UCRL-52424

SAFETY ANALYSIS REPORT ON MODEL UC-609 SHIPPING PACKAGE

R. R. Sandberg

August 1977

MASTER

Work performed under the auspices of the U.S. Department of Energy by the UCLLL under contract number W-7405-ENG-48.

LAWRENCE LIVERMORE LABORATORY
University of California/Livermore

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Price: Printed Copy $; Microfiche $3.00

Page Range	Domestic Price	Page Range	Domestic Price
001-025	$ 4.00	326-350	$12.00
026-050	4.50	351-375	12.50
051-075	5.25	376-400	13.00
076-100	6.00	401-425	13.25
101-125	6.50	426-450	14.00
126-150	7.25	451-475	14.50
151-175	8.00	476-500	15.00
176-200	9.00	501-525	15.25
201-225	9.25	526-550	15.50
226-250	9.50	551-575	16.25
251-275	10.75	576-600	16.50
276-300	11.00	601-up	[1]
301-325	11.75		

[1] Add $2.50 for each additional 100 page increment from 601 pages up.

Distribution Category
UC-71

LAWRENCE LIVERMORE LABORATORY
University of California · Livermore, California · 94550

UCRL-52424

SAFETY ANALYSIS REPORT ON MODEL UC-609 SHIPPING PACKAGE

R. R. Sandberg

MS. date: August 1977

CONTENTS

SAFETY ANALYSIS REPORT ON MODEL UC-609 SHIPPING PACKAGE

ABSTRACT

This Safety Analysis Report for Packaging demonstrates that model UC-609 shipping package can safely transport tritium in any of its forms. The report describes the package and its contents. It also evaluates the package when subjected to the transport conditions specified in the Code of Federal Regulations, Title 10, Part 71. Finally, it discusses compliance with these regulations.

1.0 INTRODUCTION

1.1 General Information

The model UC-609 shipping package will be used to provide containment and offer impact and thermal resistance for shipments containing tritium during transport under both normal and accident conditions.

Any tritium to be shipped will be placed in an appropriate storage vessel. That vessel will be placed within a stainless steel containment vessel, and the containment vessel placed within an insulated steel drum.

Each package will contain either a type-B quantity or a large quantity of tritium in any form, as defined in the Code of Federal Regulations, Title 10, Part 71 (10 CFR 71). All shipments will comply with the appropriate sections of these regulations. No exemptions are claimed.

The following points constitute the design basis of the UC-609 shipping package:

- The containment vessel is considered to be the primary containment boundary and will contain the tritium when the package is exposed to the normal or hypothetical accident conditions specified in 10 CFR 71.
- Tritium will never be loaded directly into the containment vessel but will be put into a storage vessel.
- For design and analysis purposes the storage vessel will receive no credit for tritium containment.
- Although the storage vessels receive no credit for containment, they are to be designed, certified, and tested to provide the maximum assurance of containment under all shipping conditions.

1.2 Package Description

1.2.1 Packaging

The total package weighs 500 lb. The external dimensions are 25 in. in diameter × 55 in. high (see Fig. 1). Fabrication drawings of this package are presented in Appendix A. The major components, i.e., drum, insulation, and containment vessel, are described in the following paragraphs.

The drum is fabricated from 16-gauge carbon steel to the dimensions of 24.0-in. i.d. × 52.5-in. inside height per military standard MS 27683. Two 1-in.-diam holes near the center of the drum lid prevent package rupture from internal pressure during an accidental fire. These holes are sealed weathertight by inserting molded plastic plugs. Eight 3/16-in.-thick stainless brackets secure the cover to the drum with 3/8-in.-diam stainless steel bolts (see Fig. 2).

The insulation that cradles the containment vessel within the drum is Celotex laminated military packing board (a product of the Celotex Corp.) per military specification MIL-F-26862. The insulation is fabricated into disks and annular pieces of varying thickness. When the insulation pieces are installed in the drum, an internal cavity 18 in. in diameter and 44 in. long is formed. For ease in handling, the pieces of Celotex that must be removed to gain access to the containment vessel are glued into an assembly. Laminated into that assembly is a 1/2-in.-thick disk of plywood that will prevent the ring on the containment vessel cover from penetrating the Celotex if the package is dropped on the top end. It is necessary to prevent this pentration because of

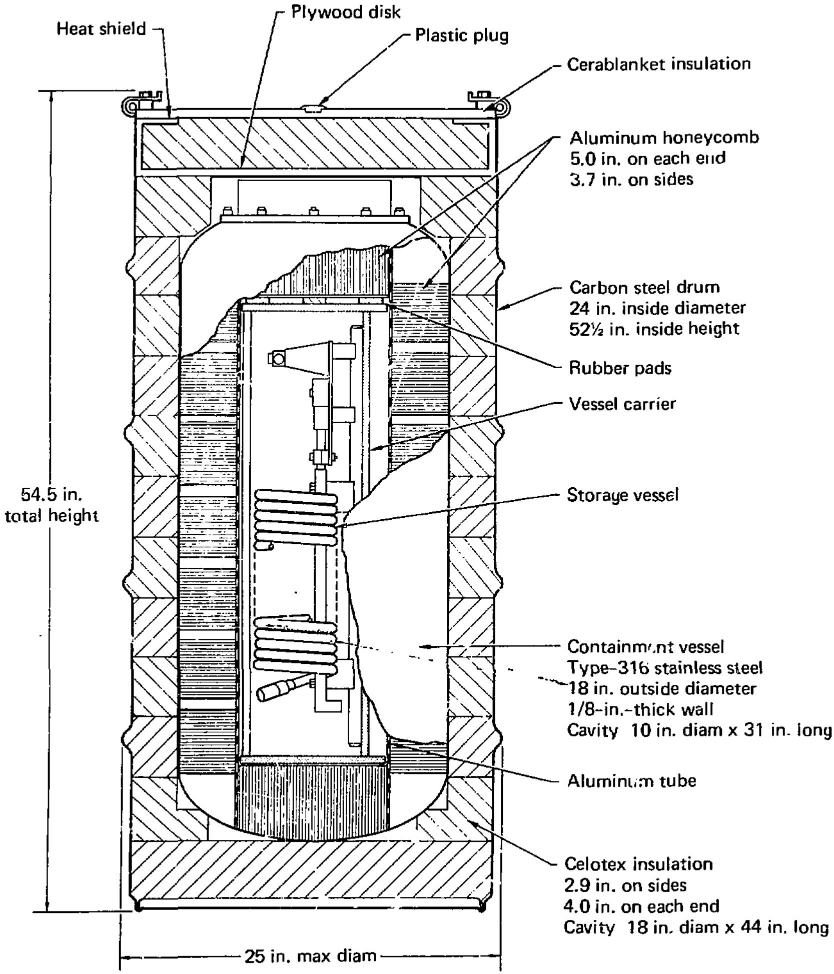


Fig. 1. Model UC-609 shipping package.

possible damage to the valves and gauge on the cover. A sheet metal heat shield covers the top edge of the Celotex cover. The function of this part is to protect the Celotex from burning if a gap occurs between the drum and its cover as a result of an accidental drop.

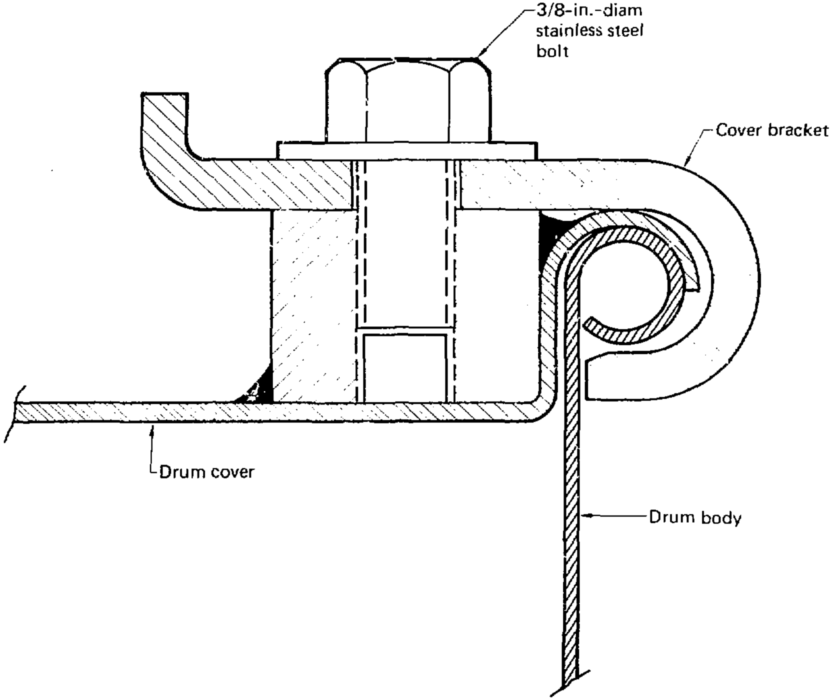


Fig. 2. Detail of drum cover bracket.

A disk of 1/2-in.-thick Cerablanket (a porous refractory fiber insulation produced by the Johns-Manville Corp.) is placed between the Celotex and the drum cover. This refractory fiber insulation performs the following functions:

- Protects the Celotex from direct exposure to flame,
- Allows venting of the internal pressure,
- Limits the inflow of air to the drum to prevent the Celotex from smoldering after exposure to fire,
- Prevents separation of the Celotex by filling the gap between the drum cover and the Celotex.

The containment vessel consists of two parts, the body and the cover. Both are 1/8-in.-thick type-316 stainless steel. The body of the vessel is made by tungsten-inert-gas welding American Society of Mechanical Engineers elliptical heads to each end of a rolled and welded tube. The head on the top end of the container body has a flange welded into it. The mating flange is part of the welded cover assembly. The primary seal between the body and cover is made when opposed knife edges on the mating flanges are forced into an annealed, oxygen-free, high-conductivity copper gasket by the torquing of eight 3/8-in. alloy steel bolts. A Viton *O-ring backs up the primary seal* and allows a leak check of the primary seal with a mass spectrometer leak detector (see Fig. 3).

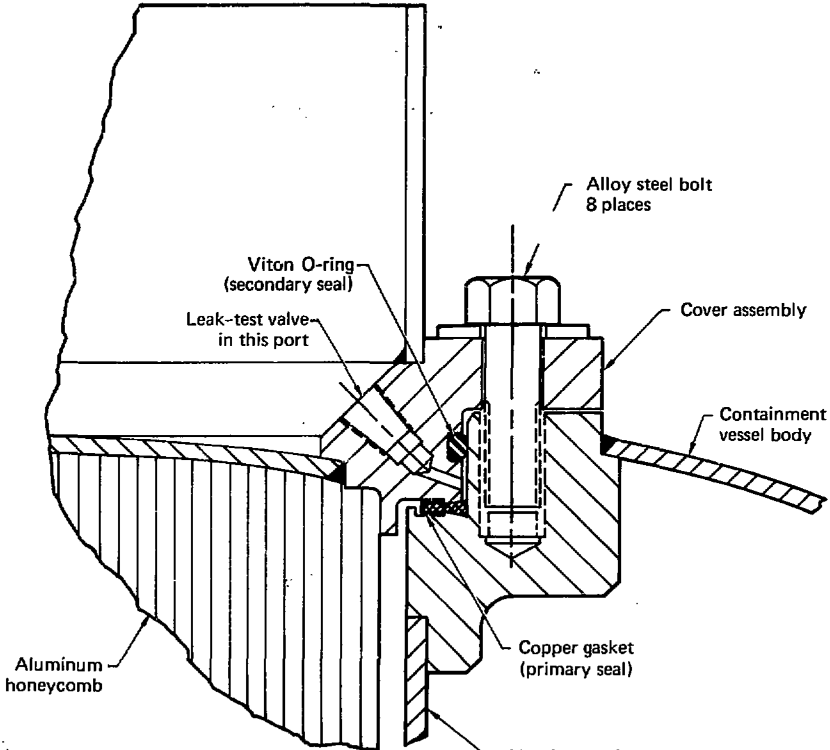


Fig. 3. Detail of containment vessel cover-to-body seal.

The cover assembly has two penetrations. One is a 1/8-in. national pipe tapered-thread female pipe port that connects to the small volume between the primary and secondary seals. A valve designated the leak-test valve is screwed into the port. The second port is in the center of the cover and connects to the main container volume. A manifold containing a 200-psi gauge and a valve is welded into this port. Both valves, the manifold, and the gauge components exposed to the container gas are type-316 stainless steel. The connections on both the valves are 1/4-in. tube, 37° male flare fittings (see Fig. 4).

Aluminum honeycomb (Hexcel Corp. designation AL-1/4-5052-0015P-3.4), 3.7 in. thick on the sides and 5 in. thick on the ends, lines the containment vessel. This honeycomb will prevent the storage vessel from impacting against the containment vessel shell if the package is accidentally dropped. The maximum force that can be transmitted through the honeycomb is its crush strength, which is 150 psi. A 10-in.-i.d. aluminum tube protects the inner surface of the honeycomb. The cavity formed within the containment vessel is 10 in. in diameter × 31 in. long (see Fig. 5).

Fig. 4. Containment vessel cover assembly.

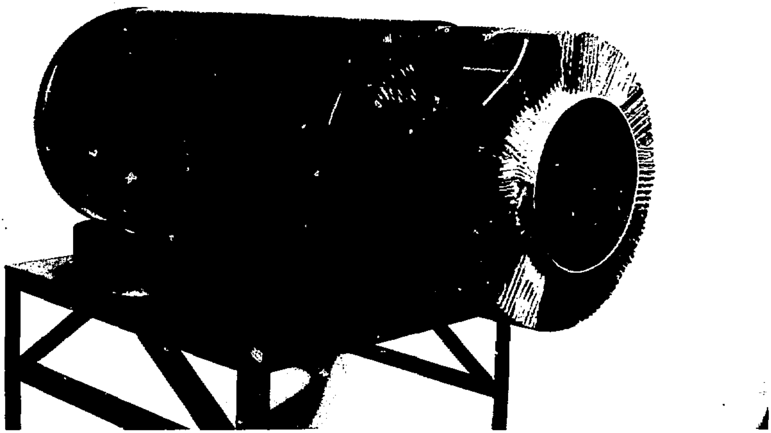


Fig. 5. Honeycomb tube assembly in containment vessel.

The vessel carrier is basically a mounting, handling, and locating fixture for the storage vessel (see Fig. 6), but the major function in the package design is to distribute any forces transmitted by the storage vessel over the entire area of the end pieces of the honeycomb. The vessel carrier may be redesigned in the future to accommodate storage vessel configurations not yet anticipated. The following restrictions must be observed in any redesign:

- Load-distributing aluminum (6061-T6) plates 1/2 in. or thicker are required between the storage vessel and the end pieces of honeycomb.
- The total weight of the storage vessel plus the vessel carrier cannot exceed 120 lb.
- If materials less dense than aluminum are used for the vessel carrier, the total volume of the components to be installed in the containment vessel must be considered (see Sec. 1.2.3).

The vessel carrier is held in position by a close fit with the aluminum tube described previously. A gap in the long axis prevents interference due to tolerance buildup. Lightly compressed rubber pads fill the gap. This method of positioning provides both axial and traverse support and restricts the movement of the vessel carrier during transport.

1.2.2 Operating Features

The operational features of this packaging are described in Ch. 7.0, Operating Procedures.

1.2.3 Contents of Packaging

The radioactive contents of this package will be tritium in any of its forms. The following restrictions apply to the use of the container:

Maximum total gas contents	30 mole
Maximum tritium contents	25 mole

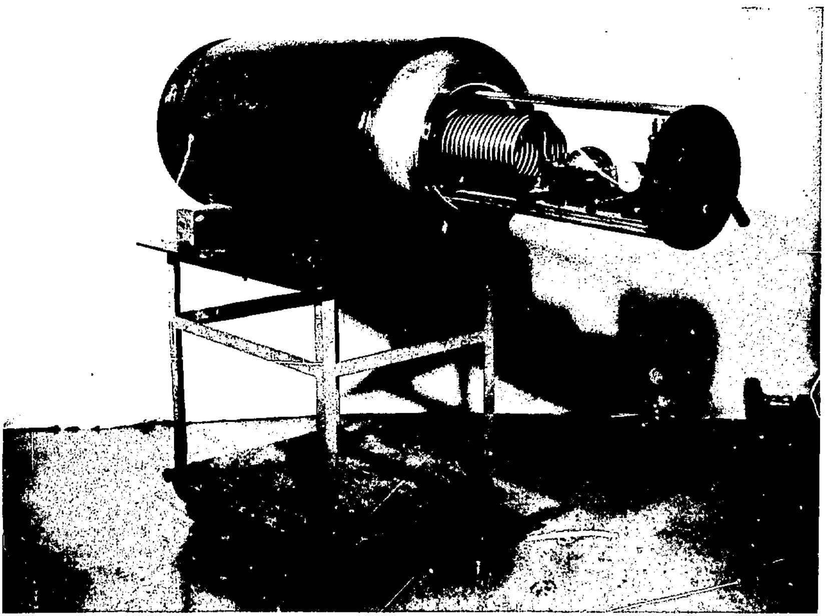


Fig. 6. Typical storage vessel mounted on vessel carrier.

Maximum radioactive decay heat	48 W
Maximum combined weight of storage vessel and vessel carrier	120 lb
Maximum combined volume of storage vessel and vessel carrier	20 litres

A maximum weight of 120 lb will limit the combined volume of the storage vessel and vessel carrier to 20 litres if the materials of construction are at least as dense as aluminum (0.098 lb/in.^{3}). If materials less dense than aluminum are used, either the maximum total volume of the vessel and the carrier or the maximum total gas contents must be reduced. New limits may be calculated using the following equation:

$$N = 34.48 - 0.224\, V_T,$$

where

N = maximum number of moles of material,

V_t = total volume of vessel and carrier.

2.0 STRUCTURAL EVALUATION

2.1 Structural Design

2.1.1 Structural Members

The principal structural members of the model UC-609 shipping package are the stainless steel containment vessel lined with impact-absorbing honeycomb, the Celotex insulation, and the carbon steel drum.

The containment vessel has a removable cover that is held in place by eight alloy steel bolts. These bolts, when tightened, force knife edges on the mating flanges into a copper gasket, providing the primary closure seal. A secondary seal is provided by an O-ring.

Two valves penetrate the cover. The first, called the fill valve, is part of a gauge manifold that is welded into the cover. This valve is used to pressurize or evacuate the container and to monitor the vessel contents. The second, called the leak-test valve, is screwed into a port that connects to the volume between the primary and secondary seals. By connecting a mass spectrometer to this valve and pressurizing the container through the fill valve, it is possible to make a very sensitive leak check of the primary seal.

The aluminum honeycomb that lines the interior of the containment vessel prevents the storage vessel from impacting against the vessel walls. A 1/8-in.-thick aluminum tube protects the honeycomb surface and acts as a load distribution member in the radial direction. Aluminum disks 1/2-in. thick act as load distribution members in the longitudinal direction.

The Celotex not only insulates but centralizes the containment vessel within the steel drum that forms the outer surface of the package. The drum cover is held on by eight special brackets secured by 3/8-in.-diam stainless steel bolts.

2.1.2 Design Criteria

The load criteria for the containment vessel are:

Maximum internal pressure	110 psig
Maximum external pressure	25 psig
Maximum combined pressure load	260 psig

The calculated maximum pressure that could occur during a normal shipment is 103 psig (see Sec. 3.4.4). The 110-psig pressure is used for conservatism.

An accidental drop of the package may result in localized crushing of the honeycomb that lines the containment vessel. If that occurs, the 150-psi crush strength of the honeycomb will be added to the 110-psig internal gas pressure.

The maximum stress in the containment vessel shell is 25% of the minimum material tensile strength. This is the value specified in the ASME *Boiler and Pressure Vessel Code*.[1] Appendix P, p. 365.

The maximum stress in the bolts used to secure the cover to the containment vessel is 60% of the minimum tensile strength. The Sturtevant *Torque Manual*,[2] p. 41, recommends a fastener tension between 60 and 70% of the minimum tensile strength.

2.2 Weights and Center of Gravity

Weights, in pounds, of the component parts of the model UC-609 package are:

Storage vessel plus vessel carrier	120 maximum
Celotex	110
Containment vessel	170
Drum	100
Total	500 maximum

The center of gravity of the package, assuming that the storage vessel is located centrally on the vessel carrier, is on the centerline of the drum and within 2 in. of the center of the long axis of the drum.

2.3 Mechanical Properties of Materials

The ASME *Boiler and Pressure Vessel Code*, Table UHA-23, pp. 182-183, specifies that the minimum yield strength of type-316 stainless steel is 30,000 psi, the minimum ultimate tensile strength is 70,000 psi, and the maximum design stress at temperatures between 93 and 149°C (200 and 300°F) is 14,600 psi.

The crush strength of the aluminum honeycomb is 150 psi. [3]

The specified minimum tensile strength for the cover retaining bolts is 170,000 psi.

2.4 General Standards for All Packages

2.4.1 Chemical and Galvanic Reactions

There is no reaction between the packaging and contents. However, some tritium can permeate through the wall of the containment vessel (see Ch. 4.0, Containment). Also there will be no significant reaction between any of the parts of the packaging. The following materials are used in the package construction:

- Aluminum
- Carbon steel
- Celotex
- Cerablanket
- Copper
- Epoxy paint
- Nylon
- Polyurethane rubber
- Silicone rubber
- Stainless steel
- Teflon
- Viton rubber
- Wood

2.4.2 Positive Closure

The closure system has two distinct levels, neither of which can be inadvertently opened.

The drum cover is fastened to the drum with eight brackets, each held in place by one bolt. Two of these bolts are secured with tamper seals.

The containment vessel cover is secured with eight bolts that may be secured with tamper seals if required for in-plant control. The two valves on the cover and the caps on their fittings also have provisions for tamper seals.

2.4.3 Lifting Devices

Not applicable. There are no lifting devices on the drum.

2.4.4 Tie-Down Devices

Not applicable. There are no tie-down devices on the drum.

2.5 Standards for Type-B and Large-Quantity Packaging

2.5.1 Load Resistance

A drum identical to the one used on this package is used on the JP 157S shipping package.[4] For qualification of that package, bags of lead shot totaling 2400 lb were stacked uniformly inside an empty drum along one side. After the lid was installed, the drum was carefully laid on its side and brought to rest with only the rim at each extreme end in contact *with supporting timbers. No deformation or* damage resulted.

That 2400-lb test was only 100 lb less than would be required for the model UC-609 package [5 × the weight of UC-609 (500 lb) = 2500 lb]. In actual use the drum is stiffened considerably by being filled with Celotex and could certainly support an additional 100 lb without damage.

2.5.2 External Pressure

External pressure will affect only the stainless steel containment vessel, because it is the only sealed volume in the package. The weakest part of that vessel from an external pressure is the cylindrical shell between the two end heads. The method for calculating the maximum allowable working pressure is outlined in the ASME *Boiler and Pressure Vessel Code*, paragraph UG-28, p.15:

D_0 = outside diam of cylindrical shell = 18.0 in.,

t = thickness of cylindrical shell = 0.125 in.,

L = design length of cylindrical section

= distance between head bend lines + 1/3 of the depth of each head

= 35 + 2[1/3(4.5)] = 38. To be conservative, use L = 40.

To find Factor B for temperatures up to 204°C (400°F), use values for L/D_0 and D_0/t in Fig. UHA-28.2 of the *Pressure Vessel Code*, p. 303.

$$\frac{L}{D_0} = \frac{40}{18} = 2.22 \ ,$$

$$\frac{D_0}{t} = \frac{18}{0.125} = 144 \ .$$

After finding that Factor B = 4500, calculate the maximum allowable external pressure (Pa) up to 204°C:

$$Pa = \frac{B}{D_0/t} = \frac{4500}{144} = 31.25 \text{ psi.}$$

2.6 Normal Conditions of Transport

2.6.1 *Heat*

2.6.1.1 Summary of Pressures and Temperatures. The maximum temperature of the containment vessel during normal transport is 76°C (see Sec. 3.4.2).

The maximum pressure in the containment vessel during normal transport is 103 psig (see Sec. 3.4.4).

2.6.1.2 Differential Thermal Expansion. Hypothetical accident tests did not cause any damage attributable to differential thermal expansion (see Sec. 2.7.3.2). Conditions of normal transport are much less severe. Thus, no problems will be encountered during normal transport or actual transport conditions.

2.6.1.3 Stress Calculations. Calculations of the stresses and maximum working pressure of the cylindrical body and the formed heads of the containment vessel were made using methods specified in the ASME *Boiler and Pressure Vessel Code*. For conservatism we used an internal pressure of 110 psig rather than the actual pressure of 103 psig.

2.6.1.3.1 Cylindrical Section.

$$P = \frac{SEt}{R + 0.6t} \qquad \text{(Ref. 1, paragraph UG-4, p. 14)}$$

where

P = pressure = 110 psig,

E = joint efficiency (Ref. 1, Table UW-12, p. 74, butt joint fully radiographed) = 100%,

S = stress,

t = shell thickness = 0.125 in.,

R = inside radius = 8.875 in.

Solving for stress,

$$S = \frac{P\,(R + 0.6t)}{Et} = \frac{110\ [8.875 + 0.6\ (0.125)]}{1.0\ (0.125)} = 7876\ \text{psi.}$$

2.6.1.3.2 Formed Ellipsoidal Heads.

$$P = \frac{2\,St}{K\,D_0 - 2t\,(K - 0.1)} \qquad \text{(Ref. 1, paragraph UA-4, pp. 226-228)}$$

where

D_0 = outside diameter = 18.0 in.,

t = shell thickness = 0.125 in.,

S = stress,

K = ellipsoidal head factor for head with ($D/2h$ = 2) (Ref. 1, Table UA 4.1, p. 228),

K = 1.0,

P = pressure = 110 psig.

Solving for stress,

$$S = \frac{P\,[K\,(D_0) - 2t\,(K - 0.1)]}{2t} = \frac{110\ [1\ (18.0) - 2\ (0.125)(1 - 0.1)]}{2\ (0.125)} = 7821\ \text{psi}\ .$$

2.6.1.3.3 Cover Bolts. The cover-to-vessel joint is assumed to be rigid. That is, we assume little or no spring effect from the copper gasket. This is a reasonable assumption, since the gasket is very thin and is plastically yielded when the joint is tightened. Therefore, any elastic recovery of the gasket will be very small relative to the bolts.

With a properly tightened rigid joint, internal pressure effects on the bolts can be eliminated and the stresses on the bolts limited to the amount caused by initial tightening.[2] To achieve this condition, the total tension in the eight bolts must be greater than the total pressure force on the cover.

The force (F) on the cover due to internal pressure is calculated as follows:

$$F = \frac{\pi}{4}(D^2)P ,$$

where

D = diam at gasket seal = 10.5 in.,

P = internal pressure = 110 psig.

$$F = \frac{\pi}{4}(10.5)^2 (110) = 9524 \text{ lb} .$$

The initial tension (L) in the bolts from torquing can be calculated as follows:

$$L = \frac{T}{0.2(D)} \quad \text{(Ref. 5, p. 34)},$$

where

D = bolt diam = 0.375 in.,

T = torque = 45(12) in.-lb

$$L = \frac{45(12)}{0.2(0.375)} = 7200 \text{ lb per bolt} .$$

The total force on the cover from the eight bolts is 57,600 lb, which is much greater than the pressure force of 9524 lb.

The stress (S) on the bolts from initial tightening is:

$$S = \frac{L}{A} ,$$

where

L = initial tension = 7200 lb,

A = tensile stress area at root of thread (Ref. 5) = 0.0878 in.^{2}

$$S = \frac{7200}{0.0878} = 82{,}000 \text{ psi} .$$

2.6.1.3.4 ***Flanges.*** A finite element analysis of the flange assembly was made.[6] At an internal pressure of 110 psig, the maximum stress was 13,000 psi.

To verify the adequacy of the flange design, one of the prototype containers was hydraulically pressurized to failure with the following result:

- At 425 psia the primary (copper gasket) seal began to leak. The secondary (O-ring) seal held.
- At 650 psia the flange had deformed to the point that the O-ring blew out, releasing the pressure. None of the bolts failed. Although all were slightly bent from the deformation of the flanges, they were easily unscrewed and removed.

2.6.1.4 Comparison with Allowable Stresses. The most highly stressed area in the 316 stainless steel containment vessel is the flanges. The 13,000-psi stress calculated for that area is approximately 90% of the maximum allowable stress of 14,600 psi per the ASME *Pressure Vessel Code* (see Sec. 2.6.1.3).

The maximum bolt stress was calculated at 82,000 psi. The Sturtevant *Torque Manual* (p. 41) recommends a maximum stress of 60% of the tensile strength, or 0.60 × 170,000 = 102,000 psi. The 82.000-psi stress is approximately 80% of that value.

2.6.2 Cold

The effectiveness of the packaging material is not significantly impaired by a temperature of −40°C. The tensile strength and ductility of the materials do not change significantly at −40°C. In fact, the tensile strength of the type-316 stainless steel used for the containment vessel increases without a loss in ductility.

2.6.3 Pressure

Reduction of the external pressure to 7.4 psia (0.5 atm) would give a maximum differential pressure across the containment vessel wall of 110.0 + 7.4 = 117.4 psig. Each vessel is tested at 200 psig and therefore would not be damaged at a pressure of 118 psig.

2.6.4 Vibration

A vibration test on one prototype package simulated transportation by common carrier as secured cargo. [7] The package was vibrated in the upright position in a sweep from 5 to 200 to 5 Hz, 12 min up and 12 min down, for a total of 84 min. The acceleration level was 1.5 g.

The tightness of all fastenings was checked before and after the test. No changes were found. The primary seal was tested before and after the test at 120 psig. No leakage was found on a mass spectrometer with a sensitivity in the 10^{-9} atm-cm ^{3}/s/div range.

2.6.5 Water Spray

The closed steel drum with the vent holes sealed by plastic plugs is impervious to water spray and is not significantly affected.

2.6.6 Free Drop

The requirements of the free-drop condition for normal transport are less severe than those for the free-drop condition of the hypothetical accident to which the prototype shipping package was actually subjected. In fact, one package was dropped twice from 30 ft with no resulting damage to the containment vessel. The results of these impact tests provide the basis for the conclusion that the package complies with the free-drop requirements for normal transport.

2.6.7 Corner Drop

Since this package is constructed primarily of metal, not wood or fiberboard, and because it weighs more than 110 lb, this test is not applicable.

2.6.8 Penetration

The required penetration test was performed on the JP 157S package, which uses the same drum and Celotex insulation as is used for the model UC-609 shipping package (Ref. 4, pp. 1-8). In those tests, maximum deflection to the drum surface was less than 1/4 in. with no damage to the Celotex insulation.

2.6.9 Compression

A drum identical to the one used on this package is used on the JP 157S shipping package (Ref. 4, pp. 1-8). To qualify that package, an empty drum was loaded to 2400 lb, and no visible damage or deformation occurred. That 2400-lb test was only 100 lb less than would be required for the model UC-609 package [5 × the weight of UC-609 (500 lb) = 2500 lb]. In actual use the drum is completely filled with Celotex and could certainly support 100 lb more than an empty drum without damage.

2.7 Hypthetical Accident Conditions

Records of tests made to verify adequacy of the design when subjected to the hypthetical accident conditions are contained in Engineering Note END 78-004 (UC-609 test records).

2.7.1 Free Drop

In the process of developing a satisfactory method of securing the drum cover, a total of seven 30-ft free drops were made on the two prototype containment vessels. The impact surface was a 1-in.-thick steel plate resting on an asphalt roadway for the first three drops and a 6-in.-thick steel plate resting on concrete for the last four. Five drops impacted the package on the edge of the drum cover with the center of gravity directly above the impact point (see Fig. 7). One drop impacted on the long axis of the drum. In all but one instance, the drum and any damaged Celotex were replaced before making another drop. In the one exception, one package was dropped on the cover and then on the side of the drum with no repair or replacement between drops.

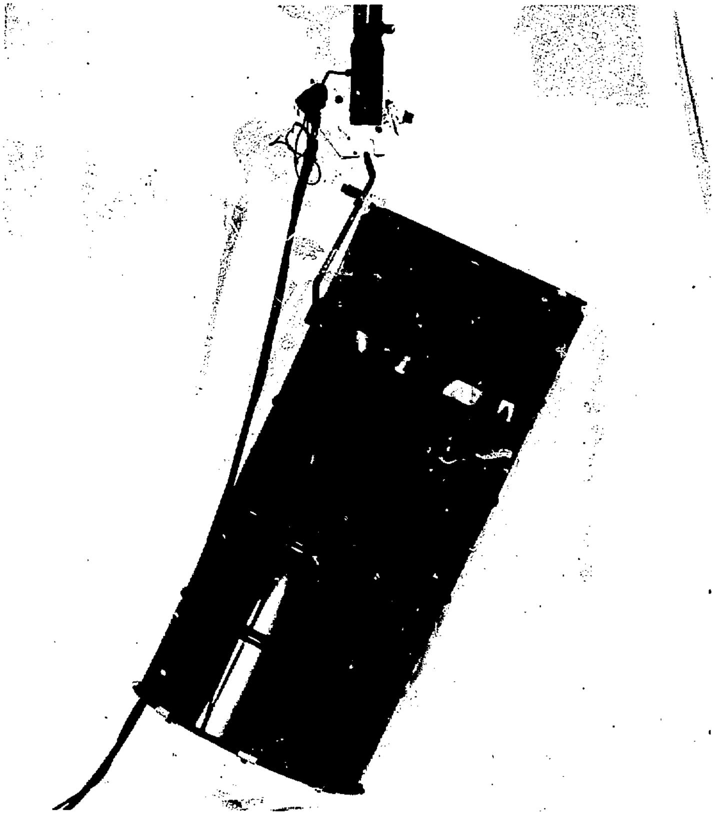


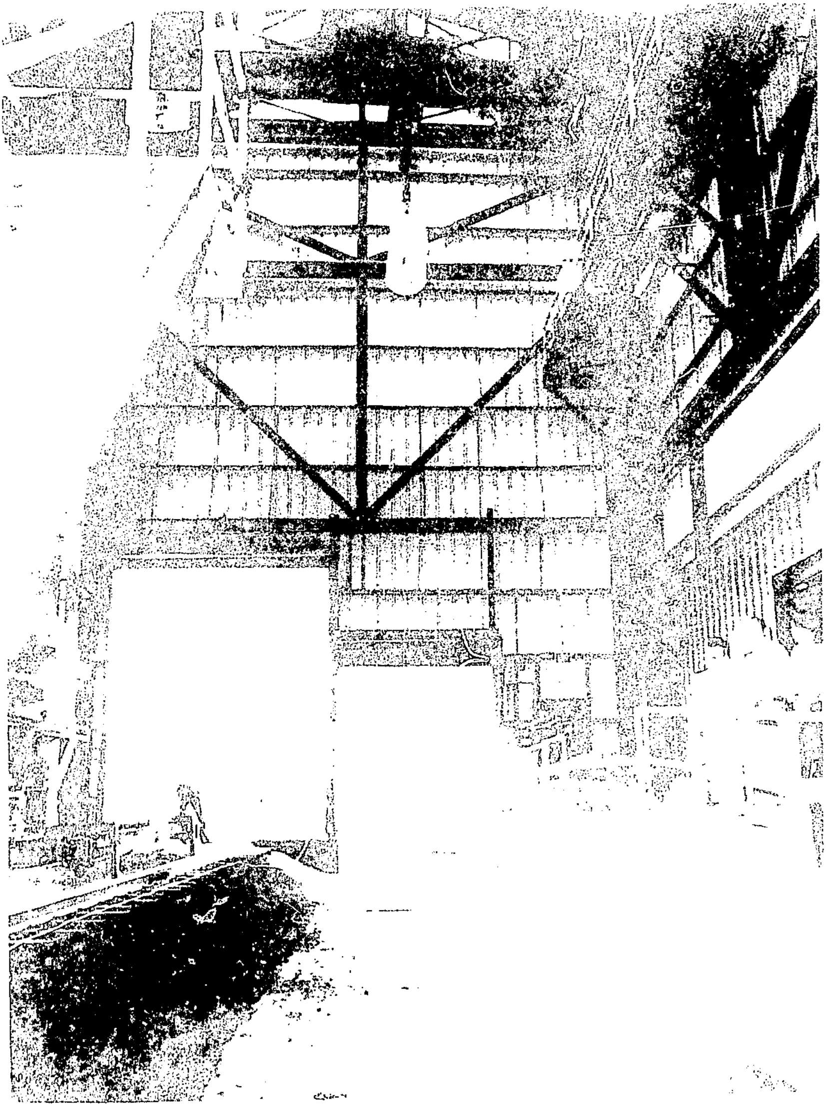
Fig. 7. Orientation of package on free drop.

A 100-lb weight (a steel bar 5 in. diam × 18 in. long) was used to simulate the heaviest storage vessel allowed for the package. On three drops this 100-lb weight was loose within the containment vessel cavity. On the other drops the weight was securely attached to the vessel carrier.

The last drop was onto the edge of the drum cover with the final drum closure system in use. On this last drop the corner was crushed about 3 in., but no opening occurred and no significant loss of insulating capacity resulted (see Figs. 8-12).

None of the drops resulted in damage to the containment vessels that impaired leak tightness. The greatest effect on the containment vessel was caused by the horizontal drop impacting on the long axis of the drum. This flattened the containment vessel to a maximum depth of 1 in. along one side. There was no loss of insulation thickness.

The copper gasket-to-flange seal was tested before and after each drop with the container pressurized to 120 psia with helium. No leakage was detectable on a mass spectrometer with a sensitivity in the 10^{-9} atm-cm^3/s/div range. All drops were made with the container at approximately 20 psia.



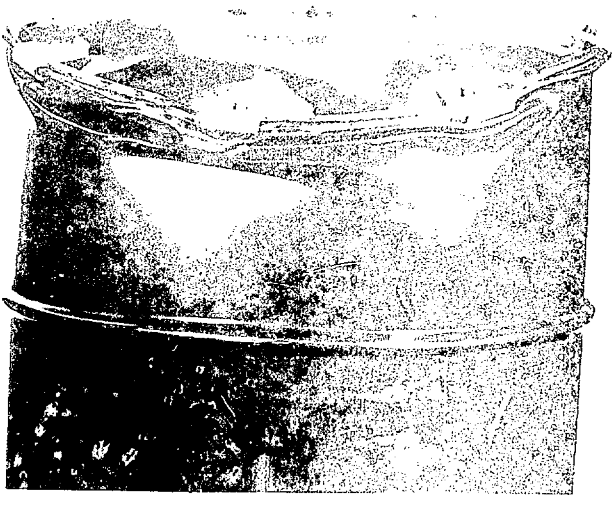
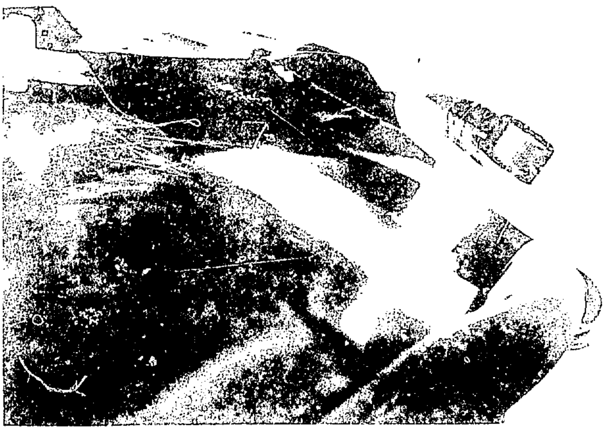
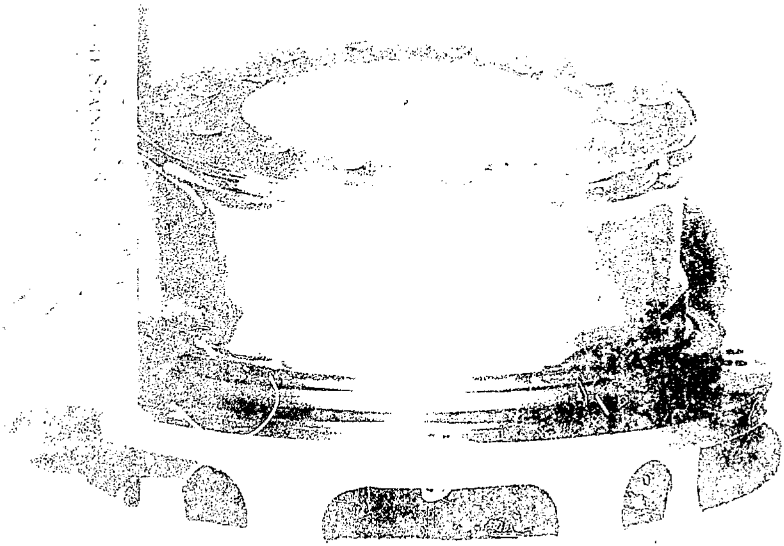
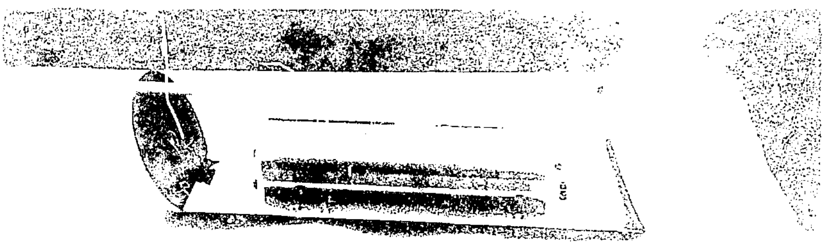


Fig. 10. Deformation of [illegible]







2.7.2 Puncture

The package used for the final drop test was dropped 40 in. onto a 6-in.-diam steel post 10 in. high. The side of the drum was indented no more than 1 in. (see Figs. 15 and 16).

2.7.3 Thermal

2.7.3.1 Summary of Pressures and Temperatures.

Assumed maximum ambient temperature before fire	38°C
Maximum containment vessel temperature	141°C (See Sec. 3.5.3.1.1)
Maximum storage vessel temperature	170°C (See Sec. 3.5.3.1.2)
Maximum containment vessel pressure	125 psig (See Sec. 3.5.4.)

2.7.3.2 Differential Thermal Expansion. The furnace test (see Sec. 3.5.1) did not cause any damage that could be attributed to differential thermal expansion. There is no rigid structural coupling of materials having dissimilar expansion rates or important temperature gradients.

The clearances, the temperature differentials involved, and the thermal expansion coefficient of the materials will minimize the effects of thermal expansion.

2.7.3.3 Stress Calculations. The effective internal pressure of the containment vessel may be temporarily increased to 260 psig as a result of a free drop. This would happen only if the honeycomb lining were crushed. At the location where crushing occurs, the 150-psi crush strength would be added to the 110-psig normal conditions pressure. Subjecting the package to the fire enivornment would increase the containment vessel temperature to 141°C and thereby increase the internal pressure to 125 psig (see Sec. 3.5.4).

The greatest stress on the containment vessel occurs on the flanges (see Sec. 2.6.1.3.4). At 260 psig the calculated maximum stress is 30,600 psi. [6]

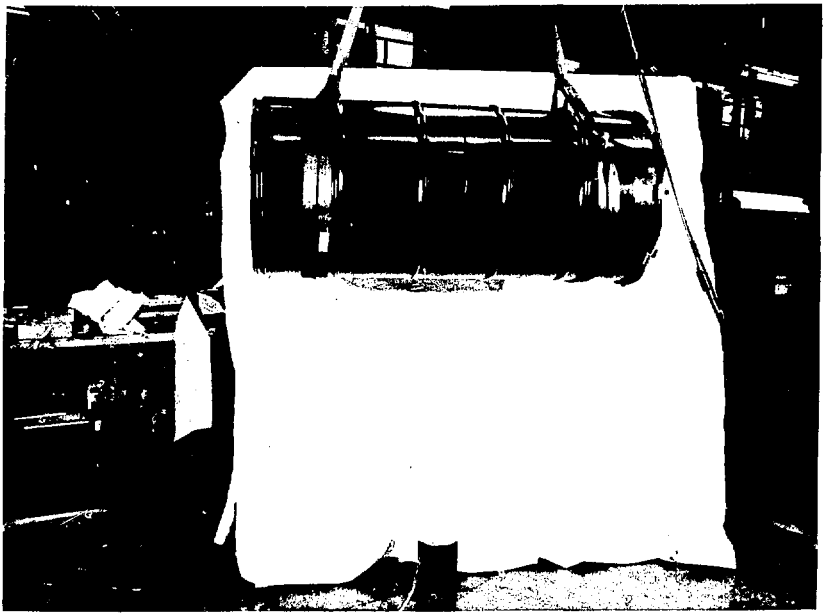


Fig. 15. Package orientation for 40-in. drop onto 6-in.-diam bar.

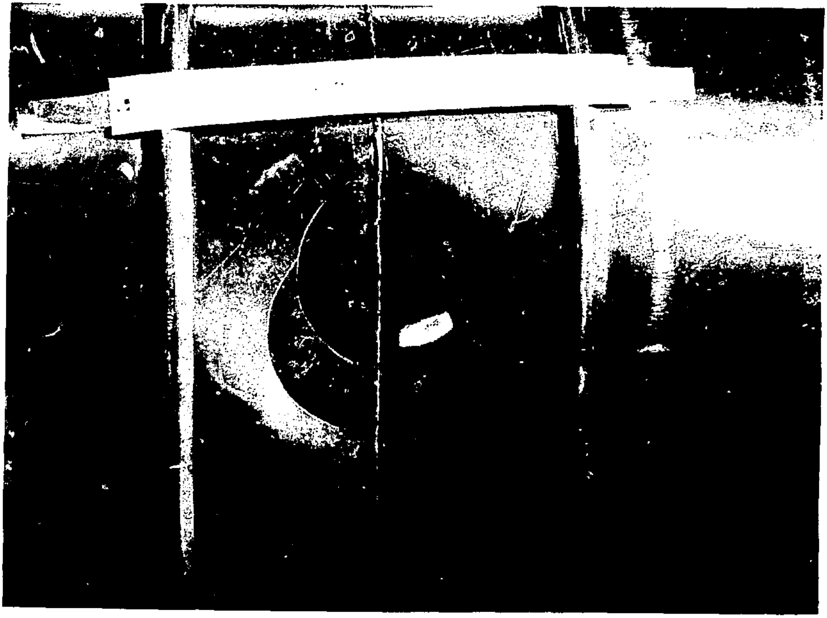


Fig. 16. Impact point for penetration test.

The force on the cover, calculated as in Sec. 2.6.1.3.3, at 260 psig is 22,513 lb. The total initial bolt tension of 57,600 lb (see Sec. 2.6.1.3.3) is much greater than the 22,513-lb force on the head. Therefore, increasing the containment vessel pressure to 260 psi will not increase the bolt stress.

2.7.3.4 Comparison with Allowable Stresses. The calculated maximum stress of 30,600 psi on the containment vessel flanges is slightly greater than the specified minimum yield of 30,000 psi that is listed in the *Pressure Vessel Code* (Table UHA-23, p. 182). A more meaningful number is that the 260-psig pressure is 61% of the 425-psia pressure that was required to cause the primary seal to leak (see Sec. 2.6.1.3.4).

2.7.4 Water Immersion

Not applicable. There is no fissionable material in this package.

2.7.5 Summary of Damage

A complete package was dropped on a flat surface and on a piston. Then it was heated in a furnace in the manner prescribed in Appendix B of 10 CFR 71. The appearance of the package after the drops is shown in Figs. 8-11. The package was *not* significantly damaged from these tests. The Celotex insulation was in good condition after the furnace test, as shown in Fig. 13. The temperature rise in the test was low enough that the tritium permeation and leakage are less than the 10-Ci release limit (see Sec. 4.3).

2.8 Special Form

Not applicable. No special form is claimed.

2.9 Fuel Rods

Not applicable. There are no fuel rods in the shipment.

3.0 THERMAL EVALUATION

3.1 Discussion

The significant thermal design feature of the UC-609 package is the Celotex insulated shipping drum. A minimum of 2.88 in. of Celotex insulation completely surrounds the containment vessel (primary containment boundary). This thickness of Celotex adequately protects the package contents during both normal transport and hypothetical accident conditions. Similar packaging, the JP157S,[4] has been used for numerous shipments over a period of several years without adverse effects due to heat.

The maximum decay heat load is 48 W. The minimum heat load is zero. Significant results of the thermal analysis follow in Secs. 3.1.1 and 3.1.2.

3.1.1 Normal Transport Conditions

Ambient air temperature	54.4°C
Maximum containment vessel temperature	76.0°C
Maximum storage vessel temperature	106.0°C*
Containment vessel pressure	103 psig

3.1.2 Hypothetical Accident Conditions

Assumed maximum ambient temperature before accident	38°C
Measured containment vessel temperature rise during furnace test	79°C
Measured temperature difference between ambient air and containment vessel	24°C
Measured temperature difference between containment vessel and storage vessel	29°C
Calculated containment vessel temperature after hypothetical fire	141°C
Calculated storage vessel temperature after hypothetical fire	170°C*
Containment vessel pressure	125 psig

*The analysis of the UC-609 package is based on the hypothetical escape of tritium from the storage vessel into the containment vessel. If that occurred, the temperature of the two vessels would be essentially the same. The temperatures noted are for the case in which all tritium remains within the storage vessel and are included as information only.

3.2 Summary of Thermal Properties of Materials

The thermal properties of Celotex and stainless steel are summarized in Table 1.

Table 1. Summary of thermal properties of materials.

Material	Density, g/cm^3	Specific heat cal/g	Thermal conductivity, $cal/s\text{-}cm^2\text{-}°C$			
			Temperature			
			30°C	49.9°C	100°C	150°C
Celotex[8,9]	0.25	0.3	1.78×10^{-4}	1.89×10^{-4}	2.03×10^{-4}	1.59×10^{-4}
Stainless steel	8.0	0.12	0.04 at all temperatures			

Heat transfer coefficients and emissivity values [10] used in the thermal calculations for heat transfer to or from the external surfaces are:

	Free convection, $cal/s\text{-}cm^2\text{-}°C$	Emissivity
Top (end) surface	8.000×10^{-5}	0.8
Cylindrical surface	7.000×10^{-5}	0.8

3.3 Technical Specification of Components

Celotex is fiberboard made from sugar cane fibers bonded with organic glue per MIL-F-26862. It is stable to 120°C.

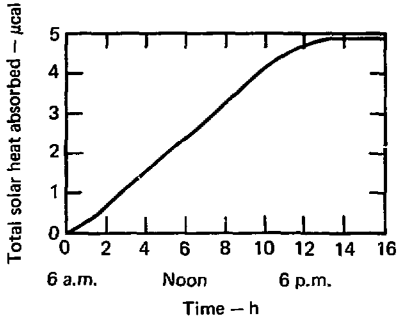
Cerablanket is a loosely spun alumina-silica refractory material 1/2 in. thick with a density of 4 lb/ft^3. It is stable to 1260°C.

3.4 Thermal Evaluation for Normal Conditions of Transport

3.4.1 Thermal Model

3.4.1.1 Analytical Model [11]. In making the thermal analysis of the UC-609 package, we assumed that the container was resting on an insulated surface in a vertical position. In this position the solar input on the horizontal top surface depends only on the relative angle between the sun rays and vertical. [12] This angle varies during the day, but the solar input never goes to zero during the daylight hours. The solar input on the vertical sides depends additionally on the orientation of the surface with respect to the east-west plane. For a specific vertical surface element this angle varies during the day, and the solar input can actually be zero during daylight. The azimuth angle of the sun, which varies with the time of day, location on the earth, time of the year, and solar declination, also affects the solar flux. [13] We obtained appropriate relationships between the various angles and the time of day for a position at 30° north latitude from May to August. We combined these with the vertical cylinder geometry and wrote a small computer code [13] to evaluate the solar flux incident on the exterior surfaces. At sea level, at the location specified above, the normal solar flux at noon on a clear day (attenuated by the atmosphere) is approximately 356 $BTU/h/ft^2$. [12] We obtained calculations for a specified zone structure of the sides and top from sunrise to sunset. We then used this information as the solar heat input for the thermal model of the structure. The daily total integrated solar flux on the package surface is shown in Fig. 17

We assumed that the sky was clear during daylight and that a cloud cover existed at night. This assumption maximizes the radiation input during the day and minimizes the radiation loss at night.



Summary of daily accumulated solar heat

Top surface (end)		3.3 Mcal
Cylindrical walls		1.6 Mcal
	Total	4.9 Mcal

Fig. 17. Daily solar heat accumulation for entire package.

The air temperature input to the model varied sinusoidally between a maximum of 54.4°C (130°F) and a minimum of 26.7°C (80°F) over repeating 24-h cycles. The maximum temperature occurred 3 h after solar noon.

To properly input the solar radiation flux, we used a three-dimensional thermal model from the outer surface through the Celotex insulation. We used a two-dimensional thermal model to simulate the inner portion (containment vessel to storage vessel) of the package. Using a two-dimensional model inside the Celotex causes the radial gradients at the inner surface of the Celotex to smooth out to an average uniform temperature in the stainless steel wall of the containment vessel. This is reasonable, especially when the aluminum honeycomb that backs up the stainless is considered. The integrated thermal model is shown in Fig. 18. We used a free convection coefficient and a radiation coefficient (see Sec. 3.2) to connect the exposed outer surface of the thermal model to the cycling boundary. (Note: The surface emissivity value used represents that of new, oxide-free, light-color paint.)

There are two major areas of thermal resistance between the outer surface of the package and the internal storage vessel. The dominating thermal resistance is in the Celotex insulation material between the outer steel drum and the containment vessel. In this closed-end cylindrical part, the thermal resistance between the outer surface and the containment vessel depends almost completely on the thermal conductivity coefficient of the Celotex. The thermal resistance of the thin outer metal wall (steel drum) is negligible compared to the thick Celotex and was not used in the thermal model. We made the Celotex thickness in the thermal model equal to the space between the outer drum and the containment vessel. This compensates for any air-gap resistances at the interfaces. The other area of major thermal resistance is between the containment vessel and the storage vessel. The heat path between these two vessels is such a complicated network of conduction, convection, and radiation that the thermal coefficients for the path cannot be reliably calculated. However, using temperature data from an experiment with constant boundary conditions and selected internal-heat-generation rates (see Sec. 3.4.1.2), we determined an equivalent convection coefficient. We used this value to calculate the storage vessel temperature for the condition in which the tritium remains within that vessel.

We used the TRUMP[14] computer program for the thermal calculations. This Lawrence Livermore Laboratory (LLL)-developed code has been thoroughly checked out and has been used for a number of years at LLL and at other agencies throughout the U.S. and abroad. Figures 19-21 show the results of the computer calculations.

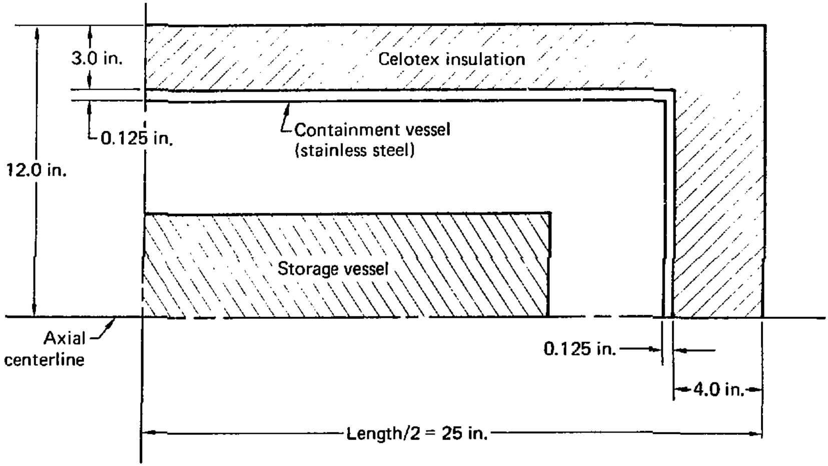


Fig. 18. Thermal model for UC-609 package.

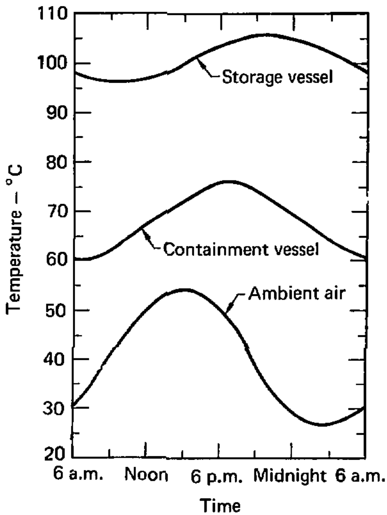


Fig. 19. Daily temperature response of UC-609 package containing 48-W heat load after exposure to desert environment for three consecutive days.

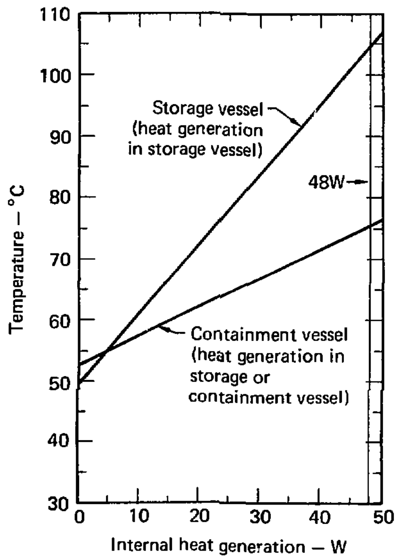


Fig. 20. Vessel temperatures after UC-609 package has been exposed to desert environment for three consecutive days.

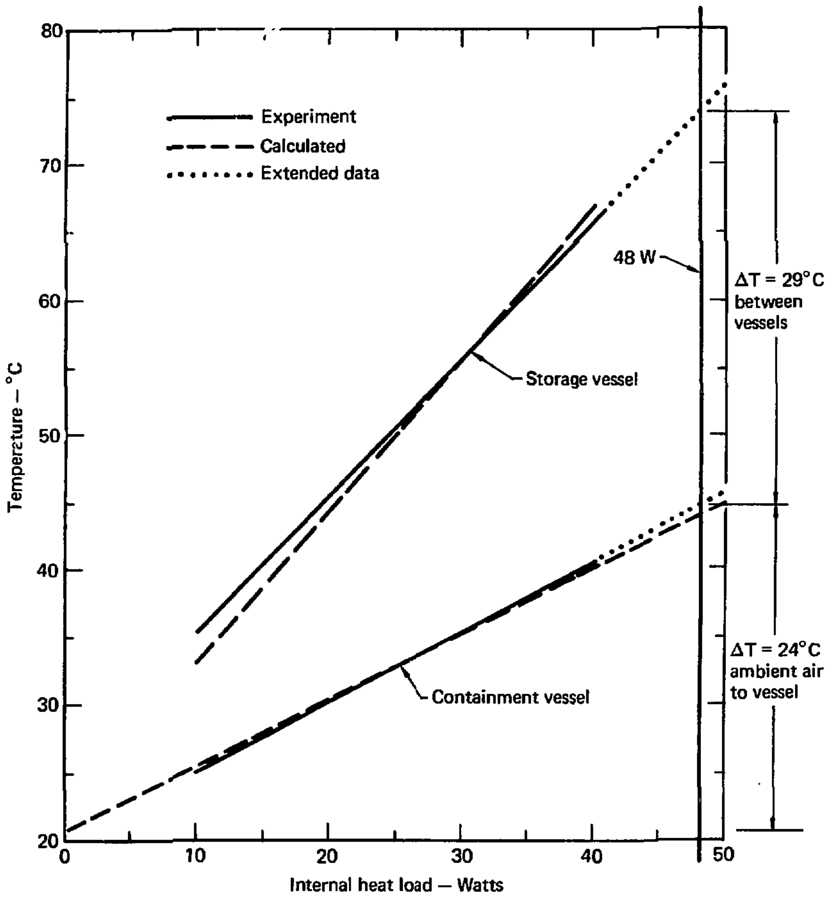


Fig. 21. Model UC-609 steady-state temperatures with constant 21°C boundary condition.

Figure 19 is the daily temperature fluctuation for both the containment and storage vessels with a 48-W heat load. The temperature cycles shown are calculated after three consecutive days in the sun and will repeat daily as long as the boundary conditions remain the same. The storage vessel curve is only for the case in which the tritium remains within that vessel and is included as information only.

Figure 20 shows the maximum daily temperatures for both vessels for internal heat loads from 0 to 50 W. As in Fig. 19, the maximum temperatures are achieved only after three consecutive days in the sun.

3.4.1.2 **Test Model.** We tested a prototype package identical to that described in Sec. 1.2.1 to determine the temperature distribution through the package at steady-state conditions under several internal heat loads with constant boundary conditions. The test was run as follows.

We attached a storage vessel containing a resistance wire to the vessel carrier. We installed the storage vessel in the containment vessel, which was in turn put in a Celotex-insulated drum. The volume inside the containment vessel was then filled with helium to 15 psia. We put the assembled package in a temperature-controlled room and applied electrical energy to the resistance wire. Thermocouples recorded the temperatures at numerous points throughout the package. Figure 21 compares the results of the test with computer calculations. The good agreement between the test data and the calculations shows that the thermal model is good and that the values used for conductivity through the Celotex and for convection between the two vessels are accurate.

3.4.2 Maximum Temperatures

Figure 19 shows that the maximum temperatures for normal transport condition are 76.0°C for the containment vessel with a 48-W heat load and 106°C for the storage vessel with the same heat load in the storage vessel.

3.4.3 Minimum Temperatures

The UC-609 package contains no materials harmfully affected by a temperature of –40°C.

3.4.4 Maximum Internal Pressure

Maximum initial gas contents of storage vessel	30 moles*
Measured volume of containment vessel	154 litres
Maximum initial pressure in containment vessel	1 atm at 0°C
Maximum temperature of containment vessel	76°C (349K)
Calculated volume of 120-lb aluminum (storage vessel + vessel carrier)	20.0 litres

If all the material in the storage vessel leaks into the containment vessel, the maximum pressure is calculated as follows:

$$P_{final} = P_{initial} + \frac{\text{Number of moles} \times \text{volume of 1 mole at standard temperature and pressure}}{\text{Volume of container} - \text{volume of contents}}$$

$$= 1 \text{ atm} + \frac{31.4 \text{ moles} \times 22.4 \text{ litres/mole}}{154 \text{ litres} - 20 \text{ litres}}$$

$$= 6.25 \text{ atm at } 0^{\circ}\text{C (273K)} .$$

$$P \text{ at } 76^{\circ}\text{C} = 6.25 \times \frac{349}{273} = 8 \text{ atm} \cong 118 \text{ psia} = 103 \text{ psig.}$$

3.4.5 Maximum Thermal Stress

The temperature differentials throughout the package are relatively small and will cause no significant thermal stresses. There is no rigid constraint among the steel, aluminum, and other packaging elements.

*Some of the tritium will decay into helium-3 within one year, thereby increasing the original 30 moles of material to 31.4 moles.

3.4.6 Evaluation of Package Performance

The package will not be affected by full sunlight and a temperature of 54°C, because the maximum temperature of the containment vessel will not exceed 76°C. It is well under the 120°C temperature that affects the Celotex and well within the temperature capabilities of the other package components. The minimum temperature of -40°C will produce no detrimental effects on the package. The containment materials are of the type that increase in strength and retain ductility at low temperature.

An internal pressure of 103 psig or an external pressure of 25 psig will not damage the containment vessel (see Secs. 2.5.2 and 2.6.1.4). Vibration and water spray will not affect the package (see Secs. 2.6.4 and 2.6.5).

Free drops and penetration will have no significant effect on the package (see Secs. 2.6.7 and 2.6.8). The compression test will produce no damage to the package (see Sec. 2.6.9).

3.5 Hypothetical Thermal Accident Evaluation

3.5.1 Thermal Model

3.5.1.1 Analytical Model. The maximum temperatures achieved during the fire are based entirely on experimental results.

3.5.1.2 Test Model. The model used for both the drop and thermal tests was identical to the packaging described in Sec. 1.2.1. A complete package was dropped on a flat unyielding surface and on a piston, then heated in a heat-treating furnace in the manner prescribed in Appendix B of 10 CFR 71. The furnace was heated to 1475°F (802°C). The package was inserted for 30 min, then removed and allowed to cool (Fig. 22).

The maximum temperatures that various points inside and outside the containment vessel reached were determined by the conditions of Tempilabels (manufactured by Tempil Corp. of New York, NY). The Tempilabels have indicator spots that permanently change color at specific temperatures. The color change occurs within 1% of the indicated temperature. Figure 23 shows Tempilabel installation inside containment vessel.

The package tested contained no radioactive materials. The containment vessel was pressurized to approximately 20 psia during both the drops and fire tests.

A separate test was performed to determine the effectiveness of the flange-to-copper-gasket seal when subjected to both pressure and temperatures. The cover and top end of one of the prototype containment vessels were heated to 121°C and pressurized internally with helium to 150 psig. The maximum leakage across the seal was 3.0×10^{-9} atm-cm ^{3}/s. The leak rate increased slowly with temperature and decreased to below the sensitivity of the mass spectrometer (5×10^{-11} atm-cm ^{3}/s/div) as the package cooled.

3.5.2 Package Conditions and Environment

The condition of the package during disassembly after the drops and fire tests is shown in Figs. 24-27. The 100-lb weight, which simulated the storage vessel, crushed the end piece of honeycomb slightly, dented the aluminum tube, and deformed the vessel carrier (see Figs. 25 and 26). The containment vessel shell was undamaged by any of the six drops. Before and after each drop the containment vessel was pressurized to 120 psia and the metal-to-metal seal leak-tested with a mass spectrometer leak detector. No leakage was observed on a leak detector with sensitivity in the 10^{-9} atm-cm ^{3}/s/div range.

The drop test did not significantly damage the Celotex and therefore was not detrimental to the container during the furnace test. Note in Figs. 24 and 27 the good (uncharred) Celotex adjacent to the containment vessel.

3.5.3 Package Temperature Calculations

Based on Tempilabel data, the maximum temperature reached by the UC-609 containment vessel in the furnace test was as follows, with no decay heat load:

Outer wall of vessel (5 places):	greater than 90°C, less than 104°C;
Aluminum tube lining vessel (2 places):	greater than 71°C, less than 77°C;
Mock storage vessel (1 place):	less than 66°C.

Note: The Tempilabel sensors change color at specific temperatures. The "greater than" temperatures are the highest value that changed color, and the "less than" temperatures are the next higher sensor that did not change.

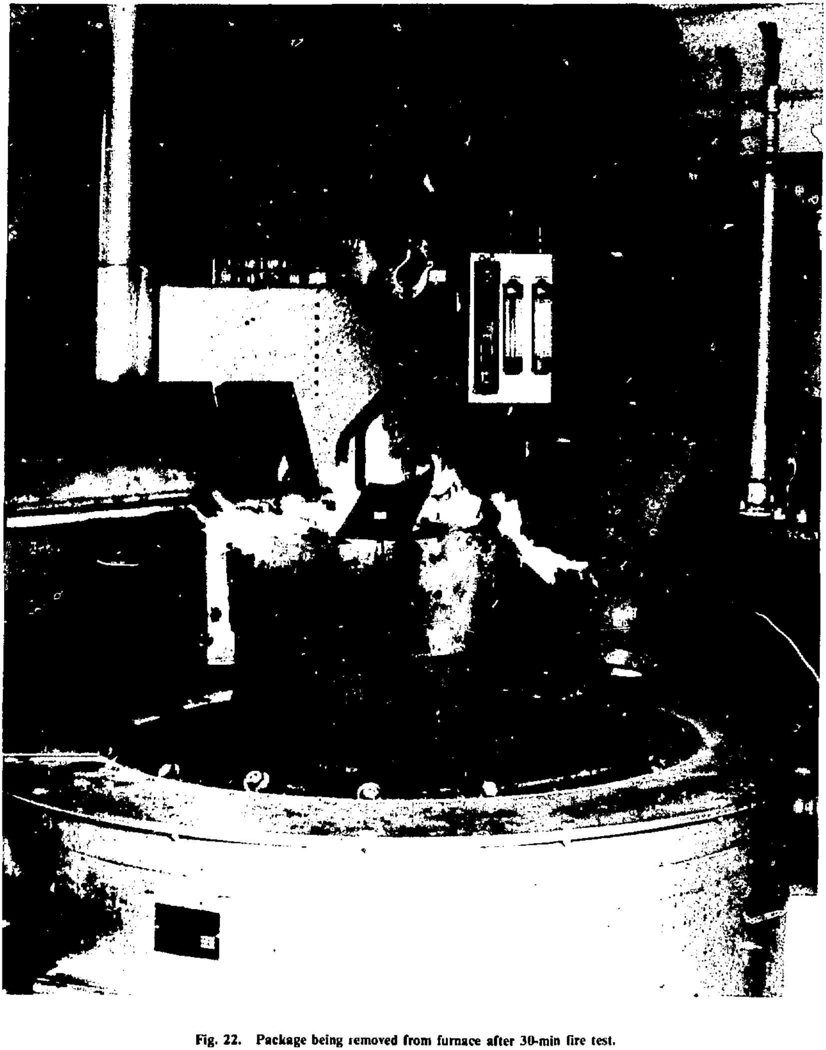


Fig. 22. Package being removed from furnace after 30-min fire test.

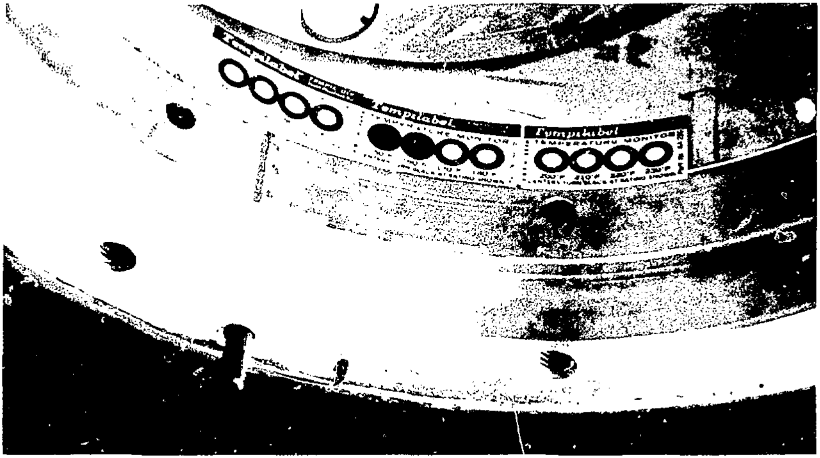


Fig. 23. Tempilabels inside containment vessel.

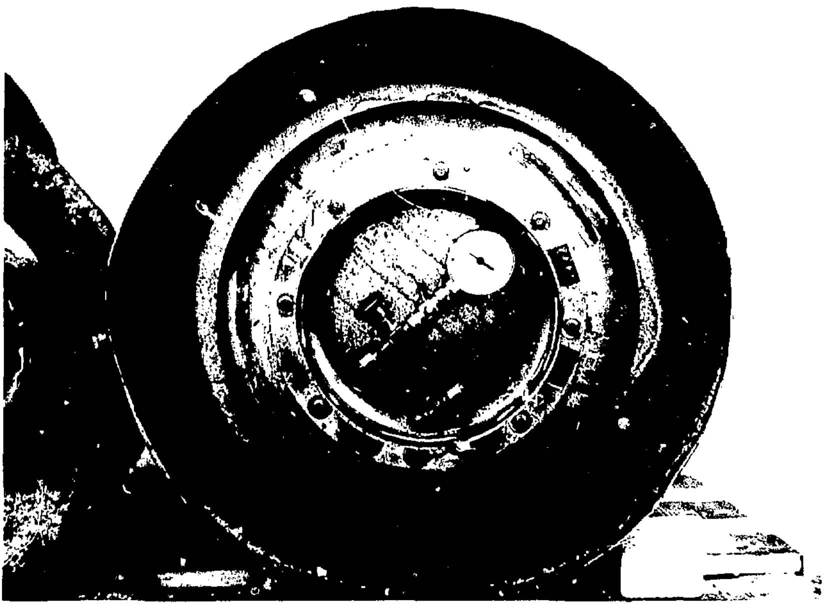


Fig. 24. Cover of containment vessel after drops and fire tests.

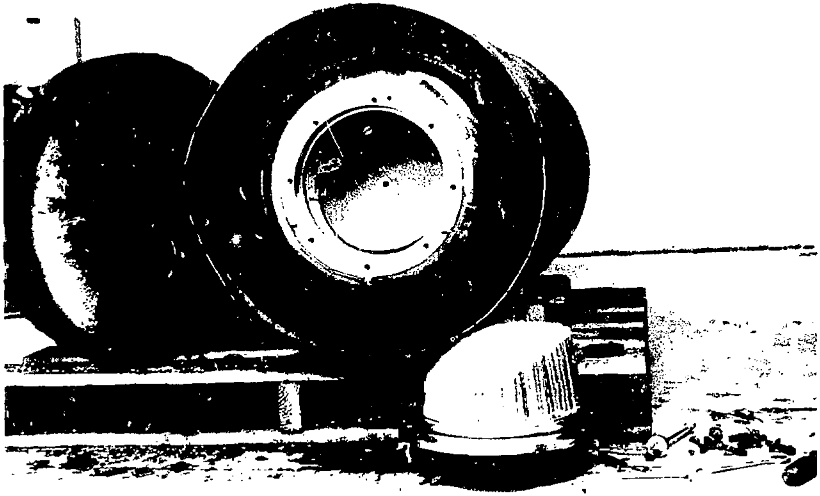


Fig. 24 Inside of containment vessel after drops and fire tests

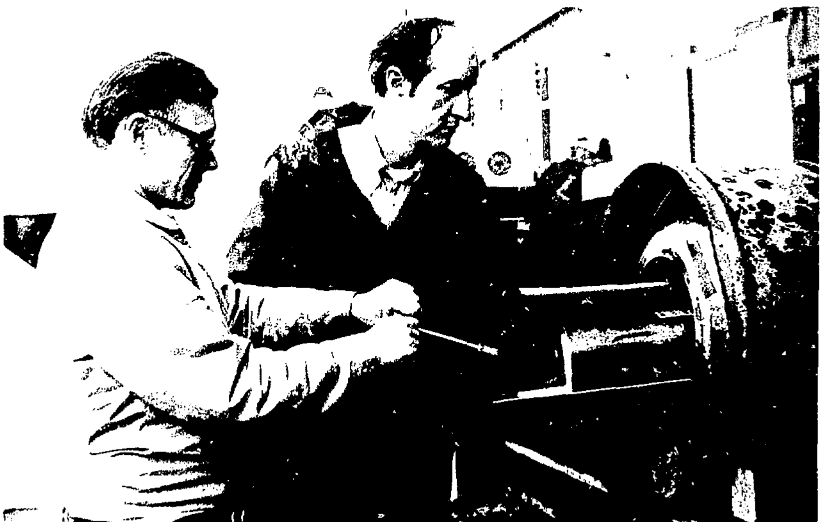


Fig. 26 Dummy vessel and carrier removal after drops and fire tests.

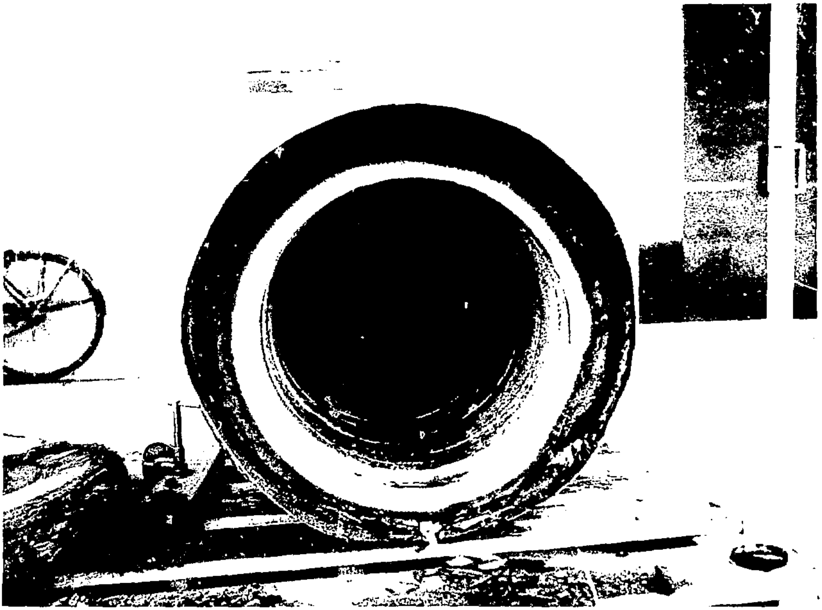


Fig. 27. Insulation condition after drops and fire tests.

The maximum temperature of the containment vessel and the storage vessel with the 48-W decay heat load can be calculated as follows:

3.5.3.1 **Containment Vessel** (Heat load in either storage vessel or containment vessel). The maximum temperature of the containment vessel is a sum of the following:

Assumed maximum ambient temperature before fire	38°C
Measured containment vessel temperature rise during fire (104°C − 25°C)	79°C
Measured temperature difference between ambient air and containment vessel (see Fig. 20 at 48 W)	24°C
Maximum temperature of containment vessel	141°C

3.5.3.2 **Storage Vessel** (Heat load in storage vessel). The maximum temperature of the storage vessel with the heat load in that vessel is the sum of the maximum temperature of the containment vessel, determined above, plus the measured temperature difference between the containment and storage vessels.

Maximum containment vessel temperature	141°C
Temperature difference between containment vessel and storage vessel (Fig. 20 at 48 W)	29°C
Maximum temperature of storage vessel	170°C

3.5.4 Maximum Internal Pressure

From Sec. 3.4.4, the maximum pressure within the containment vessel with 30 moles of gas at 0°C is 6.25 atm.

The containment vessels will be proof tested [illegible]

3.5.5 Maximum Thermal Stress

The temperature differential throughout the package is [illegible] and [illegible] stress. There is no rigid constraint between the stainless steel [illegible] the [illegible] [illegible]

3.5.6 Evaluation of Package Performance

The package evaluation indicates that it will withstand the accident conditions [illegible] of 10 CFR 71. The package was not significantly damaged during the free drop and [illegible] immersion test was not done because there is no fissile material in the package.

The greatest thermal effect is in the area of the seal made by the copper gasket. Because [illegible] thermal expansions of the copper, the stainless steel flanges, and the alloy steel bolts [illegible] of the sealing force on the gasket at 141 °C. The result is a small amount of leakage [illegible] *which stops when the container cools. This leakage rate is acceptable, especially [illegible]* seal is considered (see Sec. 4.3.2).

4.0 CONTAINMENT

4.1 Containment Boundary

The containment boundary for the [illegible] 609 package is the containment [illegible]

4.1.1 Containment Vessel

The containment vessel is a cylinder 18 in. (45.7 cm) o.d. × 40 in. [illegible] cm) thick type-316 stainless steel. The vessel is made by welding formed [illegible] rolled and welded cylinder. Access into the vessel is through a 10-in. (25.4 [illegible] one head. A cover assembly containing a mating flange closes the opening. All [illegible] welds made by the tungsten insert gas process.

4.1.2 Containment Penetration

The only penetration into the containment vessel is the valve gauge [illegible] assembly.

4.1.3 Seals and Welds

The integrity of the containment vessel is checked by a proof test at 200 psig [illegible] mediately after manufacture and every two years thereafter. The integrity of the [illegible] fill valve closure seal will be checked before each shipment at [illegible] the maximum [illegible] result if the contents of the storage vessel leaked into the containment vessel. Leak rates [illegible] atm-cm³/s will not be accepted.

4.1.4 Closure

The seal between the containment vessel and its cover is made by forcing [illegible] flanges into the opposite sides of a copper gasket. Eight 3/8-in.-diam alloy [illegible] maintain the seal during both normal and accident conditions of transport.

4.2 Requirements for Normal Conditions of Transport

Only superficial mechanical damage was sustained on similar packages when subjected to [illegible] normal conditions of transport (see Secs. 2.6.1 – 2.6.9 and 3.4).

4.2.1 Release of Radioactive Material

Gaseous tritium permeates the material of construction at rates dependent upon pressure, temperature, concentration, and other factors. Therefore, the requirement in 10 CFR 71.35 (a) (i) that there be no release from the containment vessel during normal conditions of transport is considered to be satisfied by compliance with International Atomic Energy Agency (IAEA) regulations, paragraph 230 (a). This regulation restricts the loss of contents to no more than Factor $A_2 \times 10^{-6}$/h.[15] Factor A_2 for tritium equals 1000 Ci (Ref. 15, Table VIII), and the permissible release is

$$(1000 \times 10^{-6}\ \text{Ci/h}) \times \left(\frac{1}{3600\ \text{s/h}}\right) \times \left(\frac{1}{2.57\ \text{Ci/cm}^3}\right) = 1.08 \times 10^{-7}\ \text{cm}^3/\text{s} \ .$$

4.2.1.1 Permeation through Stainless Steel. Steady-state permeation through the containment vessel wall is assumed to have been reached when

$$\left(\frac{Dt}{L^2}\right) = 0.45 \quad \text{(Ref. 16)} \ ,$$

where

t = time in s,
L = thickness of diffusion barrier = 0.317 cm (0.125 in.),
D = diffusion rate in cm ^{2}/s = $4.7 \times 10^{-3} e^{-(12900/RT)}$ (Ref. 17),
R = 1.987 cal/mole K,
T = temperature = 349K (76°C) (see Sec. 3.1.1).

The above relationship shows that the time to reach steady state is 10^4 days. Since the time for normal transport is considered to last not more than 30 days, the nonsteady-state situation applies. The flowrate through the container wall for very short times can be calculated using the following equation:

$$\ln F = \ln \left[2C_1 \left(\frac{D}{\pi t}\right)^{1/2}\right] - \frac{L^2}{4Dt} \quad \text{(Ref. 16)} \ ,$$

where

C_1 = surface concentration = $C\sqrt{P}$ atm-cm ^{3}/cm ^{3} (Ref. 17),
C = $1.28\, e^{-(1400/RT)}$ atm-cm ^{3}/atm $^{1/2}$-cm ^{3}
P = internal pressure = 8.0 atm, 118.0 psia (see Sec. 3.4.4),
T = 349K (see Sec. 3.1.1),
D = diffusion rate in cm ^{2}/s = $4.7 \times 10^{-3} e^{-(12900/RT)}$,
R = 1.987 cal/mole K,
L = thickness = 0.317 cm,
F = flowrate, atm-cm ^{3} of tritium (T_2)/s/cm ^{2}.

Using a containment vessel area of 1.8×10^4 cm ^{2} (a right circular cylinder 18 in. diam × 40 in. long), the flow through the vessel wall at 30 days is less than 10^{-100} atm-cm ^{3} T_2/s, which is far below the allowable 1.08×10^{-7} atm-cm ^{3} T_2/s. Therefore, there is no problem with permeation through the containment vessel walls during normal transport.

4.2.1.3 Permeation through Copper Gasket. Because permeation of tritium through copper is less than through stainless steel, and the area for permeation through copper is so much smaller, the diffusion through the gasket is too small to have an effect.

4.2.1.3 Total Release for Normal Transport. The total release during transport is the sum of permeation through the stainless steel and the copper gasket plus any leakage.

Permeation through stainless steel $< 1 \times 10^{-100}$ atm-cm ^{3} T_2/s

Permeation through copper gasket $<< 1 \times 10^{-100}$ atm-cm ^{3} T_2/s

Leakage past gasket (see Sec. 7.1) $< 1 \times 10^{-8}$ atm-cm ^{3} T_2/s

Leakage from total vessel (see Sec. 8.1.3) $< 1 \times 10^{-8}$ atm-cm ^{3} T_2/s

The total release from all the above is less than 2×10^{-8} atm-cm ^{3} T_2/s, which is less than the allowable 1.08×10^{-7} atm-cm ^{3} T_2/s; therefore, the normal transport mode is acceptable.

4.2.2 Pressurization of Containment Vessel

Although tritium decay produces two volumes of helium for each volume of tritium lost, the increase in pressure is negligible because of the short duration of a shipment (30 days or less).

The gases within the containment vessel cannot ignite or explode because no oxygen is present. The container volume is pumped out and backfilled with helium before each shipment.

4.2.3 Coolant Contamination

There is no coolant in the UC-609 package.

4.2.4 Coolant Loss

Not applicable.

4.3 Containment Requirements for the Hypothetical Accident Conditions

The performance of the package during the hypothetical accident tests is given in Secs. 2.7.1 – 2.7.5. The results indicate that the package can withstand the mechanical abuse and fire that these tests comprise.

4.3.1 *Fission Gas Products*

Not applicable. There are no fission gas products in this package.

4.3.2 Release of Contents

For purpose of analysis the accident conditions 141°C and 9.10 atm (see Secs. 3.5.3.1 and 3.5.4) are considered to exist for 12 h. (This is conservative because the regulations permit artificial cooling of the package after 3 h.) During and as a result of the hypothetical accident conditions, the regulations [10 CFR 71.36 (a) (2). ii] specify a maximum release of 10 Ci for Group IV radionuclides. No leak rates are specified for tritium in Group VII; however, tritium is also a Group IV material, so the Group IV leak rate is used.) The release rate required to lose 10 Ci in 12 h is 9×10^{-5} atm-cm ^{3} T_2/s.

4.3.2.1 Permeation through Stainless Steel. The time required to reach steady-state permeation through the containment vessel wall at a temperature of 141°C was found to be approximately 700 days. Since the time of concern is much shorter, we must do a short-time calculation as in Sec. 4.2.1.1. The flowrate then becomes less than 1.8×10^{-96} atm-cm ^{3} T_2/s after 12 h at 141°C.

4.3.2.2 Permeation through Copper Gasket. The permeation through the copper gasket is less than through the steel, so it is negligible in this case.

4.3.2.3 Total Release for Accident Conditions. For the accident condition, total release is the sum of all permeation and leaks.

Permeation through stainless steel $< 1 \times 10^{-95}$ atm-cm ^{3} T_2/s

Permeation through copper gasket $<< 1 \times 10^{-95}$ atm-cm ^{3} T_2/s

Leakage past gasket (see Sec. 7.1) $< 1 \times 10^{-8}$ atm-cm ^{3} T_2/s

Leakage total vessel (see Sec. 8.13) $< 1 \times 10^{-8}$ atm-cm ^{3} T_2/s

The total release from all of the above is less than 2×10^{-8} atm-cm ^{3} T_2/s, which is much less than the 9×10^{-5} atm-cm ^{3} T_2/s that is allowable. Therefore, the containment vessel meets the requirements for the assumed accident conditions.

5.0 SHIELDING EVALUATION

It is unnecessary to evaluate shielding for this package, since the radioactive material (tritium) is a weak beta emitter and gives off no penetrating radiation, and the resultant bremsstrahlung radiation is insignificant.

5.1 Discussion and Results

Not applicable.

5.2 Source Specification

Not applicable.

5.3 Model Specification

Not applicable.

5.4 Shielding Evaluation

Not applicable.

6.0 CRITICALITY EVALUATION

The radioactive material (tritium) in this package is not fissile. Therefore, nuclear criticality safety is of no concern in the shipment of this package.

6.1 Discussion and Results

Not applicable.

6.2 Package Fuel Loading

Not applicable.

6.3 Model Specification

Not applicable.

6.4 Criticality Calculations and Experiments

Not applicable.

6.5 Critical Benchmark Experiments

Not applicable.

7.0 OPERATING PROCEDURES

7.1 Procedure for Loading the Package

The model UC-609 package is loaded per END 77-21. An empty containment vessel is visually inspected for damage with special attention to assure that

- the internal cavity is clean and free of foreign material,
- the O-ring and metal gasket sealing surfaces are clean and undamaged,
- the valves and the gauge on the cover are in good condition.

A tritium-loaded storage vessel with a leak rate of less than 1×10^{-9} atm-cm ^{3}/s is mounted on the vessel carrier. That assembly is put into the containment vessel, and the cover is installed with a new copper gasket.

The containment vessel is evacuated, then pressurized with helium through the fill valve to a minimum of 1 1/2 times the pressure that would occur if the storage vessel vented into the containment vessel. (The maximum test pressure is 170 psia for a storage vessel containing 30 moles of gas.) A mass spectrometer leak detector is connected to the open leak-test valve, and the leak rate across the copper gasket is measured. To be acceptable, the leak rate must be less than 1×10^{-8} atm-cm ^{3}/s. Upon completion of the test, the pressure is vented to atmospheric and both valves are closed and capped. The valve caps and cover bolts have provisions for lockwire. Tamper seals may be installed if required for in-plant control.

The shipping drum is opened and inspected for significant defects or damage. The sealed containment vessel is then placed within the overpack, the insulation cover is installed, and the Cerablanket insulation is put in place. Finally the drum cover is installed. The cover is held on by eight special brackets, which are secured by eight bolts. Two of the cover retaining bolts are sealed with tamper seals. After attachment of the necessary labels, the sealed overpack is ready for shipment.

7.2 Procedure for Unloading the Package

After monitoring the exterior of the package for radioactivity, the seals on the lid retaining bolts are broken and the lid and insulation cover are removed. A sample of the gas within the container is monitored by metering through the fill valve. When the gas is ascertained to be "clean," the bolts can be removed and the cover lifted. Removal of the storage vessel from the carrier completes the unloading procedure.

7.3 Preparation of an Empty Package for Transport

No special procedures are required to prepare an empty model UC-609 package for transport. Any container that becomes radioactively contaminated will be removed from service.

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

8.1 Acceptance Tests

8.1.1 Visual Inspection

Upon receipt, the containment vessel will be inspected for bulges, dents, mars, or other obvious defects. The shipping packaging will be inspected for obvious damage such as cracks or voids in the insulation or damage to the drum. The acceptance criteria for the various components and assemblies that make up the package are specified on the applicable fabrication drawings. Noncomplying parts are to be rejected for rework or replacement.

8.1.2 Structural and Pressure Tests

Each containment vessel is to be proof tested at 200 psig with helium for a minimum of 4 h before its first use and every 2 years thereafter. Before each shipment, the container is proof tested at 1.5 times the maximum pressure possible during the shipment.

8.1.3 Leak Testing

Each containment vessel will be leak tested with helium before its first usage at 150 psig. Maximum leakage allowable is less than 1×10^{-8} atm-cm ^{3}/s.

Before each shipment, the primary seal will be leak tested at 1.5 times the maximum pressure that could occur during the shipment. Maximum leakage allowable is less than 1×10^{-8} atm-cm ^{3}/s.

8.1.4 Component Tests

8.1.4.1 Valves. The valves on the containment vessel cover will be checked for leakage during shipping preparations (see Secs. 7.1 and 8.1.3).

To qualify the fill and leak-test valves for usage at temperature, three of each were pressurized to 105 psig at 121°C. No leakage was detected on a mass spectrometer with a sensitivity of 1.9×10^{-11} atm-cm ^{3}/s/div.

8.1.4.2 Gaskets. The primary and secondary cover seals will be tested prior to each use by vacuum and pressure tests (see Secs. 7.1 and 8.1.3).

To qualify the primary and secondary seals at temperature, the following test was run. The cover area of a prototype containment vessel was heated to 121°C and then pressurized to 150 psig. A maximum leakage of 3.1×10^{-9} atm-cm ^{3}/s was observed across the primary seal. This leak stopped as the temperature decreased. The secondary seal held the vacuum required for the use of a mass spectrometer. The above leakage can be tolerated (see Sec. 4.2.2).

8.1.4.3 Miscellaneous. The bourdon tube gauge that is part of the fill valve manifold will be leak tested before each shipment in the same manner as the valves and gaskets. The high-temperature test of the gaskets described in Sec. 8.1.4.2 included the valves and the gauge that are on the containment vessel cover. No leakage from either the gauge or the valves was found.

8.1.5 Test for Shielding Integrity

Not applicable.

8.1.6 Thermal Acceptance Test

The thickness and condition of the Celotex insulation will be checked as the packages are received. No further testing is necessary, based on results found during development of this packaging.[8]

8.2 Maintenance Program

8.2.1 Structural and Pressure Tests

The containment vessels are to be pressure tested prior to each shipment (see Sec. 8.1.3). The pressure is measured on a Heise gauge, which is accurate to ± 1 psi.

8.2.2 Leak Tests

The containment vessel will be leak tested at the same time it is pressure tested prior to each shipment. The sensitivity of the tests is the sensitivity of a mass spectrometer leak detector, typically between 1×10^{-10} and 1×10^{-9} atm-cm ^{3}/s.

8.2.3 Subsystems Maintenance

Not applicable. There are no subsystems requiring periodic maintenance.

8.2.4 Valves, Rupture Disks, and Gaskets on Containment Vessel

The valves will be tested before each usage and replaced as necessary. A new copper gasket is to be used for each shipment. The O-ring will be inspected before each use and replaced as necessary.

8.2.5 Shielding

Not applicable.

8.2.6 Thermal

The insulation and drum are to be inspected for moisture, voids, or cracks prior to loading the containment vessel into the package. Damaged items will not be used for shipment.

8.2.7 Miscellaneous

The containment vessel is to be retested at 200 psig every two years.

9.0 QUALITY ASSURANCE REQUIREMENTS

9.1 General Information

The quality assurance functions for the UC-609 package are the inspection tests and certifications that are required during fabrication and over the entire life of the package (see Fig. 28).

The most important criterion that the package must meet if it is to operate safely and successfully is that the containment vessel be leaktight and structurally sound. That criterion is met as follows:

- The drawings require that the manfacturer provide certification of the materials used for structural components. That certification along with the dimensional inspection data is reviewed by the project engineer before the components can be used in assemblies. Reference: END 77-20, Components Inspection Form.
- Structural welds are made and inspected per the requirements of the ASME *Pressure Vessel Code*. The nondestructive test reports plus other assembly data is reviewed by the project engineer before a package is released for use. Reference: END 77-19, Assembly and Fabrication Record.
- Every completed containment vessel is pressure tested at 200 psig and leak tested at 150 psig before the first usage and every two years thereafter. Reference: END 77-914, Containment Vessel Safety Note.
- Before each shipment the copper gasket seal is leak tested at 1.5 times the maximum pressure that would occur if all the gas in the shipment were released into the containment vessel. Reference: END 77-21, Packing and Test Procedure.

A second important criterion for successful operation is that the package not deteriorate with use. That criterion is achieved as follows:

- All structural parts that may come in contact with hydrogen during shipping are made from materials that are not affected by hydrogen (type-316 stainless steel and oxygen-free, high-conductivity copper).
- Before each shipment, the entire package is completely inspected and any damaged or nonconforming components are replaced. References: END 77-21, Packing and Test Procedure; END 77-22, Packing Check List.
- Every two years the containment vessel is completely inspected and pressure tested by a group completely independent of the users.

The third important criterion for successful use is that the package must be used correctly and within the design limits that have been approved. This is accomplished by having all packing, testing, and maintenance operations performed according to written procedures with a check list that covers each step of the procedure. All operations are performed by trained technicians. A qualified professional (engineer, chemist, health physicist, etc.) inspects and approves all work.

9.2 Organization

Mechanical Engineering Department management is responsible for quality assurance of the UC-609 package at LLL. Quality assurance is an integral part of the design-fabrication-operational system in each working engineering group at LLL. This system also includes an independent check at all organizational levels.

Personnel in the various groups shown on the organization chart (Fig. 29) have been trained and have acquired expertise in their respective fields.

Fabrication, shipping, and testing operations are performed with approved procedures.

9.3 Quality Assurance Program

9.3.1 Procedures

The fabrication and testing of the UC-609 shipping package is covered by a written procedure. Reference: END 77-16, Fabrication Specification. Quality assurance is also incorporated into the operating and maintenance procedures.

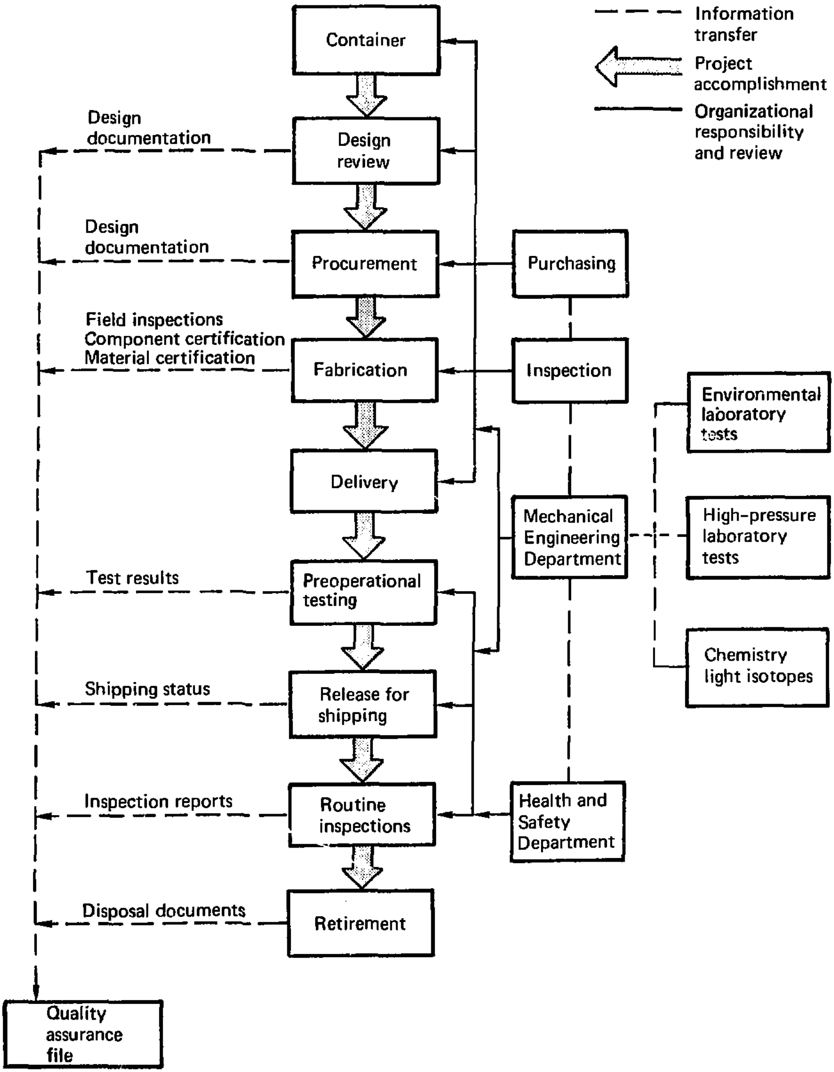


Fig. 28. Inspection tests and certificates required by quality assurance program for UC-609 package.

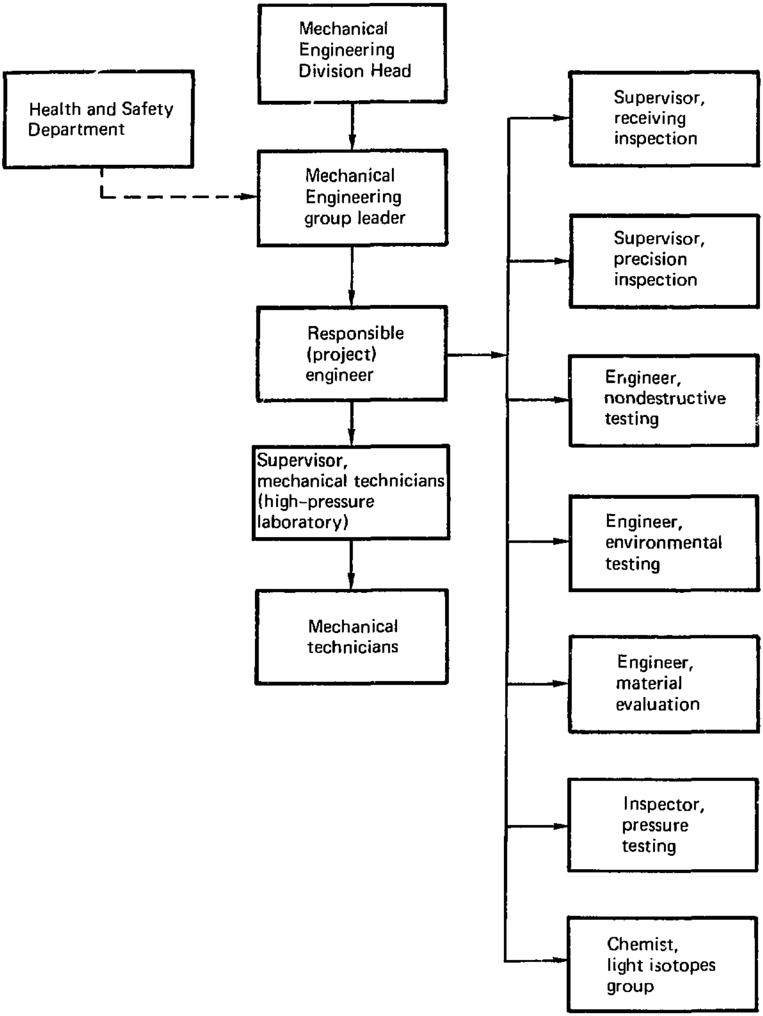


Fig. 29. Organization chart for LLL Mechanical Engineering Department.

9.3.2 Approvals

Quality assurance functions are incorporated into the fabrication and operating procedures. The procedures are reviewed and approved by the engineering group leader.

9.3.3 Safety-Related Items

Safety-related or "Q items" are the containment vessel, the insulation, and the shipping drums. The "non-Q item" is the storage vessel.

9.3.4 Training

The mechanical technicians that will perform the various operations involved in fabricating, testing, and shipping are trained by mechanical engineers using approved procedures.

9.4 Design Review

The UC-609 shipping package has been independently reviewed by the Separations and the Separations Technology Departments of the Savannah River Plant of E. I. duPont de Nemours and Co.

9.5 Procurement Document Control

The component and assembly drawings are the procurement documents that specify the minimum acceptable quality.

9.6 Instruction, Procedures, and Drawings

All fabrication, testing, shipping, and maintenance are performed in accordance with written procedures. Activities that affect the quality of a shipment are certified on "use every time" procedures or certification sheets.

Refer to Ch. 7.0, Operating Procedures, for specific information relating to procedures governing activities with this packaging.

9.7 Document Control

Operating procedures and drawings are given an independent review by the engineering group supervisor and by the technician group supervisor. The reviewers thoroughly understand that quality assurance is an integral part of the design, construction, and operations at LLL.

Documents to be controlled are LLL drawings and procedures. Drawing and procedure changes must be approved by the engineering group leader. It is his responsibility to verify that any proposed change will not violate the substance of the Safety Analysis Report on Packaging. The Mechanical Engineering Department records section maintains a file of the latest revisions. The master files reflect the latest revisions and is updated as soon as changes are released. Newly revised copies of documents are issued to the appropriate groups as soon as released.

9.8 Control of Purchased Material, Equipment Parts, and Services

The drawings require that fabricators provide mill test reports for the critical materials used. At LLL, dimensional inspections and radiographic examinations are made. Only after the above data have been reviewed and approved by the project engineer are the parts tagged and stored for use in a secure, limited-access storage area. The results of these inspections will be included in the quality assurance record file.

9.9 Identification and Control of Materials, Parts, and Components

Verification of material and identification of parts for use on the UC-609 shipping package are discussed in Sec. 9.8.

9.10 Control of Special Processes

The welding on the containment vessel is controlled by visual and radiographic inspections. All welding must meet the requirements of the ASME *Boiler and Pressure Vessel Code*, Sec. VIII, paragraph UW-51. Radiographic inspections will be made by LLL by qualified personnel in the nondestructive test section of Mechanical Engineering Department.

9.11 Inspection

Each lot of parts will be inspected and the inspection results reviewed before the parts are released for use. See Sec. 9.7.

9.12 Test Control

9.12.1 Preoperational Test Program

The only preoperational tests required for the UC-609 shipping package are the proof test and the leak test of the containment vessel. That testing will be accomplished using written test procedures that have been approved by engineering supervision. The tests will be performed at LLL by high-pressure technicians and observed by a pressure inspector. The project engineer must review and certify that the test results meet the requirements before the container can be used.

9.12.2 Acceptance Tests and Maintenance Program

See Secs. 8.2.1 and 8.2.2 for discussion.

9.13 Control of Measuring and Test Equipment

9.13.1 Calibration

Standard helium leaks used in calibrating mass spectrometer leak detectors are purchased from reputable manufacturers who certify the leak rate of each unit.

9.13.2 Standards

The Heise gauges used to pressurize the containment vessel are periodically calibrated on dead-weight testers.

9.14 Handling, Storage, and Shipping

Written operating procedures in Ch. 7 cover the handling and storage of UC-609 packaging components.

Shipment of UC-609 packages will comply with U.S. Department of Energy and Department of Transportation requirements. On receipt, all packaging is visually inspected for obvious damage.

9.15 Inspection, Test, and Operational Status

The status of each UC-609 package is maintained by a procedure which outlines and records each required step in the preparation of a package for shipment. See Ch. 7.

A tag indicating that the containment vessel has been successfully proof tested and leak tested is attached by the pressure inspector. The packaging is not complex, and its status is determined per Ch. 7 and 8.

9.16 Nonconforming Materials, Parts, or Components

9.16.1 Disposition

Nonconforming packaging will be tagged, removed from service as soon as it is identified, and replaced with a spare. The nonconforming packaging, if repaired, will be repaired using an approved procedure and standard maintenance techniques.

9.16.2 Acceptance

Inspections of packaging at the vendor's shop or upon receipt may result in rejection of material.

9.17 Corrective Action

Nonconforming packaging may be repaired by the vendor or by LLL, depending on the cost and payment allocations made between the purchasing department and the vendor. Repairs are to be made using approved procedures.

9.18 Quality Assurance Records

The records for the UC-609 containment package will be kept on permanent file at LLL.

9.19 Audits

LLL Materials Management will make annual audits to determine if the packaging is being used in an approved manner.

REFERENCES

1. American Society of Mechanical Engineers, *Boiler and Pressure Vessel Code* (American Society of Mechanical Engineers, New York, 1974), Sec. VIII, Div. 1.
2. L. A. Sturtevant, *Torque Manual* (P. A. Sturtevant Co., Addison, IL), pp. 33-41.
3. *Mechanical Properties of Hexcel Honeycomb Materials*, Document No. TSB 120 (Hexcel Corporation, Dublin, CA, 1974), p. 16.
4. A. A. Gates and P. G. McCarthy, *Safety Analysis Report — Packages, JP157S Packages*, Savannah River Plant, Aiken, SC, Rept. DPSPWD 76-124-2 (title U, report SRD) (1976), pp. 1-3.
5. H. A. Rothbart, *Mechanical Design and Systems Handbook* (McGraw-Hill Book Co., New York, 1964), Table 20.2, p. 20-7.
6. M. S. Burger, *General Purpose Shipping Container Stress Analysis*, Lawrence Livermore Laboratory, Rept. END 77-10 (1977).
7. *Environmental Test Methods*, U.S. Department of Defense, Rept. MIL-STD-810C (Fig. 514.2-7, p. 514.2.40; Table 514.2-VII, p. 514.2-39).
8. R. C. Lum, *Thermal Conductivity of Celotex*, Lawrence Livermore Laboratory, Job No. 240388 (1975).
9. D. Ornellas, private communication (1978).
10. J. P. Holman, *Heat Transfer* (McGraw-Hill Book Co., New York, 1968), 2nd ed., pp. 199, 385.
11. G. C. Schaack and D. A. Schauer, *Thermal Study of Tritium Transfer Container*, Lawrence Livermore Laboratory, Rept. END 77-15 (1977).
12. F. Krieth, *Principles of Heat Transfer* (International Textbook Co., Scranton, PA, 1962) pp. 217-226.
13. D. A. Schauer, *FED — A Computer Program to Generate Geometric Input for the Heat Transfer Code TRUMP*, Lawrence Livermore Laboratory, Rept. UCRL-50816, Rev. 1 (1973).
14. A. L. Edwards, *TRUMP — A Computer Program for Transient and Steady-State Temperature Distribution in Multidimensional Systems*, Lawrence Livermore Laboratory, Rept. UCRL-14754, Rev. 2 (1969).
15. International Atomic Energy Agency, *Regulations for the Safe Transportation of Radioactive Materials*, Safety Series No. 6, Rev. ed. (1973).
16. J. Crank, *Mathematics of Diffusion*, 2nd ed. (Clarendon Press, Oxford, 1975), pp. 51-52.
17. M. R. Loutham and R. G. Derrick, *Hydrogen Transport in Austenitic Stainless Steel*, Savannah River Plant, Aiken, SC, Rept. DP-MS-73-10 (1973).

RW

APPENDIX A: ENGINEERING NOTES

LAWRENCE LIVERMORE LABORATORY · UNIVERSITY OF CALIFORNIA

ENGINEERING NOTE

	FILE NO.	PAGE
SUBJECT	END 77-16	
	NAME	
	DATE July 7, 1977	

UC-609 SHIPPING CONTAINER

FABRICATION SPECIFICATION

by

Ronald R. Sandberg

Approved by: D C Holton

LL-388 (REV. 8/71)

1.0 SCOPE

This specification covers the fabrication, inspection, examination, and testing of Model UC-609 shipping containers. The container shall be manufactured in accordance with the listed drawings and the requirements of this specification.

2.0 APPLICABLE DOCUMENTS

2.1 *Assembly Drawings*

Title	Number
Model UC-609 Shipping Container	AAA76-109771
Vessel Assembly	AAA75-113083
Leak Test Assembly	AAA75-113967
Cover Assembly	AAA77-102165
Insulation Cover Assembly	AAA77-104161
Insulation, Body	AAA77-104163
Drum Assembly	AAA77-104165
Vessel Carrier Assembly	AAA75-112930

2.2 Sub-Assembly and Detail Drawings

Gasket	AAA75-108816
Liner Honeycomb Assembly	AAA77-103369
Containment Vessel Liner	AAA75-113591
Honeycomb Segment	AAA77-103389
Honeycomb Plug	AAA75-111105
Head to Cylinder Weldment	AAA75-111306

2.2 cont'd

Top Head	AAA75-104814
Semi-Elliptical Head	AAA75-113082
Cover Machined and Welded	AAA75-104817
Plug Backing Plate	AAA77-102164
Fill Valve Assembly	AAA76-106629
Nupro Valve Mod.	AAA76-106627
Weld Tee (Rework)	AAA76-106619
Plug (Reworked)	AAA76-106618
Leak Test Valve Assembly	AAA76-106616
Hoke Valve (Rework)	AAA76-106617
Insulation Cover	AAA77-104164
Heat Shield	AAA77-104162
End Flange	AAA75-112931
Mounting Plate	AAA75-104815
Brace	AAA75-112928
Spacer Block	AAA76-118323
Identification Plate	AAA77-104603
Bracket - Drum Cover	AAA76-115288
Handle Assembly	AAA77-101635

2.3 Documents

Model	UC-609	Pressure Test Report	END 77-18
"	"	Assembly Fab. Record	END 77-19
"	"	Component Inspect. Form	END 77-20
"	"	Packing & Test Procedure	END 77-21
"	"	Packing Check List	END 77-22
"	"	Safety Note	END 77-914

3.0 MATERIAL

All materials used in fabricating the containment package must be certified by the supplier as meeting the drawing requirements. Where required by the drawings, a mill test report shall be provided. The mill test report shall include the ASTM specification number, Type, grade, finish, manufacturers name, the heat number, and the results of chemical analysis and mechanical properties tests.

4.0 WELDING

Welding shall be done using methods and materials specified on the applicable drawings.

4.1 Fitting and Alignment

Edges to be welded shall be uniform and free of foreign materials. Parts to be welded shall be fitted, aligned, and retained in position during the welding operation so that the full penetration required by the drawings is obtained.

4.2 Cleaning of Surfaces to be Welded

Surfaces to be welded shall be free of foreign materials such as grease, oil lubricants, and marking paints.

4.3 Repair of Weld Defects

Visible defects such as cracks, pinholes, and incomplete fusion, as well as defects that can only be detected by prescribed examinations or tests, shall be removed. Then the joint shall be rewelded. The repaired weld shall be retested as required of the original weld and to be acceptable must meet the quality requirements of the original weld.

5.0 INSPECTION AND TEST CERTIFICATION

A component inspection form (END 77-20) and/or an assembly fabrication record (END 77-19) must be completed for each lot of components or assemblies. (A lot is defined as a series of parts/assemblies made from one drawing at the same time.) Each completed inspection document must be reviewed and signed by the engineer responsible for directing the fabrication of the containers before the parts are released for use. Non-conforming parts are to be returned to the supplier for rework or replacement as required.

The acceptance proof and leak test must be documented by the completion of a pressure test report (END 77-18). The pressure test report must contain the signature of the responsible engineer before the parts are released for use.

6.0 RECORDS

A permanent QA file shall be started and maintained for each container manufactured. As a minimum that file must contain:

1. Results of acceptance inspections (END 77-19, END 77-20)
2. Proof and Leak Test Certifications (END 77-18)
3. Records of periodic inspections and retests
4. Use record copies of packing check lists (END 77-22)
5. Records of any rework or component replacement.
6. Weld radiography records.

TITLE:	FILE NO. END 77-18	PAGE 1
MODEL UC-609 SHIPPING CONTAINER PRESSURE TEST REPORT	WRITTEN BY R. Sandberg	DATE 7/5/77
	CHECKED BY J C Holton	DATE 4/6/78

Reference: Drawing AAA75-113967, Safety Note END 77-914

Container Serial No.____________________

1. Sensitivity of mass spectrometer:

   ____________atm cc/s/div. (hand probe)

   ____________atm cc/s/div. (integrated leak test)

   Standard Leak No.__________________

   with a leak rate of________________

2. Proof pressure ___________psig for ______________hr

3. Leak test pressure __________________psig

4. Leak rates:

   Across Cu gasket _____________________atm cc/s

   External ____________________________atm cc/s

   (total must be less than 2 x 10^{-8} atm cc/s)

Tested by_______________________________Date____________________

Inspector: Pressure tested label applied:

_______________________________Date____________________

Approved for use__________________________Date____________________

TITLE:	FILE NO. END 77-19	PAGE 1
MODEL UC-609 SHIPPING CONTAINER ASSEMBLY FABRICATION RECORD	WRITTEN BY R. Sandberg	DATE 7/5/77
	CHECKED BY SC Holton	DATE 4/6/78

Assembly ______________________ Drawing No. ______________________

Lot No. ______________________ Size of Lot ______________________

List Serial Nos. ______________________

Supplier ______________________

LLL P.O. No. ______________________ Cost $ ____________ each

ITEM	SPECIFICATION	REMARKS
1	Component parts inspected and approved for use (attach inspection forms END77-20)	
2	___% of assemblies inspected for dimensional compliance	
3	General comments on workmanship and quality of assemblies	
4	Acceptable assemblies tagged with LLL P.C. No. and Lot No.	

Inspection: Accepted ______________________ Date ____________

N.D. Tests Accepted ______________________ Date ____________

______________________ Date ____________

Approved for use ______________________ Date ____________

TITLE:	FILE NO.		PAGE
MODEL UC-609 SHIPPING CONTAINER COMPONENT INSPECTION FORM	END 77-20		1
	WRITTEN BY R. Sandberg	DATE 7/5/77	
	CHECKED BY D C Holler	DATE 4/6/78	

Part__________ Drawing No.__________

Lot No.__________ Size of Lot__________

List Serial Nos.__________

Supplier__________

LLL P.O. No.__________ Cost $__________ each

ITEM	SPECIFICATION	REMARKS
1	Material - meets drawing requirements, certification attached	
2	___% of parts inspected for dimensional compliance. Summary attached.	
3	General comments on workmanship and quality of parts	
4	Acceptable parts tagged with LLL P.O. No. and Lot No.	

Inspection: Accepted__________ Date__________

N.D. Tests Accepted __________ Date__________

__________ Date__________

Approved for use __________ Date__________

LAWRENCE RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA

ENGINEERING NOTE

SUBJECT	FILE NO. END 77-21	PAGE 1
	NAME R. Sandberg	
	DATE July 5, 1977	

MODEL UC-609 SHIPPING CONTAINER

PACKING & TEST PROCEDURE

BY

RON SANDBERG

July 5, 1977

Approved by: [signature]

RS:jm

RL-398 (Rev.4/57)

SUBJECT: MODEL UC-609 SHIPPING CONTAINER PACKING & TEST PROCEDURE

NAME: R. Sandberg

DATE: July 5, 1977

Reference assembly drawing AAA76-109771.

1. Packing check list END 77-22 to be completed by individuals assembling container for shipment.
2. Mount storage vessel on vessel carrier per users written procedure. Record pertinent information about storage vessel on check list.
3. Inspect interior of containment vessel, seal areas of flanges, and cover valves for cleanliness and damage. Clean or replace parts as required.
4. Inspect "O" ring and copper gasket for nicks, cuts, scratches, etc. (A new copper gasket is to be used for each shipment.) Coat "O" ring with a light film of silicone vacuum grease.
5. Install vessel carrier into container. Use care to avoid damaging sealing surface on flange.
6. Verify that the rubber pads on the container cover are compressed a minimum of 0.06 inches when the cover is in place. Add additional pads if necessary.
7. Install and torque cover bolts as follows:
   A. Verify that bolts meet drawing requirements. (170,000 psi min. ult tensil str.)
   B. Coat bolt threads and under-side of heads with "Kopr-Kote".
   C. Torque bolts in order stamped next to holes to 20 Ft - Lb. Go around pattern twice.
   D. Increase torque to 45 Ft - Lb. Go around pattern until no bolt movement is observed.

8. Leak test container as follows:
   A. Evacuate the container volume (through the fill valve) to less than 150 Torr (3 psia).
   B. Pressurize through the fill valve with helium to the pressure determined from the table on page 5. Close the fill valve.
   C. Determine the sensitivity of a mass spectrometer leak detector with a standard leak.
   D. Connect the leak detector to the open leak check valve and to the closed fill valve. Measure leakage across gasket and across fill valve seat.
   E. Vent pressure to atmospheric.
   F. Close both valves, and cap fittings.
9. If required for in plant control install tamper seals on cover bolts and on valves.
10. Inspect celotex insulation, drum, drum cover and drum cover brackets for damage. Replace parts as necessary. Remove any old shipping labels.
11. Verify that plastic plugs are in place in drum cover.
12. Install container into insulating overpack. Use enough ½ inch thick ceroblanket disks on top of the insulation cover so that approximately 100 pounds force must be applied to the cover to engage the cover brackets.
13. Torque bolts securing drum cover to 20 ft.-lb. and install tamper seals on two bolts 180^0 apart.
14. Monitor package for contamination: must be less than 150 d/m/100 cm^2 beta-gamma.

15. Install appropriate labels in conformance with DOT regulations. Also attach tag identifying shipment.

16.

MODEL UC-609 SHIPPING CONTAINER
TABLE OF PRESSURES & TEMP. FOR VARIOUS QUANTITIES OF GAS

Quantity of gas moles (1)	Decay heat load watts	Containment vessel Temp (2)		Pressure (psia) (3)	
		°C	°K	Equilibrium	Test (4)
2	3.8	54.8	327.8	23.5	35.5
4	7.7	56.7	329.7	29.6	45
6	11.5	58.5	331.5	35.7	54
8	15.4	60.4	333.4	41.9	63
10	19.2	62.2	335.2	48.2	73
12	23.0	64.0	337.0	54.5	82
14	26.9	65.9	338.9	60.9	92
16	30.7	67.7	340.7	67.4	102
18	34.6	69.6	342.6	73.9	111
20	38.4	71.4	344.4	80.5	121
22	42.2	73.2	346.2	87.2	131
24	46.1	75.1	348.1	93.9	141
25	48.0	76.0	349.0	97.3	146
26	48.0	76.0	349.0	100.5	151
28	48.0	76.0	349.0	106.8	161
30	48.0	76.0	349.0	113	170

Notes:

(1) Gas is considered to be 100% tritium up to 25 moles of gas. For quantities greater than 25 moles the amount over 25 moles is considered to have no decay heat load.

(2) Temperatures are the maximums for "normal" conditions of transport.

(3) Equilibrium pressure is calculated as if all of the gas in the shipment were within the containment vessel at the listed temperature. The following equation was used:

$$P = 1 + \left[\frac{N\,(22.4)}{134^*}\right] \frac{T}{273}\ (14.7)$$

where N = Number of Moles of Material

T = Max. Temp. For Normal Transport

* 134 = Net Volume of Containment Vessel with 20 litre Storage vessel & carrier inside. (120 lb total - Aluminum)

(4) Test pressure is 1.5 times the equilibrium pressure.

TITLE: Model UC-609 Shipping Container Packing Check List	FILE NO. END 77-22	PAGE 1
	WRITTEN BY R. Sandberg	DATE 7/6/77
	CHECKED BY D C Notten	DATE 4/6/78

Reference: Dwg. AAA76-109771, Procedure END 77-21

Container Serial No.____________________

Storage Vessel:

Serial No.______________ Dwg. No.______________

Contents______________g moles ($\leq$25 g moles T_2, $\leq$30 g moles total)

Leak rate______________ ($<1 \times 10^{-9}$ atm cc/s)

Weight______________ ($\leq$100 pounds)

Certified by____________________________date__________

Item	Specification		Remarks
1	Storage vessel mounted to vessel carrier per users written procedure (Attach signed copy)		
2	Interior of container, flanges, and valves clean and free of defects: Record Retest Date		
3	"O" Ring and new copper gasket inspected. "O" Ring coated with vac grease		
4	Rubber pads on cover compressed against vessel carrier a minimum of 0.06 inch when the cover is in place		
5	Cover bolts: Use certified parts only from bonded storage.		
6	Cover bolts torqued to 45 ft-lb		
7	Pressure Test: a) Container evacuated to less than 150 torr Actual Pressure ________ torr b) Pressurized to ________ psia (see END 77-21 Table on Page 5		

TITLE:	FILE NO.		PAGE
Model UC-609 Shipping Container Packing Check List	END 77-22		2
	WRITTEN BY R. Sandberg	DATE 7/6/77	
	CHECKED BY	DATE	

Item	Specification		Remarks
7 cont'd	c) Sensitivity of leak detector: __________ atm cc/s/Div. Standard leak No.__________ Leak rate __________ d) Leak rate: Across gasket__________ Across fill valve seat_____ (Must be less than 1×10^{-8} atm/cc/s total) e) Container vented to atmospheric pressure, valves closed, and fittings capped		
8	Tamper seals on cover if required: Record Locations: Record No's. if Applicable:		
9	Drum, Celotex, and drum closure brackets inspected. Plastic plugs in place in drum cover		
10	Ceroblanket disks in place on top of insulation cover		
11	Bolts on drum cover brackets torqued to 20 ft-lb		
12	Tamper seals on two cover securing bolts 180° apart. Record No's. if Applicable._____		
13	Package monitored for radioactivity must be less than 150 d/m/mℓ 100 cm^2 beta-gamma		
14	Appropriate DOT labels and tag identifying shipment in place.		
15			

TITLE: Model UC-609 Shipping Container Packing Check List	FILE NO. END 77-22		PAGE 3
	WRITTEN BY R. Sandberg	DATE 7/6/77	
	CHECKED BY	DATE	

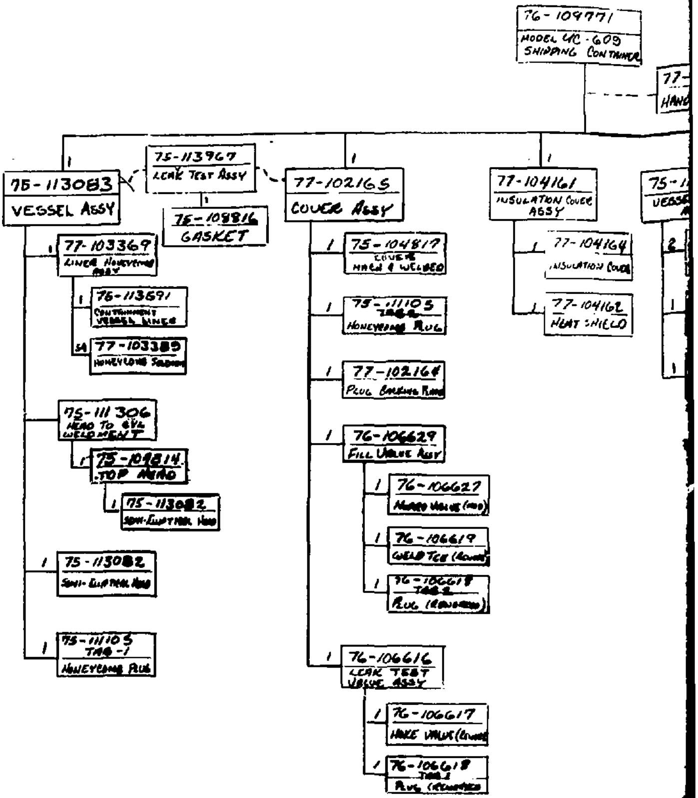
Shipment Packed and Tested by ______________________

Date______________________

Inspected and Approved by ______________________
Light Isotopes Chemist

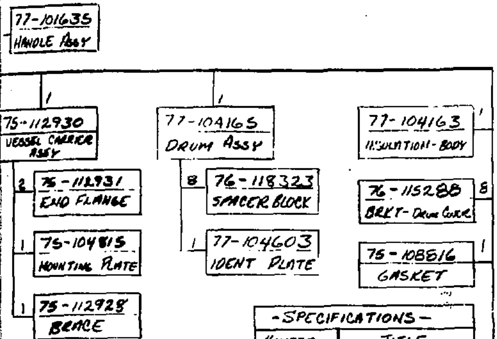
____
LLL Materials Management

APPENDIX B: FABRICATION DRAWINGS



B			8-77		ADDED SPECIF
LET.			DATE	ZONE	CHANGE

1



-SPECIFICATIONS-

NUMBER	TITLE
END 77-16	FABRICATION SPEC.
END 77-18	PRESS TEST RECORD
END 77-19	ASSY. FAB. RECORD
END 77-20	COMPONENT INSP. FORM
END 77-21	PACKAGING PROCEDURE
END 77-22	PACKING CHECK LIST
END 77-914	SAFETY NOTE

2

ITEM	PART NO.	MATERIAL / DESCRIPTION	REQ'D	SPEC. NO.	LLL STOCK NO.

NO. REQ'D PER ASSY.

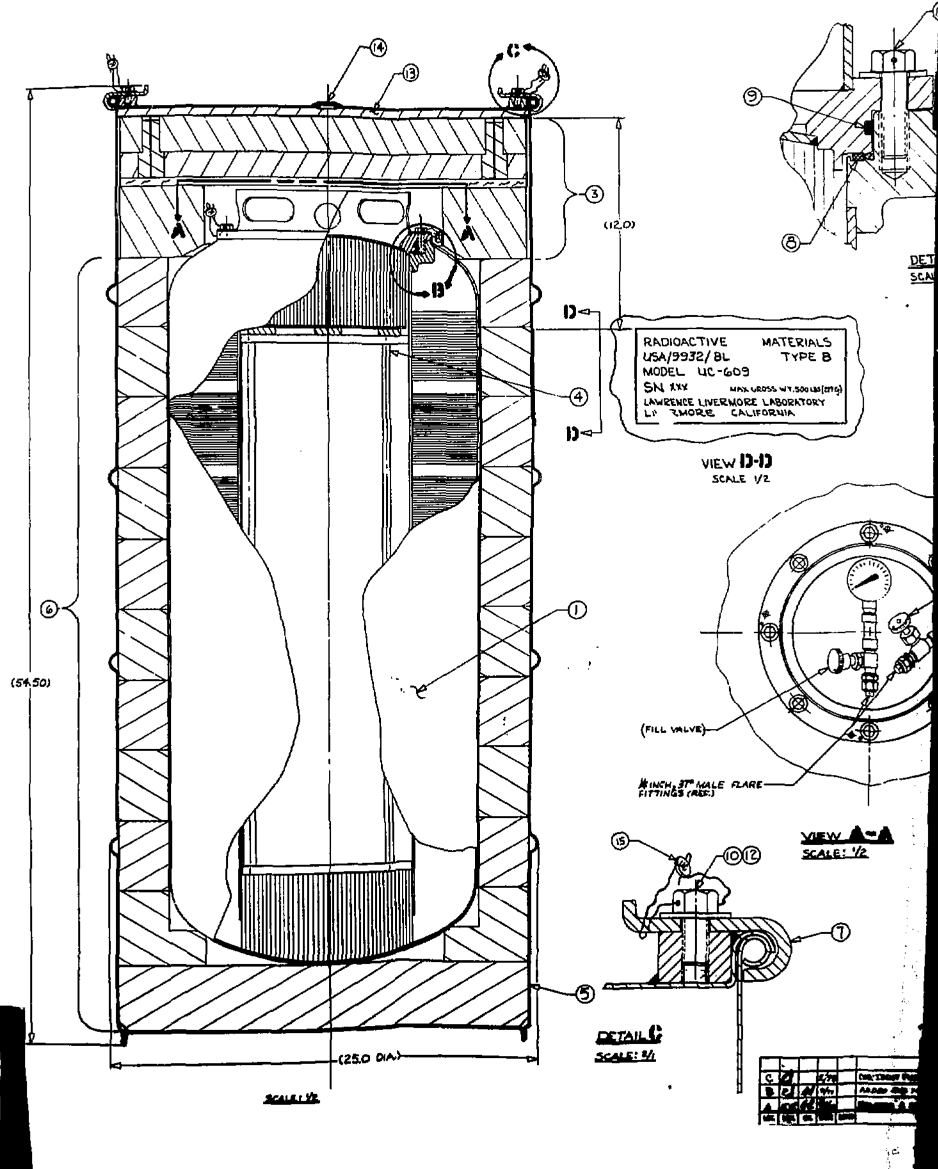
DR. D. DUNSTAN 2-77
CHK.
APPROVED [illegible]
SHOWN ON
DATE

LAWRENCE LIVERMORE LABORATORY
MECHANICAL ENGINEERING DEPARTMENT
UNIVERSITY OF CALIFORNIA

CLASSIFICATION

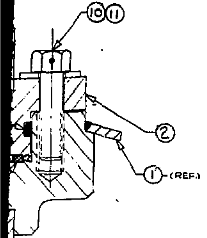
MAJOR UNIT U.S. 609 CONTAINER
SUB ASSY.
DETAIL DRAWING LIST
J.O.
COPY
DRAWING NO. AAA 77-155-11-3B
ACCT. NO.
SHEET 1 OF 1

IFICATIONS



14
13
C
3
(12.0)
A
A
B
9
8
D
D
RADIOACTIVE MATERIALS
USA/9932/BL TYPE B
MODEL UC-609
SN XXX MAX GROSS WT. 500 LBS (227 kg)
LAWRENCE LIVERMORE LABORATORY
CALIFORNIA
VIEW D-D
SCALE 1/2
4
6
(54.50)
1
(FILL VALVE)
1/4 INCH, 37° MALE FLARE FITTINGS (REF.)
VIEW A-A
SCALE: 1/2
15
10 12
7
5
DETAIL C
(25.0 DIA.)
SCALE: 1/2

3



DETAIL B
SCALE 2/1

NOTES:

1. BOLT SPECIFICATIONS:

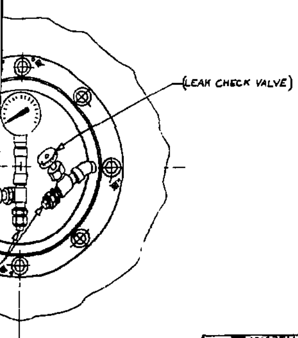
ITEM NO. 11

a) 3/8-24 UNF-3A CAP SCREW 1.25 LONG
b) MATERIAL: ALLOY STEEL WITH A MINIMUM ULTIMATE TENSILE STRENGTH OF 170,000 PSI
c) HEAD STYLE OPTIONAL BUT MUST BE DRILLED FOR SEAL WIRE.

ITEM NO. 12

a) 3/8-24 UNF-3A CAP SCREW .75 LONG
b) MATERIAL: CORROSION RESISTANT STEEL WITH A MINIMUM ULTIMATE TENSILE STRENGTH OF 80,000 PSI.
c) HEAD STYLE OPTIONAL BUT MUST BE DRILLED FOR SEAL WIRE.

2. ASSEMBLE AND TEST PACKAGE FOR SHIPMENT PER END 77-21 △8



A-A
1/2

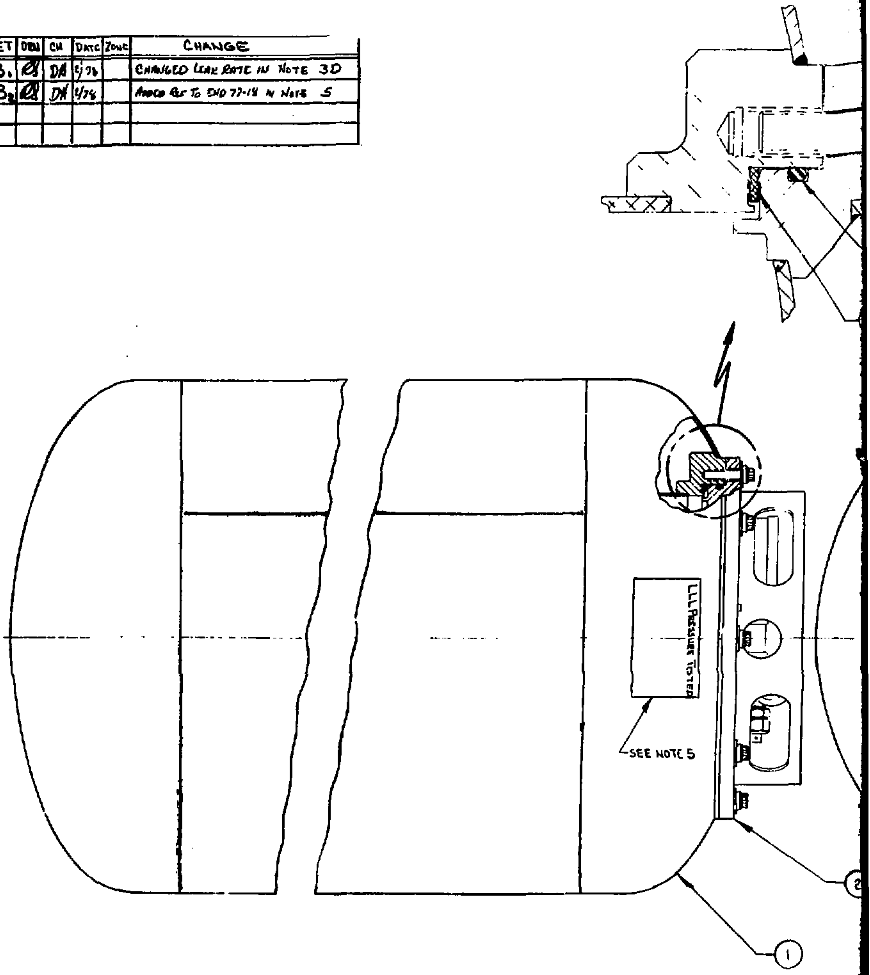
	77-101635	HANDLE ASSY	REF	
15		TAMPER SEAL	2	STYLE OPTIONAL
14		PLASTIC VENT PLUG	2	[illegible]
13		CERA BLANKET, 24" DIA. X 1/2" THK, [illegible]	1	[illegible] JOHN MANVILLE
12		SCREW 3/8-24 UNF-3A X 3/4" LG, CAP	8	SEE NOTE #1
11		SCREW 3/8-24 UNF-3A X 1 1/4" LG, CAP	8	SEE NOTE #1
10		WASHER-FLAT 1" O.D. X [illegible] I.D. X .062 THK.	16	CRES [illegible]
9	NO. 2-275	O-RING 10.484" I.D. X .139" DIA. (VITON)	1	PARKER NO. 2-275
8	75-10[illegible]	GASKET	1	COPPER - OFHC
7	76-115[illegible]	BRACKET, DRUM COVER	8	CRES - TYPE 304
6	77-104163	INSULATION, BODY	1	CELOTEX
5	77-104165	DRUM ASSY	1	CARBON STEEL
4	75-112[illegible]	VESSEL CARRIER ASSY	1	AL - 6061-T651
3	77-104161	INSULATION COVER ASSY	1	CELOTEX
2	77-10[illegible]	COVER ASSY	1	CRES - TYPE 316
1	[illegible]	VESSEL ASSY	1	CRES - TYPE 316
ITEM	PART NO.	NOMENCLATURE / DESCRIPTION	REQD	SPEC. NO.

LAWRENCE LIVERMORE LABORATORY
MECHANICAL ENGINEERING DEPARTMENT
UNIVERSITY OF CALIFORNIA

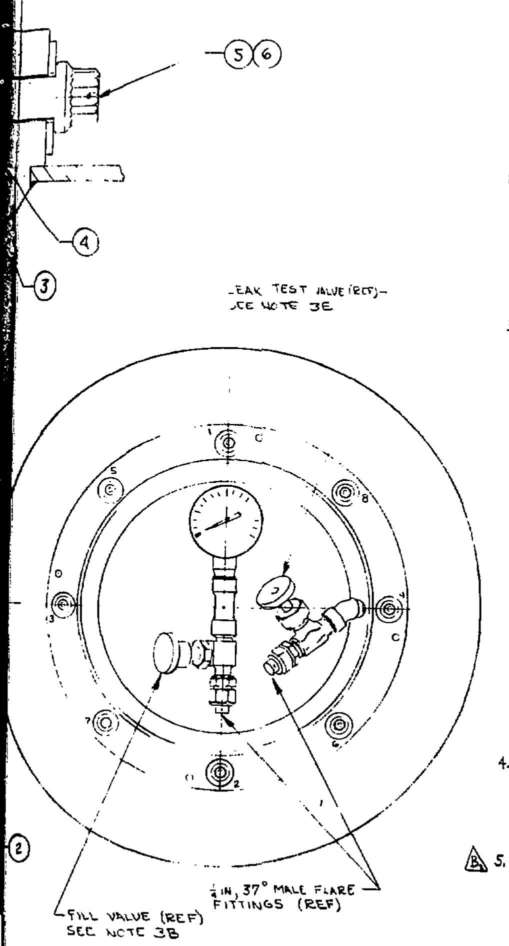
MODEL UC-609
SHIPPING CONTAINER

AAA 76-109771-0C

LET	DRN	CH	DATE	ZONE	CHANGE
B1		DA	2/78		CHANGED LEAK RATE IN NOTE 3D
B2		DA	4/78		ADDED REF TO END 77-18 IN NOTE 5



MAJOR UNIT: MODEL (UC-609) SHIPPING CONTAINER	ACCT. NO.	DR K. LINDBERG	DATE 11/75
SUB ASSEMBLY: CONTAINMENT VESSEL LEAK TEST ASSY	SHOWN ON	CHK [signature]	3/../..
DETAIL		APPROVED [signature]	3 .. 77



LET	DRN	CH	DATE	ZONE	CHANGE
A1			8/77		PSIG (WAS) PSI ; 150 PSIG (WAS) 125 PSI
A2			8/77		1x10⁻⁸ (WAS) 1x10⁻⁹
A3			8/77		CHANGED NOTE 3F
A4			8/77		ADDED NOTE 5

NOTES:

1. COAT 'O' RING WITH A LIGHT FILM OF SILICONE VACUUM GREASE BEFORE INSTALLING IN GROOVE.

2. COAT BOLT THREADS WITH "KOPR-KOTE" AND TORQUE IN ORDER STAMPED NEXT TO HOLES AS FOLLOWS:
   - A. TORQUE ALL BOLTS TO 20 FT-LB. GO AROUND PATTERN TWICE.
   - B. INCREASE TORQUE TO 45 FT-LB. GO AROUND PATTERN UNTIL NO BOLT MOVEMENT IS DETECTED

3. PROOF AND LEAK TEST CONTAINER AS FOLLOWS:
   - A. AFTER A TUBE IS ATTACHED TO THE FILL VALVE, INSTALL THE CONTAINER IN A LARGE PLASTIC BAG. SEAL ALL OPENINGS WITH TAPE.
   - B. PRESSURIZE THROUGH THE FILL VALVE TO 200 PSIG WITH HELIUM. HOLD PRESSURE FOR A MIN. OF 4 HOURS (A1)
   - C. VENT PRESSURE TO 150 PSIG
   - (A1) D. LEAK CHECK CONTAINER WITH A MASS SPEC. LEAK DETECTOR HAND PROBE BY CUTTING A SMALL HOLE IN THE PLASTIC BAG. NO LEAKAGE GREATER THAN 1×10^{-8} STP CC/SEC IS ALLOWED.
   - E. CONNECT LEAK DETECTOR DIRECTLY TO THE LEAK TEST VALVE AND MEASURE LEAKAGE ACROSS THE COPPER GASKET SEAL. NO LEAKAGE GREATER THAN 1×10^{-9} STP CC/SEC IS ALLOWED. (A2)
   - (A3) F. RECORD PERTINENT DATA ABOUT PROOF/LEAK TESTS ON END 77-18 (PRESSURE TEST REPORT)
   - G. VENT PRESSURE TO ATMOSPHERIC.
   - I. CLOSE BOTH VALVES & CAP FITTINGS.

4. BOLT SPECIFICATION: 3/8-24 UNF-3A ALLOY STEEL BOLT 1.25 LONG MATL TENSIL STRENGTH — 170,000 PSI MIN. HEAD STYLE - OPTIONAL BUT MUST BE DRILLED FOR LOCKWIRE

(A4) 5. PRESSURE INSPECTOR IS TO COMPLETE PRESSURE TEST REPORT (END 77-18) ATTACHMENT OF A LLL PRESSURE TESTED LABEL WILL CERTIFY THE INSPECTORS ACCEPTANCE OF THE VESSEL. (SEE SAFETY NOTE END 77-914.)

ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.
6		WASHER - 1" OD x 25/64 ID x .062 TK	8	CRES-304,302 & 316	FF-W-92 TYPE A	5310-21881
5		BOLT - SEE NOTE 4	8	ALLOY STL		
4		"O" RING, 10.484 I.D x .139 DIA	1	VITON	PARKER No 2-275	
3	75-108816	GASKET	1	Cu-OFHC		
2	77-102165	COVER ASSEMBLY	1	CRES-316		
1	75-113083	VESSEL ASSEMBLY	1	CRES-316		

NO. REQ'D PER ASSEM.

DO NOT SCALE

1. DIMENSIONING AND TOLERANCING ARE PER ANSI Y14.5, 1973
2. POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE).
3. SURFACE TEXTURE PER ANSI B46.1.

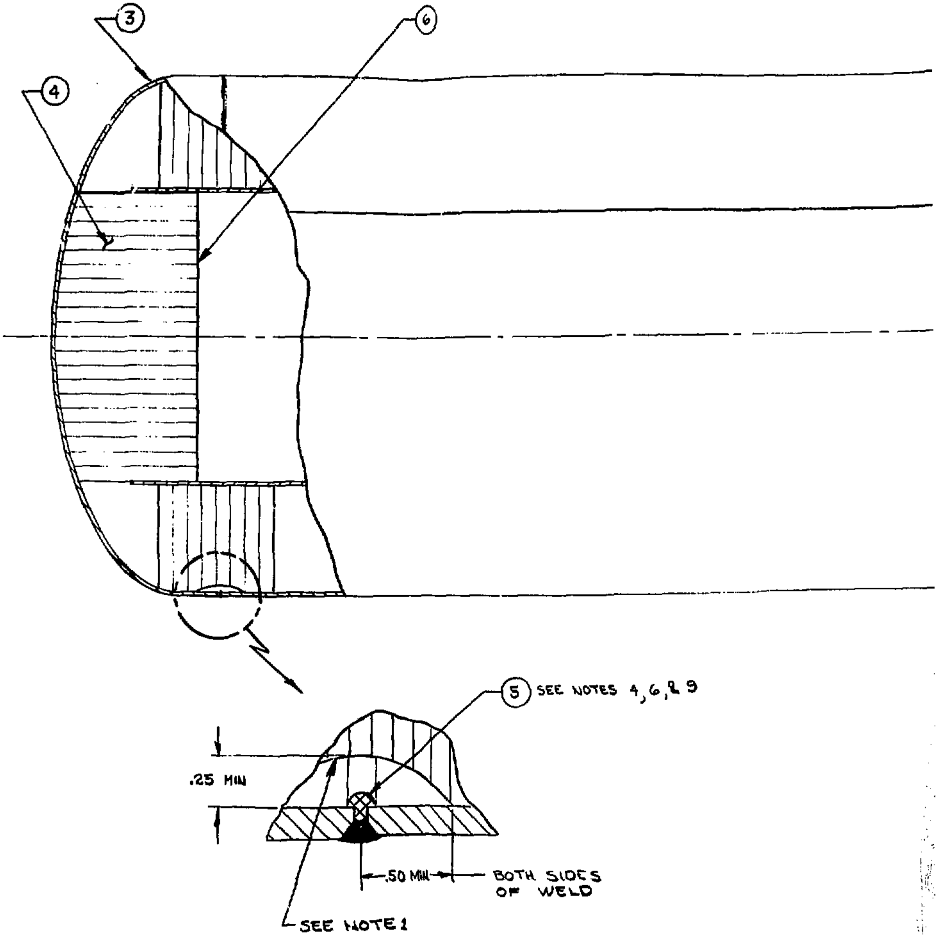
CLASSIFICATION

LAWRENCE LIVERMORE LABORATORY
University of California

DRAWING NO. AAA75-113967-OB

B | SCALE HALF | COPY

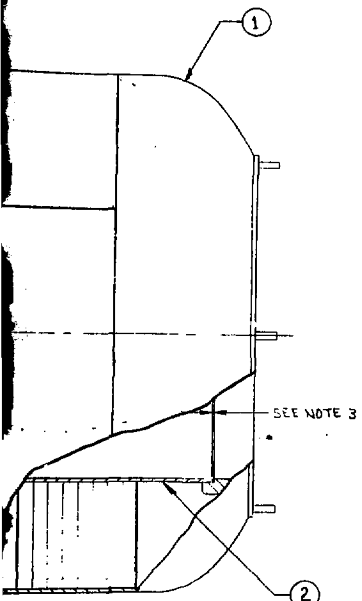
2



3

MODEL (UC-609) SHIPPING CONTAINER	5150-05	R. SINDBERG	3-9-77
VESSEL ASSEMBLY	[illegible]	[illegible]	3-29-77
		BC [illegible]	3-31-77

LET	DRN	CH	DATE	ZONE	CHANGE
A	ℛ		2/77		REDRAWN



NOTES

1. CRUSH HONEYCOMB IN WELD AREA TO PROVIDE THE MIN WELDING CLEARANCE INDICATED.
2. CEMENT HONEYCOMB INTO ASSY USING SILASTIC 732 RTV (MFD BY DOW CORNING CORP) ADHESIVE TO COVER APPROXIMATELY 1/8 OF THE AREA BEING BONDED. PREVENT ADHESIVE FROM CONTACTING WELD JOINT AREA.
3. CENTER BOTTOM END OF HONEYCOMB ASSY (ITEM 2) IN CYL (ITEM 1) SO THAT GAP BETWEEN LINER TUBE AND FLANGE SOCKET IS UNIFORM AND DOES NOT EXCEED .062 AT ANY POINT. CONCENTRICITY TO BE MAINTAINED BY DRIVING 1/2 INCH WIDE AL SHIMMS OF SUITABLE THICKNESS BETWEEN HONEYCOMB AND STEEL CYL
4. CONSUMABLE INSERT SPECIFICATIONS: ARCOS E.B. INSERT, TYPE A, 1/8 INCH SIZE, TYPE 316 STAINLESS. MFD BY ARCOS CORP. PHILADELPHIA PA.
5. FABRICATOR TO SUPPLY COPY OF MILL TEST REPORT FOR INSERT MATL. USED.
6. FULL PENETRATION, TIG PROCESS WELD. SEE ARCOS CORP RECOMMENDATIONS FOR FIT UP AND ROOT PASS WELD. FILLER WIRE TO BE UNCOATED TYPE 316 STAINLESS
7. CEMENT .032 THICK DISC (ITEM 6) TO HONEYCOMB PLUG (ITEM 4) BEFORE INSTALLATION OF PLUG INTO ASSY.
8. CEMENT PLUG (ITEM 4) TO BOTTOM HEAD (ITEM 3) AFTER WELDING.
9. RADIOGRAPH NOTED WELD PER THE REQTS. OF THE ASME PRESSURE VESSEL CODE, SECTION VIII, PARAGRAPH UW-51

4

ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.
6		DISC-9.94±.06 DIA x .032 THICK		AL-6061-T6	QQ-A-250/11	9532-40094
5		CONSUMABLE INSERT		CRES-316L		
4	75-111105-TAB1	HONEYCOMB PLUG	1	AL		
3	75-113082	SEMI-ELLIPTICAL HEAD	1	CRES-316		
2	77-103369	LINER HONEYCOMB ASSY.	1	AL		
1	75-111306	TOP HEAD TO CYL. WELDMENT	1	CRES-316		

NO. REQ'D PER ASSEM.

DO NOT SCALE

1. DIMENSIONING AND TOLERANCING ARE PER ~~[illegible]~~ ANSI-Y14.5, 1973
2. POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE).
3. SURFACE TEXTURE PER ANSI B46.1.

CLASSIFICATION

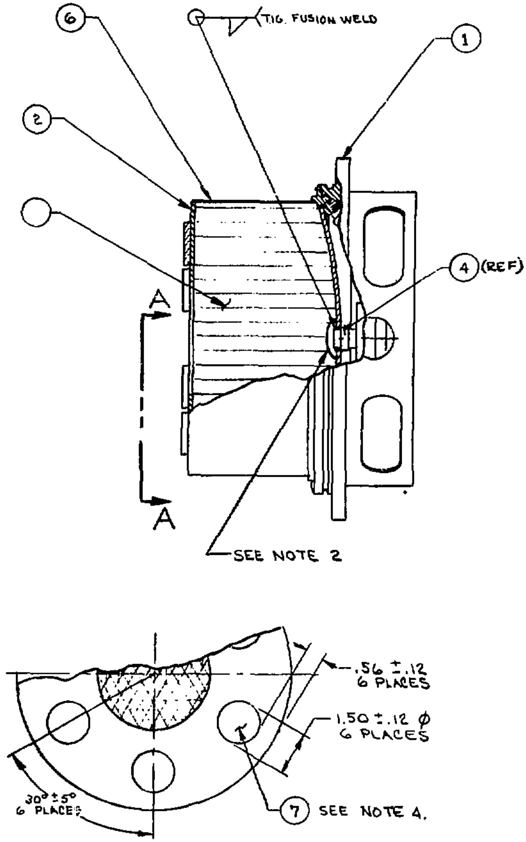
THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE LABORATORY. REPRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT

LAWRENCE LIVERMORE LABORATORY
University of California

DRAWING NO. AAA75-113083-0A

D | SCALE HALF | COPY

MAJOR UNIT	ACCT. NO.	DR	DATE					JOB NO.
MODEL 4C-609 SHIPPING CONTAINER		R SINNBERG	3/7/77					
SUB ASSEMBLY COVER ASSY	SHOWN ON 76-109771 75-113967	CHK	3-25-77					
DETAIL		APPROVED	3-31-77					



VIEW A-A

LET	DRN	CH	DATE	ZONE	CHANGE

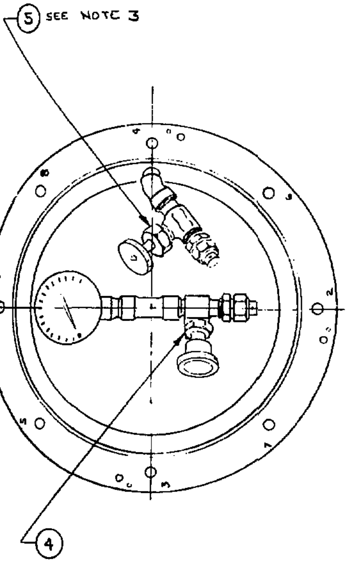
NOTES:

1. CEMENT HONEYCOMB (ITEM 3) TO ITEM 1 AND ITEMS 2 & 6 TO HONEYCOMB USING SILASTIC 732 RTV (MFD. BY DOW CORNING CORP). COVER APPROXIMATELY 1/8 OF THE AREA BEING BONDED WITH ADHESIVE.

2. CRUSH HONEYCOMB FOR A MIN. OF 0.06 CLEARANCE ON THE VALVE TO FLANGE WELD.

3. SEAL PIPE THREADS OF ITEM 5 USING LOCTITE HIGH PERFORMANCE PIPE SEALANT WITH TEFLON (LOCTITE CATALOG NO 92-31) AFTER INSTALLATION, HIGHEST POINT ON VALVE ASSY MUST BE BELOW RIM OF FLANGE.

4 CEMENT RUBBER DISC TO COVER USING SILASTIC DESCRIBED N NOTE 1



ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.
7		RUBBER SHEET - 1/4 IN THICK		NEOPRENE, CELLULAR, MED. HARDNESS - (AMS 3198)		
6		AL SHEET - .016 THICK	AR	AL - 1100 - O	QQ-A-250/1	9535 - 1154S
5	76 - 106616	HOKE VALVE ASSY	1	CRES - 316		
4	76 - 106629	VALVE GAGE ASSY	1	CRES - 316		
3	75 - 111105 TM2	HONEYCOMB PLUG	1	AL		
2	77 - 102164	PLUG BACKING PLATE	1	AL - 6061-T6		
1	75 - 104817	TOP FLANGE MACHINED	1	CRES - 316		

NO. REQ'D PER ASSEM.

DO NOT SCALE

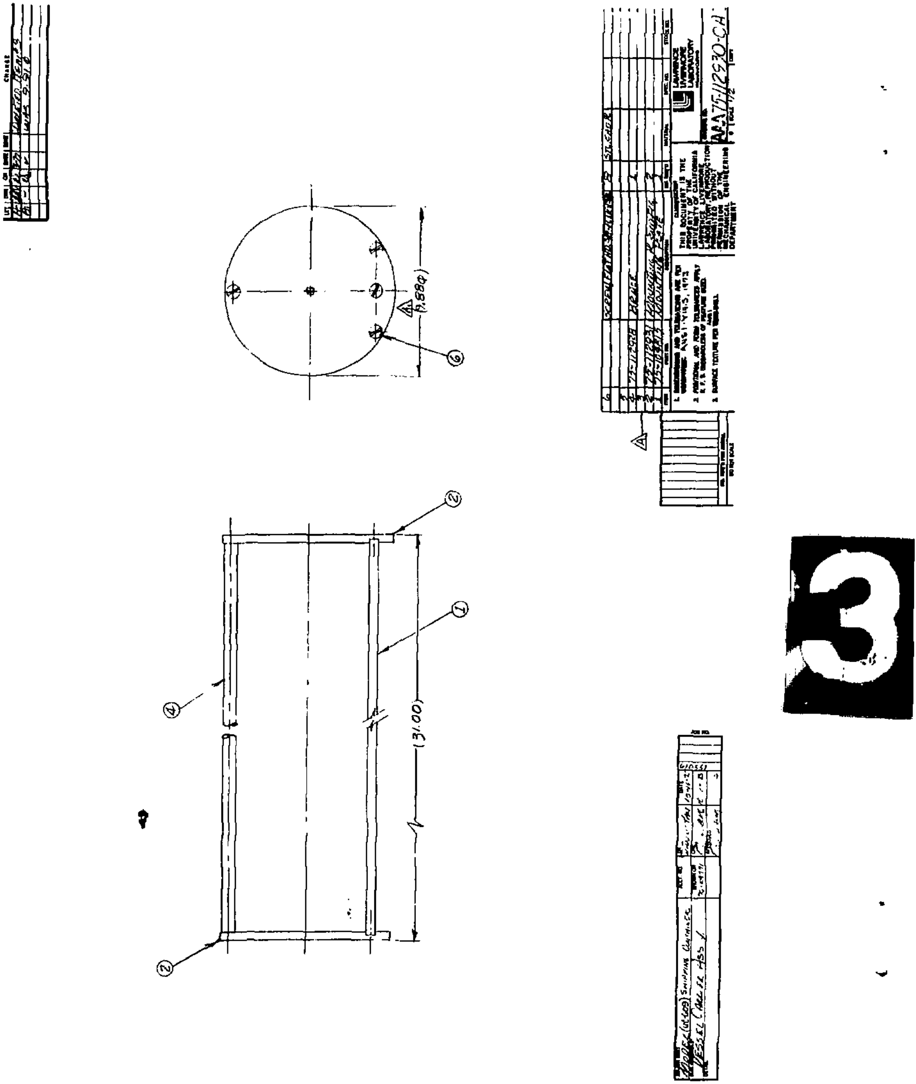
1. DIMENSIONING AND TOLERANCING ARE PER ANSI Y14.5, 1973
2. POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE).
3. SURFACE TEXTURE PER ANSI B46.1.

CLASSIFICATION

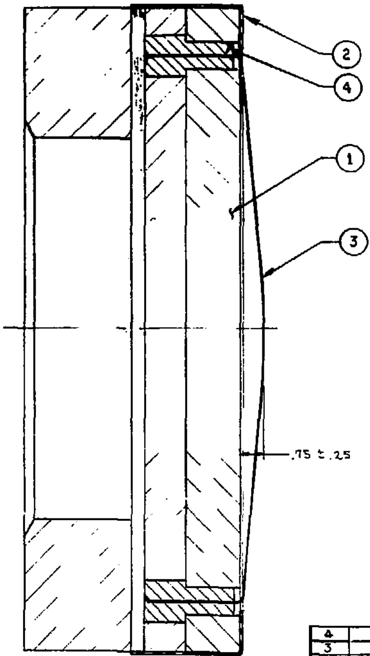
LAWRENCE LIVERMORE LABORATORY
University of California

DRAWING NO.
AAA77-102165-00

B | SCALE HALF | COPY



(31.00)
AAA75-112530-CH
LAWRENCE LIVERMORE LABORATORY



LET	DRN	CH	DATE	ZONE	CHANGE

NOTES:

1. CENTER WEBBING IN HOLES AND POUR SCOTCHCAST 221 ENCAPSULATING RESIN AROUND WEBBING TO WITHIN ¼ INCH OF SURFACE. MIX RESIN COMPONENTS PER MFR. RECOMMENDATIONS

2. CEMENT HEAT SHIELD (ITEM 2) TO INSULATION (ITEM 1) USING SILASTIC 732 RTV MFD BY THE DOW CORNING CORP. COVER APPROXIMATELY ⅛ OF THE SURFACE AREA TO BE BONDED WITH ADHESIVE.

MAJOR UNIT	ACCT. NO.	DR	DATE
MODEL (UC-609) SHIPPING CONTAINER	5C16-01	R. SANDBERG	3/3/77
SUB ASSEMBLY: INSULATION COVER ASSY	SHOWN ON: 76-109771	CHK: [signature]	3/ '77
DETAIL		APPROVED: [signature]	3-31-77

JOB NO.

ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.
4		SCOTCHCAST ENCAPSULATING RESIN	AR	RESIN No. 221A,B	3M I.D. No. 80-7002-2102-3	
3		NYLON WEBBING, 1IN. WIDE	AR	NYLON	MIL-W-4088 TYPE 17	
2	77-104162	HEAT SHIELD	1	CRES-304	QQ-S-766	
1	77-104164	INSULATION COVER	1	CELOTEX	MIL-F-26862	

NO. REQ'D PER ASSEM.

DO NOT SCALE

1. DIMENSIONING AND TOLERANCING ARE PER ~~USASI~~ ANSI Y14.5, 1973
2. POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE).
3. SURFACE TEXTURE PER ~~USAS~~ ANSI B46.1.

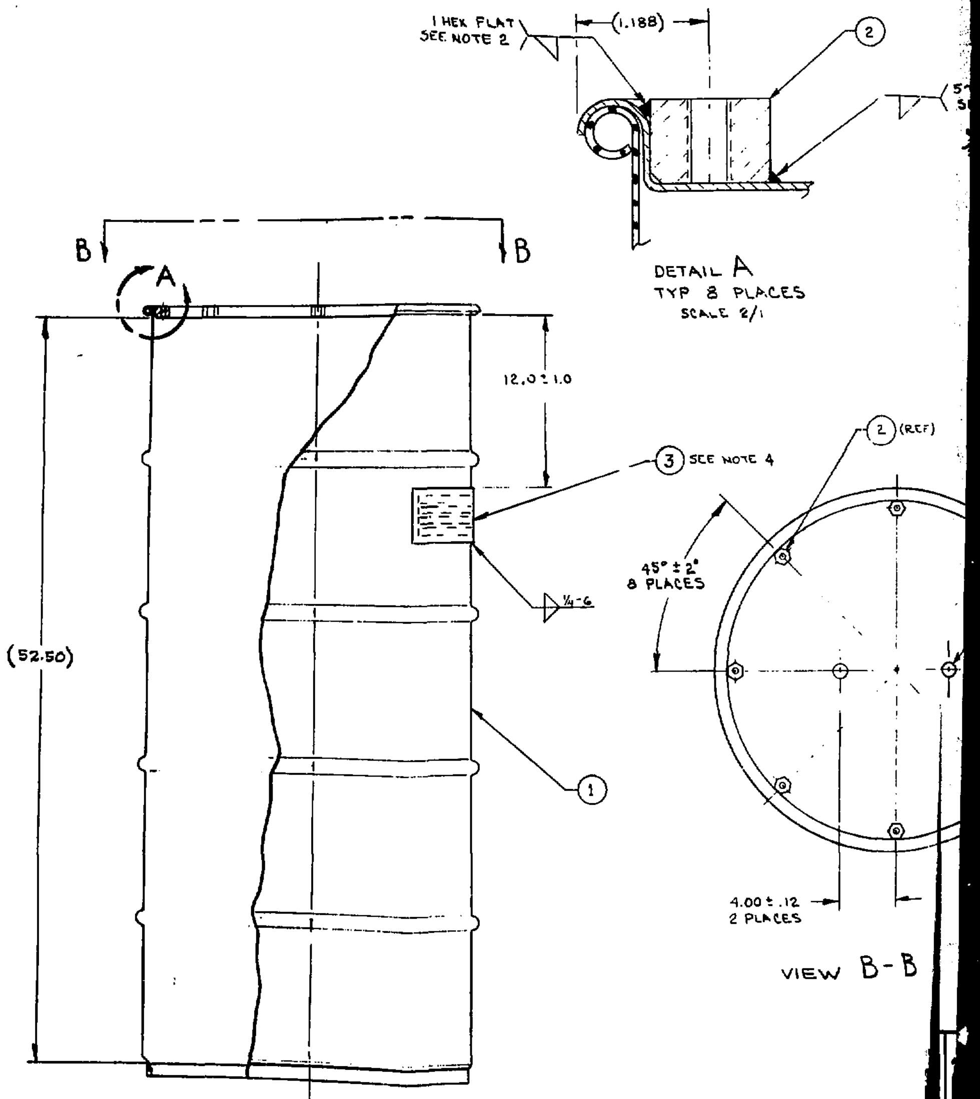
CLASSIFICATION

THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE LABORATORY. REPRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT

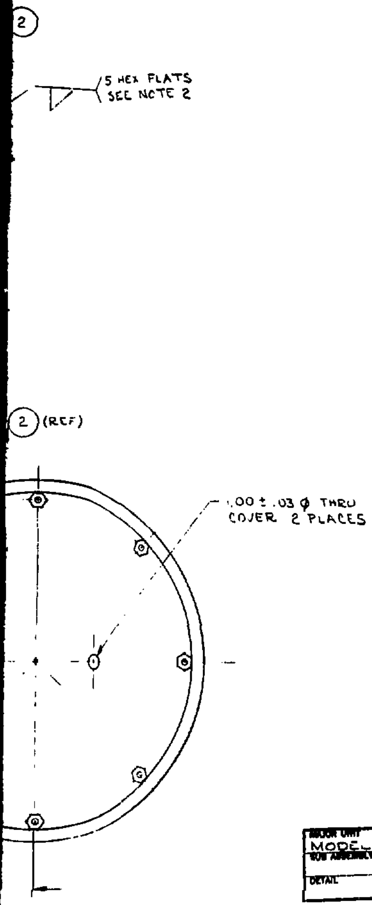
LAWRENCE LIVERMORE LABORATORY
University of California

DRAWING NO. AAA77-104161-00

C | SCALE HALF | COPY


1 HEX FLAT
SEE NOTE 2
(1.188)
2
DETAIL A
TYP 8 PLACES
SCALE 2/1
B
B
A
12.0 ± 1.0
(52.50)
3 SEE NOTE 4
1/4-6
1
2 (REF)
45° ± 2°
8 PLACES
4.00 ± .12
2 PLACES
VIEW B-B

LET	DRN	CH	DATE	ZONE	CHANGE
A	RS		8/77		52.50 ±.125 (WAS) ± .500



NOTES.

1. ITEM 1 - CARBON STEEL DRUM PER MILITARY STANDARD MS 27683 WITH THE FOLLOWING EXCEPTIONS:
   a.) BODY AND COVER TO BE 16 GAGE (.0673) MATL.
   b.) INSIDE HEIGHT TO BE 52.50 ±.125. (A)
   c.) INSIDE DIAMETER TO BE 24.00 ±.03.
   d) MIN OF 4 ROLLING HOOPS EQUIDISTANT.
   e) LOCKING RING & GASKET ARE NOT REQD.

2. USE WELDING PROCEDURE THAT MINIMIZES DISTORTION OF COVER. COVER MUST FIT DRUM AFTER WELDING.

3. PAINT INSIDE & OUTSIDE OF DRUM & COVER AS FOLLOWS:
   a.) ALL SURFACES MUST BE FREE OF RUST, OIL, OR OTHER FOREIGN MATL. (SANDBLASTING IS REQD FOR RUSTED MATL.
   b) PRIME WITH BODY BROS PAINT INC EPOXY PRIMER NO. 4221 SGY7086. APPLY PER MFR. RECOMMENDATIONS.
   c) FINISH COAT - OSHA SAFETY BLUE MODIFIED EPOXY ENAMEL (BODY BROS PAINT INC. PRODUCT NO. 1125-BE-6560 MIN. FILM THICKNESS ONE MILL (.001 INCH) APPLY PER MFR RECOMMENDATIONS.

4. BEND IDENTIFICATION PLATE TO CONFORM TO DRUM BODY - MASK PLATE WHEN PAINTING

MAJOR UNIT: MODEL LL-609 SHIPPING CONTAINER	ACCT. NO.	DR. R. SANDBERG	DATE 3/4/77	
SUB ASSEMBLY: DRUM ASSY	SHOWN ON 76-109771	CHK [signature]	3-29-77	
DETAIL		APPROVED [signature]	3-31-77	

3

B - B

ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.
3	77-104603	IDENTIFICATION PLATE	1	CRES 304		
2	76-118323	SPACER BLOCK	8	STEEL		
1		STEEL DRUM - SEE NOTE 1	1	STEEL	MS 27683	

NO. REQ'D PER ASSEM.

DO NOT SCALE

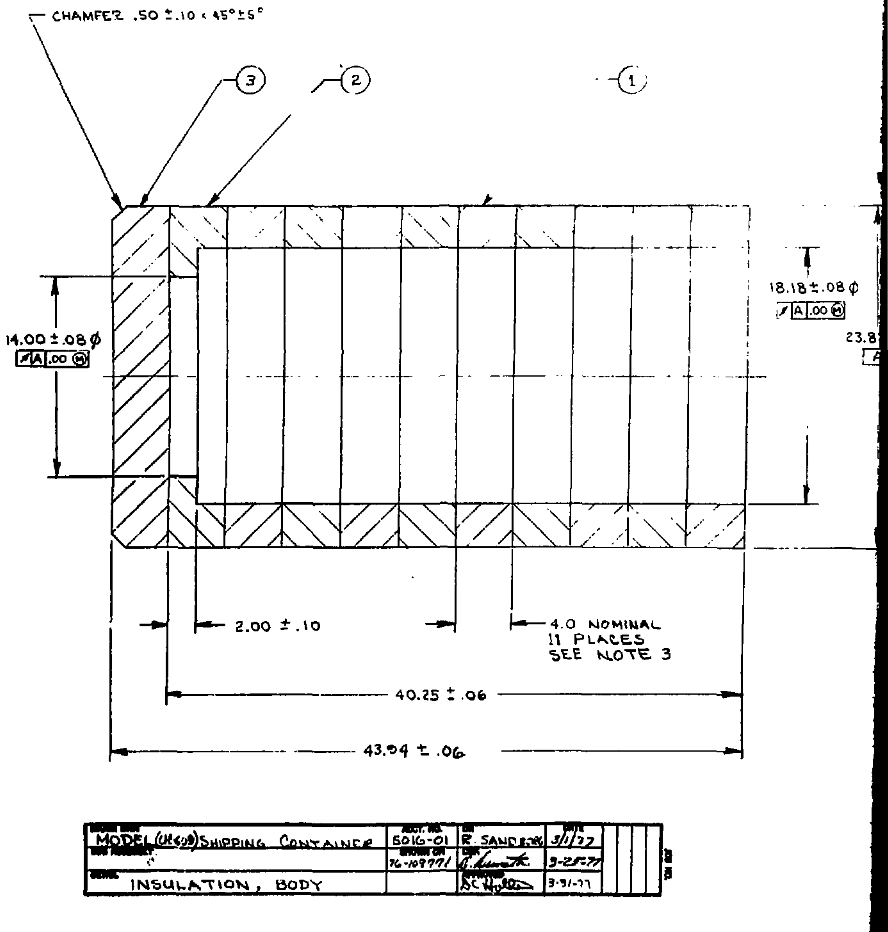
1. DIMENSIONING AND TOLERANCING ARE PER ANSI Y14.5, 1973
2. POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE).
3. SURFACE TEXTURE PER ANSI B46.1.

CLASSIFICATION

LAWRENCE LIVERMORE LABORATORY
University of California

DRAWING NO. AAA77-104165-0A

B | SCALE HALF | COPY



MODEL (UC-609) SHIPPING CONTAINER	5016-01	R. SANDERS	3/1/77
	76-109771		3-28-77
INSULATION, BODY			3-31-77

LET	DRN	CH	DATE	ZONE	CHANGE
A	RS		3/79		CHG SPEC ON CELOTEX (WAS) MIL-F-27682
B	WCI		3-79		WAS MIL-F-27682 (NOTE #1)

NOTES:

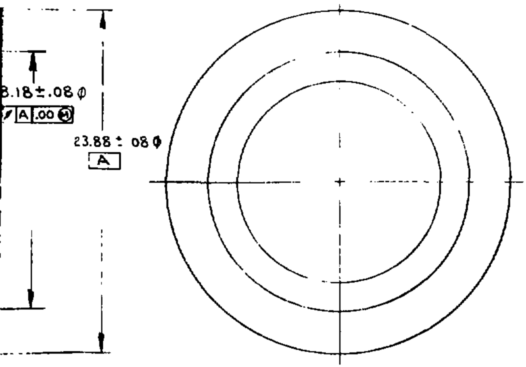
B — 1. MATERIAL: CELOTEX INDUSTRIAL BOARD PER MIL-F-26862 EXCEPT PARAGRAPHS 3.7 WATER ADSORPTION, 3.10.10 MODULUS OF RUPTURE WET, 3.11 FUNGUS RESISTANCE, & 4.4.7.2 MOISTURE RETENTION

2. FABRICATOR MADE JOINTS TO EQUAL FACTORY LAMINATIONS. DO NOT LAMINATE THE 4 INCH THICK RINGS & DISK TOGETHER

3. THE INDIVIDUAL RINGS AND THE DISC ARE TO BE NOMINALLY 4.0 IN. THICK. TO ADJUST THE TOTAL LENGTH OF THE STACK, ONE OR MORE RINGS MAY BE FROM 3.5 TO 5 INCHES THICK AS REQD.

4. PACKAGE ASSEMBLY TO PREVENT SEPARATION OR DAMAGE DURING SHIPMENT.

5. MATERIAL CERTIFICATION REQD FOR CELOTEX USED IN ASSY.



ITEM	PART NO.	DESCRIPTION	NO. REQ'D	MATERIAL	SPEC. NO.	STOCK NO.
3		DISC - SEE NOTE 1	1	CELOTEX	MIL-F-26862	
2		STEPPED RING - SEE NOTE 1	1	CELOTEX	MIL-F-26862	
1		RING - SEE NOTE 1	9	CELOTEX	MIL-F-26862	

NO. REQ'D PER ASSEM.

DO NOT SCALE

1. DIMENSIONING AND TOLERANCING ARE PER ANSI Y14.5, 1973
2. POSITIONAL AND FORM TOLERANCES APPLY R. F. S. (REGARDLESS OF FEATURE SIZE).
3. SURFACE TEXTURE PER ANSI B46.1.

THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF CALIFORNIA LAWRENCE LIVERMORE LABORATORY. REPRODUCTION PROHIBITED WITHOUT PERMISSION OF THE MECHANICAL ENGINEERING DEPARTMENT

LAWRENCE LIVERMORE LABORATORY
University of California

DRAWING NO. AAA 77-104163-0B

B | SCALE 1/4 | COPY