ORNL-5407

Safety Analysis Report for Packaging (SARP) of the Oak Ridge National Laboratory Foamglas Shipping Container

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OAK RIDGE NATIONAL LABORATORY
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SAFETY ANALYSIS REPORT FOR PACKAGING (SARP) OF THE OAK RIDGE NATIONAL LABORATORY FOAMGLAS SHIPPING CONTAINER

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ABSTRACT

An analytical evaluation of the Oak Ridge National Laboratory (ORNL) Foamglas Shipping Container was made to demonstrate its compliance with the regulations governing offsite radioactive material shipping packages. The evaluation encompassed five primary categories: structural integrity, thermal resistance, radiation shielding, nuclear criticality safety, and quality assurance. The results of the evaluation show that the container complies with the applicable regulations.

1. INTRODUCTION

When a package is to be used in offsite shipments of radioactive or fissile material, it is subject to regulations governing its structural integrity, heat dissipation capabilities, shielding ability, nuclear criticality safety, and quality assurance. The safety standards for the packaging of radioactive and fissile materials are set forth in Chapter 0529 of the United States Department of Energy (DOE) Manual.[1] To secure approval for shipment, it must be shown by test, by experimental data, or by computational methods that the package complies with these regulations. The Oak Ridge National Laboratory (ORNL) Foamglas Shipping Container was evaluated both by test and analyses and shown to meet all applicable regulations. The methods used and the results of the evaluation are reported here.

The ORNL Foamglas Shipping Container is illustrated in Fig. 1.1. Seventy-two containers have been fabricated from drawings[2,3] and identified by the applicable Department of Transportation (DOT) Special Permit No. 5795 (Appendix 9.1); most remain in service (see Sect. 6). An Interim Certificate of Compliance has been issued (Appendix 9.2), and the containers have been properly identified. This SARP, when approved, will complete the Nuclear Regulatory Commission (NRC) requirements, and a permanent certificate of compliance will be issued. The container is used to ship uranium and plutonium isotopes either singly or in mixture as metal or oxide. Shipments employing polyethylene bottles will be limited to 5 W heat output. Other shipments will be limited to 10 W.

As shown in Fig. 1.1, the radioactive material in its container is placed inside the flanged and gasketed stainless steel inner chamber that is centered in a 55-gal drum. The space between the inner chamber and the drum is filled with Foamglas. (See Sect. 1.1 for composition of Foamglas).

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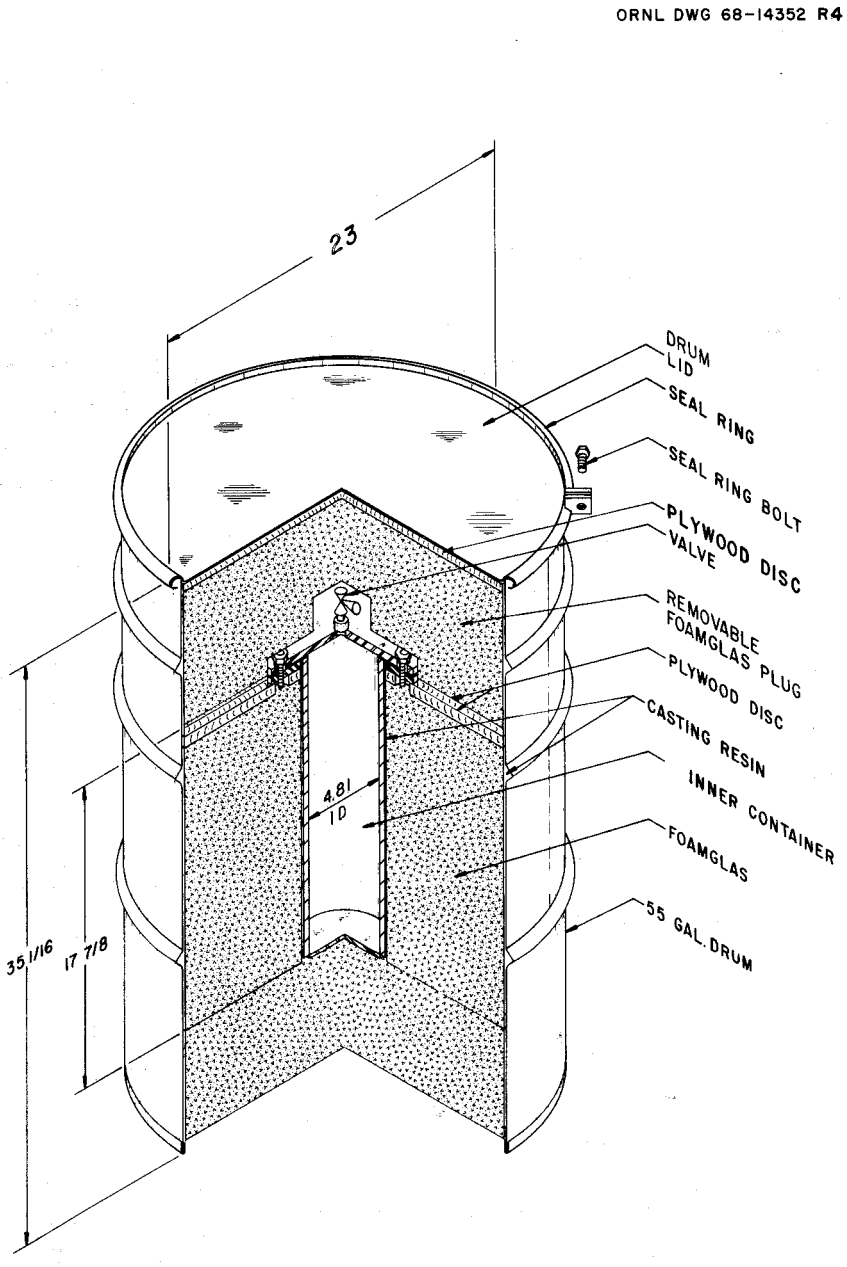

Fig. 1.1 Foamglas Shipping Container.

1.1 Description of Foamglas Shipping Container

The part numbers listed in this text refer to encircled numbers in Fig. 1.2. The external part of the Foamglas Shipping Container (Fig. 1.2) is a carbon steel drum, 23.0 in. OD by 35-1/16-in. long (part 10), which is identified as a Specification 17H package (Sect. 2.1).

Suspended inside the drum is a flanged and gasketed stainless steel inner container which meets specification 2R (Sect. 2.2) and has inside dimensions of 4.81 in. diam by 18 in. long. The side wall of the inner container is made from a 5-in.-diam sched-80 pipe (part 11) which has a 0.375-in. wall. The bottom of the inner container is a 1/4-in.-thick plate (part 12) welded to the pipe. The flange (part 9) of the inner container is 1/2 in. thick by 10 in. OD and is welded to the outside of the pipe. The body flange is drilled and tapped with eight 3/4-in. by 10 NC holes on an 8-1/2 in. pitch diameter. The top removable matching flange (part 7) is 1/2 in. thick and is held to the body by eight 3/4-in. by 1-1/4-in.-long NC hex head bolts (part 6). A silicone rubber gasket 1/8 in. thick, 5 in. ID by 10 in. OD (part 8), separates and seals the body flange and the top flange.

A 22-3/8-in.-diam by 5-3/4-in.-thick Foamglas[4] disc (part 1) is inserted into the bottom of the drum on which is placed a hollow Foamglas cylinder 5-11/16 in. ID x 22-3/8 in. OD x 16-1/4-in. high (part 2). On top of the Foamglas hollow cylinder is placed a 3/4-in.-thick plywood disc, 22-3/8 in. OD by 5-11/16 in. ID (part 3), which has eight 1-in.-diam holes to match the bolt circle of the inner container flange. The ends of the bolts that protrude through the flange are covered with a material that prevents resin (see below) from sealing to them, and the inner container is positioned in the cavity with the bolts coinciding with the holes in the plywood disc.

The top plug is a 22-3/8-in.-diam by 10-in.-high assembly consisting of a 9-in.-thick Foamglas unit (part 4) held between two pieces of 1/2-in.-thick plywood (parts 18-19). The assembly is held together with four bolts, washers, and nuts (parts 20-23). The bottom of the plug is relieved with a hole to match the flange and with finger holes in the top for use in lifting and handling the plug.

The top plug is now covered with a thin coating of a flexible casting resin[5] (part 15). This same casting resin is used to fill the voids between the Foamglas and the inner container, the drum, and the plywood disc. The inner container must be weighted down during this operation so that it will not float and thus be mislocated. A minimum quantity of casting resin is used to fill the voids and form a very thin layer on the top of the plywood disc. After the casting resin has set thoroughly, the outside of the casting resin on the Foamglas plug and the top of the casting resin on the plywood disc is given a thin coating of an epoxy resin[6] (part 16). The various typical bonds and air gaps are shown in the circles to the right in Fig. 1.2. The external surface of the drum is coated with a grey intumescent paint[7] (part 17).

After the coating resin has cured, the Foamglas Shipping Container is ready to be assembled by inserting the top Foamglas plug into the drum and placing the lid on the drum. A foam rubber gasket is used between the lid and the drum. The drum lid is held in place with a bolted closure ring which has a safety wire to signal tampering or accidental opening of the drum. The tare weight of the shipping container is 200 lb. The loaded weight is approximately 215 lb.

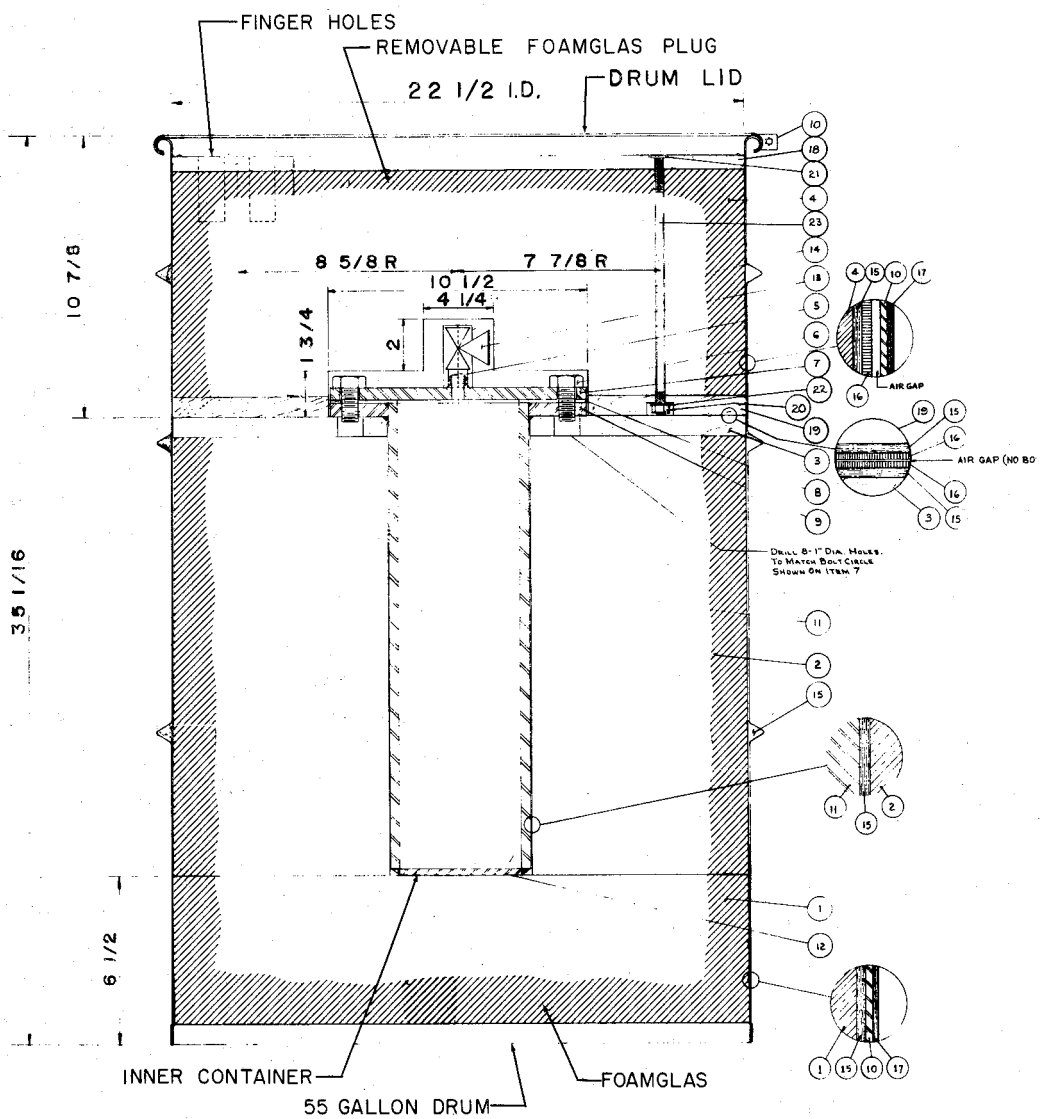

Fig. 1.2 Section of Foamglas Shipping Container showing band and air gaps.

The radioactive or fissile material to be shipped is contained inside a bottle within a sealed metal can. The bottles and cans in the inner container (Fig. 1.2) are packed with either crumpled aluminum foil or vermiculite to avoid damage.

The Foamglas used in the Foamglas Shipping Containers described in this report were fabricated with borated glass. Since March 5, 1973, Foamglas has been manufactured from boron-free glass. A comparison of the analysis of the two types of Foamglas is given in Table 1.1.

1.2 Intended Use of Foamglas Shipping Container

The Foamglas Shipping Container is used to ship uranium or plutonium isotopes either singly or in mixture, in the form of metal or oxide. The uranium may contain up to 100% ^{233}U, ^{235}U, or ^{238}U. Plutonium in quantities greater than 50 g will contain at least 60 wt % ^{239}Pu, more ^{240}Pu than ^{241}Pu, and ^{238}Pu will be considered as part of the ^{239}Pu. Metals or oxides will be packaged inside bottles contained in a sealed metal shipping can. The container including the contents is rated as Fissile Class II with the quantity limitations noted in Table 1.2. Any shipment will be limited to a source strength such that the radiation levels will not exceed those specified in the DOT regulations.[8] Shipments employing polyethylene bottles will be limited to heat outputs of 5 W, while other shipments will be limited to 10 W. Should new containers be built using Foamglas manufactured to new specifications, a reevaluation of transport indices must be made. Necessary changes will be resubmitted to DOE for approval.

2. STRUCTURAL EVALUATION

The Foamglas Shipping Container design has been analyzed to determine its behavior under normal operating conditions (Sect. 3). A Foamglas container was built in accordance with the design and has been subjected to hypothetical accident conditions[9] detailed in Sect. 4. Results of the analysis indicate that the package meets all structural requirements of DOE Manual, Chapter 0529.[1] The containers have been used for many years under DOT Permit 5795 and have always performed structurally as intended.

2.1 DOT Specification 17H–Steel Drum[10]

Paragraph 178.118. Specification 17H - steel drums. Single trip container. Removable head required.

Paragraph 178.118-1. Compliance. (a) Required in all details.

Paragraph 178.118-2. Rated capacity. (a) Rated capacity as marked, see Paragraph 178.118-10 (a) (3). Minimum actual capacitiy of containers shall be not less than rated (marked) capacity plus 4 percent. Maximum actual capacity shall not be greater than rated (marked) capacity plus 5 percent or rated (marked) capacity plus 4 percent plus 1 quart, whichever is the greater.

Table 1.1. Analysis of foamglas

Compound or element	Material manufactured before March 5, 1973	Material manufactured after March 5, 1973
	(%)	(%)
SiO_2	71.8	73.75
Al_2O_3	4.4	4.35
CaO	3.8	4.35
Na_2O	11.4	11.53
K_2O	0.9	0.64
B_2O_3	3.9	
SO_3	0.3	0.33
F	0.3	
MgO	3.2	4.41
FeO		0.17
Li_2O		0.47

Table 1.2 Limits for quantities of fissile material for shipments using the Foamglas Shipping Container[11]

Transport Index	Mass (kg of X)		
	Metal	UO_2 Oxide H:X ≤ 0.4	UO_2 Oxide H:X ≤ 3
		Uranium-235	
	(ρ = 18.76 g U/cm^3)	(ρ = 8.09 g U/cm^3)	(ρ = 4.48 g U/cm^3)
0.1	17.2 kg	18.8 kg	15.4 kg
0.2	19.5	24.1	18.4
0.3	20.8	28.2	20.4
0.5	23.0	33.8	23.0
1.0	25.6	43.7	27.4
2.0	28.8	56.1	32.8
		Plutonium-239	
	(ρ = 19.7 g Pu/cm^3)	(ρ = 8.73 g Pu/cm^3)	(ρ = 4.71 g Pu/cm^3)
0.1	5.3 kg	10.5 kg	9.2 kg
0.2	5.6	11.6	10.7
0.3	5.8	12.4	11.8
0.5	6.2	13.5	13.3
1.0	6.5	14.9	15.6
2.0	7.0	16.5	18.3
		Uranium-233	
	(ρ = 18.4 g U/cm^3)	(ρ = 8.08 g U/cm^3)	(ρ = 4.46 g U/cm^3)
0.1	7.5 kg	11.1 kg	8.3 kg
0.2	8.0	12.6	10.1
0.3	8.3	13.7	11.5
0.5	8.8	15.0	13.3
1.0	9.2	17.1	16.2
2.0	9.9	19.3	19.8

Paragraph 178.118-3. Composition. (a) Sheets for body and heads to be low-carbon, open-hearth, or electric steel.

Paragraph 178.118-5. Seams. (a) Body seams welded.

Paragraph 178.118-6. Parts and dimensions. (a) Parts and dimensions as follows in Table 2.1.

Paragraph 178.118-7. Convex heads. (a) Convex (crowned) heads not extending beyond level of chime required for drums of 25 gal capacity or over; minimum convexity of 3/8 in. required.

Paragraph 178.118-8. Closures.
(a) Adequate to prevent leakage; gaskets required.

(b) Drums over 5 gallons capacity must be closed by means of 12 gauge bolted ring with drop forged lugs, one of which is threaded, and having 5/8 in. bolt and nut for drums over 30 gallons capacity. Five gallon drums must be of lug type closure with cover having at least 16 lugs. Equally efficient types of closures are authorized upon demonstration and proof of satisfactory tests to representative of Bureau of Explosives.

(c) For closure with threaded plug or cap, the seat (flange, etc.) for plug, or cap, must have three or more threads; two drainage holes of not over 5/16 in. diameter are allowed. Plug, or cap, must have sufficient length of thread to engage three threads when screwed home with gasket in place. *Provided*, that for containers having a capacity of 12 gal and less the seat (flange, etc.) for plug, or cap, must have two or more complete threads and plug, or cap, must have sufficient length of thread to engage two threads when screwed home with gasket in place.

(1) Closures of screw-thread type or closed by other positive means, of any material or design, may be authorized by the Bureau of Explosives for use, upon satisfactory proof of efficiency.

Paragraph 178.118-9. Defective containers. (a) Leaks and other defects to be repaired by method used in constructing container, not by soldering.

Paragraph 178.118-10. Marking. (a) Marking on each container by embossing on head, except that such embossment must be on the permanent head for drums having removable heads, with raised marks, or by embossing or die stamping on footring on drums equipped with footrings, or on metal plates securely attached to drum by brazing or welding not less than 20 percent of the perimeter, as follows:

Table 2.1 Parts and dimensions.

Marked capacity not over (gallon)	Type of container	Minimum thickness, uncoated sheets (gauge)			Rolling hoops		
		Body sheet	Bottom head sheet	Removable head sheet	Type	Minimum Size (gauge or in.)	Minimum Weight (pounds per ft)
5	Straight side	24	24	20	None	-	-
30	Straight side	18	18	18	(1)	-	-
55	Straight side	18	18	14(3)	(2)	-	-

(1) Rolled or swedged in hoops.

(2) Each drum must have three rolled or swedged in hoops, one to be placed in the body near the top curl.

(3) 16 gauge authorized provided there are one or more corrugations in the cover near the periphery.

Steel sheets of specified gauge shall comply with the following:

Gauge No.	Nominal thickness(1) (in.)	Minimum thickness(1) (in.)
14	0.0747	0.0677
16	0.0598	0.0533
18	0.0478	0.0428
20	0.0359	0.0324
24	0.0239	0.0209

(1) Thickness shall be measured at any point on the sheet not less than 3/8 in. from an edge.

(1) DOT-17H. The letters STC located near the DOT mark to indicate "single-trip container." In addition, when the container is of stainless steel, the type of steel used in body and head sheets as identified by American Iron and Steel Institute type number and also the letters HT following steel designation on containers subjected to stress-relieving or heat-treatment during manufacture (for example, DOT-17H-304 or DOT-17H-304 HT as applicable) shall be shown. These marks shall be understood to certify that the container complies with all specification requirements.

(2) Name or symbol (letters) of maker; this must be recorded with the Bureau of Explosives.

(3) Gauge of metal in thinnest part, rated capacity in gallons, and year of manufacture (for example, 12-55-50). When gauge of metal in body differs from that in head, both must be indicated first (for example 14/12-55-50 for body gauge and head 12 gauge).

Paragraph 178.118-11. Size of markings. (a) Size of markings (minimum); 1/2 in. high for 33-gallons or less, 3/4 in. for over 33 and not over 55 gallons.

Paragraph 178.118-12. Type tests. (a) Samples taken at random and closed as for use, shall withstand prescribed tests without leakage. Tests to be made of each type and size by each company starting production and to be repeated every four months. Samples last tested to be retained until further tests are made or for one year, whichever period is shorter. The type tests are as follows:

(1) Test by dropping, filled with water to 98 percent capacity, from height of 4 ft onto solid concrete so as to strike diagonally on chime, or when without chime seam, to strike on other circumferential seam; also additional drop test on any other parts which might be considered weaker than the chime. Closing devices and other parts projecting beyond chime or rolling hoops must also be capable of withstanding this test.

(2) Hydrostatic pressure test of 15 lb per sq in. sustained for 5 minutes.

Paragraph 178.118-13. Leakage test. (a) Each container shall be tested, with seams under water or covered with soapsuds or heavy oil, by interior air pressure of at least 7 lb per sq in. for containers over 12 gallons capacity and at least 5 lb for others. Equally efficient means of testing are authorized upon demonstration and proof of satisfactory tests to representative of Bureau of Explosives. Leakers shall be rejected or repaired and retested. Containers not required to be tested with heads in place except that samples taken at random and closed as for use, of each type and size, must be tested at start of production and repeated every four months. Samples so tested must be retained until further tests are made.

2.2 DOT Specification 2R[10]

Paragraph 178.34. Specification 2R; inside containers, metal tubes.

Paragraph 178.34-1. Materials. (a) Metal tubes shall be stainless steel, malleable iron, or brass, or other materials having equivalent physical strength and fire resistance.

Paragraph 178.34-2. Manufacture.

(a) The ends of the tubes must be fitted with screw-type closures or flanges (see Paragraph 178.34-4), except that one or both ends of the tube may be permanently closed by a welded or brazed plate. Welded or brazed side seams are authorized.

(b) Welding or brazing must be done in a workman-like manner and must be free from defects.

Paragraph 178.34-3. Size. (a) Inside diameter of the tube shall not exceed 12 inches, exclusive of flanges for handling or fastening devices, and shall have wall thickness and length in accordance with the following dimensions listed in Table 2.2.

Table 2.2 Wall thickness and length dimensions.

Inside diameter maximum		Wall thickness minimum			Length maximum	
		Threaded closure				
Inches	Centi-meters	Inches	Milli-meters	Flanged closure	Inches	Centi-meters
2	5	3/32	2.5	Not less than that	16	41
6	15	1/8	3.2	prescribed for sched-	72	183
12	30	1/4	6.5	ule 40 pipe.	72	183

Paragraph 178.34-4. Closing devices. (a) Closing devices shall be as follows:

(1) Screw-type, caps or plugs; number of threads per inch must not be less than United States standard pipe threads and must have sufficient length of thread to engage at least 5 threads when securely tightened.

(2) Openings exceeding 3 inches inside diameter may be closed by securely bolted flanges and leak-tight gasket.

Paragraph 178.34-5. Marking. (a) Each container shall be marked with the words "Radioactive Material," in letters at least one-fourth inch in height, either by embossing or diestamping directly onto the container, or by securely affixing by welding or brazing a metal plate bearing this notation to the container.

2.3 Compliance with AEC Manual Chapter 0529

Supporting data indicating compliance of the ORNL Foamglas Shipping Container with the requirements of the packaging standards of DOE Manual Chapter 0529 are given below. Where applicable, the requirements of Chapter 0529 are given in quotes followed by the necessary comments and calculations.

I. "Definitions and Exemptions"

I.A. "Definitions" - No comment is required.

II. "Package Standards"

II.A. "General Standards for all Packaging"

II.A.1. "Packaging shall be of such materials and construction that there will be no significant chemical, galvanic, or other reaction among the packaging components, or between the packaging components and the package contents."

Evaluation of Requirements Stated in II.A.1. The Foamglas Shipping Container inner specification 2R container, the primary containment vessel, is constructed of 300-series stainless steel which is compatible with the containers used. Therefore, there will be no significant chemical, galvanic, or other reaction among the packaging components, between the packaging components and the containment vessel, or between the packaging components and the package contents.

II.A.2. "Packaging shall be equipped with a positive closure which will prevent inadvertent opening."

Evaluation of Requirements Stated in II.A.2. The "specification" 2R inner container (containment vessel) is sealed with a silicone rubber gasket and eight 3/4-in. cap screws. The drum lid is held in place by a bolted closure ring. The bolted closure ring has a lock nut and a safety wire. The package is thus equipped with a positive closure which will prevent inadvertent opening.

II.A.3. "Lifting Devices"

Evaluation of Requirements Stated in II.A.3. Not applicable. This shipping container does not have special lifting devices; it is handled as an ordinary 55-gal drum.

II.A.4. "Tie-down Devices"

Evaluation of Requirements Stated in II.A.4. Not applicable. This shipping container does not have special tie-down devices; it is handled as an ordinary 55-gal drum.

II.B. "Structural Standards for Large Quantity Packaging"

> "Packaging used to ship a large quantity of radioactive material, as defined in I.A.6., shall be designed and constructed in compliance with the structural standards of this section. Standards different from those specified in this section may be approved by the manager or other designated official if the controls proposed to be exercised by the shipper are demonstrated to be adequate to assure the safety of the shipment."

Evaluation of Requirements Stated in II.B. The package is designed and constructed in compliance with the structural standards of this section.

> II.B.1. "Load Resistance - Regarded as a simple beam supported at its ends along any major axis, packaging shall be capable of withstanding a static load, normal to and uniformly distributed along its length, equal to 5 times its fully loaded weight, without generating stress in any material of the packaging in excess of its yield strength."

Evaluation of Requirements Stated in II.B.1. The Foamglas Shipping Container loaded as required as a simple cylindrical beam is shown in Fig. 2.1.

The reactant force acting on the end of the simple beam (R_1) is found as follows:

$$R_1 = 5\underline{W}/2 = 537.5 \text{ lb}, \tag{2.1}$$

where

$\underline{W}$ = weight of beam, 215 lb.

The unit loading (ω) is found as follows:

$$\omega = 5\,\underline{W}/L = 30.7 \text{ lb/in.}, \tag{2.2}$$

where

L = length of beam, 35 in.

From these loadings the maximum bending moment (M_{max}), which is in the center of the beam, is calculated as follows:

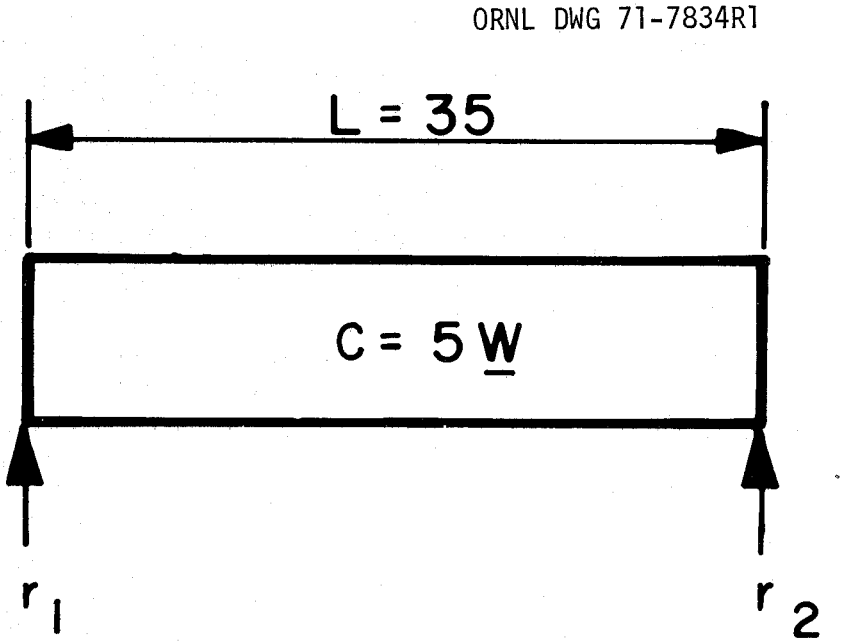

Fig. 2.1 Foamglas Shipping Container loaded as a simple cylindrical beam.

$$M_{max} = R_1 (L/2) - (12l^2/8) = 4705 \text{ in.-lb.} \quad (2.3)$$

The moment of inertia (I) is calculated as follows:

$$I = \pi/4 (r_o^4 - r_1^4) = 225 \text{ in.}^4, \quad (2.4)$$

where

r_o = radius of outside of drum, 11.3 in.,

r_1 = radius of inside of drum, 11.25 in.

The maximum bending stress (S_b), which is also at the center of the beam, may be calculated as follows:

$$S_b = M_{(max)} r_o / I = 236 \text{ psi } (<25{,}000 \text{ psi}). \quad (2.5)$$

Since the maximum bending stress is well below the yield stress for steel used in the drums, the Foamglas Shipping Container exceeds the load resistance requirement. The Foamglas, which was not considered in this calculation, will also help the drum to resist bending.

II.B.2. "*External Pressure* - Packaging shall be adequate to assure that the containment vessel will suffer no loss of contents if subjected to an external pressure of 25 pounds per square inch gauge."

Evaluation of Requirements Stated in II.B.2. The inner containment vessel upon which principal reliance is placed to retain radioactive material during transport will not suffer loss of contents should the shipping container be subjected to an external pressure of 25 psig. Some buckling of the 55-gal drum will occur, although it will be restrained and the damage minimized by the Foamglas which is inside the drum. Foamglas has an ultimate compressive strength of 100 psi.

The maximum allowable external working pressure (Pa) for which the shell of the inner container is usable, may be calculated[11] as follows:

$$Pa = B/(do/t) = 10{,}500/(5.563/0.375) = 708 \text{ psia}, \quad (2.6)$$

where

B = 10,500, the value read from Fig. UHA-28.3, Appendix V in Ref. 12,

do = 5.563 in., OD of the cylindrical shell,

t = 0.375 in., thickness of the cylindrical shell plate.

Inner Container Head. - The design pressure of the inner container head may be calculated[13] as follows:

$$P = St^2/Cd^2 = 173 \text{ psi}, \tag{2.7}$$

where

P = working pressure, psi,

S = maximum allowable stress value, 13,300 psi,

t = thickness head, 0.5 in.,

C = factor, 0.25,

d = diam, 8.5 in.

Inner Container Bottom. - The design pressure of the inner container bottom may be calculated[13] as follows:

$$P = St^2/Cd^2 = 144 \text{ psi}, \tag{2.8}$$

where

P = working pressure, psi,

S = maximum allowable stress value, 13,300 psi,

t = thickness bottom, 0.25 in.,

C = factor, 0.25 in.,

d = diam, 4.81 in.

Since the inner container is designed to withstand much more than 25 psi differential pressure, it will not be affected adversely by 25-psig external pressure, if the gasket is in place and properly loaded by the bolts. ORNL operating procedures (Appendix 9.3) require that all seals are properly made up, checked, and approved prior to shipment; consequently, the container will not be affected by external pressure and there will be no loss of contents.

II.C. "Criticality Standards for Fissile Material Packages"

Criticality Evaluation of Foamglas Shipping Container and Contents. The criticality evaluation was made based on the Foamglas Shipping Container and its 5-in. sched-80 pipe

(4.81-in. ID) by 18-in.-long inner container and the permissible mass limits (mass in kg X) found are shown in Table 1.2. The allowable fissile material mass per container was determined for Class II shipment based on a 50-unit transport rule.[14] There are no restrictions on the shape of the fissile solids or oxides.

II.C.1. "A package used for the transport of fissile material shall be so designed and constructed and its contents so limited that it would be subcritical if it is assumed that water leaks into the containment vessel, and:

a. water moderation of the contents occurs to the most reactive credible extent consistent with the chemical and physical form of the contents; and

b. the containment vessel is fully reflected on all sides by water."

Evaluation of Requirements Stated in II.C.1. The criticality evaluation established limits of contents for solids (Table 1.2) which ensure subcriticality if water leaks into the containment vessel and moderates the contents to the most reactive credible extent and the containment vessel is fully reflected on all sides by water.

II.D. "Evaluation of a Single Package"

II.D.1. "The effect of the transport environment on the safety of any single package of radioactive material shall be evaluated as follows:

a. the ability of a package to withstand conditions likely to occur in normal transport shall be assessed by subjecting sample package or scale model, by test or other assessment, to the normal conditions of transport as specified in II.E., below, and:

b. the effect on a package of conditions likely to occur in an accident shall be assessed by subjecting a sample package or scale model, by test or other assessment, to the hypothetical accident conditions as specified in II.F., below."

Evaluation of Requirements Stated in II.D.1. An evaluation of the Foamglas Shipping Container by test and other assessment establishes that the package will be able to withstand conditions likely to occur in normal transport (see II.E. below) and as a result of the hypothetical accident (see II.F. below).

II.D.2. "Taking into account controls to be exercised by the shipper, the manager or other designated official may permit the shipment to be evaluated together with or without the transporting vehicle, for the purpose of one or more tests."

Evaluation of Requirements Stated in II.D.2. Not applicable.

II.D.3. "Normal conditions of transport and hypothetical accident conditions different from those specified in II.E. and II.F., below, may be approved by the manager or other designated official if the controls proposed to be exercised by the shipper are demonstrated to be adequate to assure the safety of the shipment."

Evaluation of Requirements Stated in II.D.3. Not applicable.

II.E. "Standards for Normal Conditions of Transport for a Single Package."

II.E.1. "A package used for the shipment of fissile material or a large quantity of radioactive material, as defined in I.A.6., shall be so designed and constructed and its contents so limited that under the normal conditions of transport specified in Sect. 3.

a. there will be no release of radioactive material from the containment vessel;

b. the effectiveness of the packaging will not be substantially reduced;

c. there will be no mixture of gases or vapors in the package which could, through any credible increase of pressure or an explosion, significantly reduce the effectiveness of the package;

d. radioactive contamination of the liquid or gaseous primary coolant will not exceed 10^{-7} curies of activity of Group I radionuclides per milliliter, 5×10^{-6} curies of activity of Group II radionulides per milliliter; 3×10^{-4} curies of activity of Group III and Group IV radionuclides per milliliter; and

e. there will be no loss of coolant or loss of operation of any mechanical cooling device."

Evaluation of Requirements Stated in II.E.1. Conditions of normal transport as defined by Annex 1, DOE Manual Appendix 0529 are listed in Sect. 3 of this report. After each condition

of normal transport, the evaluation applicable to the Foamglas Shipping Container is presented. The evaluations in Sect. 3 indicate that the above conditions will be met under normal conditions of transport.

II.E.2. "A package used for the shipment of fissile material shall be so designed and constructed and its contents so limited that under the normal conditions of transport specified in Sect. 3 considered individually:

a. the package will be subcritical;

b. the geometric form of the package contents would not be substantially altered;

c. there will be no leakage of water into the containment vessel. This requirement need not be met if, in the evaluation of undamaged packages under II.H.1., II.I.1.a., or II.J.1., below, it has been assumed that moderation is present to such an extent as to cause maximum reactivity consistent with the chemical and physical form of the material; and

d. there will be no substantial reduction in the effectiveness of the packaging, including:

(1) reduction by more than 5 percent in the total effective volume of the packaging on which nuclear safety is assessed;

(2) reduction by more than 5 percent in the effective spacing on which nuclear safety is assessed, between the center of the containment vessel and the outer surface of the packaging; or

(3) occurrence of any aperture in the outer surface of the packaging large enough to permit the entry of a 4-inch cube."

Evaluation of Requirements Stated in II.E.2. The evaluation in Sect. 3 indicates that the above conditions will be met under normal conditions of transport.

II.E.3. "A package used for the shipment of a large quantity of radioactive material as defined in I.A.6., shall be so designed and constructed and its contents so limited that under the normal conditions of transport specified in Sect. 3 considered individually, the containment vessel would not be vented directly to the atmosphere."

Evaluation of Requirements Stated in II.E.3. Under normal conditions of transport, the containment vessel is not designed to, nor will it, vent directly to the atmosphere.

II.F. "Standards for Hypothetical Accident Conditions for a Single Package."

II.F.1. "A package used for the shipment of a large quantity of radioactive material, as defined in I.A.6., or the shipment of fissile material when the package will contain more than .001 curie of Group I radionuclides, .05 curie of Group II radionuclides, 3 curies of Group III radionuclides, 20 curies of Group IV and Group V radionuclides, or radionuclides in special form or 1000 curies of Group VI or Group VII radionuclides shall be so designed and constructed and its contents so limited that if subjected to the hypothetical accident conditions specified in Sect. 4 as the Free Drop, Puncture, Thermal, and Water Immersion conditions, in the sequence listed in Sect. 4 it will meet the following conditions:

a. the reduction of shielding would not be sufficient to increase the external radiation dose rate to more than 1000 millirems per hour at 3 feet from the external surface of the package.

b. no radioactive material would be released from the package except for gases and contaminated coolant containing total radioactivity exceeding neither:

(1) 0.1 percent of the total radioactivity of the package contents; nor

(2) 0.01 curie of Group I radionuclides, 0.5 curie of Group II radionuclides, 10 curies of Group III radionuclides, 10 curies of Group IV radionuclide, and 1000 curies of inert gases irrespective of transport group."

"A package need not satisfy the requirements of this paragraph if it contains only low specific activity material as defined in I.A.7., above, and is transported on a motor vehicle, railroad car, aircraft, inland water craft, or hold or deck of a seagoing vessel assigned for the sole use of the shipper."

Evaluation of Requirements Stated in 11.F.1. Conditions of the hypothetical accident sequence as defined in Annex 2, DOE Manual Appendix 0529, are listed in Sect. 4 of this report. After each condition of the hypothetical accident, the evaluation applicable to the Foamglas Shipping Container is presented. It is concluded that when the cask and its contents are subjected to the hypothetical accident sequence of free drop, puncture, thermal and water immersion, it will meet the conditions listed above.

II.F.2. "A package used for the shipment of fissile material shall be so designed and constructed and its contents so limited that if subjected to the hypothetical accident conditions specified in Sect. 4 as the Free Fall, Puncture, Thermal, and Water Immersion conditions, in the sequence listed in Sect. 4 the package would be subcritical. In determining whether this standard is satisfied, it shall be assumed that:

a. the fissile material is in the most reactive credible configuration consistent with the damaged condition of the package and the chemical and physical form of the contents;

b. water moderation occurs to the most reactive credible extent consistent with the damaged condition of the package and the chemical and physical form of the contents; and

c. there is reflection by water on all sides and as close as is consistent with the damaged condition of the package."

Evaluation of Requirements Stated in II.F.2. The package has been designed, constructed, and its contents so limited that if subjected to the hypothetical accident conditions (see Sect. 4) of free drop, puncture, thermal, and water immersion (in that order), the package will be subcritical under the conditions listed above.

II.G. "Evaluation of An Array of Packages of Fissile Material."

II.G.1. "The effect of the transport environment on the nuclear criticality safety of an array of packages of fissile material shall be evaluated by subjecting a sample package or a scale model, by test or other assessment, to the hypothetical accident conditions specified in II.H., II.I., or II.J., below, for the proposed fissile class, and by assuming that each package in the array is damaged to the same extent as the sample package or scale model. In the case of a Fissile Class III shipment, the manager or other designated official may, taking into account controls to be exercised by the shipper, permit the shipment to be evaluated as a whole rather than as individual packages, and

either with or without the transporting vehicle, for the purpose of one or more tests."

Evaluation of Requirements Stated in II.G.1. See II.I. for evaluation.

II.G.2. "In determining whether the standards of II.H.2., II.I.1. (b)., and II.J.2., below, are satisfied, it shall be

a. the fissile material is in the most reactive credible configuration consistent with the damaged condition of the package, the chemical and physical form of the contents, and controls exercised over the number of packages to be transported together; and

b. water moderation occurs to the most reactive credible extent consistent with the damaged condition of the package and the chemical and physical form of the contents."

Evaluation of Requirements Stated in II.G.2. See II.I.1. for evaluation.

II.H. "Specific Standards for a Fissile Class II Package". Not applicable.

II.I. "Specific Standards for a Fissile Class II Package."

II.I.1. "A Fissile Class II package shall be so designed and constructed and its contents so limited, and the number of such packages which may be transported together so limited, that:

a. five times that number of such undamaged packages would be subcritical in any arrangement if closely reflected by water; and

b. twice that number of such packages would be subcritical in any arrangement if each package were subjected to the hypothetical accident conditions specified in Sect. 4 as the Free Drop, Thermal, and Water Immersion conditions, in the sequence listed in Sect. 4 with close reflection by water on all sides of the array and with optimum interspersed hydrogenous moderation unless there is a greater amount of interspersed moderation in the packaging, in which case that greater amount may be considered. The condition of the package shall be assumed to be as described in II.G., above.

II.I.2. The transport index for each Fissile Class II package is calculated by dividing the number 50 by the number of such Fissile Class II packages which may be transported together as determined under the limitation of 1., above. The calculated number shall be rounded up to the first decimal place."

Evaluation of Requirements Stated in II.I.1. and II.I.2. An evaluation of the Foamglas Shipping Container was made by the ORNL Criticality Committee[14] and they, in their evaluation, assigned transport indexes for each quantity of fissile material (see Table 1.2). This container meets the requirements for a Fissile Class II shipment.

II.J. "Specific Standards for a Fissile Class III Shipment." Not applicable.

3. COMPLIANCE WITH STANDARDS FOR NORMAL CONDITIONS OF TRANSPORT AND EVALUATION

3.1 Heat Evaluation

"*Heat* - Direct sunlight at an ambient temperature of 130°F in still air."

The heat load generated by the contents varies from 0 to 10 W max (0 to 34.1 Btu/hr). In addition, there is an estimated solar heat load of 144 Btu/hr·ft^2 impinging on a projected package area of approximately 5.1 ft^2 (height times diameter). The ambient temperature is assumed to be 130°F. The effect of these loads on the external skin temperature of the cask is calculated as follows:

$$q_s + q_a/A_o = h_o (T_o - T_a) + \sigma F [(T_o + 460)^4 - (T_a + 460)^4], \quad (3.1)$$

where

q_s = solar heat load, 736 Btu/hr, (on projected cask area),[15]

q_a = internal heat load, Btu/hr,

A_o = heat transfer area of outside of package, not including ends, 17.2 ft^2,

h_o = free convection film coefficient,[16] $0.24 (T_o - T_a/d)^{0.25}$,

d = OD of cask, 1.875 ft,

T_o = temperature of outside of cask, °F,

T_a = temperature of air, 139°F,

σ = Stefan Boltzman constant, 0.173 x 10^{-8} Btu/hr ft^2 °R,

F = emissivity factor, 0.30. (A conservative emissivity factor was chosen since the value of the emissivity factor for the intumescent paint is not known.)

Table 3.1 contains the solutions for this equation for T_o at 0, 5, and 10 W.

Table 3.1 Temperature of the outside shell as it is affected by solar radiation and internal heat loads

Internal heat load (W)	Outside skin temperature (°F)
0	172.8
5	173.7
10	174.5

A 10-W heat source will produce a 275°F inner container temperature calculated by ORTHIS on the same basis. Such a temperature is suitable for solids, and consequently, this limit was requested and approved. The silicone rubber gasket on the inner container will indefinitely withstand continuous exposure to temperatures of 300°F.

3.2 Cold Evaluation

"*Cold* - An ambient temperature of -40°F in still air and shade."

The drum is made from low-carbon, open-hearth, or electric steel that has reasonably good low-temperature ductility. Exposure to ambient temperatures of -40°F may, under very adverse conditions, produce cracks in the drum. Even though the drum does not provide a line of containment, the casting resin[5] forms a bond between the drum and the Foamglas. The drum will not change shape or size because of exposure to cold, and the resin bond ensures that the package will remain in one piece.

The silicone rubber gaskets used for the inner container are suitable for use down to

-70°F. The stainless steel of the inner container has good low-temperature ductility. Therefore, no loss of contents will occur as a result of -40°F exposure in still air and shade.

3.3 Pressure Evaluation

"*Pressure* - Atmospheric pressure of 0.5 times standard atmospheric pressure."

The inner container will withstand more rigorous pressure differentials than 1/2 atm when properly closed and sealed. The drum gasket may leak and equalize the pressure outside and inside the drum; however, each drum has this internal pressure applied to it as part of its specifications (see Sect. 2.1).

3.4 Vibration Evaluation

"*Vibration* - Vibration normally incident to transport."

Containers similar to this one have withstood the vibrations incident to normal transport for several years; therefore, it is expected that no difficulty will be experienced due to vibration in the future.

3.5 Water Spray Evaluation

"*Water Spray* - A water spray sufficiently heavy to keep the entire exposed surface of the package except the bottom continously wet during a period of 30 minutes."

This drum and its gasket will withstand without leakage a water spray sufficiently heavy to keep the entire exposed surface of the drum continuously wet for 30 min.

3.6 Free-Drop Evaluation

"*Free Drop* - Between 1-1/2 and 2-1/2 hours after the conclusion of the water spray test, a free drop through 4 ft onto a flat essentially unyielding horizontal surface, striking the surface in a position for which maximum damage is expected."

Free drops of the Foamglas Shipping Container[17] from 30 ft (only 4 ft required under normal transport) caused some superficial damage to the container such as denting the shell and fracturing the Foamglas. Neither of these occurrences affected the integrity of the flanged and bolted inner container or the drum seal closure.

3.7 Corner-Drop Evaluation

"*Corner Drop* - A free drop onto each corner of the package in succession or in the case of a cylindrical package, onto each quarter of each rim, from a height of 1 ft. This test does not apply to packages which are not constructed primarily of wood or fiberboard, or to packages exceeding 10,000 lb in weight."

When the Foamglas Shipping Container,[17] was dropped onto its bolted seal ring from 30 ft (only 1 ft required for a corner drop under normal transport conditions), the seal ring was not dislodged. Even if it had been dislodged, the integrity of the inner steel containment vessel would not have been affected since it is fabricated from pipe and equipped with heavy bolted flanges.

3.8 Penetration Evaluation

"*Penetration* - Impact of the flat circular end of a vertical steel cylinder 1-1/4 in. in diameter and weighing 13 lb, dropped from a height of 4 ft onto the exposed surface of the package which is expected to be most vulnerable to puncture."

Penetration tests on similar drum-type shipping containers[18] using a 13 lb, 1-1/4-in.-diam steel rod dropped from a height of 4 ft caused only a slight denting of the steel.

3.9 Compression Evaluation

"*Compression* - For packages not exceeding 10,000 lb in weight, a compressive load equal to either five times the weight of the package or two pounds per square inch multiplied by the maximum horizontal cross section of the package, whichever is greater. The load shall be applied during a period of 24 hours, uniformly against the top and bottom of the package in the position in which the package would normally be transported."

The stress created in the steel drum by a weight imposed on the head of five times the weight of the package is determined by

$$S_d = 5(\underline{W})/\pi\,(d)(T) = 5(215)/\pi(23.0)(0.043) = 346 \text{ psi}, \tag{3.2}$$

where

$\underline{W}$ = weight of fully loaded drum, 215 lb,

d = diameter of drum, 23.0 in.,

T = thickness of drum body, 0.043 in.

The stress created in the steel drum by a pressure on the head of 2 psi is determined by

$$S_d = 2(\pi d^2)/4(\pi)(d)(T) = 2(\pi)(23.0)^2/4(\pi)(23.0)(0.043) = 267 \text{ psi.} \quad (3.3)$$

Neither of these stresses exceeds the compressive strength of the steel shell of the drum.

4. COMPLIANCE WITH STANDARDS FOR HYPOTHETICAL ACCIDENT CONDITIONS AND EVALUATION

4.1 Free-Drop Evaluation

"*Free Drop* - A free drop through a distance of 30 feet onto a flat essentially unyielding horizontal surface, striking the surface in a position for which maximum damage is expected."

Three Foamglas Shipping Containers were dropped[17] through a distance of 30 ft onto a flat, esentially unyielding horizontal surface. The first container was dropped twice, once on the bottom corner and once on the top corner. The damage to this container is shown in Fig. 4.1. The second and third containers were dropped on the bottom corner with damage very similar to that shown in Fig. 4.2. No damage was discernible to the inner container or its closure.

The reduction in volume to the Foamglas Shipping Container was approximately 1.0% and would not affect the closeness of stacking in any way.

4.2 Puncture Evaluation

"*Puncture* - A free drop through a distance of 40 inches striking, in a position maximum damage is expected, the top end of a vertical cylindrical mild steel bar mounted on an essentially unyielding horizontal surface. The bar shall be 6 inches in diameter, with the top horizontal and its edge rounded to a radius of not more than one-quarter inch, and of such a length as to cause maximum damage to the package, but not less than 8 inches long. The long axis of the bar shall be normal to the package surface."

Three Foamglas Shipping Containers were dropped through a distance of 40 in. onto a 6-in.-diam rod as described. Only superficial denting of the outer drum was observed. Figure 4.3 shows typical damage to a drum. There was no damage to the inner container or its seal.

4.3 Thermal Evaluation

"*Thermal* - 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

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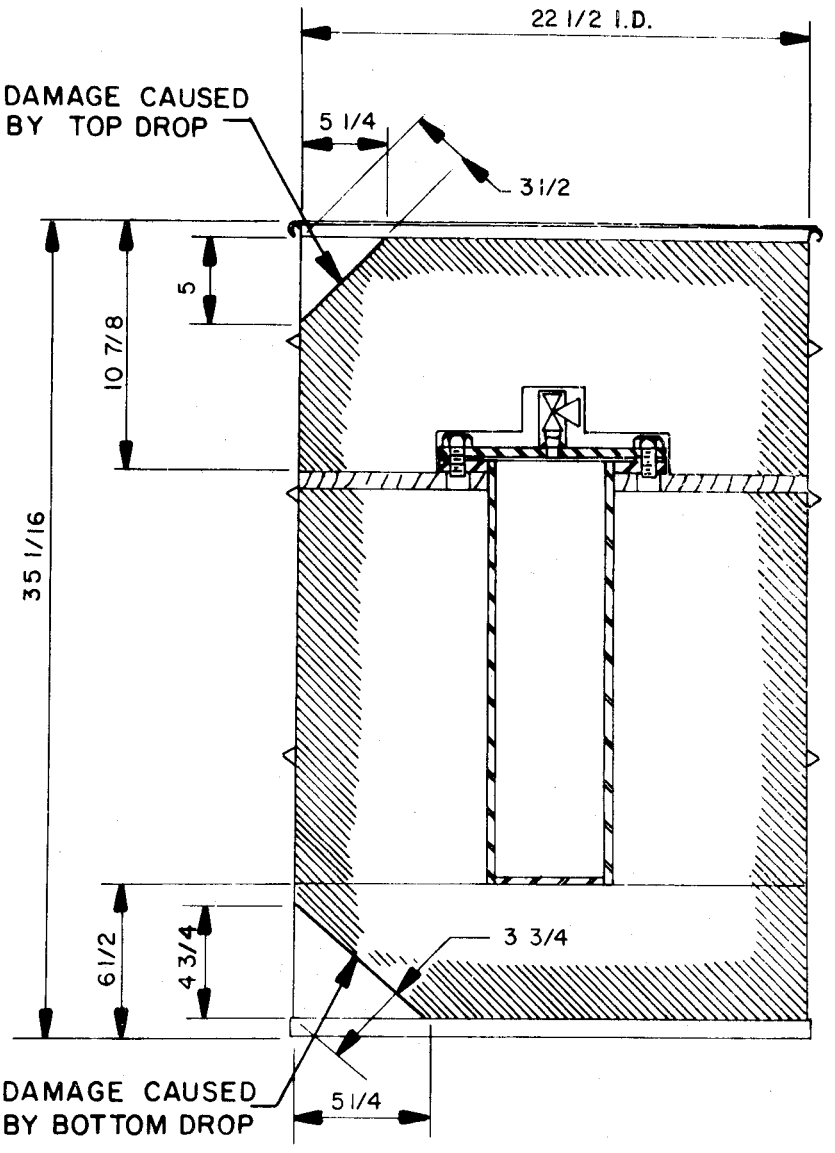


Fig. 4.1 Damage to Foamglas container a a result of corner drops.

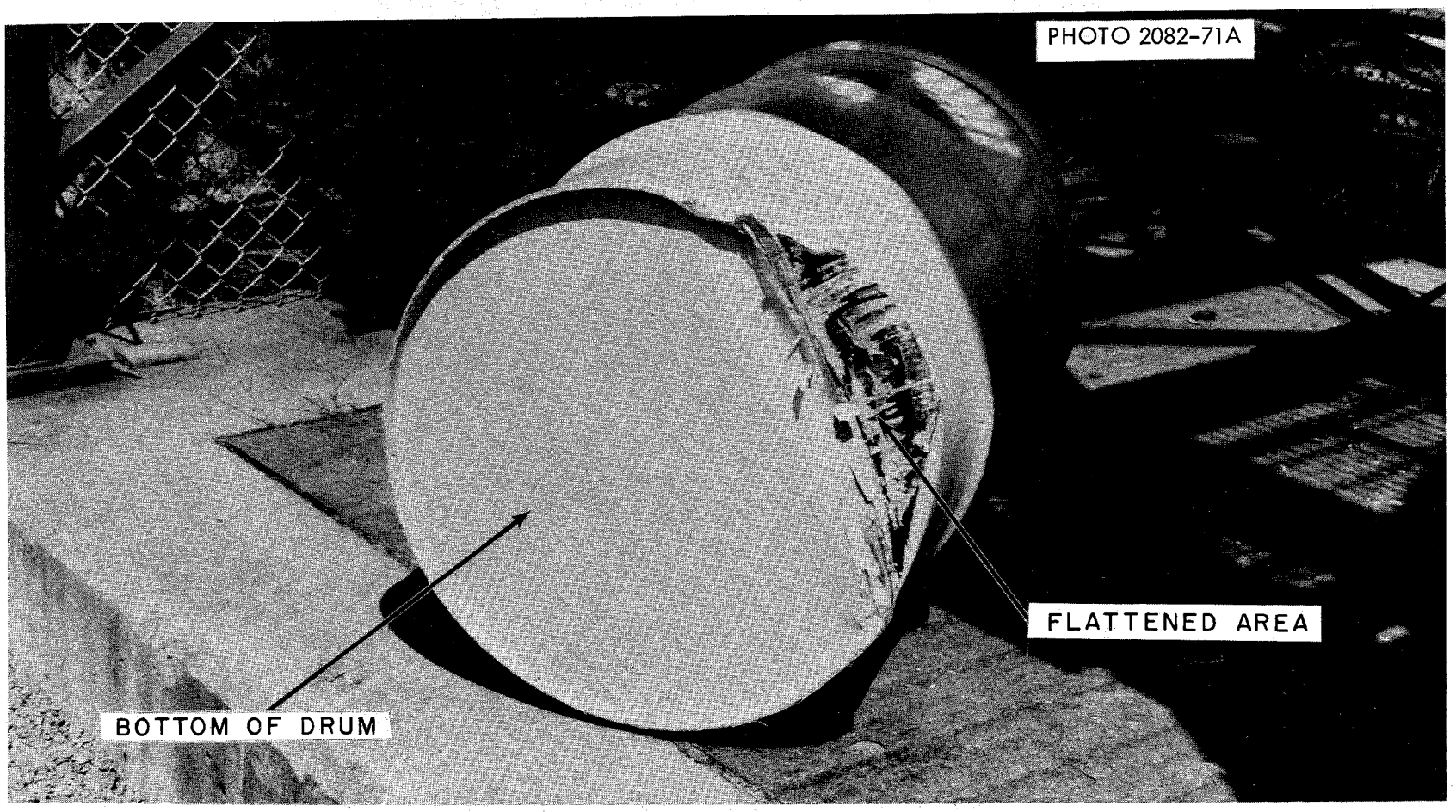


Fig. 4.2 Photograph of typical damage resulting from corner drop.

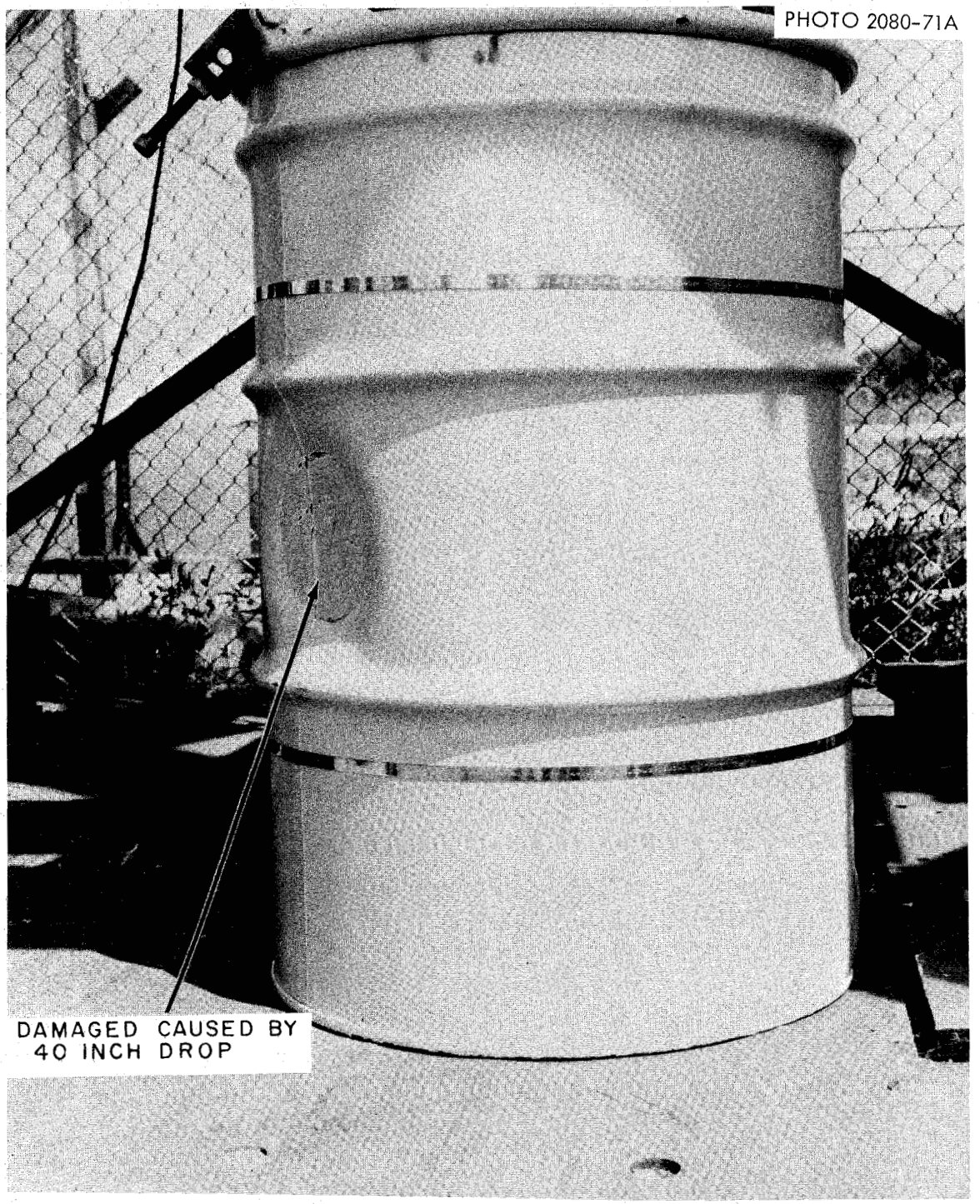


Fig. 4.3 Photograph showing typical puncture damage resulting from 40-in. drop on the 6-in. piston.

shall not be cooled artificially until after the 30-minute test period has expired and the temperature at the center of the package has begun to fall."

Two Foamglas Shipping Containers were subjected to the 1475°F thermal test[17] after they had been subjected to the previous two tests as required. Both tests were made in an electric furnace.[19] The first test was made with a shipping container which had the epoxy covering over the Foamglas plug and between the Foamglas and the drum. It was necessary to repeat the test since the temperatures observed in the drum while it was in the furnace were erroneous due to electrical current leakages to the grounded thermocouples. This test proved that the fire test destroyed the epoxy on the outer 1 in. of the container; therefore, the epoxy was left off the Foamglas plug and omitted between the Foamglas and the drum on the second test.

The second test using ungrounded shielded thermocouples confirmed the fact that the inner container, its gasket, and the polyethylene bottle were undamaged as a result of the thermal test. The epoxy surrounding the flanged inner container was undamaged as a result of the thermal test. The temperature records during the thermal test are shown in Figs. 4.4, 4.5, and 4.6. Figure 4.4 shows the temperatures recorded in the furnace on two thermocouples placed 12 in. from the outside surface of the drum, and a thermocouple placed on the inside surface of the drum. This figure indicates that the intumescent paint insulated the container surface for 44 min after it was immersed in the 1475°F furnace environment. The nominal test as noted above is for 30 min. This test was run for 50 min to allow 20 min for the furnace to fully recover to its 1475°F environment. Figure 4.5 gives the temperatures inside the container on an expanded scale during the period of time the container was in the furnace. Figure 4.6 extends the time scale to the point at which all temperatures are decreasing.

The maximum temperature reached by the water in the polyethylene bottle was 158°F at 400 min after the start of the test. Extrapolating the temperature for a 100°F starting temperature would have resulted in a liquid temperature of 183°F.

The thermal test destroyed the gasket on the drum and the epoxy to a depth of 1 in. The temperature of the gasket on the flanged inner container remained below 203°F and, consequently, the inner container remained sealed throughout the test. The temperature of the water in the polyethylene bottle and the flange, which should be close to the gasket temperature, is shown in Figs. 4.5 and 4.6 as a function of time in the fire environment.

4.4 Water Immersion Evaluation

"*Water Immersion* - Immersion in water for 24 hours to a depth at least 3 feet."

Immersion in water to a depth of 3 ft following the free-drop, puncture, and fire tests will result in water being admitted to any void areas that may have developed between the drum and the Foamglas because the drum gasket will be lost in the fire. The Foamglas is a closed cell construction which excludes water. The silicon rubber inner container gasket will not be destroyed by the fire; therefore, the inner container will be sealed at the start of the test and is expected to remain in that condition throughout the test. Only localized fracturing and crushing of the Foamglas plus destruction of the outer layer of epoxy occurs as a result of the accident environment. The spacing and moderation upon which the criticality evaluation is

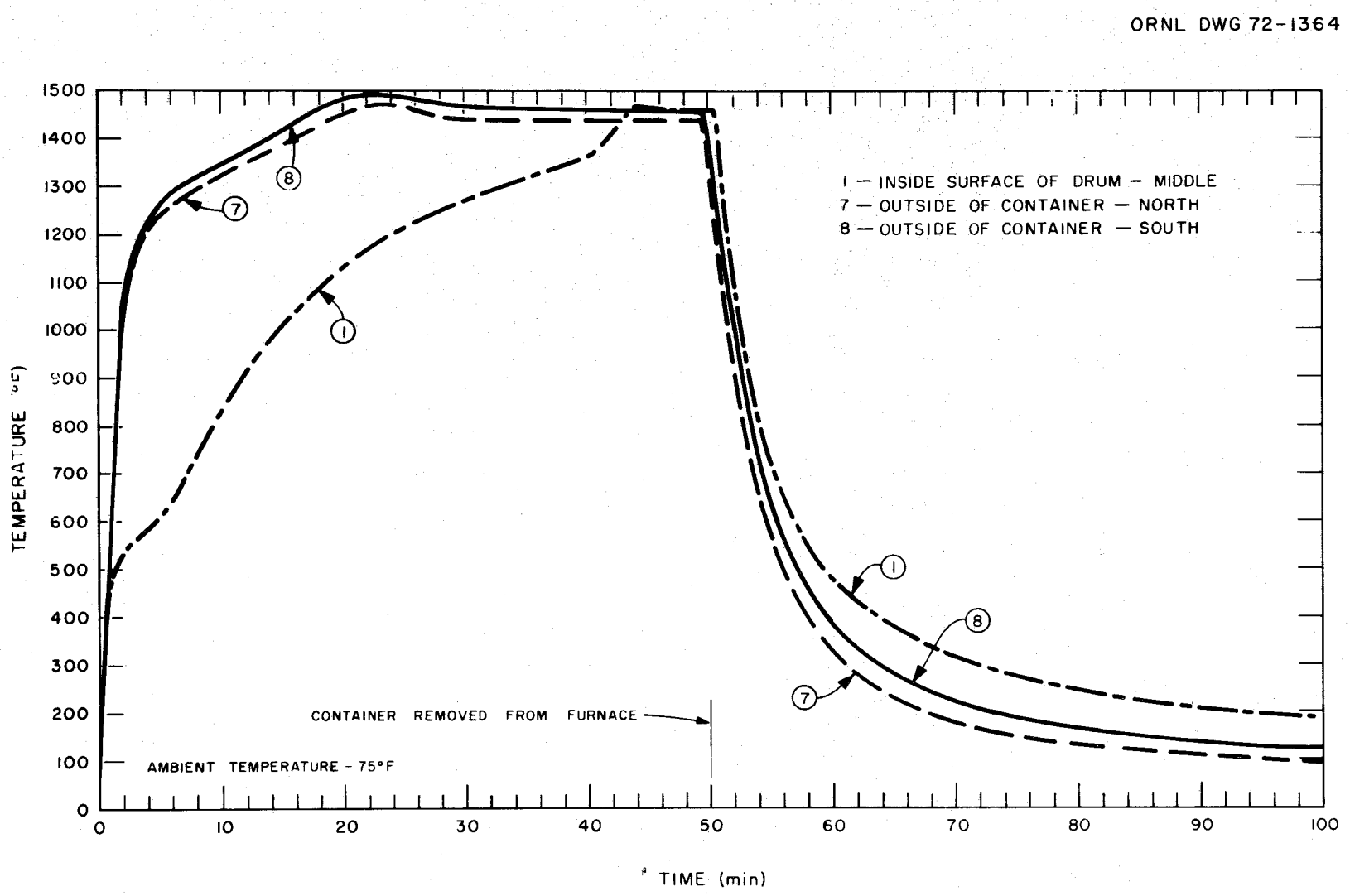


Fig. 4.4 Temperature record of furnace air and outside shell of drum.

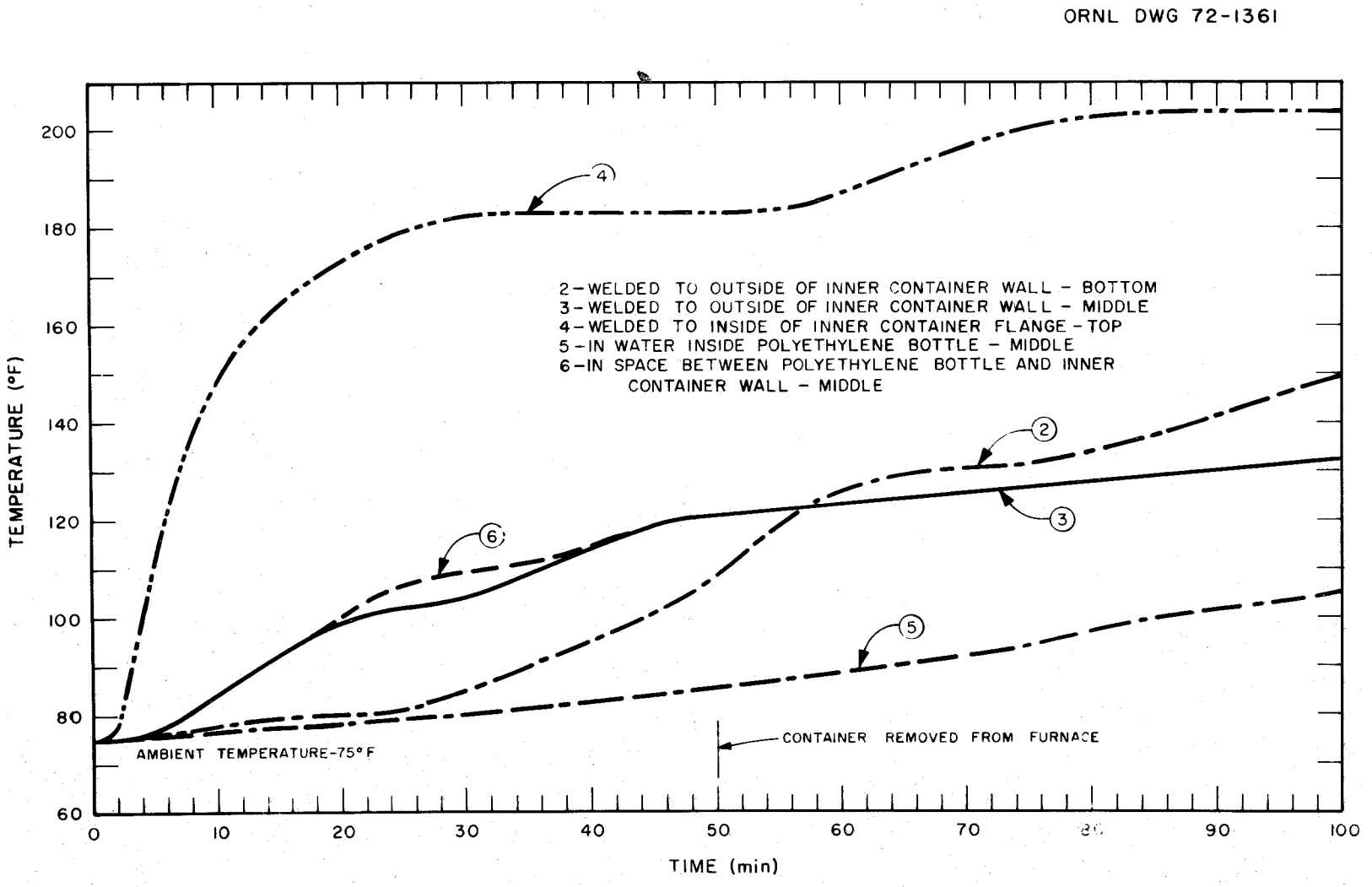


Fig. 4.5 Temperatures inside Foamglas Shipping Container for first 100 min.

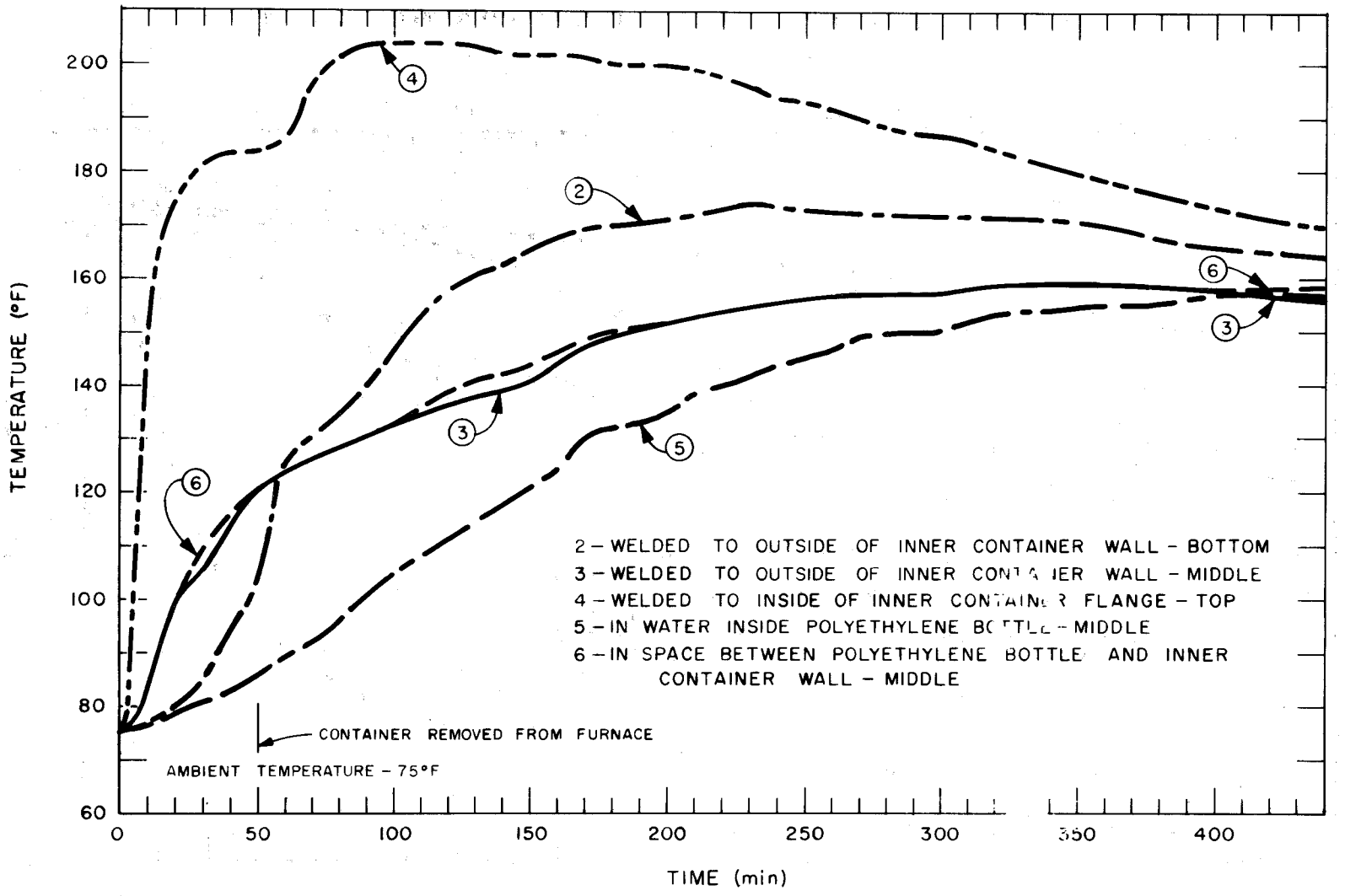


Fig. 4.6 Temperatures inside Foamglas Shipping Container until all temperatures had peaked.

based remains essentially unchanged; consequently, more than twice the number of damaged packages is required to achieve criticality, and the quantities of fissile materials based on undamaged containers are minimized.

5. NUCLEAR CRITICALITY SAFETY

The criticality evaluation of the Foamglas package established limits of content for solid and liquid fissile materials contained in a single package as a function of the transport index. Fissile material loadings are always less than is permitted by the analysis. The allowable quantities are given in Table 1.2.

6. QUALITY ASSURANCE

The Foamglas inner containers were built prior to the adoption of a formal quality assurance program by the NRC and ORNL. However, long standing practice in the Chemical Technology Division has been to obtain marked and certified material for use in containers such as these inner containers. In addition, qualified welders using standard qualified welding procedures were used for this type of work. Since records concerning these fabrications are not available, the following checks of each container were made to verify that high fabrication standards were maintained (Appendix 9.4).

1. Metal of the body flange, body, and bottom of the inner container, and the closure flange were tested with a thermoelectric comparator to determine that the steel used was austenitic stainless steel as required on the fabrication drawings.
2. Accessible welds were visually inspected.
3. A leak test was performed on each inner container to determine its integrity and to ensure that there were no through cracks or other discontinuities in the welds.
4. All bolts were checked, and worn or nonalloy steel bolts were replaced by alloy steel bolts.
5. Cracks and other breaks in the epoxy coating of the Foamglas were noted and repaired.

The inspection program now covers the majority of the containers in use (Appendix 9.4). Records of this program are maintained in Building 3019. This inspection program will continue until all packages have been inspected and certified as having passed the inspection. Assurance of the high standards of the containers will be maintained by annual inspections (Appendix 9.4). The section chief of the pilot plant section of the Chemical Technology Division is responsible for seeing that the quality assurance inspections are continued as required.

7. SUMMARY

A combination of experimental tests and computational methods was used to evaluate the ORNL Foamglas Shipping Container and to determine that the requirements for offsite shipping containers were being met. In addition to the evaluation, this SARP contains operating and inspection procedures.

8. ACKNOWLEDGMENTS

The aid and cooperation of Mr. J. R. Parrott and his assistants of the Pilot Plant Section, and Mr. O. J. Smith and his assistants of the Inspection Engineering Department is gratefully acknowledged.

9. APPENDIXES

Appendix 9.1 Department of Transportation Special Permit No. 5795 and Revisions

DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS REGULATIONS BOARD
WASHINGTON, D.C. 20590

SPECIAL PERMIT NO. 5795

This special permit is issued pursuant to 49 CFR 170.13 of the Department of Transportation (DOT) Hazardous Materials Regulations, as amended, and on the basis of the September 9, 1968, petition by Oak Ridge National Laboratory, Oak Ridge, Tennessee.

1. The OAK RIDGE NATIONAL LABORATORY is hereby authorized to ship fissile radioactive material, further described as unirradiated enriched uranium and plutonium, in accordance with the provisions of the U. S. Atomic Energy Commission (USAEC), Oak Ridge Operations Office, approval dated August 15, 1968, and as further provided for herein.

2. The authorized packaging consists of a DOT Specification 6M metal packaging (33 F.R. 14935, October 4, 1968).

3. For shipment of nitrate solutions, no polyethylene bottle may be used which has also been used as a storage vessel for nitrate solutions for more than 30 days. Any internal pressure within the polyethylene bottle must have been relieved within 48 hours prior to shipments. An O-ring seal (Viton-Fluorelastomer, or approved equivalent) must be used as a part of the cap closure. The cap must be subjected to at least 15 foot-pounds of torque during closure. Venting is authorized. Bottles must conform to the requirements of DOT Specification 34 (except §178.19-2(b). The package is not authorized for nitrate solutions containing free nitric acid in strength exceeding 6 molar. The package is exempted from the provisions of §173.268 of the DOT regulations.

4. The closure device must have affixed to it a tamperproof lock wire and seal, or equivalent, adequate to prevent inadvertent opening of the container, and of a type that must be broken if the package is opened.

5. The authorized contents of each package consists of Uranium-233, Uranium-235, or Plutonium-239 as metal or oxide, or nitrate solution, either singly or in mixture, as limited by Appendix A herein. The uranium may contain up to 100 per cent U^{233}, U^{235}, or U^{238}. Other uranium isotopes will be $\leq$ 5 w/o. Plutonium shall contain at least 60 w/o Pu^{239}, not more than 1.5 w/o Pu^{241}, more Pu^{240} than Pu^{241}, and less than 1 per cent Pu^{238}.

6. Packages are authorized for shipment as Fissile Class II, with the appropriate transport indices as listed in Appendix A herein to be assigned to each package (unless, however, external radiation levels dictate a higher assignment).

7. Prior to each shipment authorized by this permit, the consignee must be notified of the dates of shipment and expected arrival.

8. The outside of each package must be plainly and durably marked "DOT SP 5795" and "FISSILE RADIOACTIVE MATERIAL", in connection with and in addition to the other markings and labels prescribed by the DOT regulations. Each shipping paper issued in connection with shipments made under this permit must bear the notation "DOT SPECIAL PERMIT NO. 5795" in connection with the commodity description thereon.

9. The permit does not relieve the shipper from compliance with any requirements of the DOT regulations, except as specifically provided for herein.

10. Shipments are authorized only by motor vehicle.

11. The shipper is required to furnish an experience report to this Board upon expiration of the permit or when any amendment is requested. This report must include the approximate number of packages shipped, and the number of packages involved in any loss of contents.

12. This permit shall expire October 31, 1970.

Issued at Washington, D.C., this 16th day of October 1968.

W. R. Fiste

W. R. Fiste
For the Administrator
Federal Highway Administration

Address all inquiries to: Secretary, Hazardous Materials Regulations Board, U.S. Department of Transportation, Washington, D.C. 20590. Attention: Special Permits.

cc:
Bureau of Explosives, AAR
Federal Highway Administration
Atomic Energy Control Board, Canada
U. S. Atomic Energy Commission, Mr. Kaye

APPENDIX A

TABLE OF AUTHORIZED PACKAGE CONTENTS

Form of Material	Max. of Fissile Material (Kilograms) U^{235}	U^{233}	Pu^{239}	Transport Index
Metal	16.0	7.2	5.5	0.2
Metal	18.5	8.4	6.2	0.3
Metal	20.0	9.1	6.9	0.4
Oxide	20.0	9.2	7.2	0.2
Oxide	24.7	10.6	8.4	0.3
Oxide	27.0	11.5	9.1	0.4
Nitrate Solution	2.1	-	-	0.5
Nitrate Solution	-	0.9	-	0.8
Nitrate Solution	-	1.4	-	1.0

DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS REGULATIONS BOARD
WASHINGTON, D.C. 20590

REVISED SPECIAL PERMIT NO. 5795

Pursuant to 49 CFR 170.13 of the Department of Transportation (DOT) Hazardous Materials Regulations, as amended, and on the basis of the October 29, 1968, petition by the Oak Ridge National Laboratory, Oak Ridge, Tennessee:

Special Permit No. 5795, authorizing the shipment of certain unirradiated fissile radioactive materials in a DOT Specification 6M metal packaging, is hereby amended by changing paragraph (2) to read as follows:

> "2. The authorized packaging consists of a metal drum-type "birdcage" conforming to DOT Specification 6L except that the centering mechanism and vermiculite prescribed in §§178.103(c) and (d) may be replaced by foamglas (rigid Pittsburgh-Corning borosilicate foamglas, Union Carbide fire-resistant fiberglass-embedded phenolic foam SP-9, or equivalent)."

All other terms of the permit remain unchanged. The permit currently in effect consists of the original issue and this revision.

Issued at Washington, D.C., this 12th day of December 1968.

W. R. Fiste

W. R. Fiste
For the Administrator
Federal Highway Administration

Address all inquiries to: Secretary, Hazardous Materials Regulations Board, U.S. Department of Transportation, Washington, D.C. 20590. Attention: Special Permits.

cc:
Bureau of Explosives, AAR
Federal Highway Administration
Atomic Energy Control Board, Canada
U. S. Atomic Energy Commission, Mr. Kaye

SECOND REVISED SPECIAL PERMIT NO. 5795

Pursuant to 49 CFR 170.13 of the Department of Transportation (DOT) Hazardous Materials Regulations, as amended, and on the basis of the January 24, 1969, petition by the U. S. Atomic Energy Commission, Richland, Washington and the approval by the U. S. Atomic Energy Commission, Washington, D. C., dated February 4, 1969.

Special Permit No. 5795 is hereby amended by revising paragraph (3) to waive the requirements of §§178.19(2) (b), 178.19-6, and 178.19-7 (c)(2) for the DOT Specification 34 polyethylene bottle, as referenced in the subject paragraph.

All other conditions of this permit remain unchanged. The complete permit currently in effect consists of the original issue, and the First and Second Revisions.

Issued at Washington, D. C.:

ss/ D. W. Morrison — March 10, 1969
(Date)

for W. R. Fiste
For the Administrator
Federal Highway Administration

Address all inquiries to: Secretary, Hazardous Materials Regulations Board, U. S. Department of Transportation, Washington, D. C. 20590. Attention: Special Permits.

Dist: a, d, h, i
Oak Ridge National Laboratory, Oak Ridge, Tenn.

DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS REGULATIONS BOARD
WASHINGTON, D.C. 20590

THIRD REVISED SPECIAL PERMIT NO. 5795

Pursuant to 49 CFR 170.15 of the Department of Transportation (DOT) Hazardous Materials Regulations, as amended, and on the basis of the April 16, 1969, petition by the U. S. Atomic Energy Commission, Oak Ridge, Tennessee:

Special Permit No. 5795, authorizing the shipment of unirradiated fissile radioactive materials in the ORNL Foamglas Shipping container, is hereby amended by revising paragraphs (1) and (2) and adding a new paragraph (1)(a) as follows:

"1. Shipments of large quantities of fissile radioactive materials are hereby authorized in the packaging as described in this special permit. This packaging, when constructed and assembled as prescribed herein, with the contents as authorized herein, meets the standards prescribed in the DOT regulations, sections 173.396(c)(3) and 173.398(c). Shipments must be in accordance with the provisions of the U. S. Atomic Energy Commission (USAEC), Oak Ridge Operations Office approval dated August 15, 1968, and as further provided for herein.

"1a. Each user of this permit, other than the petitioner named above, and the previously identified petitioners (Oak Ridge National Laboratory and U. S. Atomic Energy Commission, New Brunswick Laboratory) shall register his identity with this Board prior to his first use of the permit.

"2. The authorized packaging consists of a metal, drum-type "birdcage" which conforms to DOT Specification 6L, except that the centering mechanism and vermiculite, as prescribed in §§178.103(c) and (d) may be replaced by foamglas (rigid Pittsburgh-corning borosilicate foamglas, Union Carbide fire-resistant, fiberglass embedded phenolic foam SP-9, or equivalent). Flanged closure of the inner containment vessel is authorized.

All other terms of the permit as revised remain unchanged. The complete permit currently in effect consists of the original issue and the Second and Third Revisions.

Continuation of 3rd Rev SP 5795

Issued at Washington, D.C.:

D. W. Morrison
for W. R. Fiste
For the Administrator
Federal Highway Administration

May 26, 1969
(Date)

Address all inquiries to: Secretary, Hazardous Materials Regulations Board, U.S. Department of Transportation, Washington, D.C. 20590. Attention: Special Permits.

Dist: a, d, h, i
U. S. Atomic Energy Commission, New Brunswich, N.J.
U. S. Atomic Energy Commission, Richland, Washingtor

DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS REGULATIONS BOARD
WASHINGTON, D.C. 20590

FOURTH REVISED SPECIAL PERMIT NO. 5795
(COMPLETE REVISION)

This special permit is reissued pursuant to 46 CFR 146.02-25 of the U. S. Coast Guard (USCG) Dangerous Cargo Regulations and 49 CFR 170.15 of the Department of Transportation (DOT) Hazardous Materials Regulations, as amended, and on the basis of the December 5, 1969, petition by Oak Ridge National Laboratory, Oak Ridge, Tennessee.

1. Shipments of large quantities of fissile radioactive materials, n.o.s., are hereby authorized in the packaging as described in this special permit. This packaging, when constructed and assembled as prescribed herein, with the contents as authorized herein meets the standards prescribed in the DOT regulations, Sections 173.395(c)(2), 173.396(c)(3), and 173.398(c). Shipments must be in accordance with the provisions of the U. S. Atomic Energy Commission (USAEC), Oak Ridge Operations Office approval number 69-017 dated November 10, 1969, or other equivalent USAEC approvals, and as further provided for herein.

2. Each shipper, under this permit, other than the petitioner named above, and the previously identified petitioners: U. S. Atomic Energy Commission, New Brunswick, New Jersey and the U. S. Atomic Energy Commission, Richland, Washington, shall register his identity with this Board prior to his first shipment, and shall have a copy of this permit in his possession before making any shipment.

3. The packaging authorized by this permit consists of a metal, drum-type birdcage, which has a 55-gallon volume DOT Specification 17H, or equivalent, open-head steel outer drum, with bolted ring closure. The inner containment vessel, which is a flanged and gasketed closure DOT Specification 2R, of stainless steel, 18" long by 4.81" I.D., is centered and supported within the outer drum by means of a plywood disc and rigid foamglas insulation material (per USAEC Material Specification SP-9) which fills the entire void space between the inner and outer containers. The annular spacer between the inner container, drum, foamglas and plywood disc is filled with epoxy resin which also covers the foamglas piece in the void above the inner container. The tare and gross weights of the package are about 200 and 215 pounds respectively. Solids must be additionally contained in innermost sealed metal cans and liquids within polyethylene bottles, within the inner containment vessel. The package is identified as the Foamglas Shipping Container, and is described on Oak Ridge National Laboratory's drawing number 68-14352R1 and M-12166-CD-005-D (plastic bottle).

4. For shipment of nitrate solutions, no polyethylene bottle may be used which has also been used as a storage vessel for nitrate solutions for more than 30 days. Any internal pressure within the polyethylene bottle must have been relieved within 48 hours prior to shipment. An "O"-ring seal (Viton-Fluorelastomer, or approved equivalent) must be used as part of the cap closure. The cap must be subjected to at least 15 foot-pounds of torque during closure. Venting is authorized. Bottles must conform to the requirements of DOT Specification 34 except for §§178.19-2(b), 178.19-6, and 178.19-7(c)(2). The package is not authorized for nitrate solutions exceeding 6 molar. The package is exempted from the provisions of §173.268 of the DOT regulations.

5. The contents of each package authorized by this permit consist of large quantities of fissile radioactive material, n.o.s., as uranium-233, or plutonium-239, as solid metal or oxide or solution, either singly or in mixtures, as further limited in the Appendix hereto. The uranium may contain up to 100% U-233, U-235, or U-238. For quantities of plutonium exceeding 50 grams, the plutonium shall contain at least 60 w/o Pu-239, more Pu-240 than Pu-241, and Pu-238 will be considered part of the Pu-239. The maximum thermal decay energy of the contents shall not exceed either 10 watts (for solids) or 5 watts (for liquids).

6. The authorized packaging meets the requirements for shipment as Fissile Class II, with the applicable transport indices as prescribed in the Appendix hereto, to be assigned to each package (unless, however, external radiation levels dictate a higher assignment).

7. The authorized package described herein is hereby certified as meeting the specific requirements of the International Atomic Energy Agency's (IAEA) "Regulations for the Safe Transport of Radioactive Material", Safety Series No. 6, 1967 edition, as follows:

a. Marginal C-6.2.2 - The package design meets the requirements for Type B packaging for radioactive materials.

b. Marginal C-6.2.3 - The package design meets the requirements for Type B packaging for large quantity (source) radioactive materials. Specifically, the packaging design meets the requirements of Marginal C-6.2.3.1(a) for unilateral approval.

c. Marginal C-6.2.4 - The package design meets the requirements for Fissile Class II, shipments.

d. Marginal C-2.4.3 - The packaging design is based on the ambient conditions.

e. Marginal C-6.5 - No special transport controls are necessary during carriage and no special arrangements have been prescribed, except as specified herein.

8. The outside of each package must be plainly and durably marked "USA DOT SP 5795" and "TYPE B", in connection with and in addition to the other markings and labels prescribed by the DOT regulations. Each shipping paper issued in connection with shipments made under this permit must bear the notation "DOT SPECIAL PERMIT NO. 5795", in connection with the commodity description thereon.

9. Each package must have its gross weight plainly and durably marked on the outside of the package.

10. This permit authorizes shipments by vessel, passenger-carrying aircraft, cargo-only aircraft, motor vehicle, and rail.

11. For shipments by water:

a. A copy of this permit must be carried aboard any vessel transporting radioactive material under these terms.

b. The shipper or agent shall notify the USCG Captain of the Port in the port area through which the shipment is to be made, and of the time, date, and place of loading or unloading. When the initial notification is given in a port area, it must be accompanied by a copy of this permit, addressed to the attention of that Captain of the Port.

12. The shipper is required to furnish an experience report to this Board before expiration of the permit and when any amendment is requested. This report must include the approximate number of packages shipped, and the number of packages involved in any loss of contents. The modes of transportation used for these shipments must also be shown.

13. Prior to each shipment authorized by this permit, the shipper shall notify the consignee and, for export shipments, the competent authority of any country into or through which the package will pass, of the dates of shipment and expected arrival.

14. Any incident involving loss of contents of the package must be reported to this Board at the earliest feasible moment following the incident.

15. This permit does not relieve the shipper or carrier from compliance with any requirement of either the DOT regulations, including 46 CFR 146 to 149 of the USCG Regulations, except as specifically provided for herein, or the regulations of any foreign government into or through which the package will be carried.

16. This permit expires January 31, 1972, and may be revoked for cause at any time.

Issued at Washington, D.C.:

E. G. Grundy, Capt. — 4 February 1970 (Date)
For the Commandant
U. S. Coast Guard

S. Schneider — 19 MAR 1970 (Date)
For the Administrator
Federal Aviation Administration

W. R. Fiste — 1-29-70 (Date)
For the Administrator
Federal Highway Administration

Mac E. Rogers — JAN 30 1970 (Date)
For the Administrator
Federal Railroad Administration

Address all inquiries to: Secretary, Hazardous Materials Regulations Board, U.S. Department of Transportation, Washington, D.C. 20950. Attention: Special Permits.

Dist: a, b, c, d, e, h, i
U. S. Atomic Energy Commission, New Brunswick, N.J.
U. S. Atomic Energy Commission, Richland, Washington

APPENDIX

TABLE OF AUTHORIZED PACKAGE CONTENTS

Transport Index	Metal	UO_2 Oxide H:X ≤ 0.4	UO_2 Oxide H:X ≤ 3	Aqueous Solution (Any Concentration
		Uranium-235		
	(ρ = 18.76 g U/cm^3)	(ρ = 8.09 g U/cm^3)	(ρ = 4.48 g U/cm^3)	
0.1	17.2 kg	18.8 kg	15.4 kg	2.35 kg
0.2	19.5	24.1	18.4	-
0.3	20.8	28.2	20.4	-
0.5	23.0	33.8	23.0	-
1.0	25.6	43.7	27.4	-
2.0	28.8	56.1	32.8	-
		Plutonium-239		
	(ρ = 19.7 g Pu/cm^3)	(ρ = 8.73 g Pu/cm^3)	(ρ = 4.71 g Pu/cm^3)	
0.1	5.3 kg	10.5 kg	9.2 kg	2.35 kg
0.2	5.6	11.6	10.7	-
0.3	5.8	12.4	11.8	-
0.5	6.2	13.5	13.3	-
1.0	6.5	14.9	15.6	-
2.0	7.0	16.5	18.3	-
		Uranium-233		
---	(ρ = 18.4 g U/cm^3)	(ρ = 8.08 g U/cm^3)	(ρ = 4.46 g U/cm^3)	
0.1	7.5 kg	11.1 kg	8.3 kg	1.58 kg
0.2	8.0	12.6	10.1	2.06
0.3	8.3	13.7	11.5	2.35
0.5	8.8	15.0	13.3	-
1.0	9.2	17.1	16.2	-
2.0	9.9	19.3	19.8	-

DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS REGULATIONS BOARD
WASHINGTON, D.C. 20590

SPECIAL PERMIT NO. 5795
FIFTH REVISION

Pursuant to 46 CFR 146.02-25 of the U.S. Coast Guard (USCG) Dangerous Cargo Regulations and 49 CFR 170.15 of the Department of Transportation (DOT) Hazardous Materials Regulations, as amended, and on the basis of the November 5, 1971, petition by Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Special Permit No. 5795 is hereby amended as follows:

1. In paragraph (4), the 30 day limit on use of polyethylene bottles which have also been used as a storage vessel for nitrate solutions is hereby increased to 90 days.

2. In paragraph (7b), the last sentence, relating to unilateral approval, is hereby deleted.

3. Paragraph (10a) is added to read as follows:

"10a. For shipments by air, a copy of this permit, kept current, must be carried aboard each aircraft transporting radioactive material under these terms."

4. Paragraph (16) is amended to read as follows:

"16. This permit expires on January 31, 1974."

All other terms of this permit, as revised, remain unchanged. The complete permit currently in effect consists of the Fourth and Fifth Revisions.

Issued at Washington, D.C.:

R.G. Schwing, Capt.
For the Commandant
U.S. Coast Guard

6 December 1971
(DATE)

for W.R. Fiste
For the Administrator
Federal Highway Administration

8 DEC 1971
(DATE)

Mac E. Rogers
For the Administrator
Federal Railroad Administration

DEC 15 1971
(DATE)

Ellis C. Langford
For the Administrator
Federal Aviation Administration

17 DEC 1971
(DATE)

Address all inquiries to: Secretary, Hazardous Materials Regulations Board, U.S. Department of Transportation, Washington, D.C. 20590. Attention: Special Permits.

Dist: a, b, c, d, e, h, i
U.S. Atomic Energy Commission, New Brunswick, New Jersey
U.S. Atomic Energy Commission, Las Vegas, Nevada
The Dow Chemical Company, Golden, Colorado
U.S. Atomic Energy Commission, Richland, Washington

DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS REGULATIONS BOARD
WASHINGTON, D.C. 20590

SPECIAL PERMIT NO. 5795
SIXTH REVISION

Pursuant to 46 CFR 146.02-25 of the U. S. Coast Guard (USCG) Dangerous Cargo Regulations and 49 CFR 170.15 of the Department of Transportation (DOT) Hazardous Materials Regulations, as amended, and on the basis of the May 19, 1972 petition by Oak Ridge National Laboratory (Union Carbide Corporation), Oak Ridge, Tennessee.

Special Permit No. 5795 is hereby amended as follows:

1. Paragraph (1) is changed to require that shipments must be in accordance with the provisions of U. S. Atomic Energy Commission, Oak Ridge Operations Office Certificate of Approval No. 72-003, dated May 1, 1972, or other equivalent USAEC approval.

2. The existing appendix (Table of Authorized Contents) is revised and replaced by the appendix attached hereto. Changes involve loadings of U-233 solutions only.

All other terms of this permit, as revised, remain unchanged. The complete permit currently in effect consists of the Fourth, Fifth and Sixth Revisions.

Issued at Washington, D.C.:

R. G. Schwing, Capt.
For the Commandant
U. S. Coast Guard

16 June 1972
(DATE)

for W. R. Fiste
For the Administrator
Federal Highway Administration

22 JUN 1972
(DATE)

for Mac E. Rogers
For the Administrator
Federal Railroad Administration

27 June 1972
(DATE)

Ellis C. Langford
For the Administrator
Federal Aviation Administration

(DATE)

Address all inquiries to: Secretary, Hazardous Materials Regulations Board, U. S. Department of Transportation, Washington, D.C. 20590. Attention: Special Permits.

Dist: a, b, c, d, e, h, i
U. S. Atomic Energy Commission, Richland, Washington
U. S. Atomic Energy Commission, New Brunswick, N.J.
Dow Chemical Company, Golden, Colorado
U. S. Atomic Energy Commission, Las Vegas, Nevada

APPENDIX

TABLE OF AUTHORIZED PACKAGE CONTENTS

Transport Index	Metal	UO_2 Oxide H:X $\leq$ 0.4	UO_2 Oxide H:X $\leq$ 3
		Uranium-235	
	(p = 18.76 g U/cm^3)	(p = 8.09 g U/cm^3)	(p = 4.48 g U/cm^3)
0.1	17.2 kg	18.8 kg	15.4 kg
0.2	19.5	24.1	18.4
0.3	20.8	28.2	20.4
0.5	23.0	33.8	23.0
1.0	25.6	43.7	27.4
2.0	28.8	56.1	32.8
		Plutonium-239	
	(p = 19.7 g Pu/cm^3)	(p = 8.73 g Pu/cm^3)	(p = 4.71 g Pu/cm^3)
0.1	5.3 kg	10.5 kg	9.2 kg
0.2	5.6	11.6	10.7
0.3	5.8	12.4	11.8
0.5	6.2	13.5	13.3
1.0	6.5	14.9	15.6
2.0	7.0	16.5	18.3
		Uranium-233	
	(p = 18.4 g U/cm^3)	(p = 8.08 g U/cm^3)	(p = 4.46 g U/cm^3)
0.1	7.5 kg	11.1 kg	8.3 kg
0.2	8.0	12.6	10.1
0.3	8.3	13.7	11.5
0.5	8.8	15.0	13.3
1.0	9.2	17.1	16.2
2.0	9.9	19.3	19.8

Appendix 9.2 Certificate of Compliance and IAEA Competent Authority Certification

UNITED STATES
ATOMIC ENERGY COMMISSION
OAK RIDGE OPERATIONS
P.O. BOX E
OAK RIDGE, TENNESSEE 37830

AREA CODE 615
TELEPHONE 483-

JAN 30 1974

Union Carbide Corporation
Nuclear Division
Attn: Dr. Herman Postma, Director
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

INTERIM CERTIFICATE OF COMPLIANCE AEC-OR USA/5795/BF

Gentlemen:

Enclosed are two (2) copies of the subject certificate (Form AEC-618).

The interim certificate, issued in accordance with Section D of AECIAD 5201-1, will remain in effect pending final approval. Please arrange to:

1. Remark each package with the prescribed identification symbol and number (Part 1a, Form AEC-618), and

2. Prepare a Safety Analysis Report (SARP) in accordance with the requirements set forth in AECIAD 5201-3 for review by OR and Headquarters. We understand the SARP is scheduled for completion in early March 1974.

By copy of this letter, copies of the certificate are being distributed to registered users.

Sincerely,

for Joseph A. Lenhard, Director
Research & Technical Support Division

AUT:LGB

Enclosure:
AEC-OR USA/5795/BF (2 cys.)

cc: J. H. Hill, w/o encl.
W. H. Travis, w/o encl.
J. N. Cook, ALO, w/encl.
R. L. Garrison, RLO, w/encl.
C. E. Ishmael, CHO, w/encl.
A. Neumann, NVO, w/encl.
D. M. Krieg, Dow Chemical, Golden, Colorado, w/encl.
H. Smith, SRO, w/encl.
A. A. Anselmo, Aerojet Nuclear, Idaho Falls, Idaho, w/encl.
Nuclear Fuel Services, Erwin, Tennessee, w/encl.

INTERIM

Form AEC-618
(9-72)
AECM 5201

U.S. ATOMIC ENERGY COMMISSION

CERTIFICATE OF COMPLIANCE

For Radioactive Materials Packages

1a. Number	1b. Revision No.	1c. Page No.	1d. Total No. Pages
AEC -OR USA/5795/BF	0	1 of 3	3

2. Authority

This certificate is issued pursuant to Sections 173.394, 173.395, and 173.396 of the Department of Transportation Hazardous Materials Regulations as amended (49 CFR 170-189 and 14 CFR 103), and AEC Manual Chapters 5201 and 0529.

3. CONDITIONS

3a. This certificate is issued on the basis of SAFETY ANALYSIS REPORT FOR PACKAGING (SARP)

(1) Prepared by: Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, Tennessee 37830

(2) Number: ORNL-TM-3713

(3) Date Published: April 1973

3b. The packaging described in the SARP and further described in item 4 below, when constructed and assembled as prescribed in the SARP, with the contents as authorized herein, meets the standards prescribed in DOT regulations.

3c. The outside of each package must be plainly and durably marked with the letters and number shown in item 1a. on this form in accordance with the standards for markings in paragraph 173.24(b) of 49 CFR 173.

3d. This certificate does not relieve the consignor from compliance with any requirements of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies.

3e. Each user of packages approved under this certificate shall register his name and address with the issuing office.

4. Description of Packaging and Authorized Contents, Restrictions, and References:

Packaging consists of a metal, drum-type birdcage which has a 55-gallon volume DOT Specification 17H, or equivalent, open-head steel outer drum, with bolted ring closure. The inner containment vessel, which is a flanged and gasketed closure DOT Specification 2R, of stainless steel, 18" long x 4.81" I.D., is centered and supported within the outer by means of a plywood disc and rigid Pittsburg-Corning foamglas insulation, which fills the entire void space between the inner and outer containers. Casting resin is used to fill the foamglas and the drum, the foamglas and the inner container, between and over the top plug. The tare and gross weights of the package are about 200 and 215 pounds, respectively. Solids must be additionally contained in inside sealed metal cans and liquids within inside polyethylene bottles. The package is identified as the ORNL foamglas shipping container. Descriptions are found on ORNL Dwg. Nos. 68-14352R3 (assembly) and M-12166-CD-005-D (plastic bottle).

TO BE COMPLETED BY AEC

5a. Address (of AEC Approving Official)

US. Atomic Energy Commission
P.O. Box E
Oak Ridge, Tennessee 37830

5b. Signature (of AEC Approving Official) W. H. Travis Acting

5c. Name and Title (of AEC Approving Official)
William H. Travis, Director
Safety & Environmental Control Division

6. Expiration Date (If appropriate)

7. Date: January 30, 1974

a. For shipment of nitrate solutions, no polyethylene bottle may be used which has also been used as a storage vessel for nitrate solutions for more than 30 days. Any internal pressure within the polyethylene bottle must have been relieved within 48 hours prior to shipment. An "O"-ring seal (Viton-Fluorelastomer, or approved equivalent) must be used as part of the cap closure. The cap must be subjected to at least 15 foot-pounds of torque during closure. Venting is permitted. Bottles should conform to the requirements of DOT Specification 34, except for SS178.19-2(b), 178.19-6, and 178.19-7(c)(2). The package is not approved for nitrate solutions exceeding 6 molar.

b. The approved contents of each package consist of large quantities of fissile radioactive material, n.o.s., as uranium-233, or plutonium-239, as solid metal or oxide or solution, either singly or in mixtures, as further limited in the Appendix hereto. The uranium may contain up to 100% ^{233}U, ^{235}U, or ^{238}U. For quantities of plutonium exceeding 50 grams, the plutonium shall contain at least 60 w/o ^{239}Pu, more ^{240}Pu than ^{241}Pu, and ^{238}Pu will be considered part of the ^{239}Pu. The maximum thermal decay energy of the contents shall not exceed either 10 watts (for solids) or 5 watts (for liquids).

c. The packaging meets the requirements for shipment as Fissile Class II, with the applicable transport indices as prescribed in the Appendix hereto, to be assigned to each package (unless, however, external radiation levels dictate a higher assignment).

OFFICE OF THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

IAEA CERTIFICATE OF COMPETENT AUTHORITY

Type B Fissile Radioactive Material Package Design

Certificate Number USA/5795/BF

This establishes that the packaging design described herein, when loaded with the authorized radioactive contents, has been certified by the National Competent Authority of the United States as meeting the regulatory requirements for Type B packaging for fissile radioactive materials as prescribed in IAEA1/ Regulations and §§ 49 CFR 173.393b, 173.396(c)(3); 46 CFR 146.19-100; and 14 CFR 103 of the USA2/3/4/ Regulations for the transport or radioactive materials.

I. Package Identification - ORNL foamglas shipping container - ORNL Drawing Numbers 68-14352R3 and M-12166-CD-005-D.

II. Packaging Description - The packaging authorized by this certificate consists of an outer container which is a 55 gallon DOT Specification 17H (or equivalent) open-head steel drum. The inner container is a stainless steel DOT Specification 2R, 18" long and 4.81" I.D. with a flanged and gasketed closure. The inner vessel is centered and supported within the drum by a plywood disc and rigid Pittsburg-Corning Foamglas insulation which fills the entire void between drum and inner container. An epoxy resin fills the spaces between foamglas and drum, between foamglas and inner container, and between and over the top foamglas plug. Solids are additionally contained within sealed metal cans and liquids within polyethylene bottles.

For shipment of nitrate solutions, no polyethylene bottle may be used which has also been used for storage of nitrate solution for more than 90 days. Any internal pressure within the polyethylene bottle must have been relieved within 48 hours prior to shipment. An o-ring seal (Viton-Fluorelastomer or approved equivalent) must be used as part of the cap closure. Venting is permitted. Bottles must conform to DOT Specification 34, except for §178.19-2(b), 178.19-6 and 178.19-7(c)(2). Nitrate solutions may not exceed 6 molar.

III. Authorized Radioactive Contents - The authorized contents consist of large quantities of fissile radioactive materials, n.o.s. as uranium-235, uranium-233 or plutonium-239 in the form of metal, oxides or solutions, singly or as mixtures as further limited in Appendix A attached hereto. The uranium may be any enrichment of uranium-233 or 235. For plutonium in excess of 50 grams, the plutonium must contain at least 60 w/o plutonium-239 and more plutonium-240 than plutonium-241. Plutonium-238 will be considered part of plutonium-239. The maximum thermal decay energy shall not exceed 10 watts for solids or 5 watts for liquids.

Shipments are authorized as Fissile Class II, with a transport index assigned to each package in accordance with Appendix A, unless external radiation levels dictate a higher assignment.

IV. General Conditions -

a. Each user of this certificate must have in his possession a copy of this certificate.

b. Each user of this certificate, other than U. S. Atomic Energy Commission, Oak Ridge Operations Office, Oak Ridge, Tennessee shall register his identity in writing to the Office of Hazardous Materials, U. S. Department of Transportation, Washington, D. C. 20590.

c. This certificate does not relieve any consignor or carrier from compliance with any requirement of the Government of any country through or into which the package is to be transported.

V. Marking and Labeling - The package must bear the marking USA/5795/BF as well as the other marking and labels prescribed by the USA Regulations.

VI. Expiration Date - This certificate, unless renewed, expires on March 31, 1977.

This certificate is issued in accordance with the requirements of the IAEA and USA Regulations and in response to the February 15, 1974 petition by the USAEC Oak Ridge Operations Office, Oak Ridge, Tennessee, and in consideration of the associated information provided in USAEC Oak Ridge Operations Office approval AEC-OR USA/5795/BF dated January 30, 1974.

Certified by:

A. W. Grella, Chief
Technology Division
Office of Hazardous Materials
U. S. Department of Transportation

March 15, 1974
(DATE)

1/ "Safety Series No. 6, Regulations for the Safe Transport of Radioactive Materials, 1967 Edition published by the International Atomic Energy Agency (IAEA) Vienna, Austria.

2/ Title 49, Code of Federal Regulations, Parts 100-199, USA.

3/ Title 46, Code of Federal Regulations, Part 146, USA.

4/ Title 14, Code of Federal Regulations, Part 103, USA.

This certificate supersedes in its entirety, DOT Special Permit No. 5795 with respect to international shipments.

9.3 Operating Procedures Applicable to the Foamglas Shipping Container

The procedures for using the Foamglas Shipping Container at ORNL involve specific operating processing equipment used by the Pilot Plant Section of the Chemical Technology Division. References to this processing equipment have been deleted from the procedures as much as possible. Note that blanks are left in the procedures for checking, initialing, or dating each entry, and signing and dating each page. It should also be noted that with this type of operating procedure, a new procedure will be required for each new pilot plant or change in applicable processing equipment. Each procedure, before it can be used, must be approved by the Operations Group, the Technical Group, and the Project Leader.

Approved:

Operations Group _____ Rev. Date 12/11/73

Technical Group _____ Shipment No. _____

Project Leader _____ Date _____

1.1 Solids Receiving and Storing Run Sheet

1.1.1 Receiving Operations

1. Open truck and have HP check surfaces of truck and drums for radiation and contamination.

2. Determine, in advance, the type of can holding the UO_2 in the shipping container; must be magniform-sealed can _____.

****
* Criticality Spec: ID of inner can ≤ 3.25 in., *
* UO_2 density ≤ 5.7 kg/ft of can. *
****

3. Transfer drums from truck to crane bay area south of Bldg. 3019 (record drum number on receiving sheet No. 1 or No. 2.

4. Lift shipping container into penthouse using crane _____.

5. Place shipping container on blotter paper, near the storage well specified by supervision (Well No. _____).

6. Obtain key from supervisor to allow removal of bar from top of well bank thus allowing removal of shield plug from storage hole _____.

7. Remove bar _____.
Be sure valve in off-gas line from the storage hole is open _____.

8. Place elevator over well bank top, adjacent to storage hole to be opened _____.

9. Pull electrical breaker for crane power so there will be no possible contact with a "hot" electrical wire _____.
(Place "Do Not Operate" tag on breaker _____.)

Technician _____, Date _____

10. Lift shield plug from storage hole with HP surveillance to determine if any air activity or surface contamination is present inside hole. If none, leave hole open. If present, cover hole and determine best method of handling before proceeding. (A bag-out procedure may be required)

11. Examine hole for water.

* *
Criticality Spec: No water is allowed in hole.
* *

12. Open shipping container with HP Surveillance _____.

13. Check operation of lifting device, Fig. 9.1 _____.

14. Place personnel; one on elevator, one at vacuum pump starting switch and vacuum breaker valve, and one at shipping container _____.

15. Place lifting head over can in shipping container. Allow suction cup to contact top of can _____.

16. Start vacuum pump with vent (vacuum breaker) valve closed _____.

17. Lift can out of shipping container and place it and lifting head in specified storage hole; lower the can to the bottom of the hole or to the top-most can in the hole* _____.

18. Open vacuum breaker valve and shut off vacuum pump to release lifting head from can _____.

19. Raise lifting head to penthouse. Check for contamination and store _____.

20. Replace storage hole shield plug _____.

21. Set locking bar in position and close lock _____.

22. Record transfer _____. (Penthouse or 3100 Vault Transaction Log)

Technician _____, Date _____

23. Inspect empty drum (Inspection Record No. 1) _____.
(Repair drum or replace damaged parts, if necessary.)

Supervisory approval, by _____. Date _____.

24. Assemble drum and store at (location) _____.

*If can is to be examined (from a distance) set it on blotter paper on floor, with most of can shielded by lead brick, and remove lifting head. Then place lifting head on can with HP observance and continue.

Technician _____, Date _____

SHIPPING DRUM INSPECTION RECORD No. I REV. DATE 12/10/73

(Inspections are to be made when drums are received AND when they are to be filled)

DATE	DOT No.	DRUM No.	Check (√) if OK, if not, use note no. & explain at bottom of page								By Initials	REMARKS
			Contamination									
			Inside	Outside	Insert	Bolts	Flange	Gasket	Cavity	Labels		

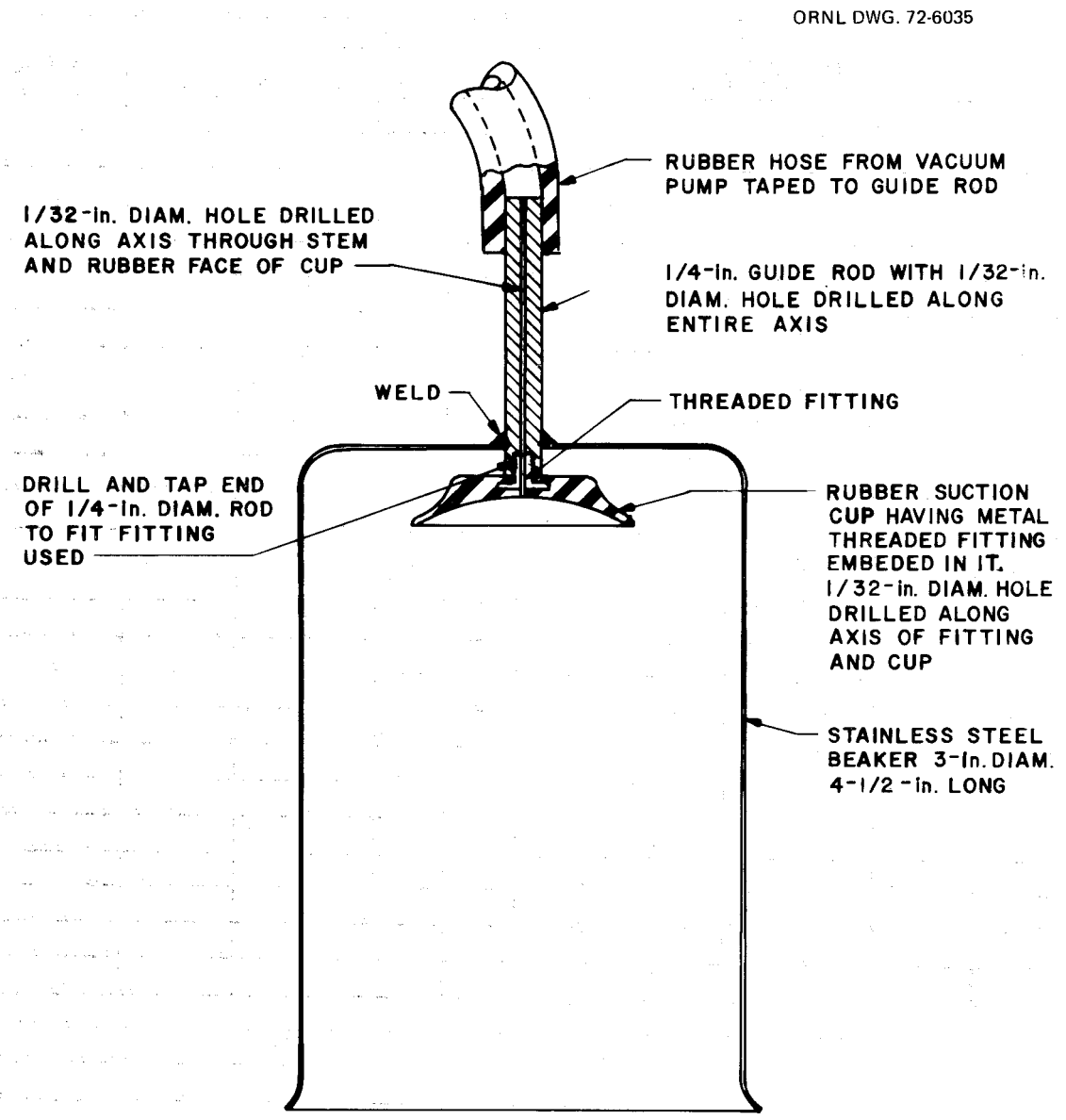


Fig. 9.1 Remotely operable can lifting head.

Penthouse or 3100 Vault* Transaction Log Rev. Date 1/21/74

Date	Personnel	Transaction No.	In or out	From To* SSM No.	Container			Location in Vault	Material Type		Element Wt.,g.	Crit. Control Units (CCU)	Supv. Sig. Verify Transact.
					Type	Number	Seal No.		Compound	Fissile Element			

*Circle correct word.

Approved:

Operations Group *[signature]*

Technical Group *[signature]*

Project Leader *[signature]*

Rev. Date: 12/10/73

Date ______________

Lot No. ______________

6.11 Shipment of Product Run Sheet

* *
*Criticality Specs: Max. weight ^{233}U, as oxides, allowed in drum *
*= 8.4 kg. Weight of ^{233}U, as oxide, to be placed in each primary *
*container = 400 g. Number of primary containers per secondary *
*container (isotope can) = 2. Number of isotope cans per drum = 2. *
* *

This procedure will be performed in conjunction with procedure 6.10. Packaging-for-Shipment Run Sheet. (The shipping can has been labeled and weighed. See Table 9.1, Refer to Fig. 9.2.)

The procedure listed below covers the loading of one drum for shipment to BAPL (See attached assembly drawing of the loaded drum). Shipping data will be recorded in Tables 1 and 2 as indicated in this procedure.

1. Place loaded shipping can in plastic sleeve attached to bag-out port ______________.

2. Close the vent valve on the bag-out port ___________. (This will allow the loaded shipping can to be moved down the sleeve more easily.)

3. Force the shipping can down the plastic sleeve as far as possible and open the vent valve to collapse the sleeve ______________.

4. Place the plastic sleeve on the sealer arm, smooth out all wrinkles, arrange the sleeve so as to leave a minimum of excess plastic sleeve after the sealing operation is complete ________.

5. Heat seal the plastic sleeve ______________.

6. After the seal has cooled, cut through the middle of the sealed area, using scissors ____________________.

7. Health Physics personnel will check the outside surfaces of the

Technician ________________________________, Date ____________________

TABLE 9.1

OXIDE PRODUCT PACKING LIST WORK SHEET   REV. DATE 2/28/74

PURIFICATION DATE ________   LOT No. ________

CALCULATED BY ____________, DATE ________   VERIFIED BY ____________, DATE ________, PAGE ___ OF ___

PRODUCT CAN No. (EMBOSSED)	SHIPPING CAN WEIGHT DATA g TARE	GROSS	NET	ISOTOPE CAN No.	SHIPPING DRUM No.	O. C. TAG No.	DRUM SEAL No.	WEIGHED BY	APPROVED FOR SHIPMENT	RADIATION READING mr/hr AT 12 in.	CUMULATIVE WEIGHT g
SUB-TOTAL											
SUB-TOTAL											
SUB-TOTAL											
SUB-TOTAL											
SUB-TOTAL											
TOTAL THIS PAGE											
GRAND TOTAL OF ___ PAGES											

R-1

Ref ORNL Dwg 66-11093
10-72, R-1

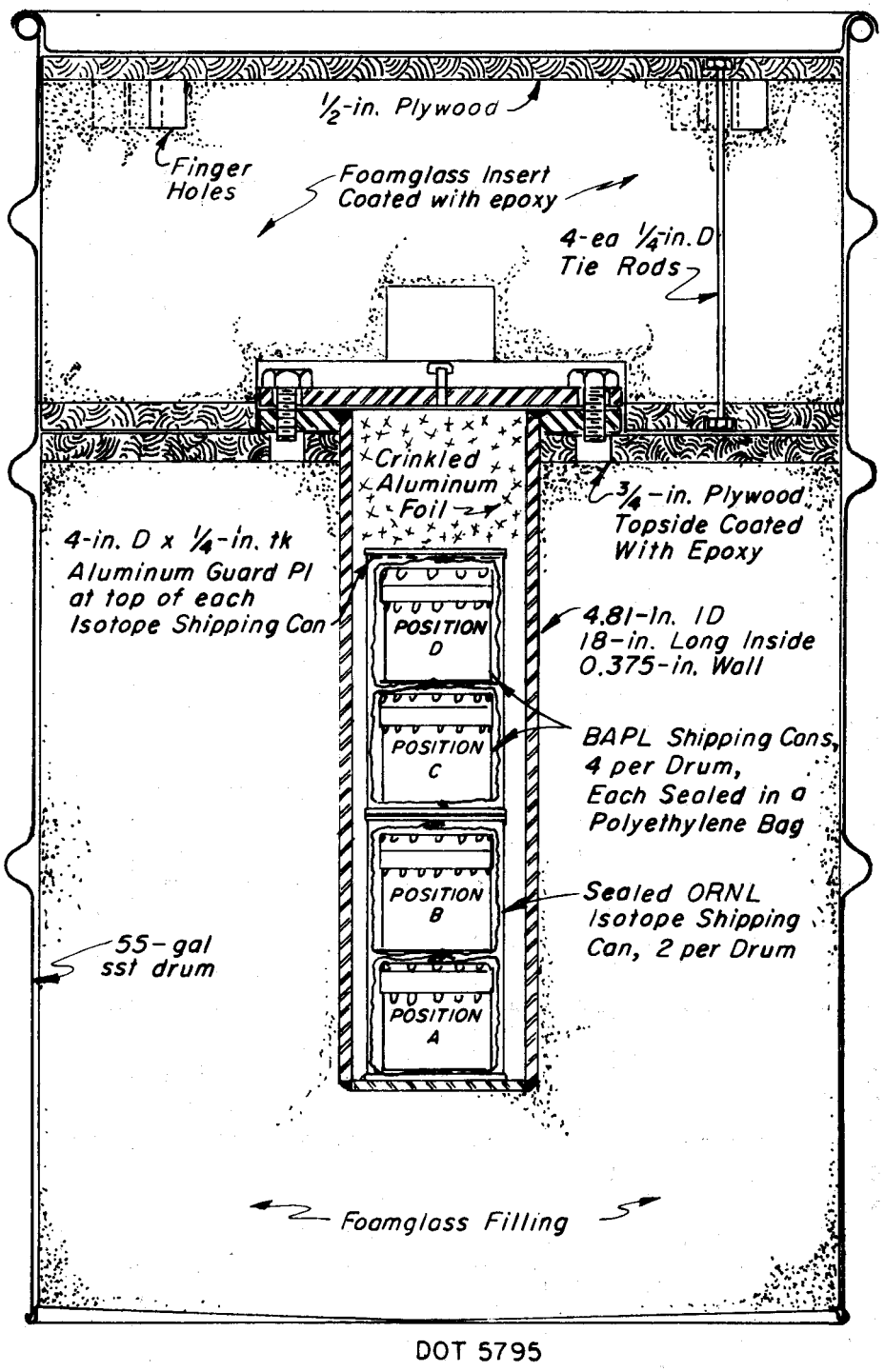


Fig. 9.2 ORNL Foamglas Shipping Container packed to ship solids.

Revision Date 12/10/73
Date
Lot No.

sealed plastic tube for contamination. (Fill in appropriate data in Table9.2)_____.

8. Place the contained shipping can in an isotope can. Place one of the labels for the shipping can on the outside of the isotope can _____.

9. Repeat steps 1-7 for second shipping can _____.

10. When two shipping cans are in the isotope can, place a metal disc over the opening to protect excess plastic _____, place a lid on the isotope can _____; place the can in the can sealer _____; and seal the isotope can _____.

11. Health Physics personnel will check the outside of the isotope can for contamination. (Fill in the appropriate data in Table 9.2)____.

12. Check that outside door of shipping vault is closed _____.

13. Open the small pass-through port in the storage vault and pass the sealed isotope can along with the two unused labels for the two shipping cans in the isotope can into the shipping vault _____.

14. Fill in all container numbers (3 sheets). Shipping Drum Inspection Record No. 1 has been completed previously) Supervisory approval, by _____, date _____.

15. Place the sealed isotope can in the DOT Approved shipping drum ____.

16. Place the label for these two product shipping cans on the side of drum in the order in which the cans are placed in the drum _____.

17. Repeat steps 1-15 for a second isotope can _____.

18. When two isotope cans are in the shipping drum, the drum is ready to be sealed:

Technician _____, Date _____

TABLE 9.2

U-OXIDE SHIPPING RECORD — REV. DATE 2/28/74

Contamination and Radiation Background

SHIPPING CAN			ISOTOPE CAN				SHIPPING DRUM								
											OUTSIDE SURFACE				
											α d/m/100 cm²		β-γ		
Can No.	Plastic Sleeve Sealed By	H. P. Clearance By	Can No.	Sealed By	H. P. Clearance By	β-γ Probe mrad per hr at 1.5-in.	Drum No.	Pressure Test Date	Sealed By	H. P. Clearance of Cavity By	Probe <300	Smear <30	Probe mrad per hr. at 1.5-in. ≤ 5	Smear d/m per 100 cm² 1000	Inspector's Signature

Revision Date 12/10/73
Date _____
Lot No. _____

18.1 Place an aluminum foil spacer in the cavity above the isotope cans _____.

18.2 Place a silicone rubber gasket on the flange of the inner container and align the bolt holes in the gasket with the threaded holes in the flange _____.

18.3 Set the inner container cover in place _____.

18.4 Tighten all bolts to 85 ft-lbs torque _____. Supervisory approval, by _____ date _____.

18.5 Check that valve is closed _____ and that top end is capped _____.

18.6 Place the foamglas insert in the top of the shipping container _____.

18.7 Check that drum lid gasket is in place _____.

18.8 Set the drum lid in place _____, install the bolted seal ring _____, and tighten the bolt with an impact wrench _____.

18.9 Place lead seal on seal ring bolt _____. (Record data, Table 9.1)

19. Health Physics personnel will then check the outside of the drum (contamination and radiation). Fill in the appropriate data in Table 9.2) _____.

At such time as the transfer truck is available for shipment and the Technical group has cleared the shipment, the drums will be loaded for shipment.

Supervisory approval to ship _____, Date/Time _____

Technical Group approval to ship _____, Date/Time _____

(Their signed, green tags must be attached to each container.)

Technician _____, Date _____

Rev. Date: 2-21-74
Lot No. _____
Date: _____

1. Place tape across the inside door of the shipping vault and hang the following tag on the tape _____:

   THIS DOOR IS NOT TO BE OPENED AT ANY TIME WHEN OUTSIDE DOOR IS OPEN!

2. Inspect interior of empty trailer:

   Waste removed _____.

   Contamination check made _____.

   Drum shoring equipment examined (Unistrut) _____.

3. Open the outside door of the shipping vault and load the full drums into the trailer, using a fork-lift truck.

   Note: Use Table 9.2 to check off each drum as loaded. Indicate drum arrangement in trailer on attached diagram. (Fig. 9.3.)

4. Shore the drums using Unistrut. Bolt the Unistrut to frame in front and rear of trailer and then across the top of each drum.

5. Prepare ORNL Radioactive Materials Packaging Information form for Isotope Shipping Department.

6. Health Physics personnel obtain radiation readings.

7. Lock the trailer, using ORNL security lock.

8. Replace above lock with that supplied by courier at time trailer is to leave area.

9. Provide Isotope Shipping Department with shipping information.

XXX Supervisory confirmation that trailer was sealed and cargo meets DOT specifications for shipment, by _____ Date _____

Time _____

Technician _____ Date _____

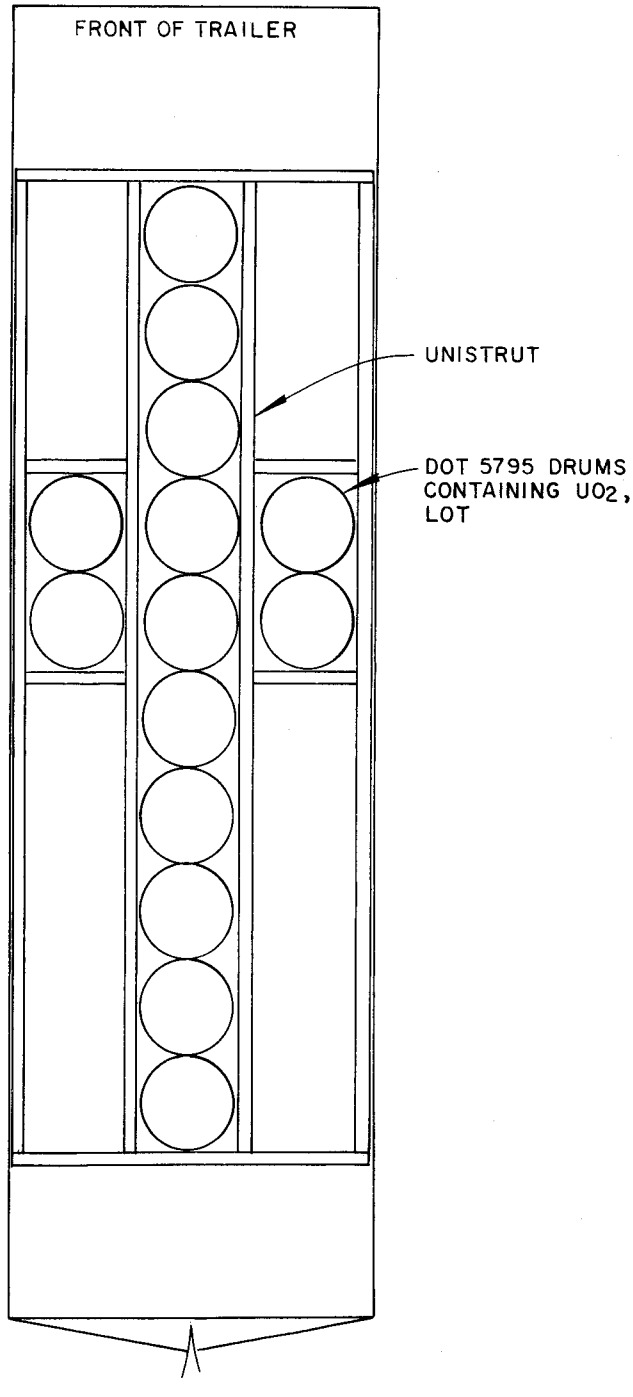


Fig. 9.3 Drum arrangement in trailer for shipment of lot.

Appendix 9.4 Inspection Procedures Applicable to the Foamglas Shipping Container

The Foamglas Shipping Container inspection procedure involves the following inspection.

Procedure 8.2S, Inner Container Pressure Test -- testing the inner container used for solids shipment. These shipments do not have valves. Tests are made annually.

Procedure No. 8.2
Rev. Date 3/7/72

8.2S Inner Container Pressure Test

Shipping Container: DOT-5795

1. Check inner container cavity for litter and contamination.
2. Clean inner container gasket and cover flange.
3. Insert test spool piece and test gasket between cover flange and inner container flange.
4. Use long test bolts - tighten (85 ft lb torque).
5. Connect to Hastings gage, vacuum pump and valve.
6. Open valve and pump down to less than to microns.
7. Close valve. Record gage reading at start and end of one hour (Fig. 9.4).

(Allowable pressure rise = 131 microns per hour)

Frequency: Annually

Record data on attached table.

Procedure 8.2S

Rev. Date 3/7/72

Inner Container Pressure Test

Shipping Container, DOT-5795

Date	Container No.	Pressure Start, microns	Pressure after 1 hr, microns	Pressure rise microns	Checked by	Remarks

Fig. 9.4 Inner container pressure test shipping container.

INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

September 5, 1973

To: B. B. Klima

From: J. R. Parrott

Subject: Status of testing of Foamglas Shipping Containers

Reference: Letter, B. B. Klima to J. R. Parrott, dated August 29, 1973.

We have reviewed the status of testing the foamglas shipping containers. The testing and location of each of the 64 containers are shown in the attached table. Of the 39 tested to date, all passed the leak test and many, with minor damage to the foamglas, were reused.

We presently have 12 at ORNL which need minor repair and 3 that have not been tested. We will repair and test these prior to any future use. In addition, we have 9 at BAPL which need repair and 11 which have not been tested. These will be returned to ORNL within the next 4 to 6 weeks and will be tested and approved prior to subsequent usage.

We have 5 containers loaned to the AEC which we are unable to locate. However, when they are returned, we will test and repair as necessary.

Each container, when approved, will be marked with a QA sticker and only those containers used.

J. R. Parrott

JRP:bjh
Attachment (1)
cc: D. E. Ferguson
R. E. Brooksbank
F. L. Daley
R. G. Nicol
G. E. Pierce
W. R. Whitson
J. F. Talley
JRP-File

ORNL FOAMGLAS SHIPPING CONTAINERS (DOT-5795)

QUALITY ASSURANCE TESTING

September 5, 1973

Container No.	Tests Completed			Location				
	Approved	In need of repair	Not Tested	ORNL	BAPL	SRP	ICPP	AEC
51	✓			✓				
52			✓		✓			
53		✓		✓				
54		✓		✓				
55		✓			✓			
56			✓		✓			
57			✓		✓			
58			✓		✓			
59	✓				✓			
60		✓		✓				
61	✓				✓			
62	✓				✓			
63		✓				✓		
64		✓			✓			
65			✓		✓			
66		✓			✓			
67		✓		✓				
68			✓		✓			
69	✓				✓			
70		✓		✓				
71	✓				✓			
72			✓					✓
73			✓	✓				
74	✓				✓			
75		✓		✓				
76		✓		✓				
77			✓		✓			
78	✓				✓			
79	✓				✓			
80			✓					✓

(Table continued)

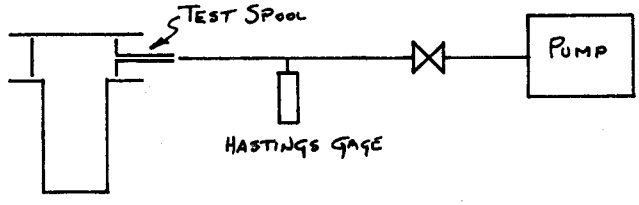
Container No.	Tests Completed: Approved	Tests Completed: In need of repair	Not Tested	Location: ORNL	Location: BAPL	Location: SRP	Location: ICPP	Location: AEC
81			✓	✓				
82		✓			✓			
83		✓			✓			
84		✓		✓				
85			✓	✓				
86			✓					✓
87			✓			✓		
88			✓					✓
89		✓			✓			
90	✓				✓			
91			✓			✓		
92			✓		✓			
93			✓					✓
94	Destroyed in testing							
95	✓				✓			
96	✓				✓			
97		✓		✓				
98	✓				✓			
99		✓		✓				
100			✓		✓			
101	✓				✓			
102			✓		✓			
103			✓			✓		
104			✓			✓		
105		✓				✓		
106			✓			✓		
107		✓		✓				
108		✓		✓				
109	✓					✓		
110	✓					✓		
111			✓		✓			
112		✓			✓			
113		✓			✓			
114		✓			✓			
115			✓				✓	
Totals	16	23	25					

Inspection Procedure 731

Survey of Foamglas Shipping Containers

Location: Bldg. 3019
Responsibility: Chem Tech: Technicians, Craft Support, HP Coverage Insp. Eng: Direction, Coordination, and Reporting

1. Use Test Spool Piece and Test Gaskets with long test bolts. Connect to hastings gage, vacuum pump, and valve:



Open valve and pump down to $< 50\ \mu$. Close valve, read gage each 15 minutes for one hour. Record readings on data sheet. Acceptance criterion 1 scc/hr = 131 μ/hr. If can fails, clean and repeat test.

2. Verify material identity of bottom, shell, flange, cover, nipple, valve, cap, or plug with a Thermo-electric Comparator. Values of-7.5 to -10 are austenitic stainless.

3. Visually inspect accessible welds.

4. Measure I.D. and depth of can.

5. Generally inspect container, noting any questionable conditions on the data sheet.

Foamglas Shipping Container No. _____

Leak Test:

Time _____ _____ _____ _____ _____

Pressure (μ) _____ _____ _____ _____ _____

Leak Rate = $\frac{(\Delta P\mu \quad)}{(\Delta t \text{ Min})}$ _____ x 125 = _____ x 10^{-6} scc/sec

Material Identity:

Bottom_____ Shell_____ Flange_____ Cover_____

Nipple_____ Valve_____ Cap_____ Plug_____ Welded ☐

Welds: Flange to shell _____

Bottom to shell _____ (full penetration?)

Bolts: Visually OK_____ Same size_____ Type_____

Unmachined portion of cover clear ID of flange ? _____

Can bonded into container ? _____

General condition of container _____

foamglas cover_____

Remarks:

Inspected By _____ Date_____

Appendix 9.5 Independent Review of SARP

INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

August 20, 1973

TO: B. B. Klima

SUBJECT: Survey of Foamglas Shipping Containers

Inspection Engineering and Chemical Technology have surveyed 39 Foamglas shipping containers to verify their adequacy for continued service. The tests and inspections to which these containers were subjected are detailed in Inspection Procedure 731 and can be summarized:

1. Each can was subjected to a leak test, using a test gasket, to demonstrate the absence of leaks in the welds and metal structure. This test was performed by evacuating the can and measuring the rate of pressure rise. Outgassing and gasket leakage bias the indicated leak rates upward, so the results of this test are conservative. An acceptance criterion of one standard cubic centimeter per hour (A leak-up of 131 μ/hr) was arbitrarily selected. All 39 cans ested exhibited acceptable leak rates, although several had to be tested a second time.

2. The bottom, the shell, the flange, the cover, the nipple, and the plug were verified as being an austenitic stainless steel with a thermoelectric comparator.[1] No material deviations were detected in the 39 cans so checked.

3. To the extent possible, the welds were visually inspected and found to be sound and to have substantially full penetration on all 39 cans.

4. The bolts were visually inspected for condition and material identity. Damaged bolts and those

---

[1]A Metal Sorting Device which indicates the electric potential induced in a material by contacting it with a heated and a cold electrode. This device discriminates austenitic stainless steel from other metals effectively.

not bearing SAE Alloy identification marks were replaced. About 40 bolts were replaced.

5. In a general visual examination, it was observed that, in nine of the can covers, a portion of the unmachined center surface mated (interfered) with the machined flange and one flange (#83) and one can cover (#114) was damaged. The inside diameters of the cans ranged from 4 3/4"-5" and the depths were 17 7/8"-18 1/16". One plastic liner (#70) was cracked and 22 of the plastic fillers needed repair.

The gaskets were not inspected. We understand that part of the loading procedure is to ensure that a good gasket of the proper material is used. It would be wise to visually inspect the surfaces of the gasket, the flange, and the cover for damage prior to each use of the can.

Subject to performing the indicated repair, thirty-nine containers (#51, 53, 54, 55, 59, 60, 61, 62, 63, 64, 66, 67, 69, 70, 71, 74, 75, 76, 78, 79, 82, 83, 84, 89, 90, 95, 96, 97, 98, 99, 101, 105, 107, 108, 109, 110, 112, 113, and 114), are considered adequate for continued service. Data sheets for these 39 are attached.

INSPECTION ENGINEERING DEPARTMENT

J. N. Robinson

JNR:pg

Attachment

cc: L. B. Shappert
O. J. Smith
J. R. Parrott
J. R. McGuffey

INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

March 25, 1974 TC 73-4

To: B. B. Klima, L. B. Shappert

From: Transportation Committee

Subject: Approval of SARP of ORNL Foamglas Shipping Container

The ORNL Transportation Committee has reviewed your submission dated March 20, 1974, of the subject SARP to fulfill the requirements (internal review) of paragraph B of AEC Immediate Action Directive 5201-3. Particular attention was given the five areas of structural integrity, thermal resistance, radiation shielding, nuclear criticality safety, and quality assurance.

The results of the evaluation show that the container meets the requirements of AECM 0529 and the SARP is approved for submission to the AEC for request of a Certificate of Compliance for approval of the cask for use of offsite shipments of fissile and radioactive materials.

E. M. King, Chairman
Transportation Committee

EMK:bb

cc: Transportation Committee

9.6 Nuclear Safety Review

REQUEST FOR NUCLEAR SAFETY REVIEW

ORNL Criticality Committee
638
EXPIRATION DATE
March, 1975

This request covers operations with fissile material in a control area and/or fissile material transfers that originate within the control area. The control area supervisor shall complete the blocks below and describe the process and/or operations to be performed, emphasizing the provisions for nuclear criticality safety on the reverse side of this page. This request shall be approved by the Radiation Control Officers of the originating Division and the Division(s) to which fissile material will be transferred.

TITLE, CONTROL AREA, AND SUMMARY OF BASIC CONTROL PARAMETERS

(To be completed by the Control Area Supervisor)

TITLE (FOR REFERENCE PURPOSES) Foamglas Shipping Container, DOT SP 5795			DATE OF 2/29/72	DATE REVIEW REQUIRED 3/1/72
CONTROL AREA	CODE NO.	BUILDING ROOM	DIVISION Chemical Technology	

TYPE AND FORM OF MATERIAL		^{238}U, ^{235}U and Pu as metal, oxide, or aqueous solution
ISOTOPIC ENRICHMENT (Wt. %)		Up to 100% ^{238}U, ^{235}U, or ^{239}Pu
QUANTITY OF FISSILE ISOTOPES	PER ISOLATED BATCH OR UNIT	See reverse side
	TOTAL IN CONTROL AREA	
	TOTAL TO BE PROCESSED	
Concentration or Density of Fissile Material		
Spacing of Fissile Units		
Proximity and Type of Neutron Reflectors or Adjacent Fissile Material		
Limit on Moderation		
Limit on Neutron Absorbers		
Limit on Volume or Dimensions of Containers		

THIS REQUEST (~~MODIFIES~~, REPLACES) NSR(S) NO. 742-R1

RECOMMENDATIONS

(To be completed by the Criticality Committee)

This endorsement is based on our present understanding of the operation (whether acquired verbally or in writing) and is subject to review and cancellation.

This request is approved on the basis of the evaluation that was performed by J. T. Thomas and described in the attached letter of February 10, 1972, to L. B. Shappert entitled "^{233}U Solution Limits for Foamglas Containers."

Use of this container for ^{233}U or Pu solution shipments must be reviewed and approved in advance by the ORNL Transportation Committee. Until such review is requested, the container shall not be used for liquid shipments.

cc: E.M.King, Chairman, Transportation Committee

Jere R. Nichols — CHAIRMAN, CRITICALITY COMMITTEE
Mar 2, 1972 — DATE

UCN-5017

PROVISIONS FOR NUCLEAR CRITICALITY SAFETY
(To be completed by the Control Area Supervisor)

Provisions for nuclear criticality safety shall be described below in accordance with Appendices II and III of the AEC Manual Chapter 0530. This shall include brief descriptions of the process and/or all operations to be performed, plans and procedures for the operations for nuclear criticality safety, and the basic control parameters. Please attach 11 copies of referenced drawings and documents.

We request that the mass limits for the subject container be revised to those shown in the following table. The only change from the previously approved limits is that the limits for aqueous solutions of ^{233}U have been decreased in order to remove the restriction that the inside radius of the solution container should not exceed 5.8 cm.

Maximum Mass in kg X

Transport Index	Metal	UO_2 Oxide H:X ≤ 0.4	UO_2 Oxide H:X ≤ 3	Aqueous Solution (Any Concentration)
		Uranium-235		
	ρ ≤ 18.76 g U/cm³	ρ ≤ 8.09 g U/cm³	ρ ≤ 4.48 g U/cm³	
0.1	17.2	18.8	15.4	2.35
0.2	19.5	24.1	18.4	--
0.3	20.8	28.2	20.4	--
0.5	23.0	33.8	23.0	--
1.0	25.6	43.7	27.4	--
2.0	28.8	56.1	32.8	--
		Plutonium-239		
	ρ ≤ 19.7 g Pu/cm³	ρ ≤ 8.73 g Pu/cm³	ρ ≤ 4.71 g Pu/cm³	
0.1	5.3	10.5	9.2	2.35
0.2	5.6	11.6	10.7	--
0.3	5.8	12.4	11.8	--
0.5	6.2	13.5	13.3	--
1.0	6.5	14.9	15.6	--
2.0	7.0	16.5	18.3	--
		Uranium-233		
	ρ ≤ 18.4 g U/cm³	ρ ≤ 8.08 g U/cm³	ρ ≤ 4.46 g U/cm³	
0.1	7.5	11.1	8.3	1.35
0.2	8.0	12.6	10.1	1.76
0.3	8.3	13.7	11.5	2.00
0.5	8.8	15.0	13.3	2.35
1.0	9.2	17.1	16.2	--
2.0	9.9	19.3	19.8	--

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EXPIRATION DATE
March, 1975

L. B. Shappert — Chem Tech

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10. REFERENCES

1. "Safety Standards for the Packaging of Fissile and Other Radioactive Materials," DOE Manual Chapter 0529 (June 14, 1973).

2. "Foamglas Shipping Container," ORNL drawing M-12165-CD-015-E.

3. "Shipping Container - 200. Polyethylene Bottle." ORNL drawing M-12166-CD-005-D.

4. Pittsburgh-Corning Foamglas insulation (or equal). Pittsburgh-Corning Company, Pittsburgh, Pennsylvania. It is a closed cellular, all-glass material which has a density of 9 lb/ft^3.

5. Casting Resin RP-3266. REN Plastics, Inc., Lansing, Michigan (or equal). (Flexible casting resin approximate hardness of D-55 Shore D Scale).

6. Coating Resin RP-3260. REN Plastics, Inc., Lansing, Michigan (or equal).

7. Intumescent Fire Retardant, Flaymbar 477, Ocean Chemicals, Inc., 520 Packard Road, Niagara Falls, N.Y. (or equal).

8. Code of Federal Regulations, Title 49, Part 173.393, i and j.

9. L. F. Stravasnik, *Special Tests for Plutonium Shipping Containers 6M, SP-5795, and LIO*, SC-DR-72 0597, Sandia Laboratories (September 1972).

10. Agent R. M. Grazianos' Tariff No. 27. "Hazardous Materials Regulations of the Department of Transportation Including Specifications for Shipping Containers," issued Aug. 13, 1973, effective Sept. 13, 1973.

11. The American Society of Mechanical Enginners, Paragraph UG-28, "Thickness of Shells Under External Pressure," p. 12, in Pressure Vessels, Division 1, ASME Boiler and Pressure Vessel Code, Section VIII, New York (1971).

12. Ibid, p. 280.

13. Ibid, p. 20.

14. J. T. Thomas, *Nuclear Criticality Safety Analysis of a 55-gal Drum Foamglas Container*, Y-DR-20 (Sept. 9, 1969).

15. L. B. Shappert, *Cask Designers Guide - A Guide for the Design, Fabrication and Operation of Shipping Casks for Nuclear Applications*, ORNL-NSIC-68 (February 1970).

16. Warren H. Giedt, *Principles of Engineering Heat Transfer*, p. 218, D. Van Nostrand, Princeton, New Jersey.

17. B. B. Klima and L. B. Shappert, *Drop, Puncture, and Thermal Tests Performed on the Foamglas Shipping Container, DOT Special Permit No. 5795*, ORNL-TM-3713 (April 1972).

18. R. L. Delnay, *Description and Evaluation of Four Pu $(NO_3)_4$ Shipping Containers*, RFP-492 (Dec. 30, 1964).

19. Hevi-Duty furnace, 4 zone, 250-1850°F range, cavity 41 in.high, 60 in. wide by 16 ft deep, with electrically powdered conveyor located in Building 9738, Y-12 Plant, Oak Ridge, Tennessee.

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