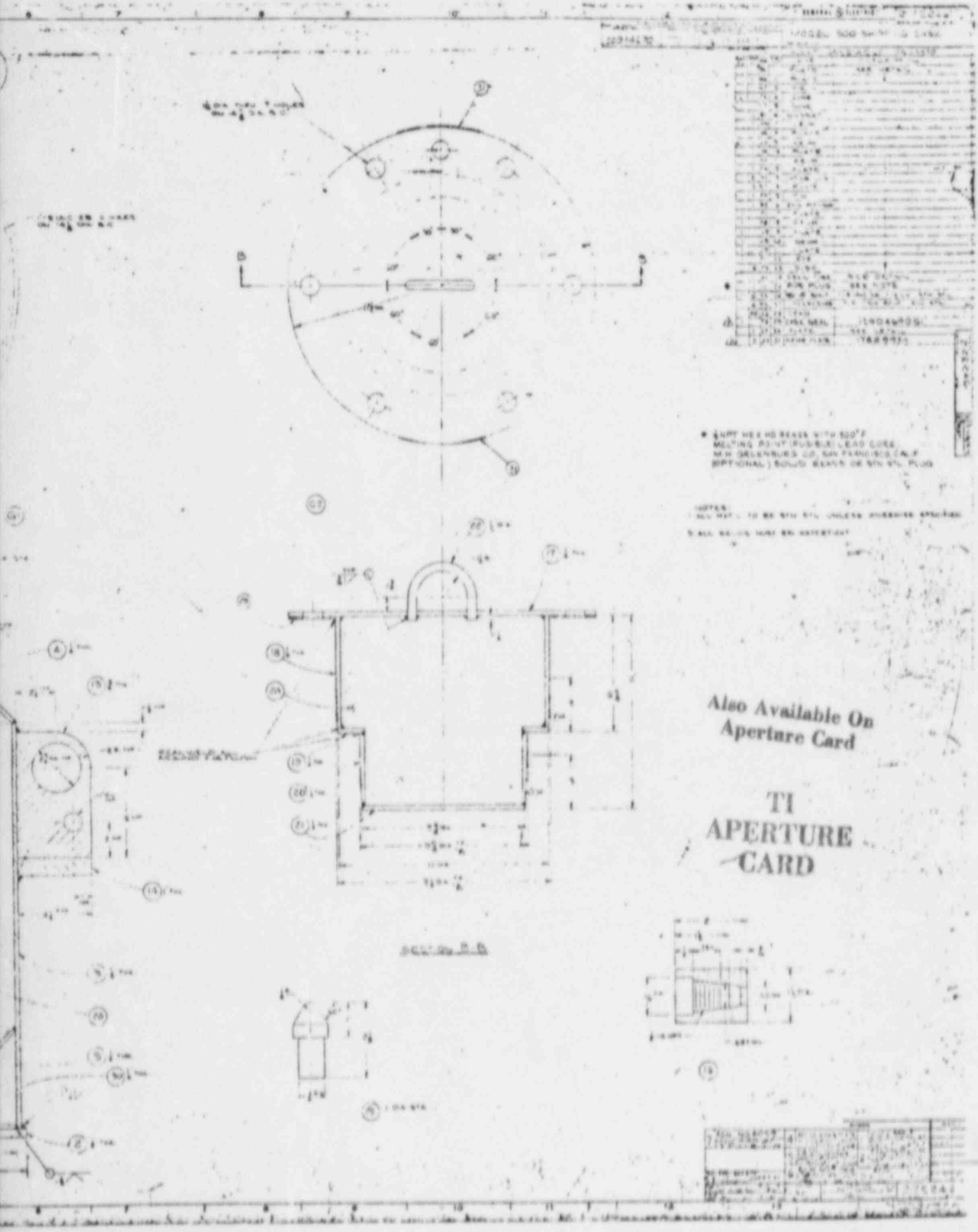
TI
APERTURE
CARD





8507180585-03

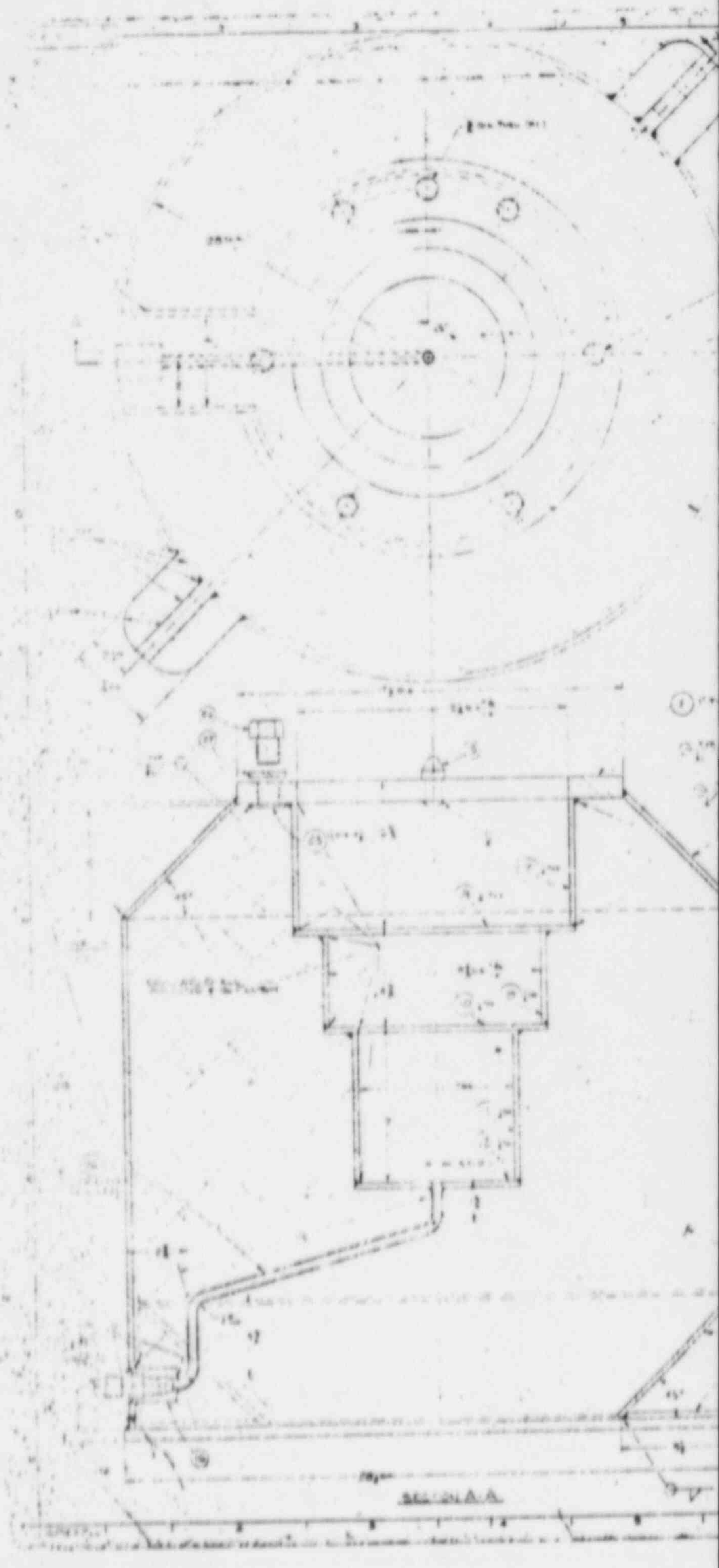

SECTION A-A

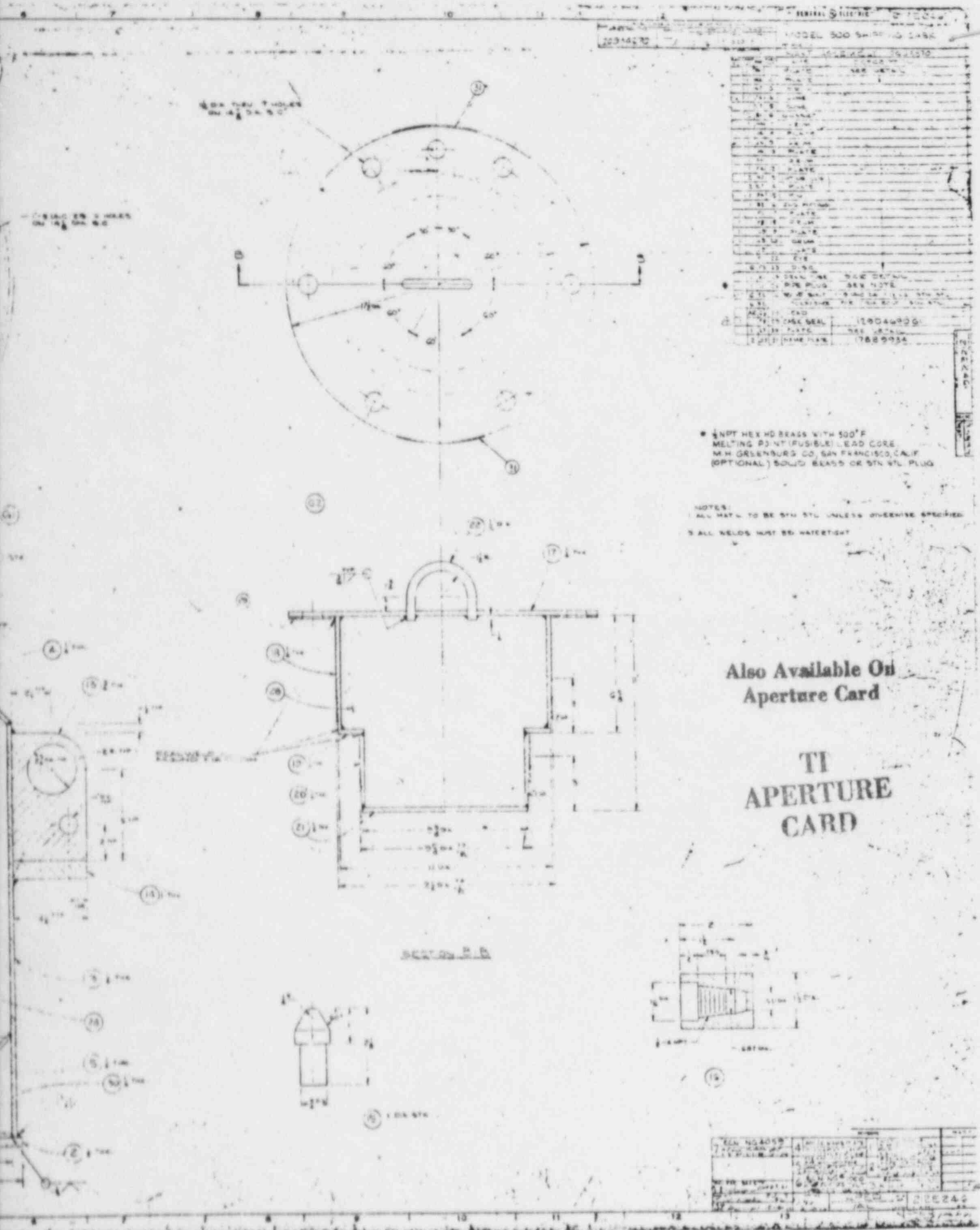


Also Available On
Aperture Card

TI
APERTURE
CARD

8507180585 - 04


SECTION A-A



Also Available On
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TI
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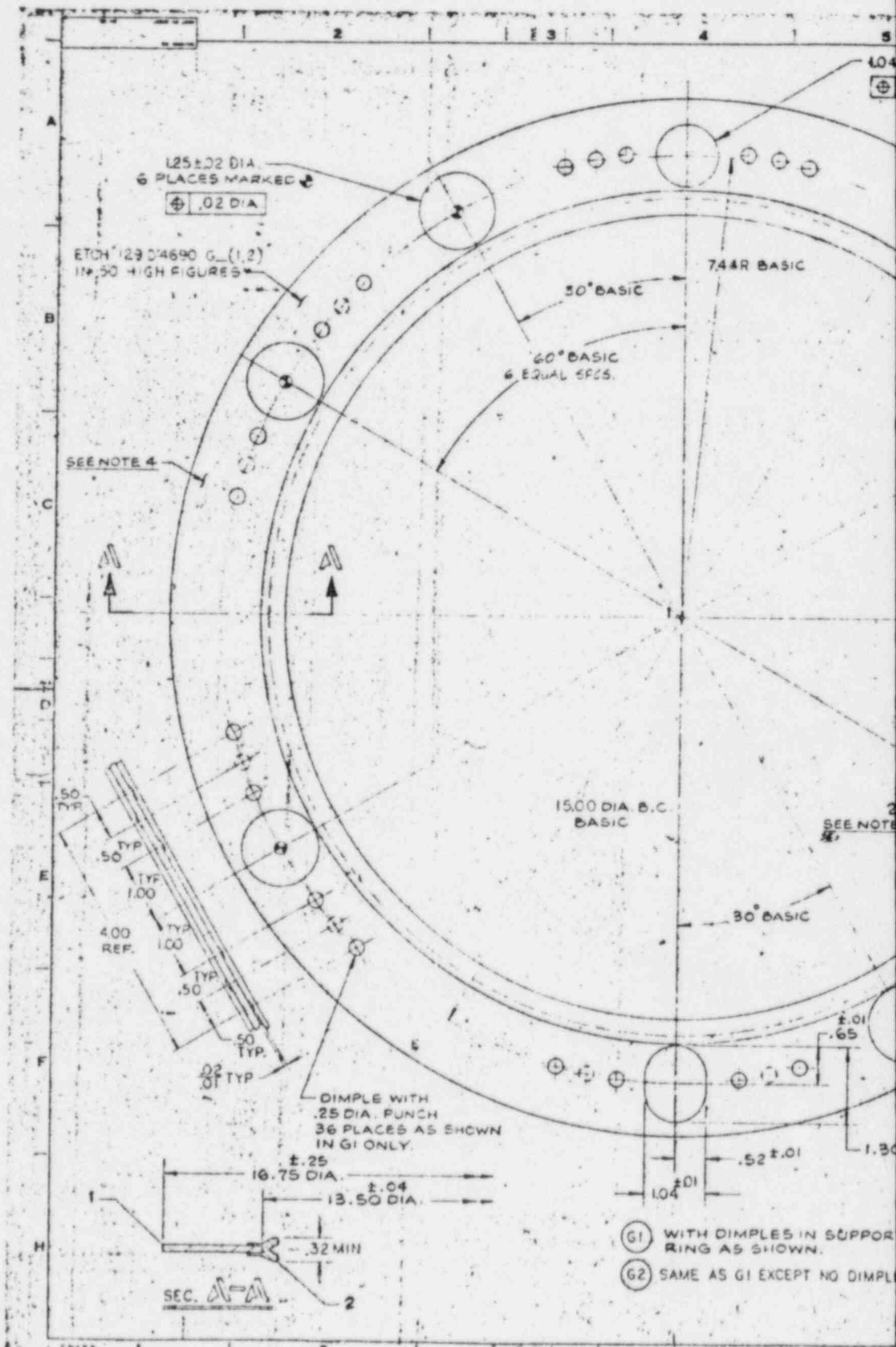
8502180585 — 05



1.25±.02 DIA.
6 PLACES MARKED 2
.02 DIA
ETCH 129 D4690 G_(1,2)
IN .50 HIGH FIGURES
7.44R BASIC
30° BASIC
60° BASIC
6 EQUAL SPCS.
SEE NOTE 4
15.00 DIA. B.C.
BASIC
SEE NOTE
30° BASIC
.50 TYP.
.50 TYP.
1.00 TYP.
4.00 REF.
1.00 TYP.
.50 TYP.
.50 TYP.
.02 .01 TYP
DIMPLE WITH
.25 DIA. PUNCH
36 PLACES AS SHOWN
IN G1 ONLY.
±.01 .65
±.25 16.75 DIA.
±.04 13.50 DIA.
.52 ±.01
1.04 ±.01
.32 MIN
SEC. A-A
G1 WITH DIMPLES IN SUPPOR
RING AS SHOWN.
G2 SAME AS G1 EXCEPT NO DIMPL

±.01 DIA.

.02 DIA.

GENERAL ELECTRIC 12904690

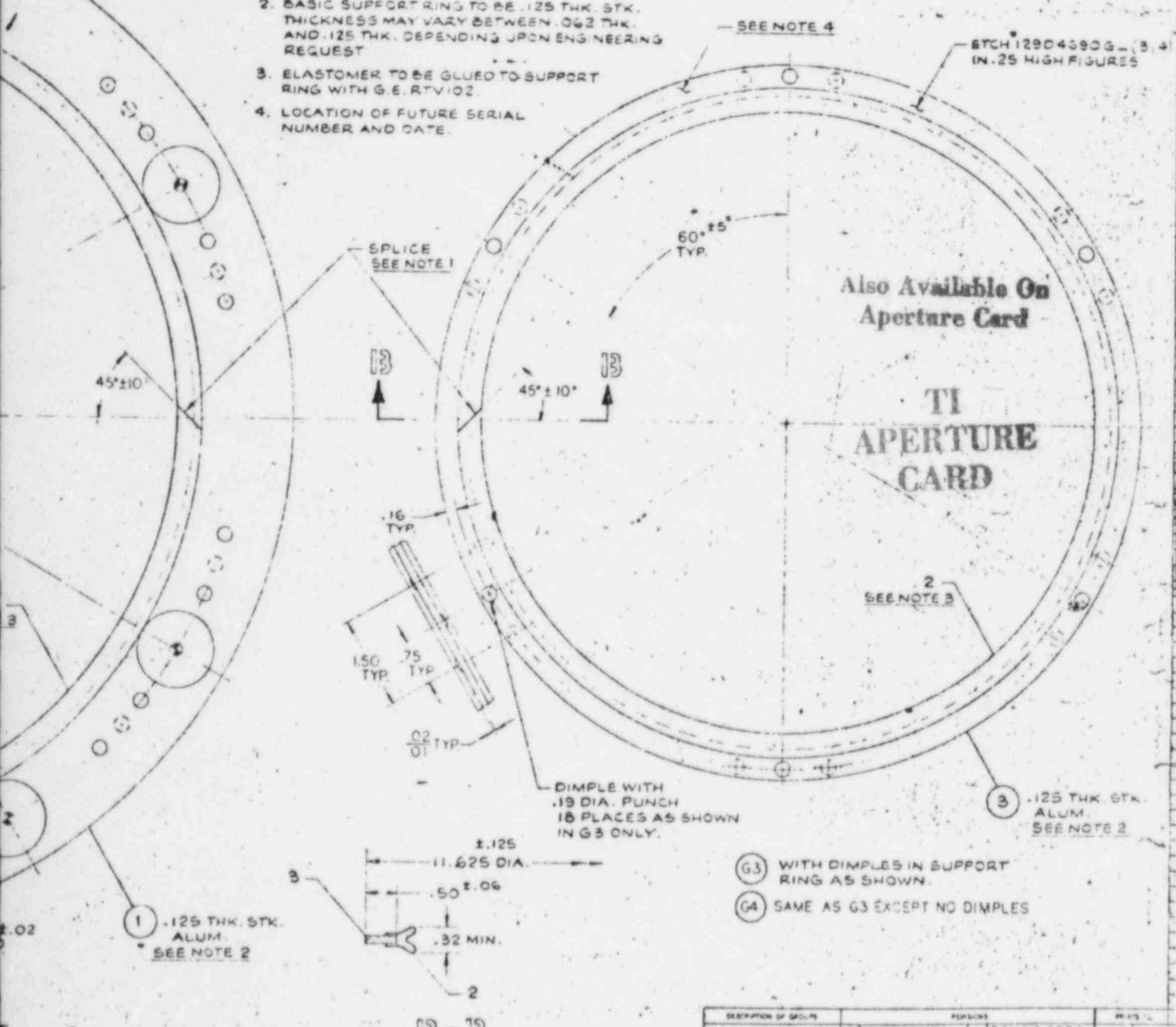
Applied practices	Surfaces	Tolerances			
20944270	125	± —	±.06	± —	12904690

MODEL 1500 LARGE CASK SEAL

G4	G3	G2	G1		NAME	DESCRIPTION
1	1	1	1	1	RING	SEE DETAIL
1	1	1	1	2	ELASTOMER	17889957
1	1			3	RING	SEE DETAIL

NOTES:

1. ELASTOMER SPLICE TO BE GLUED WITH G.E. RTV102. OPTIONAL SPLICE: 90° VULCANIZED SPLICE. SPLICE TO BE LOCATED BETWEEN HOLES.
2. BASIC SUPPORT RING TO BE .125 THK. STK. THICKNESS MAY VARY BETWEEN .062 THK. AND .125 THK. DEPENDING UPON ENGINEERING REQUEST.
3. ELASTOMER TO BE GLUED TO SUPPORT RING WITH G.E. RTV102.
4. LOCATION OF FUTURE SERIAL NUMBER AND DATE.



DESCRIPTION OF GROUPS	REVISIONS	
	1 ECN NG4330	

12904690

8507180585-06

2.0 Structural Evaluation

2.1 Structural Design

2.1.1 Discussion

The principal structural members of the package are the protective jacket, the cask, and the base. The jacket and base are steel weldments. The cask is a lead filled stainless steel weldment. These components are held together by bolts. A cross sectional view of the package may be seen in figure 1.

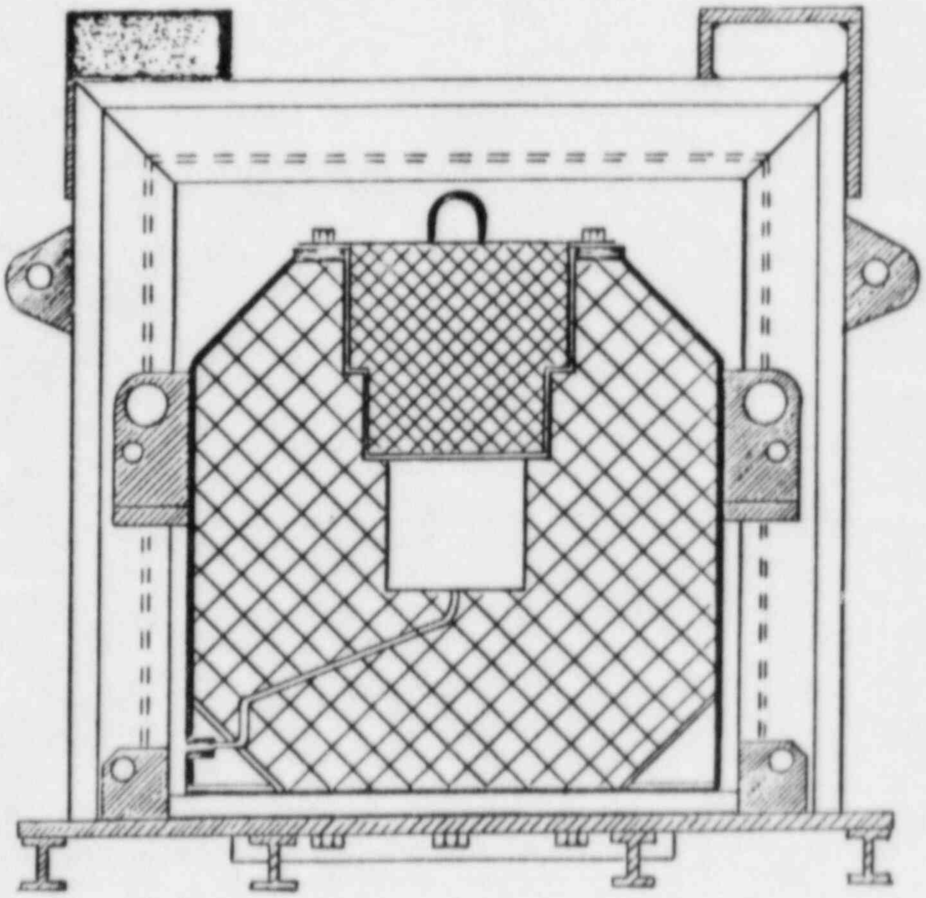


Figure 1

2.1.2 Design Criteria

The design criteria considered for the structural evaluation of the package are those that meet the requirements of 10CFR71.

2.2 Weights and Centers of Gravity

For the model GE 500 cask, the following data is applicable:

Weight of jacket, covers and bolts	1150 lbs.
Weight of base	650 lbs.
Weight of cask and lid (lid weighs 400 lbs.)	6300 lbs.
Total	8100 lbs.

The center of gravity of the complete package is located 24 13/16 inches from the bottom of the package, or just above dimensional center.

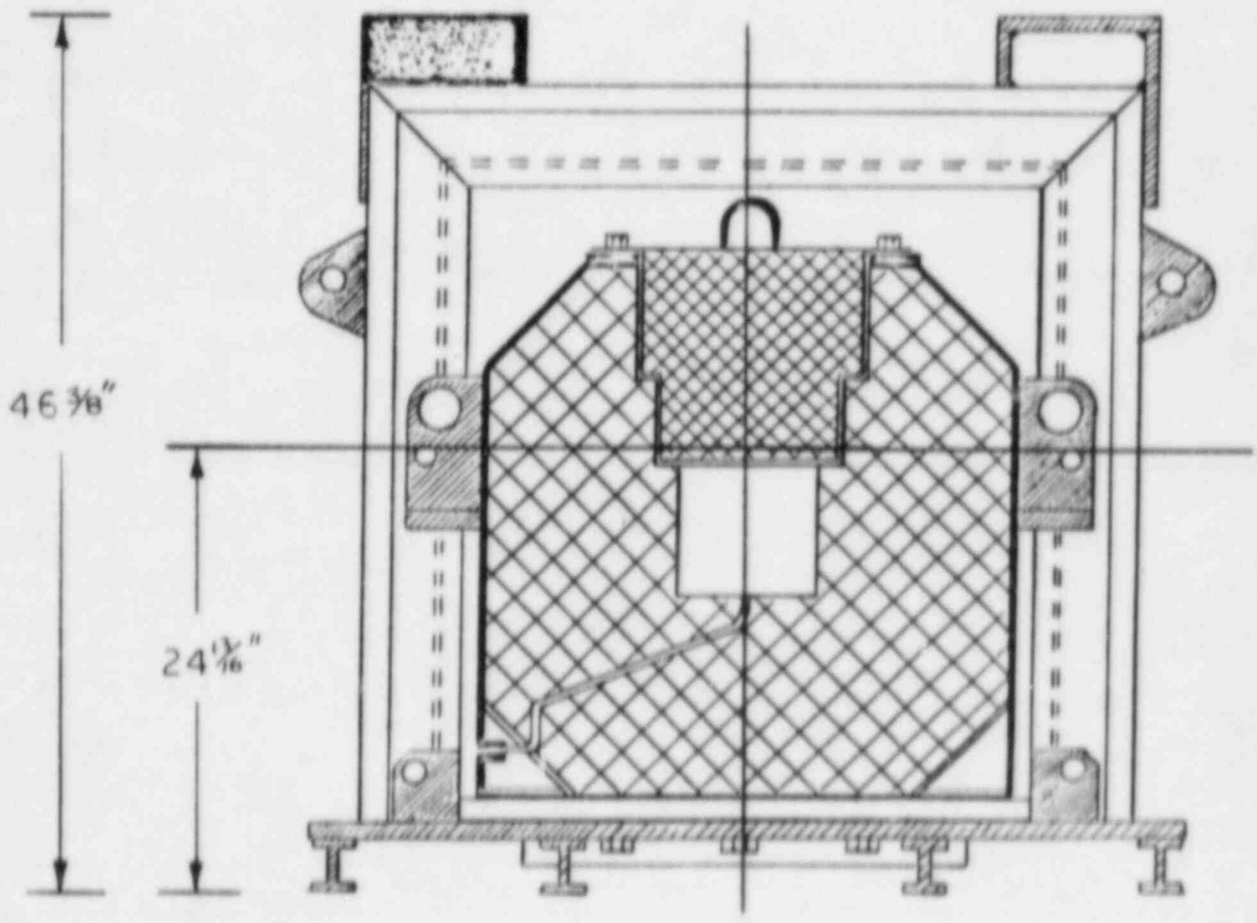


Figure 2

2.3 Mechanical properties of Materials

A242 Steel

		Reference
Shear Strength	67,000 psi	1
Yield Strength	46,000 psi	1

C1020 Steel

Shear Strength	75,000 psi	1
Yield Strength	48,000 psi	1

302 Stainless Steel

Shear Strength	90,000 psi	1
Yield Strength	40,000 psi	1

Carbon Steel Bolts

2"-4½" UNC Grade 5

Cross Sectional area	2.5 in^2	2
Minimum tensile strength	90,000 psi	2
Yield strength	58,000 psi	2

References

1. Materials Selector 1974
   Reinhold Publishing Co. Inc.

2. Fastener Standards, 5th Edition, 1980
   Industrial Fastener Institute

2.4 General Standards for All Packages

2.4.1 Chemical and Galvanic Reactions

There are no components of the packaging or its contents which are subject to chemical or galvanic reaction. The package construction is of steel and stainless steel. The only chemical material in use is exterior paint.

2.4.2 Positive Closure

The package closure system consists of a series of bolts that must be removed before the protective jacket can be removed. A second series of bolts must be removed in order to gain access to the cask cavity.

2.4.3 Lifting Devices

Attached to the protective jacket is a pair of lifting loops. These are designed to enable a fork lift truck to pick the jacket off the base and cask. They are not intended for use to lift the entire package or for tie down purposes, and are rendered inaccessable during transit by removable covers.

In normal practice, the package is moved with a fork lift truck. In the event that an overhead pickup was necessary, the tie down ears could be utilized for lifting the entire package. These ears are located on opposite sides of the jacket, approximately 7 inches below the top surface. They are 6"H x 3½"W x 2" thick with a 1½ inch hole. Reference drawing 706E790 in Appendix 1.3. The following calculation will demonstrate that these ears have been designed with a minimum safety factor of three.

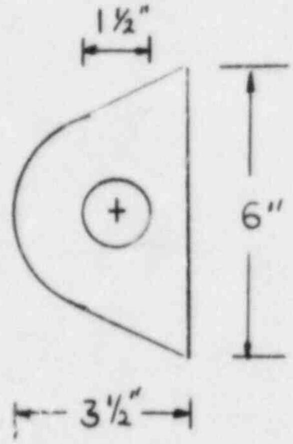


Figure 3

$S = \frac{P}{A}$ where S = unit stress in psi
P = load in lbs. (total package weight)
A = net area at cross section containing the hole (in^2)

$$S = \frac{8100 \text{ lbs}}{(3.5-1.5)(2)} = 2025 \text{ psi}$$

Yield strength for ASTM C-1020 Carbon Steel = 48000 psi

$$\text{Safety factor} = \frac{\text{yield strength (psi)}}{\text{stress (psi)}}$$

$$SF = \frac{48000}{2050} = 23.7$$

The welds used to attach the ears to the jacket will next be analyzed.

The ears are attached to the jacket with two 6 inch x ½ inch fillet welds. Each weld throat diameter is 0.353 in. The effective weld area is therefore 2.118 in^2 (6 in. x 0.355 in) per weld. The standard working stress for fillet welds is 11,300 psi (Ref. American Welding Society code for Fusion Welding). Therefore, each weld can withstand a load of 23,933 lbs (11,300 psi x 2.118 in^2), and each ear can withstand a load of 47,867 lbs. The safety factor is 5.9 for each ear.

2.4.4 Tie down devices

There are two tie down ears attached to the jacket, previously described in 2.4.3. The following analysis will demonstrate that these ears will comply with the requirements.

The tie down ears have been designed so that failure of the ear under excessive load would not impair the ability of the package to meet the other requirements of 10CFR71. This feature has been achieved by using a less strong carbon steel (C-1020) for the ears than that used for the jacket shell (A242). Therefore, damages should be confined to the ears.

The following assumptions are made for the analysis: (refer to figure 4)

1. The 10g longitudinal load is supported by tie down lines 3 and 4.

2. The 5g transverse load is supported only by lines 1 and 4 since lines 2 and 3 will not support compression.

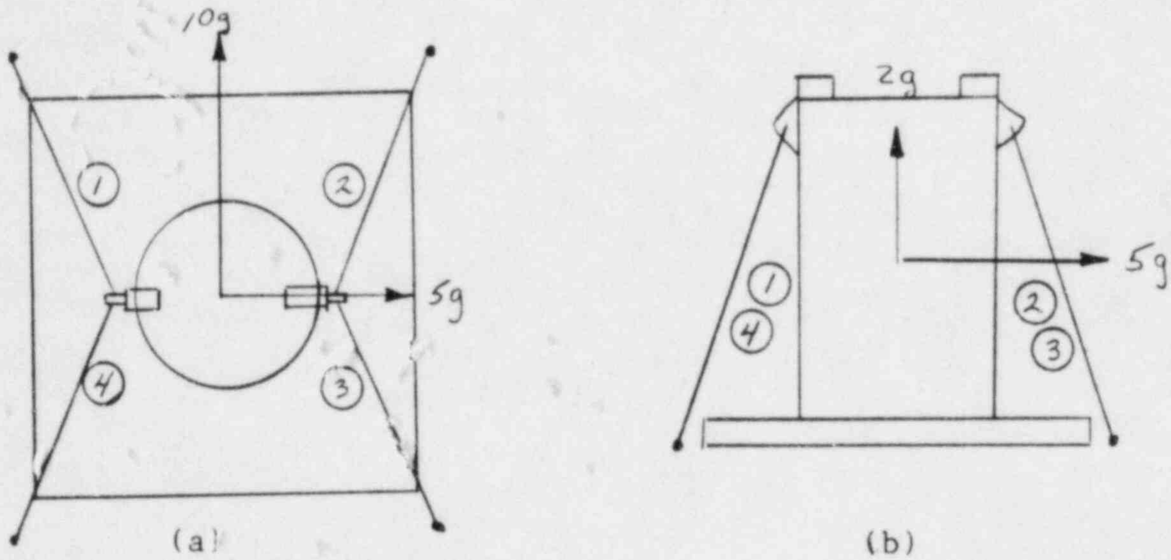


Figure 4

3. The 2g vertical load will be supported by lines 1 and 4.

4. Each tie-down device shall be capable of supporting the following loads:

   5g = longitudinal direction

   5g = transverse direction

   5g = vertical direction

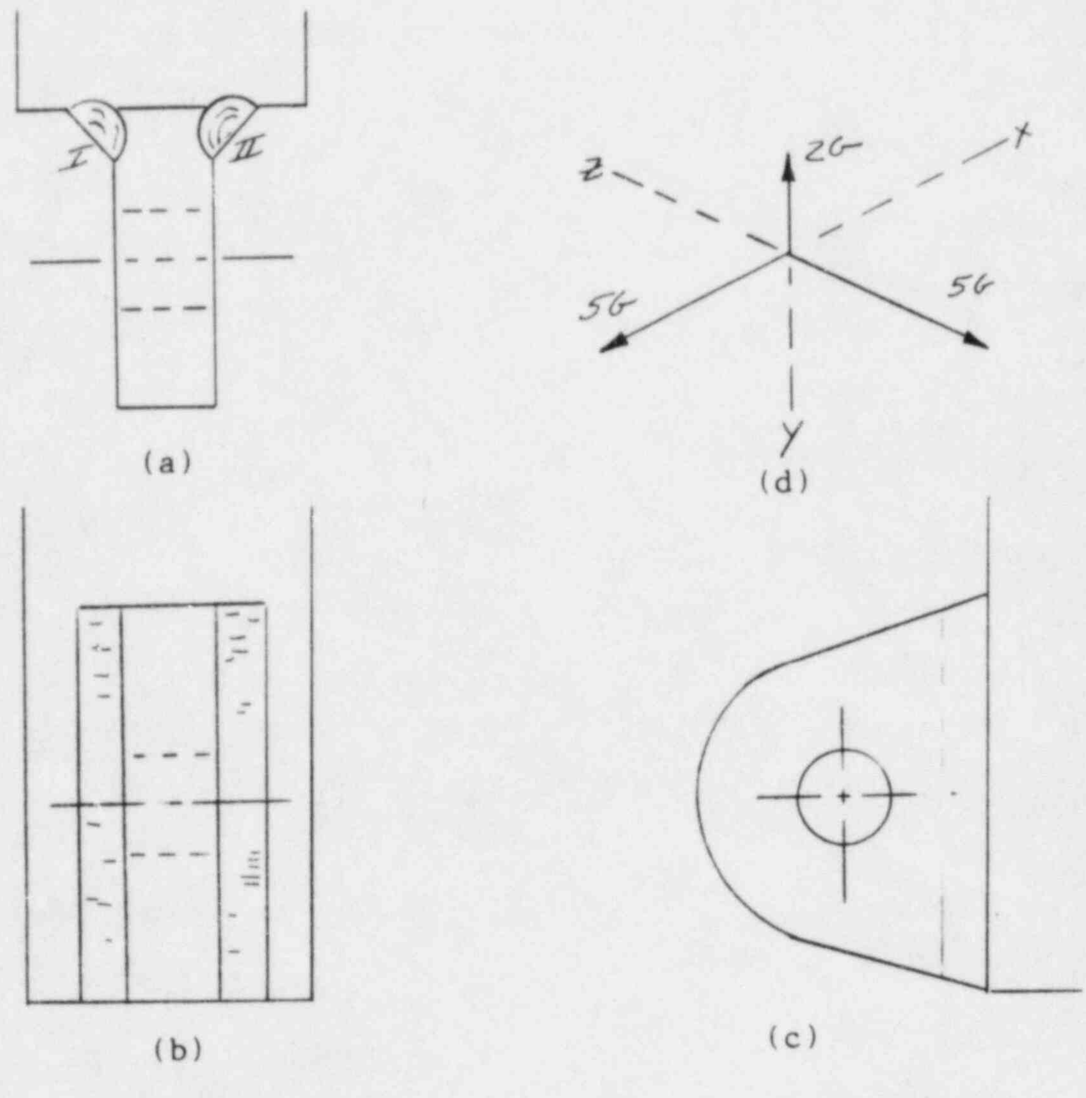


Figure 5

5. Assume weld is weaker than steel.

6. The forces are considered to act through the center of the drilled hole (figure 5).

The resultant force on the tie-down device was broken down into its component parts and then the weld stresses were found.

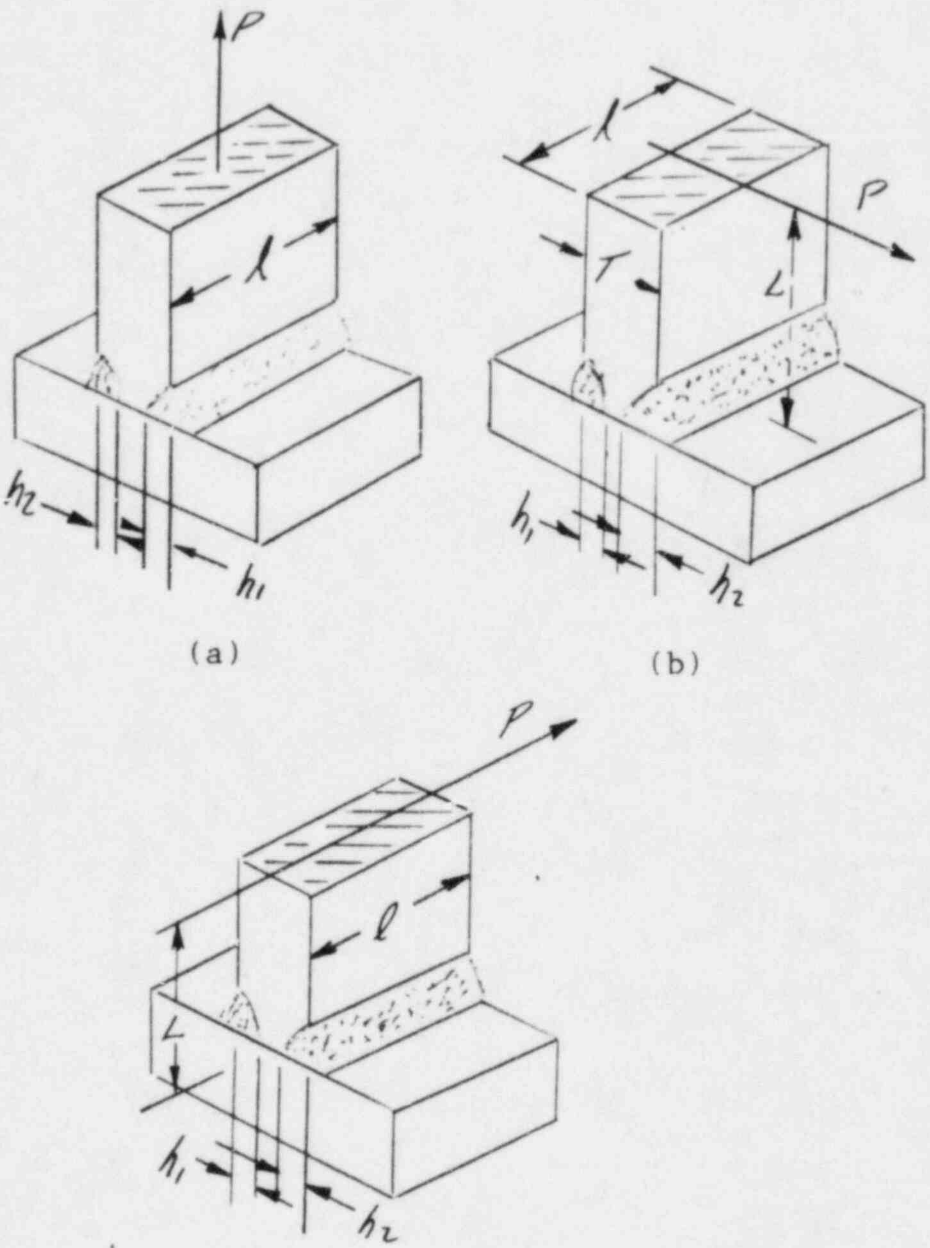


Figure 6

a) Bending stress due to the longitudinal force (Refer to fig.6b)

$$S_B = \frac{3TPL}{1h\ (3T^2 - 6Th + 4h^2)}$$

$T = 2.0$

$P = 5 \times 8100\ lb = 40{,}500\ lb$

$L = 1.5\ in$

$l = 6\ in$

$h = 0.5\ in$

$$S_B = \frac{3(2)(40500)(1.5)}{6(0.5)[3(2)^2 - 6(2)(0.5) + 4(0.5)^2]}$$

$S_B = 17{,}357\ psi$

b) Shear stress due to the longitudinal force (Refer to fig. 6b)

$$S_S = \frac{P}{2hl}$$

$$S_S = \frac{40{,}500}{2(6)(0.5)}$$

$S_S = 6750\ psi$

c) Tensile stress due to transverse force (Refer to fig. 6c)

$$S_T = \frac{P}{(h_1 + h_2)l}$$

$P = 5 \times 8100 = 40500\ lb$

$h_1 = h_2 = 0.5$

$l = 6\ in$

$$S_T = \frac{40,500}{(0.5 + 0.5)(6)}$$

$$S_T = 6750 \text{ psi}$$

d) Bending stress due to vertical force (Refer to fig. 6c)

$$S_B = \frac{3PL}{hl^2}$$

$$P = 2 \times 8100 = 16,200$$

$$L = 1.5 \text{ in.}$$

$$h = 0.5 \text{ in.}$$

$$l = 6 \text{ in.}$$

$$S_B = \frac{3(16,200)(1.5)}{(0.5)\ (6)^2}$$

$$S_B = 4050 \text{ psi}$$

e) Shear stress due to vertical force (Refer to Fig. 6c)

$$S_S = \frac{P}{2hl}$$

$$S_S = \frac{16,200}{2(0.5)(6)}$$

$$S_S = 2700 \text{ psi}$$

A free-body isometric diagram of the tie-down device shows the following stresses:

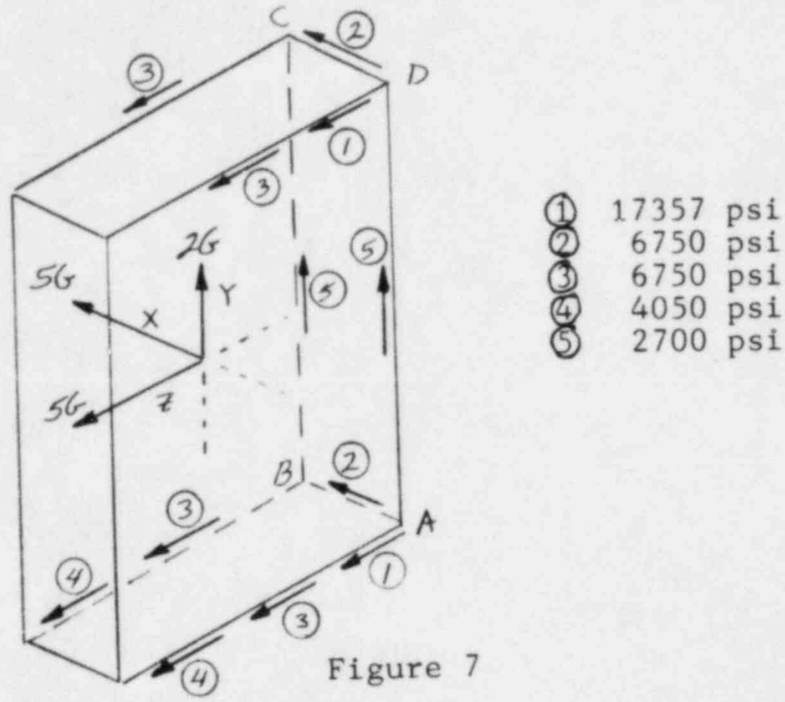


Figure 7

A unit cube near point A, the location of the highest stresses, shows the total stresses and their direction.

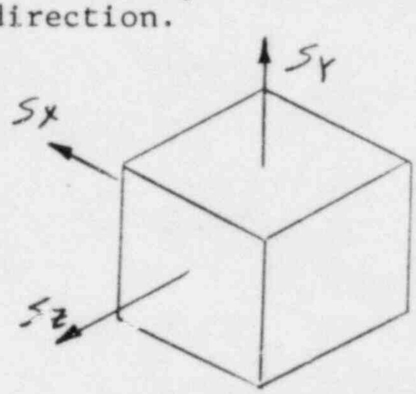


Figure 8

The stresses from Figure 7 are:

S_X = ② = 6750 psi

S_Y = ⑤ = 2700 psi

S_Z = ① + ③ + ④ = 28,157 psi

The cube is loaded with normal stress (S_Z)

and shearing stress (S_Y) in one plane and a shearing stress (S_X) only in a plane at right angles to the first plane.

When considering the plane of the shearing stress it can be shown that the resultant shearing stress (S_S) acting on the face of the plane is 9450 psi.

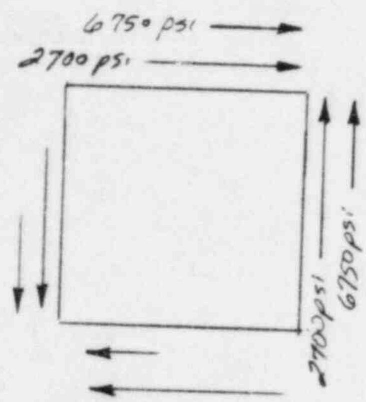


Figure 9

f) Maximum and minimum principal stresses in the tie down device

Maximum

$$S_1 = \frac{S_Z}{2} + \left[\left(\frac{S_Z}{2}\right)^2 + \left(S_S\right)^2\right]^{\frac{1}{2}}$$

$S_Z = 28,157$ psi

$S_S = S_Y + S_X = 9450$ psi

$S_1 = 14,080 + [(14,080)^2 + (9450)^2]^{\frac{1}{2}}$

$S_1 = 14,080 + (1.98 \times 10^8 + 8.93 \times 10^7)^{\frac{1}{2}}$

$S_1 = 14,080 + (2.873 \times 10^8)^{\frac{1}{2}}$

$S_1 = 14,080 + 16,950$

$S_1 = 31,030$ psi

Minimum

$$S_2 = \frac{SZ}{2} - \left[\left(\frac{SZ}{2}\right)^2 + (S_S)^2\right]^{\frac{1}{2}}$$

S_2 = 14,080 - 16,950

S_2 = -3870 psi

Factor of safety (weld) = $\frac{43,000(.85)^*}{31,030}$

F.S. = 1.18

* (.85 = weld - joint efficiency)

It may be seen from the above that the welds attaching the ears to the jacket will withstand the static force requirement. It was shown in 2.4.3 that the ear itself would withstand much greater forces. Therefore the tie down devices meet the requirements of 10CFR.

2.5 Standards for Type B and Large Quantity Packaging

2.5.1 Load Resistance

The following analysis will show that the package, if regarded as a simple beam supported at its ends along any major axis, can support a uniformly distributed load equal to five times its fully loaded weight. For the purpose of this analysis, we will consider the package as an open ended cylinder, neglecting any interior supports.

To calculate the load resistance, the maximum load per unit length is determined by dividing the shortest side by the total package weight. For this package, the worse case load would be the package load distributed along the height of the jacket outer shell.

$$\text{Load} = \frac{8100 \text{ lb}}{35 \text{ in}} = 231 \text{ lb/in}$$

For 5 times the load we have 231 lb/inch x 5 or 1155 lb/inch. Calculating the bending stress on the jacket for uniform loading:

$$M_{max} = \frac{WL^2}{8}$$

where Mmax = bending moment (inch - lbs)

W = load (lbs/inch)

L = length (inches)

Reference: Design of Weldments - James F. Lincoln Arc Welding Foundation 1968 page 7: 1-7

$$Mmax = \frac{1155 \text{ lb/in } (35in)^2}{8} = 176,860 \text{ inch-lbs}$$

The stress due to bending is:

$$S = \frac{MC}{I}$$ where

M = bending moment (in-lbs)

I = moment of inertia of section (in^4)

C = distance from neutral axis (in)

Reference: Design of Weldments - James F. Lincoln Arc Welding Foundation 1968 pag 2.6-1

$\frac{C}{I}$ for a cylinder is $\frac{32D}{\pi (D^4 - d^4)}$

where D = 33.125

d = 32.625

$$\frac{C}{I} = \frac{1060}{3.14(1203,992-1,132,927)} = \frac{1060}{3.14(71065)} = .00475$$

$$S = 176,860 \times .00475 = 840 \text{ psi}$$

This stress is well below the yield strength of the steel in the shell (40,000 psi).

2.5.2 External Pressure

For this package, the containment vessel is the shielded cask. The following analysis will show that the cask would suffer no loss of contents if it were subjected to an external pressure of 25psig.

For a cylindrical shell, the maximum allowable working pressure may be computed from the following formula

$$P_a = \frac{B}{Do/t}$$

where P_a = maximum working pressure (psi)

B = a factor for the specific material being used

Do = shell outside diameter (inches)

t = shell thickness (inches)

Reference ASME Boiler and Pressure Vessel Code Section VIII 1965 pgs 10 & 202

For the outer shell of the cask:

B = 14,000

Do = 28 inches

t = 0.25 inches

Therefore $P_a = \frac{14000}{28/0.25} = 125$ psig

Disregarding any bracing and internal support, the cask outer shell itself will resist a pressure of five times the requirement.

2.6 Normal conditions of Transport

2.6.1 Heat

Package components, constructed of steel, stainless steel and lead, are unaffected by the heat condition (ambient air at 100°F. and insolation loads of 800 g-cal/cm^2 on top, 400 g-cal/cm^2 on sides). The package surface temperature will increase, but the interior cask and its contents should remain unaffected. The amount of expansion and stress induced in the jacket as a result of this temperature rise will be nominal.

2.6.2 Cold

Under the cold conditions (ambient air at -40°F. in still air and shade), the package operation will be unaffected. There are no liquids or gases involved. The materials of construction will not be adversely affected.

2.6.3 Pressure

The package will withstand an external pressure of 0.5 standard atmospheric pressure.

2.6.4 Vibration

Inspection of the package after shipments over a period of two years has shown no evidence of damage as a result of vibration normally incident to transport.

2.6.5 Water spray

The package, constructed entirely of metal, would suffer no damage as a result of the water spray test.

2.6.6 Free Drop

A drop through a distance of 1.2 meters would have only superficial effects on the package. There would be no loss of containment from such a drop.

2.6.7 Corner Drop

Not applicable.

2.6.8 Penetration

There would be no significant damage to the protective jacket from the impact of a 1¼ inch diameter by 13 lb. mass dropped from a height of 1 meter.

2.6.9 Compression

The package is capable of withstanding a compressive load equal to five times its weight. This requirement is analyzed in 2.5.1.

2.7 Hypothetical Accident Conditions

2.7.1 Free Drop

The design and construction of the GE model 500 protective jacket was based upon extrapolation of the proven data generated during the design and construction of the GE model 100 cask and also upon the results of cask drop experiments by C.B. Clifford (1) (2) and H.G. Clarke, Jr. (3). The laws of similitude were used in an analytical evaluation (3)(4) to determine the protective jacket wall thickness that would withstand the test conditions of 49CFR173 and 10CFR71 without breaching the integrity of the model 500 cask. The increased weight and dimensions of the model 500 container over the model 100 container necessitated a protective jacket wall of 5/16 inch steel compared to a 1/4 inch wall for the model 100.

---

(1) C.B. Clifford, The Design, Fabrication and Testing of a Quarter Scale of the Demonstration Uranium Fuel Element Shipping Cask, KY-546, (June 10, 1968).

(2) C.B. Clifford, Demonstration Fuel element Shipping Cask from Laminated Uranium Metal- Testing Program, Proceedings of the Second International Symposium on Packaging and Transportation of Radioactive Materials, Oct. 14-18, 1968, pp. 521-556.

(3) H.G. Clarke, Jr., Some Studies of Structural Response of Casks to Impact, Proceedings of the Second International Symposium of Packaging and Transportation of Radioactive Materials, Oct. 14-18, 1968, pp. 373-398.

(4) J.K. Vennard, Elementary Fluid Mechanics, Wiley and Sons, New York, 1962 pp. 256-259.

The intent of the design for the GE model 500 is, during accident conditions, to sustain damage to the packaging not greater than the damage sustained by the GE model 100 during its accident condition tests. (Reference application for model 100 cask, Certificate of Compliance 5926). The model 100 cask was dropped onto a 10' x 8' x 3 inch steel plate. The orientation was onto the upper edge of the protective jacket, where the lifting and tie down devices are located. The results were that the protective jacket sustained all damages. The cask lid remained secure and there was no loss of contents from the containment vessel.

It is expected that damage not exceeding that suffered by the GE model 100 will result if the GE model 500 is subjected to the 30 foot drop test. Basically the containment vessel is a solid mass with no moving parts, protected by a steel jacket which will absorb the energy of impact.

2.7.2 Puncture

The protective outer jacket will sustain all damages resulting from the puncture test. It is expected that there will be some deformation of the jacket, but that the cask will remain unharmed. The following caluclation will demonstrate that the jacket will not be punctured.

The energy developed in the drop (E_D) is equal to the weight (W) times the drop height (d).

$$E_D = Wd = 8100 \text{ lbs } (40 \text{ in}) = 324{,}000 \text{ in-lb}$$

The energy necessary to shear the steel jacket may be calculated.

E_s = Shear Force (F_s) times the thickness (t).

F_s = Area of Shear (A) times shear strength (S).

$$E_s = A\,(S)(t)$$

$$= \pi(6''\text{DIAM})(t)(67{,}000 \text{ psi})(t)$$

$$E_s = 1{,}262{,}280\ (t^2)$$

The thickness of steel necessary to resist puncture may be determined by setting the energy necessary to shear (E_s) equal to E_D.

$$1{,}262{,}280\ (t)^2 = 324{,}000$$

$$t^2 = .257$$

$$t = .057 \text{ inches}$$

The minimum thickness of steel necessary to resist puncture is 0.507 inches.

The protective jacket is designed with a double wall of .3125 inch steel plate separated by 1 inch air space. The combined wall thickness of .625 inches will therefore resist puncture and damage to the cask.

2.7.4 Water Immersion

The model GE 500 package is a solid, rigid package that will resist an external pressure of water of 21 psi. The protective jacket has openings designed for air circulation which will allow water pressure to equalize on all sides of the jacket. In 2.5.2 an analysis was performed to show that the cask would support an external load of 25 psi.

The materials of construction would not suffer any significant damage from contact with water.

2.7.5 Summary of Damage

As a result of the hypothetical accident test sequence, the package will have sustained some damage to the outer protective jacket, but the containment vessel and its contents will have remained intact. The protective jacket will be crushed but not penetrated in the areas of impact from the free drop and the puncture test. All bolts will be in place and secured. The containment vessel will have suffered no loss of shielding and therefore the package will be as safe after the tests as it was before the tests.

2.8 Special Form

Not applicable.

2.9 Fuel Rods

Not applicable.

2.10 Appendix

3.0 Thermal Evaluation

3.1 Discussion

The Model GE 500 package is basically a transportation package. There are no subsystems involved. The primary thermal design feature is in the steel protective jacket, with a double wall to insulate from external thermal sources, and also designed to allow air circulation for package cooling necessary from internal thermal sources. Analyses performed on similar packages demonstrates that the package will prevent structural damage, breach of containment, and loss of shielding under the noraml and hypothetical accident conditions.

The maximum decay heat load shall not exceed 780 watts.

3.2 Summary of Thermal Properties of Materials

Melting point

Carbon steel	2750°F.
Lead	670°F.
Stainless Steel (302)	2550°F.

3.3 Technical Specifications of Components

Not applicable.

3.4 Thermal Evaluation for Normal Conditions of Transport

3.4.1 Thermal Model

Equilibrium temperature recordings for the GE Model 1500 cask (Reference Certificate of Compliance 5939) were taken. The package was loaded to 3028 watts (97% capacity), which resulted in the following data.

Cavity wall	307°F.
Maximum lead temp	307°F.
Inner shell of jacket	139°F.
Outer shell of jacket	99°F.
Ambient	80°F.

The GE Model 1500 package is larger, but of the same design as the Model 500 package. The cask outer surface-to-cavity distance is comparable, being only 1 1/8 inches greater for the Model 1500. The Surface Area for heat dissipation in the Model 500 is approximately 55% of the area available in the Model 1500; however, the watt loading for the Model 500 is 25% of the loading for the Model 1500. Therefore, it is anticipated that equilibrium temperatures for the Model 500 cask with an internal heat load of 780 watts would be approximately the same as those for the model 1500 cask.

3.4.6 Evaluation of Package performance

It is expected, that under the Heat Conditions, (ambient air at 100^{o}F and insolation of 800 g cal/cm^{2} on top, 400 g cal/cm^{2} on sides), the package surface temperature will rise, but that the cask temperatures, and certainly the temperature of the contents will not change significantly. Likewise, under the cold conditions (ambient air of -40^{o}F in still air and shade) the package surface temperature will drop, but the temperature of the contents will not change significantly.

Since the contents are in special form, there are no internal pressures to consider. Thermal stress is minimal due to the materials of construction.

3.5 Hypothetical Accident Thermal Evaluation

3.5.1 Thermal Model

The Thermal Model used was GE Model 1500 cask (Reference Certificate of Compliance 5939).

That package was assessed using the General Electric Transient Heat Transfer Computer Program Version D (THTD), which allows the analysis of the general transient problems involving conduction, convection, and radiation. The program allows the thermal properties of the materials to be entered as a function of temperature and the boundary conditions to be entered as a function of time.

The significant assumptions, approximations, and boundary conditions used for the analysis are listed below:

1. Fire temperature 1472^{o}F.
2. Effective Fire Esmissivity 0.9
3. Fire shield surface Emissivity and constant with temperature 0.8

4. Emissivity of other surfaces 0.8 and constant with temperature.

5. There is intimate contact between the lead shielding and the stainless steel shell of the cask.

6. There is negligible heat transfer by conduction through the pipes used as spacers between the cask and the first shield and between the two shields of the protective jacket.

7. There is negligible heat transfer by convection between the two shields of the protective jacket and between the cask and first shield of the protective jacket.

8. There is an internal heat load of 3,120 watts with a temperature profile as outlined in 3.4.1.

Conditions 1 through 3 above are specified in 10CFR71. Condition 4 is quite conservative particularly for the stainless steel shell of the cask. Condition 5 is conservative since for most shielded casks the lead is not bonded to the outer steel shell. The presence of a small gap between the lead and the steel would tend to insulate the lead thus reducing its temperature rise. Conditions 6 and 7 are not conservative but rough calculations indicate that the effect of these assumptions may increase the temperature rise of the shielded cask only 10% to 15%. Also, they are more than compensated for by the conservatism of condition 4, which may overestimate the temperature rise by as much as 60% depending on the condition of the surfaces. Condition 8 lists thermocouple recordings from a 3028 thermal watt internal load. The thermal properties other than emissivity were used as functions of temperature.

With these assumptions, the problem yields to an axi-symmetric conduction-radiation solution. For the analysis using THTD, the packaging was divided into nodes or regions. The two protective jacket shields were each divided into two nodes. The outer stainless steel shell of the cask was divided into two nodes. The lead was divided into several nodes. Finally, the cask cavity wall (stainless steel) was considered a node.

3.5.2 Package Conditions and Environment

It is expected that the package will sustain minor damage to the protective jacket during the free drop and puncture tests, and that the containment vessel will be virtually undamaged. Therefore, it is reasonable to consider the resultant package, for purposes of thermal resistance, as essentially undamaged.

3.5.3 Package Temperatures

The computer program calculations were run for a 30 minute fire. The calculations indicate a maximum temperature of less than 390°F for the lead after 30 minutes and no lead melting could be expected. Although a coast-up analysis was not performed on this container, the resulting maximum lead temperature, after equilibrating for forty minutes, is expected not to exceed 470°F.

These results, obtained from an analysis of a GE Model 1500 container, will hold true for the Model 500 package. Appendix 3.6 contains a writeup of the analysis performed on a GE Model 100 package. It contains a graph of temperature rise during the thermal tests and also a coast up analysis of temperature during the cool down period immediately following the test. The Model GE 500 package is expected to perform in a similar manner, though at higher temperature.

3.5.4 Maximum Internal pressures

Not applicable.

3.5.5 Maximum Thermal Stresses

Not applicable.

3.5.6 Evaluation of package performance

The package will not incur structural damage, breach of containment or loss of shielding as a result of the hypothetical accident thermal conditions. The temperatures reached by the lead are not high enough to cause the lead to melt - therefore shielding is unaffected. The steel components of the package do not reach temperatures high enough to cause damage.

3.6 Appendix

Predicted Thermal Response of General Electric Shielded Containers during the 10CFR71 Standard Fire.

EXHIBIT A

PREDICTED THERMAL RESPONSE

OF

GENERAL ELECTRIC SHIELDED

CONTAINERS DURING THE 10CFR71

STANDARD FIRE

Introduction and Problem Definition

The following thermal analysis of the General Electric shielded shipping containers was performed in accordance with 10CFR71.36, as described in Appendix B (3) to 10CFR71. The conditions of 10CFR71.36 do not preclude melting of the shielding material but rather limit the dose rate allowable after the accident. The hypothetical accident involves a sequence of conditions involving: 1) A free drop through a distance of 30 feet onto a flat essentially unyielding surface. 2) A free drop through a distance of 40 inches onto a verticle steel cylinder 6 inches in diameter and 8 inches or more long. 3) Exposure for 30 minutes within a source of radiant heat having a temperature of 1475°F and an emissivity coefficient of 0.9, or equivalent. For calculational purposes, it shall be assumed that the package has an absorption coefficient of 0.8. The package shall not be cooled artificially until after the 30 minute test period has espired and the temperature at the center of the package has begun to fall. 4) Immersion in water for 24 hours to a depth of at least 3 feet.

The General Electric approach to this problem was to protect the shielded cask for future use while meeting the requirements of Appendix B to 10CFR71. Two primary design criteria were established for the protective jacket. 1) Provide maximum protection for the shielded cask during the required impact tests with a high confidence of zero cask weld damage as an objective, and 2) provide maximum protection for the shielded cask during the 30 minute fire with zero melting as an objective, yet maintain compatibility with the internal heating load which must be dissipated from the cask during normal transport.

Several methods of protecting the shielded cask during the drop and during the fire have been devised by other designers. The protection generally has been constructed of wood or combinations of wood and metal. Two objections to the general use of these designs have been noted. First, while the wooden jacket does an excellent job of protecting the shielded cask from the fire and satisfactorily protects it during the drop, unfortunately, it also insulates the shielded cask during normal operating conditions. Thus, the cask operates at unnecessarily high temperatures if the transported material generates significant amounts of decay heat. Second, wooden jackets cannot be readily decontaminated in the event that they should become contaminated.

Proposed Solution

The design selected for the protective jacket consists of two steel enclosures which serve as thermal radiation shields during the fire transient as well as "crash" shields during the drop. The internal heat load can be dissipated to the ambient air by providing a path for natural air circulation through the protective jacket during normal transport. The protective jacket analyzed is shown in Figure 6.

Heat Analysis

The analysis was performed using the General Electric transient heat transfer computer program (THTD) which allows the analysis of the general transient problems involving conduction, convection, and radiation. The THTD computer program uses the implicit finite difference technique. It allows the thermal properties of the materials to be entered as a function of temperature and the boundary conditions to be general functions of time.

The significant assumptions approximations, and boundary conditions used for the analysis are listed below.

1. Fire temperature, 1472°F = 800°C.
2. Effective fire emissivity, 0.9.
3. Fire shield surface emissivity, 0.8 and constant with temperature.
4. Emissivities of other surfaces, 0.8 and constant with temperature.
5. Intimate contact between the lead shielding and the stainless steel cask shell.

6. Negligible heat transfer by conduction through the pipes used as spacers between the cask and the first shield and between the two shields.
7. Negligible heat transfer by convection between the two shields and between the first shield and the cask.
8. Internal heat load of 400 watts with recorded temperatures as outlined in Section 5.1.2 (e).

Conditions 1 through 3 above are specified in Appendix B. Condition 4 is quite conservative particularly for the stainless steel shell of the cask. Condition 5 is conservative since for most shielded casks the lead is not bonded to the outer steel shell. The presence of a small gap between the lead and the steel would tend to insulate the lead thus reducing its temperature rise. Conditions 6 and 7 are not conservative but rough calculations indicate that the effect of these assumptions may increase the temperature rise of the shielded cask only 10% to 15%. Also, they are more than compensated for by the conservatism of condition 4, which may overestimate the temperature rise by as much as 60% depending on the condition of the surfaces. Condition 8 lists thermocouple recordings from a 400 thermal watt internal load. The thermal properties other than emissivity were used as functions of temperature.

With these assumptions, the problem yields to an axi-symmetric conduction-radiation solution. For the analysis using THTD, the packaging was divided into 15 nodes or regions as shown schematically on Figure 7. The nodes were made smaller in the region of the maximum temperature gradient becoming progressively larger near the center. The protective jacket shields were each divided into two nodes. The outside stainless steel shell of the shielded cask was divided into two nodes. The first two lead nodes at the outside surface of the cask were made the same thickness as the cask shell. The remaining lead was divided into six nodes of equal thickness.

Shielded Cask and Protective Jacket Dimensions

A typical General Electric Shielded Container-Model 100 was used for the thermal analysis.

Shielded Cask Dimensions

Inside Diameter	7 5/8 inches
Steel Thickness	1/8 inch
Lead Thickness	5 7/8 inches
Steel Thickness	1/4 inch
Outside Diameter	20 1/4 inches

Protective Jacket Dimensions

First Shield

Steel Thickness	1/4 inch
Outside Diameter	22 1/4 inches

Second Shield

Steel Thickness	1/4 inch
Outside Diameter	25 1/4 inches

Results and Conclusions

The results of the analysis are shown on Figure 8. The calculations indicate a maximum temperature rise of 220°F for the lead after 30 minutes. Thus, considering the conservatism of the analysis (due to the choice of 0.8 for all emissivities), the design provides a large margin of safety during the proposed fire accident. Since no lead melting will occur, the shielding would not be reduced and maximum safety would be maintained.

The 220°F temperature rise was based on axi-symmetric geometry and boundary conditions. For the two dimensional problem (represented by a single package) a simplifying idealization applying superposition was made to arrive at the maximum lead temperature rise of 440°F. This is a conservative estimate of the package performance during the specified fire. Again, since no lead melting will occur, the shielding will not be reduced even in the event of sheath rupture and maximum safety will be maintained.

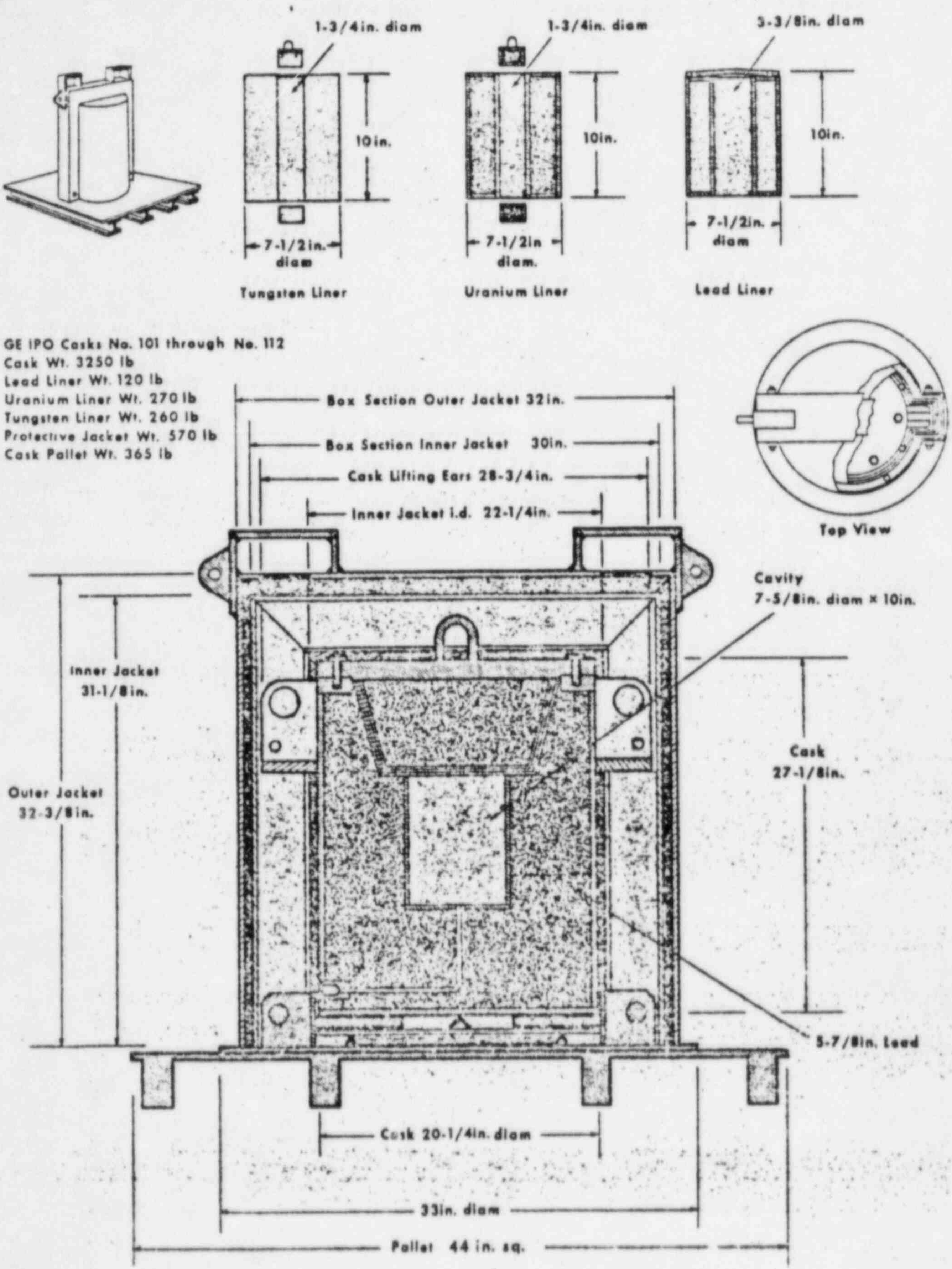


FIGURE 6 GENERAL ELECTRIC - MODEL 100 SHIELDED CONTAINER

V6773

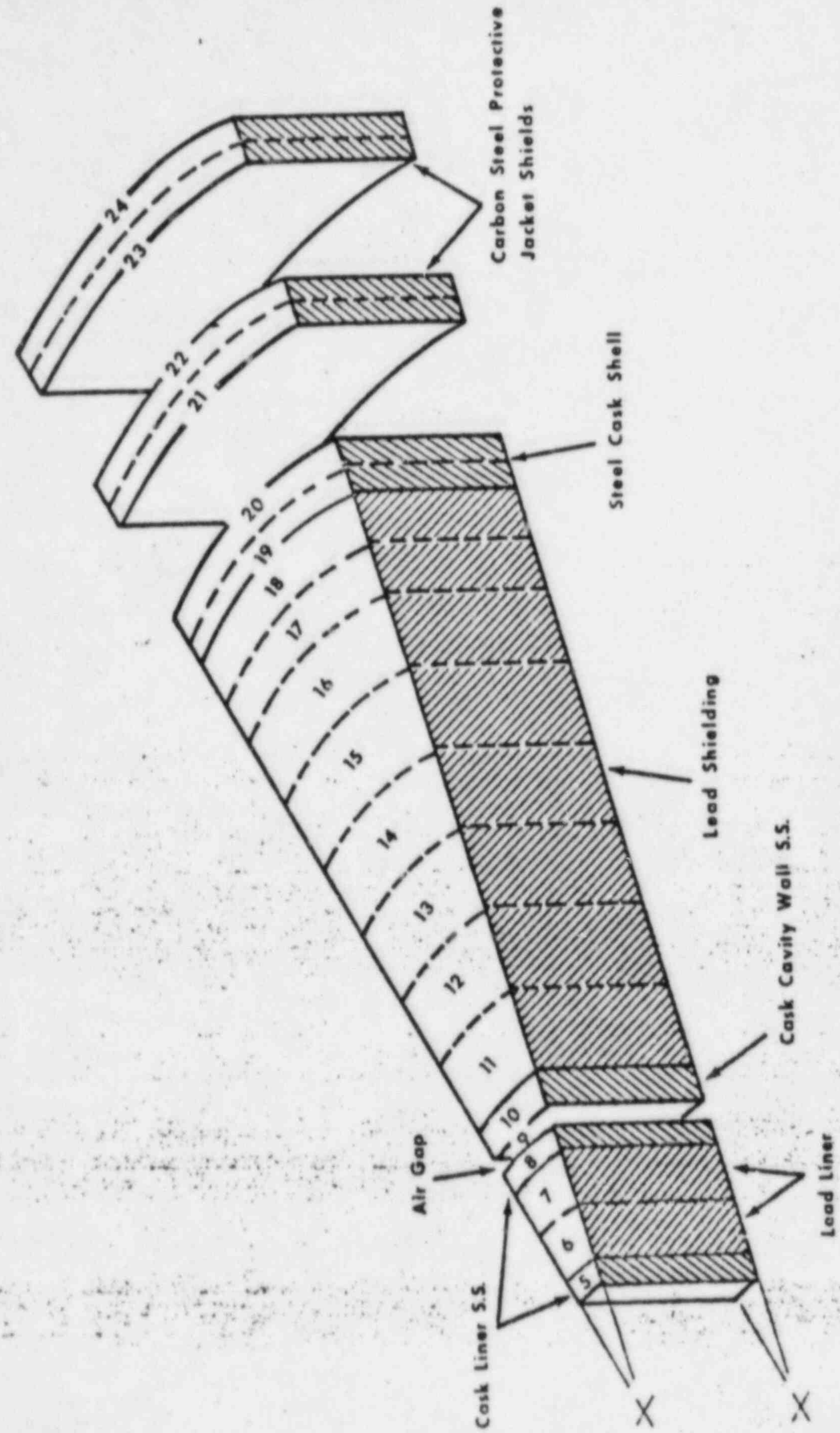


FIGURE 7. CONTAINER NODE STRUCTURE

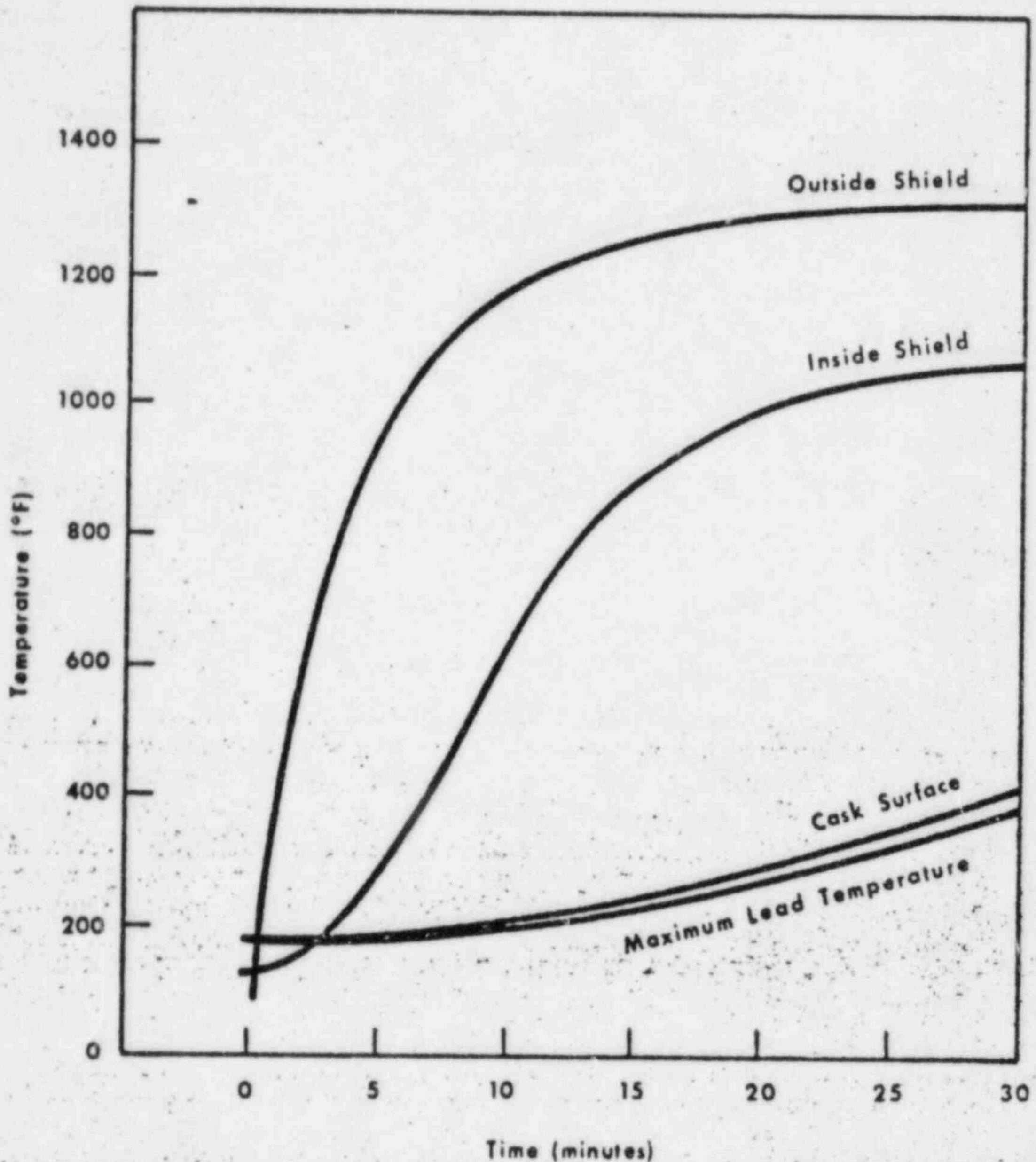


FIGURE 8. CASK & SHIELD TEMPERATURE VERSUS TIME

November 13, 1968

Mr. Blake Brown
Irradiated Fuels Branch
Division of Materials Licensing
U. S. Atomic Energy Commission
Washington, D.C. 20545

Dear Blake:

The enclosed data, including 1) a material properties table, 2) a physical model of the container with node locations, 3) the results of a coast-up analysis, and 4) a statement explaining the choice of the radial direction for the heat analysis, are submitted in accordance with the telecon between Messrs. Don Brown, Walt King, and yourself.

If additional data or details are requirdd, please let me know.

Sincerely,

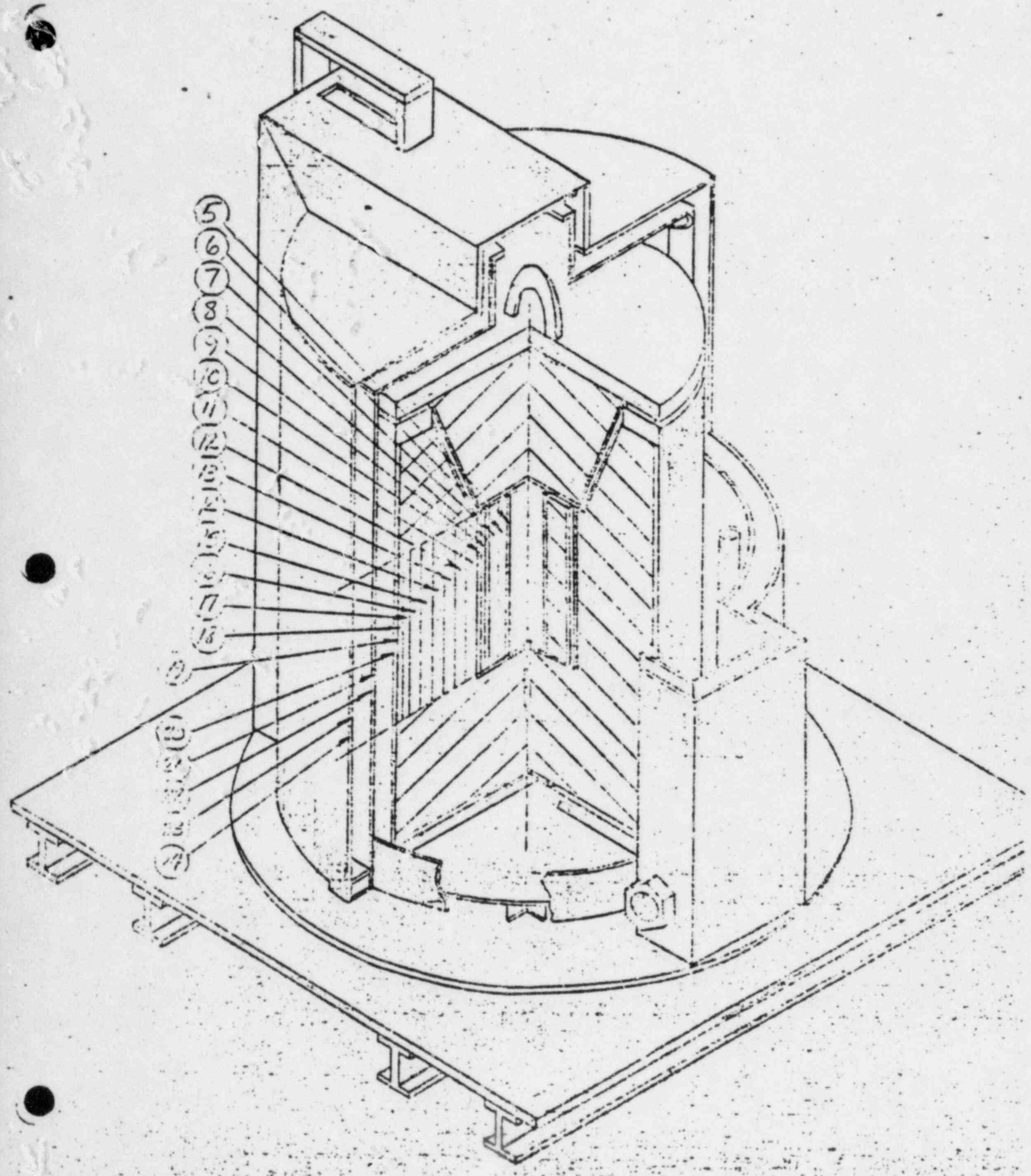
Walter H. King
Administrator-Licensing
VNC

WHK:pc

Enclosures

2)

FIGURE 1

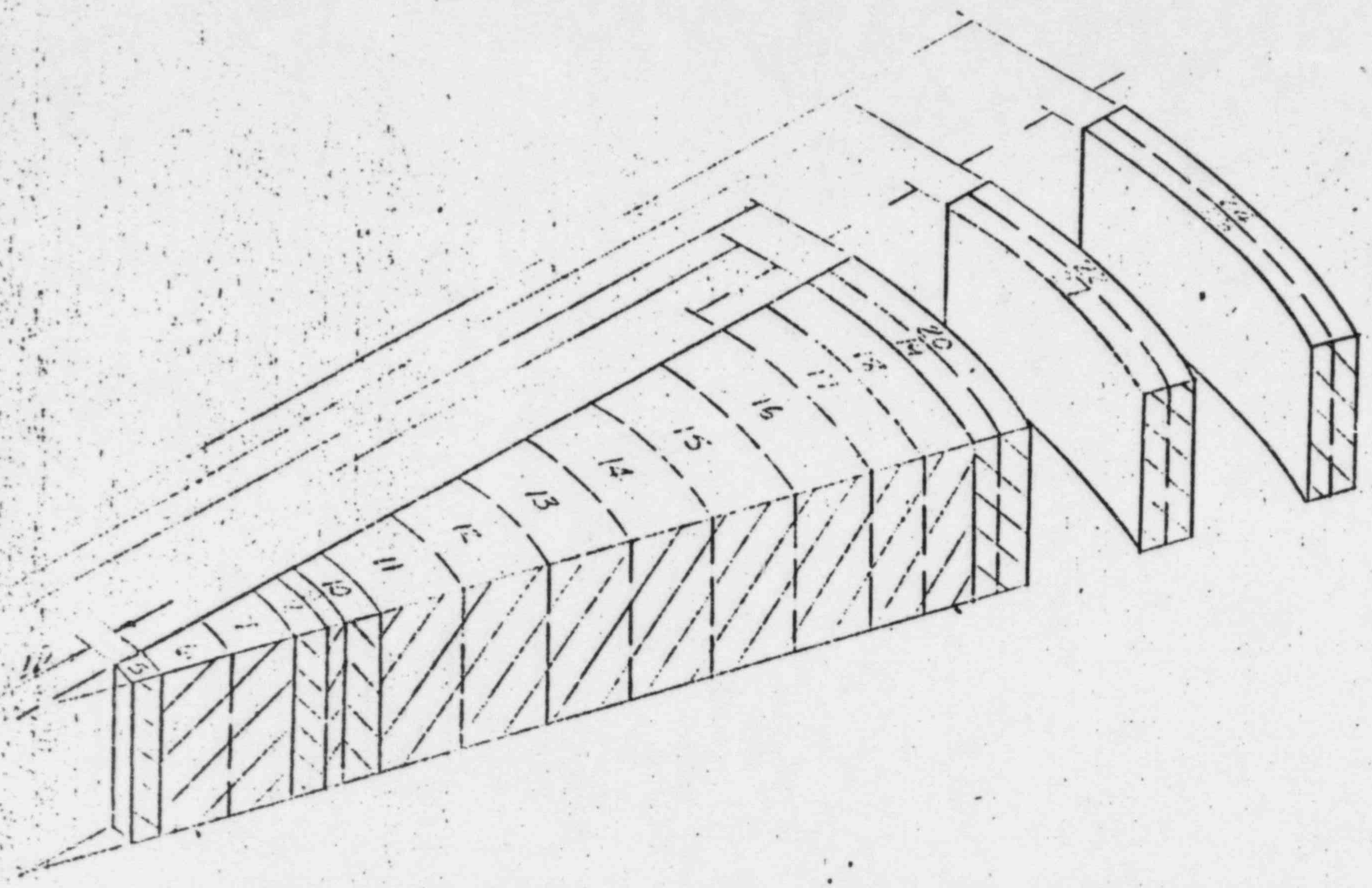


SHIELDED CONTAINER - MODIFIED

THT FIRE AND COAST-UP ANALYSIS

NODE		MAXIMUM TEMPERATURE, °F TIME = 0 MIN.	TIME = 30 MIN.	TIME = 70 M
5		440	456	
6	LEAD	440	456	556
7	LEAD	436	453	
8		434	452	
9		311	391	
10		186	332	
11	LEAD	186	332	
12	LEAD	182	335	
13	LEAD	180	342	
14	LEAD	178	351	
15	LEAD	176	364	
16	LEAD	175	379	
17	LEAD	174	391	
18	LEAD	173	396	455
19		173	401	
20		173	406	
21	PROTECTIVE JACKET	131	1064	460
22	PROTECTIVE JACKET	130	1069	
23	PROTECTIVE JACKET	96	1317	
24	PROTECTIVE JACKET	95	1321	386

FIGURE 1 ATTACHMENT



5. General Electric Shielded Container - Model 100, Number 104 Cask Temperature Coast-Up after Fire Transient

Using the temperature distribution at the end of the fire from the THT fire transient run, the 104 cask was allowed to equilibrate for forty minutes, using again the THT computer code. The resultant temperatures in various parts of the cask versus time are shown in Figures 1 and 2. The significant assumptions and approximations are:

1. Ambient (sink) temperature.	130°F
2. Effective sink emissivity.	0.9
3. Fire shield surface emissivity, and constant with temperature.	0.8
4. Emissivities of other surfaces, and constant with temperature.	0.8

5. Intimate contact between the lead shielding and the stainless steel cask shell.
6. Negligible heat transfer by conduction through the pipes used as spacers between the cask and the first shield and between the two shields.
7. Negligible heat transfer by convection between the two shields and between the first shield and the cask.
8. Internal heat load of 400 watts with temperature distribution as calculated by THT computer code at the end of the 30 minute fire.

Conditions 3, 4 and 5 are not conservative for the coast-up, but these conditions were imposed and were conservative for the fire transient, since the temperatures attained at the end of the fire would have been considerably lower with lower emissivities. Also, natural convection from the outside fire shield was not allowed but would in fact occur to some extent, and is conservative.

In order to determine the temperature distribution in the 104 cask under normal transport conditions, a test was run using a Co-60 source. The cask was instrumented with 5 chromel-alumel stainless steel clad thermocouples which were taped to and sprung against the surfaces to be measured.

A sixth thermocouple was used to measure ambient air temperature. A 25,000 Ci Co-60 source was placed in the cask cavity with a lead liner, and the system was allowed to equilibrate for approximately 5 days. The temperatures obtained were as follows:

Shielded cask cavity	440°F
External shell of cask, side	173°F
External shell of cask, top	165°F
External shell of cask, bottom	156°F
Protective jacket, outside surface, top	99°F
Protective jacket, outside surface, side	95°F
Ambient temperature	78°F

4. <u>Choice of Radial Direction for Heat Analysis</u>

In reply to the question as to why the THT fire transient analysis considered the radial direction rather than the top or bottom of the cask: This was done principally to allow consideration of the lead liner, which would not be included if the cask were analyzed through the top or bottom. Also, the distances involved are somewhat comparable; the radial distance being the shortest by about two inches.

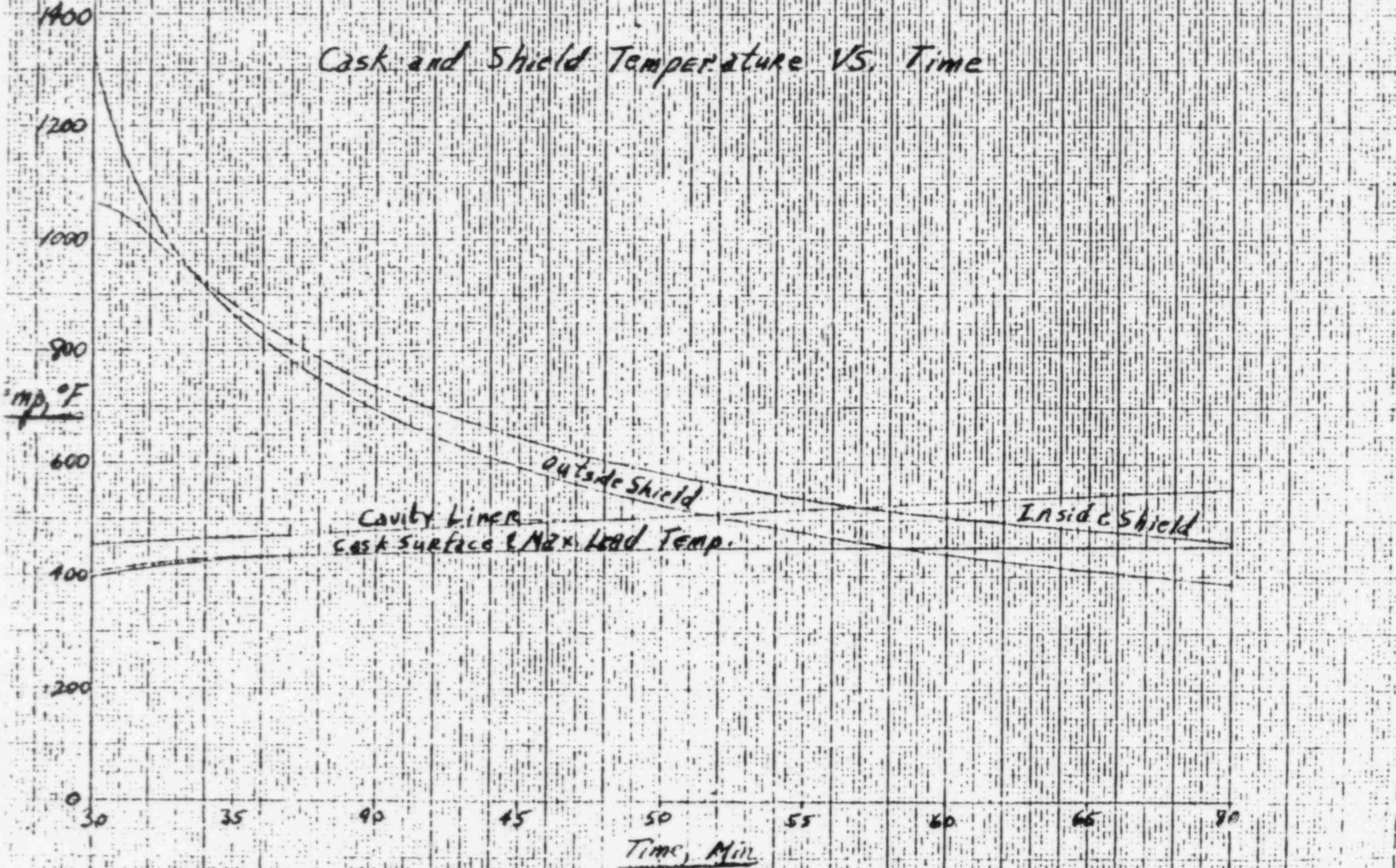


Fig 1

GCD 11/14/68

4.0 Containment

4.1 Containment boundary

4.1.1 Containment Vessel

The containment vessel for this package is the cask, which contains a cavity 7" DIAM x 7"H. The design specifications are summarized on Drawing 212E246 in Appendix 1.3.

4.1.2 Containment Penetrations

The cavity is penetrated by a ½ inch O D x 0.065 inch wall stainless steel tube gravity drain line, running from the center of the cavity bottom to the side of the outer shell near the cask bottom. It is closed with either a fusible lead cored ½NPT hex head brass pipe plug, or a solid stainless steel plug.

4.1.3 Seals and Welds

A silicone rubber gasket bonded to an aluminum backup plate provides a seal between the cask and its lid. Reference drawing 129D4690 in Appendix 1.3.

Cask welds are specified on drawing 212E246, Appendix 1.3.

4.1.4 Closure

The closure devices used for the containment vessel are 6 equally spaced 1 x 8 UNC 2A steel bolts.

4.2 Requirements for Normal Conditions of Transport

4.2.1 Release of Radioactive Material

There will be no release of radioactive material from the containment vessel. The protective outer jacket completely protects the containment vessel.

4.2.2 Pressurization of Containment Vessel

Pressurization within the containment vessel cannot occur. The radioactive material being transported is in special form.

4.2.3 Coolant Contamination

Not applicable.

4.2.4 Coolant Loss

Not applicable.

4.3. Containment Requirements for the Hypothetical Accident Conditions

4.3.1 Fission Gas Products

Not applicable.

4.3.2 Releases of Contents

There will be no release of radioactive material from the containment vessel.

5.0 Shielding Evaluations

5.1 Discussion and Results

The Model GE 500 package is designed to provide a nominal 10 inches of lead on all sides, top and bottom, of the cask cavity. All of the shielding is in the cask itself. The only removable shielding is in the cask lid.

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	60	60	60	7	7	7
Neutron	-	-	-	-	-	-
Total	60	60	60	7	7	7
Hypothetical Accident Conditions						
Gamma	60	60	60	7	7	7
Neutron	-	-	-	-	-	-
Total	60	60	60	7	7	7
10CFR Part 71 Limit	- -	--	--	1000	1000	1000

5.2 Source Specification

5.2.1 Gamma Source

The maximum quantity of radioactive material to be shipped by Advanced Medical Systems in this package is 50,000 curies of Cobalt 60. For the shielding analysis, this material was considered as a point source with an output of 1.35 RHM/curies.

5.2.2 Neutron Source

Not applicable

5.3.3 Model Specification

5.3.1 Description of the Radial and Axial Shielding Configuration

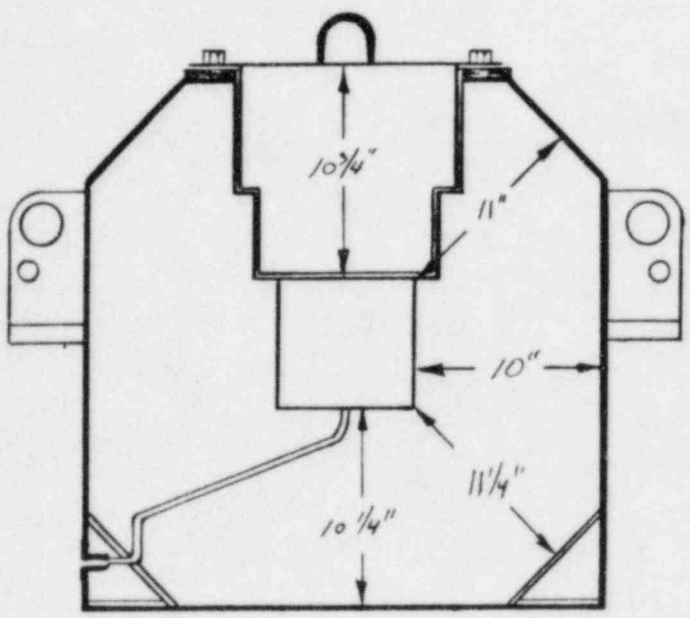


Figure 10

5.3.2 Shield Regional Densities

Not applicable.

5.4 Shielding Evaluation

There are no differences between normal conditions and accident conditions of transport, as the outer jacket is designed to protect the containment vessel from damage and loss of shielding.

The basic method used to determine the gamma dose rates at selected points outside the package was by actual measurement. Incoming shipments of Cobalt 60 in special form are routinely surveyed before acceptance. A Victoreen 491 survey meter is used. Readings are taken at the package surface and at points three feet from the surface. A summary of the highest readings recorded follows:

Quantity	Surface Reading	3' Reading
28,300 curies	40 mR	4.8 mR
35,300 curies	45 mR	5.0 mR
45,200 curies	55 mR	6.0 mR

Plotting this data on a graph and extrapolating to a maximum quantity of 50,000 curies results in a maximum surface reading of 60 mR/hr. This value is confirmed by calculations.

In practice the maximum dose rates are well below the limits of 10CFR71.

6.0 Criticality Evaluation

Not applicable.

7.0 Operating Procedures

7.1-7.2 Procedures for Loading/Unloading the Package

The following general procedure is used in the handling of the package.

a. Survey the package dose rate in accordance with internal procedures to assure the levels do not exceed acceptable limits.

b. Use appropriate capacity material handling equipment to transfer the package assembly to a clean area. The total package assembly weight is 8100 lbs.

c. Remove the wire security seal (item 6) located at the base of the jacket.

d. Remove the six bolts (item 7) from the base of the jacket.

e. Open the anti-tiedown covers (item 4). Use care not to damage the covers or lose the bolts.

f. Carefully lift the jacket off the cask, either by using the rectangular lifting eyes (item 2) on top of the jacket, or by using the tiedown lugs (item 3) and appropriately rated slings.

g. Place the jacket in a clean area.

h. Survey the external cask surfaces for radioactive contamination. If smearable contamination is detected, follow appropriate internal procedures for contamination control.

i. Lift the cask from the jacket base using the cask lifting ears (item 8). Transfer it to the shielded facility (hot cell) designated for dry loading/unloading operations.

j. Remove the cask lid bolts (item 9) and store to prevent loss, contamination, or damage. The bolts are required for reassembly.

k. Monitor the cask dose rate and carefully remove the lid from the cask using the cask lid lifting eye (item 1).

l. Inspect the seal gasket (item 11), the lid seal area, and the lid bolts for damage which could affect the integrity of the closure seal. This inspection should be conducted prior to loading material into the empty cask cavity, or after the cask contents have been removed and safely stored. If any damage is observed, notify AMS.

m. Transfer the radioactive materials and associated internal hardware into or out of the cask cavity.

n. Check the seal gasket for proper positioning and install the cask lid. Use care not to displace the gasket.

o. Monitor the cask dose rate to assure that the dose rates are within prescribed limits.

p. Install and tighten all lid bolts to assure a good lid seal.

q. Remove all old labels from cask. Apply new "FULL" or "EMPTY" label, as is appropriate.

r. Tape the interface between the cask lid and cask body with fabric-backed adhesive tape for contamination control.

s. Survey the external cask surfaces for removable contamination.

   Decontaminate to reduce smearable contamination levels to below DOT limits.

t. Return the cask to the protective jacket storage area.

u. Inspect the protective jacket, base, and bolts for damage. Notify AMS if any damage requiring repair or replacement of parts is observed.

v. Place the cask on the jacket base.

w. Align the cask on the base so the fireshield will position over the cask lifting ears and align with the bolt holes in the base assembly.

x. Position protective jacket on jacket base.

y. Install the jacket bolts and tighten.

z. Fasten anti-tiedown covers to jacket lifting eyes.

aa. Remove all old labels. Attach appropriate shipping labels and security seal. The container label contains two descriptions of contents, as follows:

Radioactive Material, Special Form n.o.s.

or

Radioacitve Material, Empty Package

Mask out the one which does not apply.

bb. Perform final radiation survey of assembled package (including smear check of external jacket surfaces) and complete shipping papers as required by applicable internal procedures and government regulations.

7.3. Preparation of an Empty Package for Transport

The following general procedure is used in preparing empty package for transport.

a. Survey the external cask surfaces for removable contamination. Decontaminate to reduce wipable contamination levels to below DOT limits.

b. Verify that the cask lid, gasket and bolts are all in place.

c. Apply an 'Empty' label to the cask.

d. Inspect the protective jacket, base and bolts for damage.

e. Assemble the package.

f. Fasten anti-tiedown covers to jacket lifting eyes.

g. Remove all old labels. Attach appropriate shipping labels.

h. Mask out the words 'Radioactive Material, Special Form n.o.s.' on the container label.

8.0 Acceptance Tests and Maintenance program

8.1 Acceptance Tests

At present, Advanced Medical Systems Inc. has no intention of constructing any new Model GE 500 packages. Should the need for new packages arise, they will be constructed under approved QA Program 0354.

8.2 Maintenance Program

Prior to each shipment, the package components are thoroughly inspected. All defects are corrected before releasing for shipment. Replacement and repair of components is performed on an as-needed basis.

8.2.1 Structural and Pressure Tests

None required.

8.2.2 Leak Tests

None required.

8.2.3 Subsystems Maintenance

Not applicable.

8.2.4 Valves, Rupture Discs, and Gaskets on Containment Vessel

The gasket used between the cask and cask lid is inspected prior to each shipment. It is replaced when inspection shows any defects or when it becomes contaminated.

8.2.5 Shielding

Not applicable. Routine surveys in accordance with transportation requirements are adequate.

8.2.6 Thermal

None required. Thermal degradation does not occur.