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**SAFETY ANALYSIS REPORT FOR PACKAGING:
THE ORNL GAS-CYLINDER FIRE AND IMPACT SHIELD**

J. H. Evans
D. L. Levine
R. E. Eversole
R. W. Mouring

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Safety Analysis Report for Packaging: the ORNL Gas-Cylinder Fire and Impact Shield

J. H. Evans R. E. Eversole
D. L. Levine R. W. Mouring

ABSTRACT

The ORNL gas-cylinder fire and impact shield was designed and fabricated at the Oak Ridge Gaseous Diffusion Plant for the transport of cylinders filled with radioactive gases. The shield was evaluated analytically and experimentally to determine its compliance with the applicable regulations governing containers in which radioactive and fissile materials are transported, and the results are reported herein. Computational and test procedures were used to determine the structural integrity and thermal behavior of the cask relative to the general standards for normal conditions of transport and the standards for hypothetical accident conditions. Results of the evaluation demonstrate that the container is in compliance with the applicable regulations.

0. GENERAL INFORMATION

0.1 Introduction

The ORNL gas-cylinder fire and impact shield was developed at the Oak Ridge Gaseous Diffusion Plant in 1967. The original design was revised in 1974 and again in 1983 to incorporate improvements and to upgrade the shields. Two shields of differing dimensions were fabricated in 1967 and were subjected to impact and fire tests as outlined in Sects. 1.5.1 and 2.2 of this report. In 1983, a shield was fabricated using the latest designs and was subjected to impact and puncture tests as outlined in Sects. 1.5.1 and 1.5.2 of this report. The shields were fabricated, inspected, examined, and filled with phenolic foam in accordance with the drawings in Appendix A. All shields now in use by ORNL and covered by this SARP are of this latest design. For the purpose of this report, the term "Hoke gas cylinder" shall designate gas cylinders manufactured by Hoke, Inc., or ORNL gas cylinders of equivalent design.

The primary use of the shields is to upgrade doubly contained gas cylinders, which meet IAEA Type A tests, to meet IAEA Type B requirements for the shipment of radioactive gases. The shields provide impact and thermal resistance for the gas cylinders during transport by rail, highway, air, and water modes for both normal and accident conditions. The contents for which the design was evaluated are outlined in Sect. 0.2.3. The packaging complies with Department of Energy (DOE) order 5480.1, Chap. III¹ and the *Code of Federal Regulations*, Title 10, Part 71.² The shields also comply with Department of Transportation (DOT) regulations published in the *Code of Federal Regulations*, Title 49, Part 173,³ and the *International Atomic Energy Agency, Safety Series No. 6, 1973 Revision*.⁴ Calculations, engineering logic, test results, and documents demonstrating compliance are presented in this report. Copies of the approval documents are reproduced in Appendix E.

0.2 Package Description

0.2.1 Container description

The features of the package are illustrated in Fig. 0.1. As-built fabrication drawings are included in Appendix A. The shield consists of two cylindrical housings, the outer one having dimensions of 24-1/8 in. by 41-7/8 in. high. The area between the inner and outer housings is filled with phenolic foam. A foam-filled plug of height 6-3/4 in. fits on top of the inner housing and is secured by a bolted flange arrangement. Eight 5/8 hex-head machine screws 3-1/2-in. in length are used in conjunction with 5/8 nuts and lock washers to secure the outer

Fig. 0.1. ORNL gas-cylinder fire shield.

closure. The phenolic foam provides some structural support and is an effective thermal insulator. Vent holes of 3/16-in. diam are located in the sides and bottom of the external housing for release of gas pressure that may be generated by decomposition of the phenolic in a fire. After the shield is filled with foam, these vent holes are sealed against the weather by two coats of an epoxy paint that does not react with the phenolic foam. The epoxy seals are designed to vent in a fire because the epoxy paint will decompose at temperatures well below 1000°F. This ability has been demonstrated by Mallet and Newlon on very similar epoxy seals.⁵

The closure of the inner housing (11-7/8 in. by 30-5/8 in. high) is afforded by 14-in.-OD, 1/4-in.-thick flanges. Twelve 3/8-in. hex-head cap screws secure the closure. Between flange and lid is a 1/8-in.-thick by 1-1/2-in.-wide Buna-N or neoprene gasket. At the base of the vessel, the inner and outer housings are joined by a 5-in.-deep cross structure of pine lumber.

The materials of construction, specified on ORNL drawing No. M-11574-EM-001 (Fig. A.1, Appendix A), are stainless steels of the following ASTM specifications: A240 plate, A240 or A167 sheet, and A276 or A479 bar or strip.

The inner containers, as specified on ORNL drawing Nos. X3E-11572-012 and X3E-11572-007 (Figs. A.3 and A.4, Appendix A), are Hoke and ORNL gas cylinders, designed and tested to meet IAEA Type A regulations⁴ for shipping radioactive gases. The largest gas cylinder will have a 16-L capacity. The arrangement of the inner liners for the various sizes of gas cylinder is shown in Fig. A.6 (Appendix A).

The net weight of the package (cylinder plus shield), containing the heaviest cylinder, is 487 lb. All calculations are based on a gross weight of about 750 lb. Compliance of this heavier package with design specifications demonstrates that the lighter packages would be well within the design limits.

0.2.2 Operational features

The shield is specifically designed to house Hoke or ORNL gas cylinders of up to a 16-L capacity. The shield is applicable for other vessels of similar construction but of lower capacities (Fig. A.6, Appendix A). Steel inserts (Fig. A.2, Appendix A), within the inner housing secure these gas cylinders from lateral or vertical motion during transport.

0.2.3 Contents

The primary containment vessels (Hoke or ORNL gas cylinders) will be used to carry shipments of up to 30,000 Ci of tritium gas, providing the decay heat load does not exceed 5 W. The maximum pressure for tritium gas shipments will be 4/5 atm (11.8 psia).

1. STRUCTURAL EVALUATION

The package complies with the structural requirements of the regulations.¹⁻⁴ The calculational results and engineering logic presented in the following subsections demonstrate compliance with these performance criteria. Additional evaluations considered pertinent to the safety and operability of the package are included. The effects of both normal and specified accident conditions on the structural integrity of the package are considered.

1.1 Mechanical Properties of Materials

The values shown in Table 1.1 are conservative values typical of materials used in the gas cylinders and the shields.⁶⁻⁸ The static properties shown provide a reasonable approximation of dynamic conditions if care is taken to ensure that the use of static values results in a conservative evaluation. For most structural materials, the static properties are much less than the dynamic properties. Numerous reports substantiate this, including Ref. 9.

Table 1.1 Mechanical properties of cask materials

Property	Symbol	Type 304L stainless steel	Type 347 stainless steel
Yield stress, psi	σ_y	28,000	35,000
Ultimate tensile strength, psi	σ_u	75,000	92,000
Modulus of elasticity, psi	E	28×10^6	28×10^6
Elongation in 2 in., %	e	50	50
Density, lb/in. ³		0.290	0.286
Allowable shear stress	ρ		
$\tau_{max} = \sigma_y/2$, psi	τ_{max}	14,000	17,500

1.2 General Standards for All Packages

The general standards for all packaging cover the chemical and galvanic reaction of the materials of the package, closure of the package, and the lifting and tie-down devices for the package. The gas cylinders and shields are constructed of type 304L or 347 stainless steel. The shields are filled with phenolic foam. There has been no evidence of any corrosive reaction between these materials or between the gases and the stainless steel cylinders.

1.2.1 Closure

The standards specify that the package be equipped with a positive closure that will prevent inadvertent opening. In this case, the outer shield lid is secured by eight 5/8-in. hex-head cap screws and qualifies as a positive closure. In addition, the closure of the inner housing lid is secured by twelve 3/8-in. hex-head cap screws.

The primary containment vessels (Hoke or ORNL gas cylinders) have seal-wired valves, which are further protected with an "O"-ring-sealed, screwed-on cap that constitutes a positive closure and provides a method of leak testing the valve after the cylinder is loaded with tritium gas (Appendix C).

1.2.2 Cask-lifting device

If a system of lifting devices is a structural part of the package, the regulations require that this system be capable of supporting three times the weight of the loaded package without generating stress in any material of the package in excess of its yield strength.

In the shield design, the lifting and tie-down device shown in Fig. 1.1 is used; it is welded to a circumferential band around the shield as shown in Fig. 1.2. Lateral stability is afforded to the devices by 3/8-in.-thick gusset plates welded to each device. There are four of these devices spaced symmetrically about the circumference of the shield. Failure of these devices

ORNL DWG 74-8416

ALL DIMENSIONS GIVEN IN INCHES

Fig. 1.1. Shield-lifting device.

would not affect the integrity of the package. Because it is likely that only two will be used, the lifting calculations are based on use of two lifting devices. The vertical load that must be supported is equal to three times the package weight, and because there are two lifting devices, each one must support 1.5 times the weight ($1.5W = 1125$ lb). The maximum stress encountered in the device would be bending stress at the base of the lugs and can be calculated using the relation

$$\sigma = Mc/I$$

(1)

ORNL DWG 74-8414

Fig. 1.2. Lifting load diagram.

The shear stress is

$$\tau = \frac{1.5W}{A} \quad (2)$$

where

$$A = \text{area at base} = 2(2-1/2)(3/8) = 1.875 \text{ in.}^2,$$

$$M = \text{bending moment} = F_y a = (1125)(1.5) = 1690 \text{ in. lb.},$$

$$c = 1.25 \text{ in.},$$

$$I = \text{moment of inertia} = (2)(bh^3)/12 = (2)(3/8)(2.5)^3/12 = 0.977 \text{ in.}^4,$$

$$\sigma = (1690)(1.25)/0.977 = 2200 \text{ psi},$$

$$\tau = 1125/1.875 = 600 \text{ psi.}$$

Thus, the lifting device complies with the stress criterion in that the stresses generated are significantly less than the yield stress and the allowable shear stress. Further, if excessive loads were applied to the lifting device, the lifting device would fail but would not affect the containment or shielding properties of the package.

1.2.3 Lid-lifting device

The lids of both the outer and inner housing (secondary containment) are of such size and shape as to make hand lifting applicable and to preclude the need for any integral lid-lifting device.

1.2.4 Tie-down devices

Regulations require that a system of tie-down devices that is a structural part of the package be capable of withstanding a static force applied to the center of gravity of the package with a vertical component of two times the weight of the package and its contents, a horizontal component along the direction of travel of ten times the weight of the package and its contents, and a horizontal component in the transverse direction of five times the weight of the package and its contents. This applied force shall not generate stresses in any material of the package in excess of the yield strength of that material. It is also required that any tie-down device that is a structural part of the package shall be so designed that failure of the device under excessive load will not impair the ability of the package to meet other requirements of the regulations. (The failure of a lifting eye would not compromise the integrity of the package in any way.)

Stress calculations for the tie-down devices follow. The loading is illustrated in Fig. 1.3. The actual geometry used to tie down the package can vary within the confines of the truck bed, which is nominally 8 ft wide. Three geometry cases will be examined, the first when $I = J = 26.6$, the second when $I = 26.6$ and $J = 15.36$, the third when $I = 15.36$ and $J = 26.6$. These values are believed to be representative of what might occur in practice.

It cannot be determined by inspection if the forward members C and D are under load. If they are under load, the normal force F_n will be located on the outer radius of the shield. To determine if C and D are loaded, it will be assumed that they are not and the location of F_n will be calculated. If the calculated location is within the confines of the shield base, these members are not loaded. However, if the calculated location is not within the boundary of the base, the members C and D must be under load to achieve equilibrium. Equation (3) shows that the location of F_n is independent of the applied force; hence, general notation in lieu of the $10W$ and $5W$ loads will be used. By summation of vertical forces,

$$F_n = 2F_z = 2T(H/L) \quad (3)$$

where T is tension in the rear members. By summation of horizontal forces,

$$F - 2F_x - F_f = 0 \quad (4)$$

$$F - 2T(J/L) - 2\mu T(H/L) = 0 \quad (5)$$

$$T = FL/2(J + \mu H) \quad (6)$$

where μ is the coefficient of friction between the base of the container and the vehicle bed. By summation of moments about axis b ,

$$NF_n + HF_f - MF = 0 \quad (7)$$

$$(2TH/L)(N + \mu H) - FM = 0 \quad (8)$$

$$N = (FML/2TH) - \mu H \quad (9)$$

Fig. 1.3. Shield tie-down load diagram.

Substituting for T ,

$$N = [M(J + \mu H)/H] - \mu H \quad (10)$$

Making numerical substitutions and taking $\mu = 0.4$ (see Appendix F), we can solve for N .

For case 1,

$$N = 8.81[26.6 + 0.4(29.75)]/29.75 - 0.4(29.75) = -0.56 \text{ in.}$$

For case 2,

$$N = 8.81[15.36 + 0.4(29.75)]/29.75 - 0.4(29.75) = -0.3 \text{ in.}$$

For case 3,

$$N = 8.81[26.6 + 0.4(29.75)]/29.75 - 0.4(29.75) = -0.50 \text{ in.}$$

The negative sign means that F_n is located forward of axis b and that the front cables are not under load. The loading configuration assumes that the tie-down lugs on the truck bed will be spaced not more than 6 ft apart. By geometry, the length of the cable is

$$L = (H^2 + I^2 + J^2)^{1/2} \quad (11)$$

where I and J are the horizontal distances from the lug to the bed tie point in the direction of travel and transverse directions and H is the elevation of the shield lug relative to the vehicle bed.

For case 1,

$$L = [(29.75)^2 + (26.6)^2 + (26.6)^2]^{1/2} = 47.96 \text{ in.}$$

For case 2,

$$L = [(29.75)^2 + (15.36)^2 + (26.6)^2]^{1/2} = 42.76 \text{ in.}$$

For case 3,

$$L = [(29.75)^2 + (26.6)^2 + (15.36)^2]^{1/2} = 42.76 \text{ in.}$$

The load in a single cable that results from the $2W$ vertical force component is

$$F_v = (2W/4)(l)/H \quad (12)$$

For case 1,

$$F_v = (2W/4)(47.96)/29.75 = 605 \text{ lb.}$$

For case 2,

$$F_v = (2W/4)(42.76)/29.75 = 539 \text{ lb.}$$

For case 3,

$$F_v = (2W/4)(42.76)/29.75 = 539 \text{ lb.}$$

The load that results from the $10W$ force is calculated by summing the moment about line b-b (Fig. 1.3).

$$\sum M = 0 \quad (13)$$

$$(N \cdot F_n) + (CG \cdot F) + (H \cdot F_v) = 0 \quad (14)$$

For case 1, using a right-handed coordinate system in which i is a unit vector oriented in the direction of the $10W$ load,

$$\begin{aligned} [0.5i(2T)(H/L)j] + (20.94j)(10W) + [29.75j(-2T)(J/L)i] &= 0 \\ 0.62Th - 209.4Wh + 33Th &= 0 \\ T &= 4671 \text{ lb} \end{aligned}$$

For case 2,

$$\begin{aligned} [3.83i(2T)(H/L)j] + (20.94j)(10Wi) + [29.75j(-2T)(J/L)i] &= 0 , \\ 5.33Tk - 209.4Wk + 21.37Tk &= 0 , \\ T &= 5882 \text{ lb} . \end{aligned}$$

For case 3,

$$\begin{aligned} [0.5i(2T)(H/L)j] + (20.94j)(10Wi) + [29.75j(-2T)(J/L)i] &= 0 , \\ 0.7Tk - 209.4Wk + 37.01Tk &= 0 , \\ T &= 4165 \text{ lb} . \end{aligned}$$

Similarly, the load that results from the transverse 5W force component is determined from

$$\sum M = (N \cdot F_n) + (CG \cdot F) + (H \cdot F_x) = 0 . \quad (15)$$

For case 1,

$$\begin{aligned} [0.5i(2T)(H/L)j] + (20.94j)(5Wi) + [29.75j(-2T)(I/L)i] &= 0 , \\ 0.62Tk - 104.7Wk + 33Tk &= 0 , \\ T &= 2336 \text{ lb} . \end{aligned}$$

For case 2,

$$\begin{aligned} [0.5i(2T)(H/L)j] + (20.94j)(5Wi) + [29.75j(-2T)(I/L)i] &= 0 , \\ 0.7Tk - 104.7Wk + 37Tk &= 0 , \\ T &= 2085 \text{ lb} . \end{aligned}$$

For case 3,

$$\begin{aligned} [3.83i(2T)(H/L)j] + (20.94j)(5Wi) + [29.75j(-2T)(I/L)i] &= 0 , \\ 5.33Tk - 104.7Wk + 21.37Tk &= 0 , \\ T &= 2941 \text{ lb} . \end{aligned}$$

The net load P in the cable from all three force components is given below.

For case 1,

$$P = 7612 \text{ lb} .$$

For case 2,

$$P = 8504 \text{ lb} .$$

For case 3,

$$P = 7645 \text{ lb} .$$

The maximum stress developed in the tie-down device will be bending where the device is welded to the drum. The component of the force in the cable that is perpendicular to the lug is

$$F = P \cos \theta , \quad (16)$$

where $\cos \theta$ = cosine of angle between cable and the vertical (H/L).

For case 1,

$$F_x = 7612 (29.75/47.96) = 4722 \text{ lb} .$$

For case 2,

$$F_x = 8504 (29.75/42.76) = 5917 \text{ lb} .$$

For case 3,

$$F_x = 7645 (29.75/42.76) = 5319 \text{ lb} .$$

The bending moment is

$$M = F_x x , \tag{17}$$

where $x = a$ (Fig. i.1).

For case 1,

$$M = 4722 (1.5) = 7083 \text{ in.} \cdot \text{lb} .$$

For case 2,

$$M = 5917 (1.5) = 8876 \text{ in.} \cdot \text{lb} .$$

For case 3,

$$M = 5319 (1.5) = 7979 \text{ in.} \cdot \text{lb} .$$

The maximum bending stress is $\sigma = Mc/I$. Using the values for c and I previously calculated (see Sect. 1.2.2), we have the following:

For case 1,

$$\sigma = (7083)(1.25)/(0.977) = 9062 \text{ psi} .$$

For case 2,

$$\sigma = (8876)(1.25)/(0.977) = 11,356 \text{ psi} .$$

For case 3,

$$\sigma = (7979)(1.25)/(0.977) = 10,209 \text{ psi} .$$

The shear stress on the pin in the tie-down device is

$$\tau = P/A .$$

For case 1,

$$\tau = (7612)/2 (1/2)^2 = 4846 \text{ psi} .$$

For case 2,

$$\tau = (8504)/2 (1/2)^2 = 5414 \text{ psi} .$$

For case 3,

$$\tau = (7645)/2 (1/2)^2 = 4867 \text{ psi}$$

Thus, the device is in the stress condition for tie-down because the stresses generated are less than the yield strength for reasonable tie-down geometries. If excessive loads were applied to the tie-down system, the tie-down system would fail without causing failure of the containment or shielding properties of the package.

Lateral stability is afforded to the devices by 3/8-in.-thick gusset plates welded to each device as shown in Fig. 1.4.

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GUSSET PLATE

Fig. 1.4. Shield-lifting and tie-down lug.

1.3 Standards for Type B and Large-Quantity Packaging

The structural standards for large-quantity packaging cover load resistance of the packaging and the external pressure that the package must withstand. Compliance of the ORNL gas-cylinder shield with these requirements is discussed in the following subsections.

1.3.1 Load resistance

When regarded as a simple beam supported at its ends, the shield must be able to withstand a static load along any major axis normal to and uniformly distributed along its

length that is equal to five times its fully loaded weight without generating stresses in any material in the shield in excess of the yield strength of that material. The equivalent cross section of the shield analyzed in this study is illustrated in Fig. 1.5.

Fig. 1.5. Shield as a simple beam.

The cross section of the shield is composed of the outer 16-gauge stainless steel shell, the phenolic foam, and the inner stainless steel shell as shown in Fig. 0.1. Because these components are located concentrically about the same axis, the moment of inertia of the composite section is the sum of the equivalent moments of inertia of the individual components. For a thin shell the moment of inertia about its center is

$$I_s = \int y^2 dA = 4 \int_0^{\pi/2} (r_m \sin^2 \theta) t r_m d\theta = \pi r_m^3 t \quad (18)$$

where

$$\begin{aligned} r_m &= \text{radius (in.)} , \\ t &= \text{thickness (in.)} . \end{aligned}$$

Neglecting the effect of the phenolic foam and the inner shell, the moment of inertia of the shield is

$$\begin{aligned} I &= \pi t (r_0)^3 , \\ &= \pi (0.0598) (12.12)^3 , \\ &= 334.5 \text{ in.}^4 \end{aligned} \quad (19)$$

The maximum bending stress is given by the expression

$$\sigma = Mc/I = 5WLr_0/8I \quad (20)$$

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$$\sigma = 5(750)(41.125)(12.12)/8(334.5) = 700 \text{ psi} .$$

The length L is the length of the outer housing. Because this stress is less than the yield stress for the housing material, it is concluded that the shield complies with the simple beam requirement.

1.3.2 External pressure

The regulations require that the shipping package be adequate to ensure that the containment vessel will suffer no loss of contents if subjected to 25 psig external pressure. For the purposes of stress calculations, it will be assumed that the foam-filled cavity is at the external pressure. One potential consequence of external pressure is buckling of the cylindrical shells of the shield. Because the outer shield housing is not airtight, there can be no pressure differential across it. The inner shield housing (secondary containment), then, must support the specified pressure without buckling. For the calculations, consider a model of the housing consisting of a right circular cylinder of 12.125 in. OD by 30.625 in. long by 0.0598 in. thick having closed ends. The critical buckling pressure can be determined using equations published by Faupel.¹⁰ For axisymmetric buckling,

$$\begin{aligned} P_{cr} &= 2E(t/R)^2/[3(1 - \nu^2)]^{1/2} , \\ P_{cr} &= (2)(30 \times 10^6)(0.0598/6.06)^2/[3(1 - 0.3^2)]^{1/2} , \\ P_{cr} &= 3436 \text{ psi} , \end{aligned} \tag{21}$$

where

- E = elastic modulus (psi),
- t = thickness of housing (in.),
- R = outside radius (in.),
- ν = Poisson's ratio,
- L = length of housing (in.).

For lobar buckling

$$\begin{aligned} F_c &= \frac{1.345E}{(1 - \nu^2)^{3/4}} \frac{(t/R)^{5/2}}{1.57(L/R) - (t/R)^{1/2}} , \\ P_{cr} &= \frac{1.345(30 \times 10^6)}{[1 - (0.3)^2]^{3/4}} \frac{(.9598/6.06)^{5/2}}{1.57(30.625/6.06) - (0.0598/6.06)^{1/2}} , \\ P_{cr} &= 53 \text{ psi} . \end{aligned}$$

Because the critical buckling pressure is greater than 25 psi, the shells will not buckle. External pressure would also load the flat base and lid of the inner housing, so a flat plate analysis must be used for the stresses in the base and lid. Using an expression from Timoshenko¹¹ for bending of a uniformly loaded circular plate clamped at the edges, the maximum stress is

$$\sigma_{\max} = 3PR^2/r^2 , \tag{22}$$

where

P = pressure (psi),

R = plate radius (in.),

t = plate thickness (in.).

For the gas-cylinder shield, both the base plate and the top plate are made of 1/4-in.-thick stainless steel plate.

The maximum stress in either plate ($t = 0.25$) is

$$\sigma_x = (3)(25)(6.06)^2/(4)(0.25)^2 = 11,020 \text{ psi}$$

This is well below the yield stress; therefore, no loss of contents can occur via the lid.

1.4 Compliance with Standards for Normal Conditions of Transport

The regulations for normal conditions of transport for a single package require that the effectiveness of the package will not be substantially reduced by the normal conditions of transport, that there will be no release of radioactive material from the containment vessel, and that there will be no gases or vapors in the package that could, through any credible increase of pressure or an explosion, significantly reduce the effectiveness of the package. There is no circulating coolant other than atmospheric air, and no mechanical cooling device is required or provided. The shield and the Type A inner container(s) are so designed that the contents will not be vented to the atmosphere under normal conditions of transport. These conditions include the effects of heat, cold, pressure, free drop, and penetration.

1.4.1 Heat

The package must be able to withstand direct sunlight at an ambient temperature of 130°F in still air without reducing the effectiveness of the packaging. A simplified one-dimensional heat transfer analysis (Sect. 2.1) was used to compute the steady-state temperature distribution in the package under the specified conditions. The surface temperature under these conditions would be approximately 208°F, and the temperature at the center of the package would be approximately 284°F.

The temperature that would exist in the package will not adversely affect the shield. The materials of construction do not suffer significant loss of physical properties at these temperatures. The continuous operating temperature limit of the neoprene gasket material is 240°F,¹² which is above the temperature at that point. The maximum service temperature of the phenolic foam¹³ is 300°F, which is also well above the temperature encountered.

The pressure in the gas cylinder and in the inner housing (Sects. 1.4.3 and 2.1) will not damage the container.

The regulations¹⁴ set forth by the Department of Transportation and the International Atomic Energy Agency further stipulate that the temperature of any accessible surface of the fully loaded shipping package shipped by common carrier shall not exceed 122°F when the package is in the shade in still air at an ambient temperature. For this computation, an ambient temperature of 100°F is assumed, and Eq. (25) in Sect. 2.1 is solved for surface temperature T_s , corresponding to the heat load q of 17.1 Btu/h (5 W). In this instance, $T_s = 100.4^\circ\text{F}$. Thus, the condition is satisfied, and there is no likelihood of any adverse effect on the package from the temperature encountered.

1.4.2 Cold

The shipping package must be able to withstand an ambient temperature of -40°F (420°R) in still air and shade. If the assumption of no internal heat load is made, a calculation can be made of the final or maximum pressure (P_2) in any cavity sealed at a pressure of 14.7 psia and a temperature of 70°F (530°R), yielding the result

$$P_2 = P_1 T_2 / T_1 = (14.7)(420)/530 = 11.65 \text{ psia} \quad (23)$$

The resulting pressure differential is not significant by comparison to the 25-psig external pressure considered in Sect. 1.3.2.

At -40°F , the type 304L or 347 stainless steel to be used would not suffer brittle fracture because its transition temperature is considerably lower than -40°F .

The neoprene gasket material has a low-temperature limit of -65°F (Ref. 12) and will not be damaged. The gas cylinder is constructed of 300 series stainless steel and would not be damaged by -40°F temperature.

1.4.3 Pressure

The regulations for normal conditions of transport specify that the package be able to withstand reduction in atmospheric pressure to 0.5 atm (the resulting pressure being 7.35 psia) at the 130°F ambient temperature condition. If the secondary containment housing is at atmospheric pressure at 70°F (530°R), then the final pressure at 230°F (790°R) (Sect. 2.1) is

$$P_2 = (14.7)(690)/530 = 19.14 \text{ psia} \quad .$$

Temperature in the inner liner (230°F) is calculated in Sect. 2.1. With the reduction in external pressure to 1/2 atm, the pressure differential across the secondary containment is

$$19.14 - 7.35 = 11.78 \text{ psi} \quad .$$

The hoop stress generated in the inner housing by this pressure is

$$\sigma_H = Pr/t = (11.78)(6.06)/(0.0598) = 1195 \text{ psi} \quad (24)$$

This internal pressure would result in bending stresses in the flat plates forming the ends of secondary containment. The magnitude of this stress can be evaluated as in Sect. 1.3.2 by the expression by Timoshenko.¹¹

$$\sigma = 3PR^2/4t^2 = (3)(11.78)(6.06)^2/(4)(0.25)^2 = 5191 \text{ psi} \quad (25)$$

These stresses are well below the yield stress and so would not damage the inner housing.

1.4.4 Vibration

The size of the outer housing of the shield is that of an 80-gal drum, and transport vibrations would not be expected to affect the integrity of the shield. The phenolic foam should further isolate the inner housing of the shield against vibrations. The bolts that seal the secondary containment are equipped with lock washers to prevent loosening.

1.4.5 Water spray

The shields are fabricated of 304L or 347 stainless steel and will not suffer appreciable corrosive damage during the water spray test. The phenolic foam is also not affected by water spray.

1.4.6 Free drop

The regulations for normal conditions of transport require that a package weighing less than 10,000 lb be capable of withstanding a free drop through a distance of 4 ft onto a flat, essentially unyielding horizontal surface, striking the surface in a position in which maximum damage is expected to result. Under this impact there should be no release of package contents (Sect. 1.5.1 and Appendix B). The tests reported in these sections are much more severe; therefore, it can be concluded that the package would survive the 4-ft drop without loss of containment or integrity.

1.4.7 Compression

It is required that packages weighing less than 10,000 lb be capable of withstanding a compression load of 5 times the container weight or 2 psi distributed uniformly across the top and bottom, whichever is greater.³⁴ In this instance, 5 times the weight of 750 lb is somewhat greater than the 2 psi condition. The maximum compressive stress in the walls is

$$\sigma = P/A = 5W/\pi D_o t = (5)(570)/\pi(23.93)(0.0598) = 835 \text{ psi} \quad , \quad (26)$$

where

D_o = mean diam of outer wall (in.) ,

t = wall thickness (in.) .

Thus, the package can support 5 times its weight with relatively low stresses generated in the walls.

1.4.8 Penetration

The regulations for normal conditions of transport also stipulate that the package be capable of withstanding the impact of the flat end of a vertical steel cylinder that weighs 13 lb, has a diameter of 1-1/4 in., and is dropped from a height of 4 ft, normally onto the exposed surface of the package that is expected to be the most vulnerable to puncture. This test would not reduce the effectiveness of the container and would result in no more than a dent in the surface of the container (Appendix F).

1.4.9 Leakage

The IAEA regulations⁴ require that Type B(U) packages, if subjected to the above tests, will restrict the loss of radioactive contents to not more than $A_2 \times 10^{-6}$ per hour. For tritium, an A_2 quantity is 1000 Ci. Tests¹⁴ have been conducted at ORNL certifying that the 2-, 5-, and 16-L tritium gas cylinders meet DOT specification 7A and IAEA Type A.

1.5 Compliance with Standards for Hypothetical Accident Conditions

The standards for the hypothetical accident condition stipulate that a package used for the shipment of fissile or a large quantity of radioactive material shall be so designed and constructed and its contents so limited that if it is subjected to the specified free-drop, puncture, thermal, and water-immersion (fissile material packages only) conditions, the reduction in shielding would not be sufficient to increase the external radiation dose rate to more than 1000 millirems/h at 3 ft from the outside surface of the package; no radioactive material would be released from the package except for gases containing total radioactivity not to exceed 0.1% of the total radioactivity of the contents of the package; and the contents would remain subcritical.

1.5.1 Free drop

The first in the sequence of hypothetical accident conditions to which the container must be subjected is a free drop through a distance of 30 ft onto a flat, essentially unyielding horizontal surface, striking the surface in a position in which the maximum damage is expected to occur.

A full-scale test model of a fire and impact shield (but of greater length and weight than the subject shield) was designed, fabricated, and tested at the Oak Ridge Gaseous Diffusion Plant as reported by Mallett and Newlon.⁵ The fire-resistant phenolic foam insulation used in the test shields was the same as the foam insulation in the subject shield. The results of their test are presented in Appendix B. The volume of deformation of the tested shield did not exceed 5% for this package, which would indicate no damage to the inner container.

Drops of a package similar to the gas-cylinder fire and impact shield were made on August 16, 1974. These drops were made to determine if a locking ring on the top of the drum would be damaged to the extent that the top of the drum would be lost. Three drops of 2 steel drums filled with vermiculite (package no. DOT SP 5765) were made from a height of 30 ft. The drops at three different angular orientations (74°, 54°, and 31°) did not cause loss or rupture of the container lid.

The latest in a series of tests was conducted on January 19, 1983. A container fabricated and inspected to ORNL drawing No. M-11574-EM-001-E, Rev. 6 (Fig. A.1, Appendix A), loaded with a 16-L tritium gas cylinder (Fig. A.3, Appendix A) filled with helium at 0.8 atm was subjected to two free-drop tests from a height of 30 ft. The testing was conducted at the ORNL tower shielding facility under the supervision of ORNL Engineering personnel. In the first test, the container struck the test pad on the rear of the container and exerted force on the closure lid with a side loading. The test container was suspended at an angle of $30 \pm 5^\circ$ from horizontal (Fig. A.7, Appendix A), hoisted until the lowest part of the container was 30 ft above the test pad, and released. Figure A.8 (Appendix A) shows the effects of the drop on the closure flange and lid. The lid was still in place after the first drop.

The second free drop was a 30-ft drop in which the center of gravity of the container was directly over the edge of the closure flange and lid. The results of this drop and the previous damage suffered by the container are shown in Fig. A.9 and A.10 (Appendix A). The closure lid and fire shield are still in place after both of these free drops. Figure 12 is a photograph of the test container disassembled after the two free-drop tests and the puncture test described in Sect. 1.5.2.

It was concluded on the basis of these testing programs that the shield would not suffer damage sufficient to damage the inner container nor would the lid be lost in the 30-ft free fall regardless of orientation during the fall.

Additional tests¹⁴ were performed on typical gas cylinders used in the gas-cylinder fire and impact shield, and the test results concluded that the 2-, 5-, and 16-L tritium cylinders meet the 1973 IAEA regulations⁴ for Type A packaging.

1.5.2 Puncture

The second in the sequence of hypothetical accident conditions to which the package must be subjected is a free drop through a distance of 40 in. to strike, in a position in which maximum damage is expected, the top end of a vertical, cylindrical mild-steel bar mounted on an essentially unyielding horizontal surface. The mild-steel bar shall be 6 in. in diameter, the top horizontal and its edge rounded to a radius of not more than 1/4 in., and of such length (not less than 8 in. long) that it will cause maximum damage to the cask. The long axis of this bar shall be normal to the surface of the cask upon impact.

In their report on a similar package, Mallett and Newlon⁶ (Appendix B) presented the results of a puncture test. Their container was dropped on its side and was dented about 1.25 in. without rupture of the wall.

The container tested in the free-drop tests on January 19, 1983, was also puncture tested. The test conformed to the hypothetical accident conditions described in the first paragraph of this section. Figure A.11 (Appendix A) is a photograph of the container after the puncture test. The wall of the container was dented but not ruptured.

Puncture tests¹⁴ on gas cylinders were performed at ORNL, and the gas cylinders meet the requirements of IAEA Type A.⁴

1.5.3 Water immersion

The final condition in the specified hypothetical accident is immersion in water to a depth of 3 ft for a period of 24 h. The foam cavity is not sealed; hence, it would be partially flooded with water. Primary and secondary containment would not be breached as a result of any of the accident conditions; hence, the contents, tritium gas, would not be in contact with the water, and no contamination would be transferred to the water. No fissile materials are transported with this shield; therefore, criticality is not a factor. The water would not decrease the effectiveness of the package as a result of corrosion or other deterioration.

1.5.4 Leakage

The IAEA regulations⁴ require that Type B(U) packages, if subjected to the above tests, will restrict the loss of radioactive contents to not more than $A_2 \times 10^{-3}$ in one week. As discussed in Sect. 1.4.9, tests¹⁴ certifying that the 2-, 5-, and 16-L tritium gas cylinders meet DOT specification 7A, IAEA Type A, and IATA regulations have been conducted.

The 16-L gas cylinder (Fig. A.3, Appendix A) that was part of the test assembly tested on January 19, 1983, was prefilled with helium at 0.8 atm and leak-tested before and after the tests of Sect. 1.5.1 and 1.5.2. Both the entire valve and valve seal were tested, and both resulted in a leak rate less than 2×10^{-8} cc/s helium. The sensitivity of the test was greater than 3×10^{-10} cc/s helium. This leak rate is equivalent to an air leak of 7.6×10^{-9} std cc/s.

2. THERMAL EVALUATION

The package must remain effective after exposure to severe thermal environments. Applicable normal and accident environments are specified in the regulations^{1-4,14} and are discussed below. Analytical evaluations and tests have been utilized to demonstrate the ability of the package to remain effective after exposure to the specified environments.

2.1 Normal Conditions of Transport

The package must be able to withstand direct sunlight at an ambient temperature of 130°F in still air without reducing the effectiveness of the packaging. A simplified one-dimensional heat transfer analysis¹⁵ was used to compute the steady-state temperature distribution in the package under the specified conditions.

To determine the temperature of the outside surface of the shield, an expression that includes convective and radiative heat transfer effects¹⁶ is used. The expression is of the form

$$q = q_c + q_R$$

$$q = h_c A_c (T_s - T_a) + 0.173 \bar{F}_{12} A \{ [(T_s + 460)/(100)]^4 - [(T_a + 460)/(100)]^4 \} \quad (27)$$

where

$$\begin{aligned} q_c &= \text{convective heat flow (Btu/h),} \\ q_R &= \text{radiative heat flow (Btu/h),} \\ h_c &= \text{convective heat transfer coefficient}^{16} = 0.19(T_s - T_a)^{1/3} \\ &\quad \text{Btu/h} \cdot ^\circ\text{F}, \\ A_c &= \text{convective heat transfer area} = 24.67 \text{ ft}^2, \\ T_s &= \text{surface temperature (}^\circ\text{F),} \\ T_a &= \text{ambient temperature, } 130^\circ\text{F,} \\ A &= \text{radiative heat transfer area} = A_c (\text{ft}^2), \\ \epsilon &= \text{emissivity of the 18-8 stainless steel,}^{17} \\ \bar{F}_{12} &= \text{gray body shape factor}^{16} (\sim 0.6). \end{aligned}$$

The heat load q on the package is a combination of the internal and solar heat loads. The maximum internal heat load is 5 W, so $q_{\text{int}} = 17.1 \text{ Btu/h}$.

Because of the cyclic nature of solar heat load and the large time constant associated with casks of this type, the solar heat load per unit area can be approximated by numerically integrating the area under a normal incident solar energy curve¹⁸ and is equal to 144 Btu/ft²·h. (This average solar heat flux is the same as was used in an example problem in Ref. 19.) The solar contribution is the major heat load in this calculation, and the exposed surface area will be conservatively calculated as the convective heat transfer area, including the top and sides but not the bottom.

$$\begin{aligned} A &= \pi r^2 + 2\pi r l \\ &= \pi(12)^2 + (2)(\pi)(12)(41.125) \\ &= 3553 \text{ in.}^2 = 24.67 \text{ ft}^2 \end{aligned} \quad (28)$$

The solar heat load is

$$q_s = (144)(24.67) = 3555 \text{ Btu/h}$$

The net heat load at the surface is

$$q = 3553 + 17 = 3570 \text{ Btu/h} .$$

The surface heat transfer equation [Eq. (27)] was solved via an iterative process to determine the surface temperature t_s corresponding to $q = 3570 \text{ Btu/h}$. In this case, $T_s = 208^\circ\text{F}$.

To determine temperature at various points in the package interior, a steady-state, one-dimensional analysis for conduction in concentric cylinders¹⁵ was used.

Figure 2.1 shows schematically the temperature distribution across the various layers of the container. To compute the temperature drop across any layer, the following expression¹⁵ was used:

$$T_i - T_o = q \ln(r_o/r_i) / 2\pi k L , \quad (29)$$

where

$$\begin{aligned} T_o &= \text{outer surface temperature } (^\circ\text{F}) , \\ T_i &= \text{inner surface temperature } (^\circ\text{F}) , \\ r_o &= \text{outer radius (in.)} , \\ r_i &= \text{inner radius (in.)} , \\ L &= \text{length (ft)} , \\ k &= \text{thermal conductivity (Btu/h}\cdot\text{ft}\cdot^\circ\text{F)} . \end{aligned}$$

To compute the temperature drop across the cylinder intervals T_{0-1} , the following expression was used:

$$\frac{T_{0-1} = Q r_1^2 / 4k}{Q = \text{internal heat load (Btu/h}\cdot\text{ft}^3)} \quad (30)$$

For the purpose of these calculations, the dimensions of the 16-L gas cylinder will be used, and L will be taken as the inside length of this cylinder ($L = 1.69 \text{ ft}$). Thermal conductivities of the various substances used are given in Table 2.1.²⁰

Using the calculated surface temperature of 208°F , one can compute the temperature inside the inner housing. The maximum value of temperature in this housing would be T_4 , on the gas-cylinder surfaces.

$$T_4 = 208 + \Delta T_{s-4} = 208 + 22 = 230^\circ\text{F} .$$

The temperature of the gas within the pressure vessel can be assumed to be uniform and equal in temperature to the inside container wall.

Table 2.2 gives the computations of all the values of ΔT using Eq. (29). The temperature at the center of the pressure vessel is

$$T_0 = 208 + \Delta T_{s-0} = 208 + 76.7 = 284.7^\circ\text{F} .$$

The maximum room-temperature filling pressure of the cylinders is 0.8 atm (11.8 psia). At 284.7°F (708°R) the inside pressure would be

$$P_2 = (744.7)(11.8)/530 = 16.52 \text{ psia} ,$$

assuming ideal gas behavior.

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Fig. 2.1. Heat transfer model.

Table 2.1. Thermal conductivities of shield materials

Material	Thermal conductivity (Btu/h · ft · °F)
Type 304L stainless steel	9.13
Air	0.016
Phenolic foam	0.097
Tritium	0.02

Source: A. L. Edwards, *A Compilation of Thermal Property Data for Computer Heat-Conduction Calculations*, UCRL-50689 (1969).

Table 2.2. Temperature drops across shield components during normal transport conditions

$\Delta T_{8-7} = [17.1 \ln(12.06/11.99)] / [(2\pi)(9.13)(1.6875)]$	$= 1.03 \times 10^{-3} \text{°F}$
$\Delta T_{7-6} = [17.1 \ln(11.99/6.06)] / [(2\pi)(0.097)(1.6875)]$	$= 11.35 \text{°F}$
$\Delta T_{6-5} = [17.1 \ln(6.06/6.00)] / [(2\pi)(9.13)(1.6875)]$	$= 1.8 \times 10^{-3} \text{°F}$
$\Delta T_{5-4} = [17.1 \ln(6.00/5.38)] / [(2\pi)(0.016)(1.6875)]$	$= 11 \text{°F}$
$\Delta T_{4-3} = [17.1 \ln(5.38/5.13)] / [(2\pi)(9.13)(1.6875)]$	$= 8.4 \times 10^{-3} \text{°F}$
$\Delta T_{3-2} = [17.1 \ln(5.13/4.31)] / [(2\pi)(0.016)(1.6875)]$	$= 17.5 \text{°F}$
$\Delta T_{2-1} = [17.1 \ln(4.31/4.03)] / [(2\pi)(9.13)(1.6875)]$	$= 1.2 \times 10^{-2} \text{°F}$
$\Delta T_{1-0} = (8.39)(.35)/(4)(.02)$	$= 36.7 \text{°F}$
Total	= 76.7° F

The hoop stress generated by this pressure is

$$\sigma_h = Pr/t \quad , \quad (31)$$

where

P = guage pressure (psig) ,

r = vessel radius (in.) ,

t = wall thickness (in.) .

Therefore, assuming atmospheric external pressure

$$\sigma_h = (16.52 - 14.7)(4.17)/(5/32) = 25.0 \text{ psi} .$$

2.2 Thermal Accident

The third in the sequence of hypothetical accident conditions specified by the regulation to which the package must be subjected is exposure for 30 min within a source of radiant heat having a temperature of 1475°F and an emissivity coefficient of 0.9. For calculation purposes, the surface of the package is assumed to have an absorption coefficient of 0.8. The package shall not be cooled artificially until 3 h after the test period has ended unless it can be shown that the temperature on the inside of the package has begun to fall in less than 3 h.

Similar packages with the same fire-resistant foam insulation, as reported by Mallett and Newlon,⁵ were tested according requirements in the previous paragraph. The complete results are presented in Appendix B and indicate that at no point in the package inner liner will the temperature reach 200°F. It is concluded, therefore, that the gas-cylinder fire and impact shield will not exceed 200°F under the same conditions.

The maximum normal shipping pressure of 0.8 atm (11.8 psia) in the tritium shipping cylinder is measured at ambient temperature. Increasing the cylinder temperature to 200°F would increase the gas pressure to 0.92 atm (14.6 psia). After manufacture, each gas cylinder was pressure tested and certified leak-tight at a pressure of 100 psig before entering service. Therefore, it may be concluded that the cylinder would not leak under accident conditions.

3. CONTAINMENT

It is required^{1-4,14} that packages maintain containment of radioactive contents during normal and specified accident conditions. The containment boundaries and capabilities of the gas-cylinder fire and impact shield are outlined below.

In this package, the gas cylinders constitute primary and secondary containment. The gasketed inner housing of the fire and impact shield serves as the third line of containment, and the outer housing, because it is not sealed, does not provide any additional containment.

The gas cylinders are routinely checked for leaks by means of an ionization-chamber leak detector and for vacuum-holding capability by the Operations Division's Radioisotope Process Group (Appendix C).

4. SHIELDING

Only Type B shipments of uncompressed tritium gas (up to 30,000 Ci) are made in the package. Tritium gas cylinders do not require shielding because of the soft beta radiation emanating from the material shipped.

5. CRITICALITY

Because no fissile materials are to be transported, a criticality evaluation is not necessary for this shield.

6. QUALITY ASSURANCE

The regulations¹⁻⁴ require packaging to be designed, fabricated, and operated in conformance with an established, formal quality assurance program. Compliance with this requirement is discussed in the following subsections.

6.1 Fabrication, Inspection, and Acceptance Tests

The fire and impact shields were fabricated in accordance with the ORNL drawing No. M-11574-EM-001-E and the gas cylinders were fabricated to ORNL drawing Nos. X3E-11572-012 and X3E-11572-007. The ORNL quality assurance procedures were applicable to quality-level-III fabrication. The welds were made in accordance with the WPS specifications and inspected as specified. The material used in modifications was obtained from UCCND stores stock, which is purchased in accordance with ASTM specifications. The phenolic foam was poured in accordance with the job specifications outlined on the drawings. The required leak tests were performed to verify the integrity and leak tightness of the gas cylinders and shields. Dimensional inspection of the completed cylinders and shields was performed. Weld and dimensional inspection reports along with leak test reports are filed in a quality assurance file.

6.2 Routing Operating and Inspection Procedures

The ORNL Operations Division has established routine operating and inspection procedures, leak tests, and standard check lists to ensure that all shipments are safe and comply with the regulations¹⁻⁴ and all ORNL procedures and regulations. A copy of the procedures and the check lists is presented in Appendix C.

6.3 Periodic Maintenance and Inspections

Prior to each shipment, routine inspections and leak checks are performed as outlined in the procedures and check lists presented in Appendix C. Maintenance is required only when routine inspections indicate damage. There are no time-degradable materials used in the construction of the containers, except for gaskets, seals, padding, and cements. Any damage or degradation to these is detected during routine inspection, and replacement is carried out. The gaskets are routinely replaced every six months.

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19. L. B. Shappert, *Cask Designer's Guide*, ORNL-NSIC-68 (February 1970), p. 143.
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Appendix A

AS-BUILT DRAWINGS

Fig. A.1. As-built drawing No. M-11574-EM-001-E.

Fig. A.2. Gas-cylinder inserts.

Fig. A.3. Hoke tritium gas cylinders.

Fig. A.4. ORNL tritium gas cylinder.

Fig. A.7. Rigging for 30° drop test of the ORNL tritium gas-cylinder fire and impact shield taken at the Tower Shielding Facility.

ORNL PHOTO 0489-83

Fig. A.8. Effects of the 30° drop test on closure lid of ORNL tritium gas-cylinder fire and impact shield.

Fig. A.9. Horizontal view of the ORNL tritium gas-cylinder fire and impact shield after center-of-gravity drop on closure.

Fig. A.10. Upright view of the ORNL tritium gas-cylinder fire and impact shield showing the effects of the center-of-gravity drop on the closure.

Fig. A.11. Effects of penetration test on the ORNL tritium gas-cylinder fire and impact shield.

Fig. A.12. Disassembled ORNL tritium gas-cylinder fire and impact shield after two 30-ft drop tests and a 40-in. puncture test.

Appendix B

FIRE AND IMPACT TEST RESULTS*

*Material in this Appendix is excerpted from Mallett and Newlon.¹

ACCIDENT TEST CONDITIONS OF TRANSPORT

Normal

The protective packages containing cylinders filled with simulated UF_6 (ferrous sulfide and lead pieces) at the normal fill weights of 250 lb for the 8-in.-diam cylinder and 450 lb for the 12-in.-diam cylinder were not subjected to the normal test requirements of AEC Manual, Chapter 0529.² The internal construction of the 12-in. container is shown in Fig. B.1. Earlier prototype packages of essentially the same configuration and strength specifications had previously completed this series of tests with negligible damage. Moreover, it was considered that successful completion of the hypothetical tests under similar but more severe conditions would ensure satisfactory compliance with normal testing.

Fig. B.1. Protective package for 12-in.-diam UF_6 cylinder.

Hypothetical

Drop test

The drop test consists of a free fall through a distance of 30 ft onto a flat, essentially unyielding horizontal surface, the package striking the surface in such a position as to suffer maximum damage.

Both 8- and 12-in.-diam-cylinder packages were dropped 30 ft, first in a horizontal position, then at a 45° angle, bottom-end downward. Areas at points of impact of both units were crushed without fracture. Beyond this, the only significant damage was the slight opening of the 8-in.-unit cover at the closing ring. This, in all probability, resulted because the original design for the 8-in. package included a standard cover having the closing ring at the top of the drum. The volume change by either impact test does not exceed 5%; the separation distances between containers is decreased slightly. As a result of this test, the design was revised and is now similar to the 12-in. design, which positions the closing ring away from the end and provides a deep protective cap for the package. This design proved satisfactory in the 12-in. design and need not be retested.

A small tear in the heat-affected zone of the base lug weld on the 8-in.-cylinder package was also observed following the horizontal drop. This rupture occurred when the lug bent as it struck the pad. Weld size, limited by the concave configuration of the shell and lug width at this point, was insufficient to properly support the lug. Lug width has since been increased to provide greater strength. The original lugs met the criteria; hence, it is not necessary to reevaluate the improvement.

The pad used in the drop tests is constructed of reinforced concrete. Embedded steel cross beams support a flush surface slab of 4-in.-thick steel armor plate. The pad is considered unyielding with respect to these packages.

Puncture test

In a free drop through a distance of 40 in., the package strikes in such a position as to suffer maximum damage (i.e., with the top end of a vertical cylindrical mild steel bar mounted on an essentially unyielding horizontal surface). The bar shall be 6 in. in diameter, with the top horizontal and its edge rounded to a radius of not more than $\frac{1}{4}$ in., and of such a length (not less than 8 in.) as to cause maximum damage to the package. The long axis of the bar shall be normal to the package surface.

Both packages subjected to the puncture test were indented about $1\frac{1}{4}$ in. without rupture of the walls.

Thermal test

The thermal test consists of exposure for 30 min within a source of radiant heat having a temperature of 1475°F and an emissivity coefficient of 0.9 or equivalent. For calculational purposes, it shall be assumed that the package has an absorption coefficient of 0.8. The package shall not be cooled artificially until after the 30-min test period has expired and the temperature at the center of the package has begun to drop.

The packages containing the 8- and 12-in. cylinders were positioned upright on railroad rails above and centered on open tanks filled with diesel oil. The diesel oil was ignited and burned for a period of 45 min at a maximum center temperature of $\sim 2200^{\circ}\text{F}$. Micromax temperature readings were obtained from thermocouples clamped to the top and sides of the drums.

Temperatures varied from top to bottom of the units, readings indicated 1100 to 1500°F at the top, 1900 to 2200°F at the center, and 1600 to 1800°F near the base. The fire lasted ~ 45 min, after which the packages were allowed to cool for 4-h before being immersed in water.

Internal temperatures were measured by positioning Temp-Plate pellet temperature indicators on the walls of the inner housings and at several places along the lengths of the cylinders. The temperature range of these devices is 120 to 450°F , indicated in $\sim 50^{\circ}$ increments. Inspection of these indicators after dismantling of the packages disclosed that the temperature had not reached 200°F at any point. This includes the area where the opening of the 8-in. cylinder package cover had occurred during the drop test, even though only $\frac{1}{4}$ in. thickness of uncharred plastic insulation remained at that location.

References

1. A. J. Mallett and C. E. Newlon, *Protective Shipping Packages for 8- and 12-inch Diameter UF_6 Cylinders*, K-1714, AEC Research and Development Report, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tenn. (Apr. 20, 1967).
2. U.S. Atomic Energy Commission, "Safety Standards for the Packaging of Fissile or Other Radioactive Materials," *AEC Manual*, vol. 0000, General Administration: Part 0500, Health and Safety, chap. 0529 (June 16, 1973).

Fig. B.2. Shipping packages for 8- and 12-in. cylinders.

Fig. B.3. View of 30-ft drop test.

Fig. B.4. Effects of end and piston drops on 12-in. package.

Fig. B.5. Effects of end and piston drops on 12-in. package.

Fig. B.6. Effects of horizontal and end drops on 8-in. package.

Fig. B.7. Effects of horizontal and end drops on 8-in. package.

Appendix C

ROUTINE PACKAGING AND INSPECTION PROCEDURES

OAK RIDGE NATIONAL LABORATORY RADIOACTIVE MATERIALS PACKAGING CERTIFICATION

THIS FORM IS REQUIRED FOR ALL RADIOACTIVE SHIPMENTS AND ALL EMPTY RETURNABLE CONTAINERS

(Routine Type A Shipments Packaged by Process Group Personnel are Exempt)

GENERAL INFORMATION

1. Origin (Division)	2. Destination
3. Method of Transport	4. Weight
5. Special Instructions	

Special Instructions Complied by

RADIOACTIVE CONTENTS

1. All major activities in curies and/or grams			
2. ☐ Analyzed? ☐ Calculated?			
3. Specify (a) ☐ Normal Form	(b) ☐ Special Form	(c) ☐ Fissile	(d) ☐ Non-Fissile
4. Radioactive Material Form: ☐ Solid ☐ Liquid ☐ Gas			
5. Heat load (watts): ☐ Calculated ☐ Estimated By			

INTERNAL CONTAINER

1. Internal Containment: ☐ Glass Bottle ☐ Plastic Bottle ☐ "2R" ☐ Conoseal ☐ Welded Capsule	
(specify capsule material) ☐ Other (explain)	
2. Contamination level on internal container: Estimated	Smeared
3. Radiation level from internal container: Measured	Calculated
4. Gaskets or seals (valves) properly installed	By
5. Leak tests of internal container	By
6. Packaging schematic attached	By

EXTERNAL CONTAINER

1. Moderator and neutron absorber present for fissile materials?	☐ Yes	By
2. External container examination	☐ Yes	By
3. Gaskets or seals properly installed	☐ Yes	By
4. Leak test	☐ Yes	By
5. Bolts torqued to _____ ft. lbs.		By
6. Tie down to skid checked	☐ Yes	By
7. Tamper seal installed	☐ Yes	By
8. Lid eye bolt removed and wire to the outside of the carrier	☐ Yes	By
9. Packaging schematic attached	☐ Yes	By

SHIPPING CONTAINER

1. Certificate of Compliance No. USA-
2. DOT Specification No.

RADIATION SURVEY

1. Surface contamination level: Alpha _____ dpm; Beta/Gamma _____ dpm
2. External radiation level _____ mrem/hr @ contact
3. Domestic shipments _____ mrem/hr @ 3 ft. from surface
4. Foreign shipments _____ mrem/hr @ 1 meter from center
5. Health Physics Surveyor _____ Date _____

TRUCK TIE-DOWN AND SHORING

1. Tie-down in accordance with SARP and Designed Layout checked by _____ (Inspection Engineering)
2. Shoring check by (if required) _____

Certifies Packaging Data is Correct for Shipment

Date

OPERATIONS DIVISION RADIOISOTOPE DEPARTMENT

BUILDING 3038

RADIOISOTOPE PACKING AND SHIPPING
OAK RIDGE NATIONAL LABORATORY

RADIOISOTOPE PACKAGING AND SHIPPING PROCEDURE OPERATIONS DIVISION

PROC. NO. 1
PAGE 1 OF 3
DATE 6/30/80

PROCEDURE FOR APPROVAL TO SHIP RADIOACTIVE MATERIAL

1. All requests to ship radioactive material are first referred to the SS Materials Management Department or to the Isotopes Sales Office for approval [reference: *Isotopes Sales Operating Manual* and the *Nuclear Materials Management Manual*, ORNL-2800 (Revised)].
2. Radioactive Materials Packaging Form (UCN-12301) is completed by the requester and attached to the Special Works data sheet (UCN-1784) or the SS Accountability document (UCN-2681). The supervisor of the Radioisotope Packing and Shipping operation reviews the information provided and flags all shipping documents for shipments requiring Type "B" shipping containers.
3. Documentation of requests for shipping radioactive materials with half-lives >14 days is submitted two full working days before the scheduled shipping date to give adequate time for review of package documentation and approval of the shipment.
4. Documentation of requests for shipment of radioactive material with a half-life of 14 days must be submitted by 1:00 p.m. on the day before the scheduled shipping date.
5. The review of packaging documentation follows the procedure established in *ORNL Guide for the Packaging of Radioactive Materials for Transport*, and *Nuclear Materials Management Manual*, ORNL-2800 (Revised).
6. A Radioactive Materials Packaging Form (UCN-12301) is required for all returnable container shipments (empty or full) and for all shipments containing >1 mCi alpha or >3 Ci beta/gamma.

PACKING AND SHIPPING PROCEDURE

1. The supervisor of the Radioisotope Packing and Shipping Operation (RPSO) receives approved shipping documents UCN-2775 (3 3-79) from the SS Materials Management and Isotopes Sales Group by 1:00 p.m. on the day before the shipment is scheduled to leave ORNL.
2. The RPSO supervisor reviews each shipping document and the Radioactive Materials Packaging Form and reports any discrepancies to the Process Group Leader for action. In the absence of the Group Leader, discrepancies in the documentation are reported to the Radioisotope Department Superintendent for action.

APPROVED:

<p>SUPERVISOR <i>R. D. Johnston</i></p>	<p>PROCESS GROUP LEADER <i>R. B. Schuch</i></p>	<p>DATE 6/30/80</p>
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OPERATIONS DIVISION RADIOISOTOPE DEPARTMENT

BUILDING 3038

RADIOISOTOPE PACKING AND SHIPPING

OAK RIDGE NATIONAL LABORATORY

RADIOISOTOPE PACKAGING AND SHIPPING PROCEDURE

OPERATIONS DIVISION

PROC. NO. 1
PAGE 2 OF 3
DATE 6/30/80

3. All shipping documents flagged as Type "B" are separated by the RPSO supervisor and handled on a personal basis until the unit is properly loaded on the transporting vehicle. He then signs the Radioactive Materials Packaging Form (UCN-12301) and immediately returns all completed documents to the Process Group Leader for a final review.
4. In the absence of the RPSO supervisor, the relief supervisor brings all shipping documents to the Process Group Leader for review and identification of shipments that require special attention of the relief supervisor.

GENERAL REGULATIONS

1. Short half-life materials (<14 days) are shipped on Tuesday and Friday of each week. Special schedules can be arranged for holiday weeks. Medical isotopes are shipped when required.
2. Long half-life materials (>14 days) are shipped on Wednesday and Thursday of each week. Shipments weighing greater than 300 lb are shipped on Friday unless special arrangements are made.
3. All packages received at Building 3038 Packing and Shipping Room must meet ORNL *Health Physics Manual* Chapter 4.2 requirements concerning internal transfers of radioactive materials and must meet DOT shipping regulations for external radiation (<200 mrem/hr at the surface and 10 mrem/hr at 3 feet). The RPSO supervisor must be notified by the originator of the shipment when he delivers his package to Building 3038.
4. For each package, bottle of product, source, target, or other form of radioactive material taken to Radioisotope Packing and Shipping, a copy of the Special Work Order or a note must be attached to the container with the following information:
 - A. Quantity of radioactivity actually being shipped.¹
 - B. Chemical form.
 - C. Concentration of radionuclide in solution, mCi/ml.
 - D. Volume or product weight.
 - E. Specific activity¹ (list as "C.F." for carrier free where applicable).
 - F. Assay date and time.¹

APPROVED:

R. D. Johnston
SUPERVISOR

PROCESS GROUP LEADER

R. W. Schuch

DATE
6/30/80

**OPERATIONS DIVISION
RADIOISOTOPE DEPARTMENT
BUILDING 3038**

**RADIOISOTOPE PACKING AND SHIPPING
OAK RIDGE NATIONAL LABORATORY
RADIOISOTOPE PACKAGING AND SHIPPING PROCEDURE
OPERATIONS DIVISION**

PROC. NO. 1
PAGE 3 OF 3
DATE 6/30/80

G. Normality of solutions of acids and bases.

H. Radiochemical purity.²

¹Unprocessed reactor and cyclotron targets are not assayed; therefore, quantity of radioactivity is calculated in these cases. Cyclotron target strip solutions should be analyzed for quantity of product radioisotope prior to shipment.

²In the case of short-lived radioisotopes, radiochemical purity assay results may be furnished after the shipment is made.

In the case of partial shipments of products listed on the Special Work Order a copy of the Special Work Order must be furnished with each partial shipment, and the items on the Special Work Order not being shipped must be marked out.

An Isotope Product Card (UCN-6216) must be filled out for every radioisotope product solution. In the case of product solutions loaded in shipping containers outside of Radioisotope Packing and Shipping, a completed copy of this form must be submitted with the product container to the Packing Supervisor with a copy to the Isotopes Sales Office.

5. The packaging and shipment of radioisotopes shall follow the *Procedures for Packaging and Shipment of Radioactive Materials Building 3038* and *ORNL Guide for the Packaging of Radioactive Materials for Transport*.

APPROVED:

SUPERVISOR	PROCESS GROUP LEADER	DATE 6/30/80
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OPERATIONS DIVISION RADIOISOTOPE DEPARTMENT

BUILDING 3033

KRYPTON AND TRITIUM FACILITY OPERATION OF THE TRITIUM SYSTEM

SHIPPING CONTAINER LOADING

PROC. NO. 10D
PAGE 1 OF 7
DATE 12/8/82

I. LEAK TESTING SHIPPING CYLINDERS BEFORE LOADING.

1. All valves closed, with system evacuated.	1. Normal standby condition.
2. Tighten valve adjustment nut to 190 in.-lbs torque with a torque wrench and record. Place wax seal on valve adjustment nut.	2. If wax seal is not broken, valve adjustment nut does not need to be retightened. Record "OK" in torque column.
3. Connect cylinder to loading line, valves 2, 3, or 4.	3. If cylinder fitting on pigtail is worn excessively, replace it.
4. Open valve 2, 3, or 4, and valves 5, 8, 9, 19, and 20.	4. Loading header will be evacuated.
5. Open cylinder valve.	5. Slowly open valves in case of pressure in cylinder.
6. Evacuate cylinder to a pressure of 0.1 mm or less on PI-4B.	6. Once per month document or daily check sheet (Procedure 6) that off-gas ion chamber is operating properly.
7. Close cylinder valve, close valves 2, 3, or 4, and valves 5, 8, 9, 19, and 20.	
8. Pressurize header to atmospheric pressure with argon, through valve 1.	
9. Set cylinder aside.	9. Must have minimum of 4 hr shelf time.
10. Reconnect cylinder to system loading line.	
11. Open valves 2, 3, or 4, and 5, 8, 9, 19, and 20.	11. Loading line will be evacuated.
12. Open cylinder valve.	12. Any increase in pressure above that observed in Step 6 denotes a leak.
13. Close cylinder valve.	13. If no leak, proceed to loading procedure. If leak is detected, disconnect cylinder and set aside for repair.

APPROVED:

SUPERVISOR
J. R. DeLoe
UCN-12830A (3 4-77)

PROCESS LEADER

J. V. Schleich

DATE
12/8/82

OPERATIONS DIVISION RADIOISOTOPE DEPARTMENT

BUILDING 3029

SOURCE DEVELOPMENT LABORATORY

QUALITY ASSURANCE PROCEDURE FOR TYPE B SHIPPING CONTAINERS

PROC. NO. 24
PAGE 1 OF 7
DATE 4/19/82

Incoming Type B Containers

1. Container is opened under the supervision of the Packing Foreman and a representative of the Health Physics Division. Radiation readings and smear levels on the external and internal surfaces are recorded. These records are stored in the auditable Quality Assurance (QA) file in Building 3029.
2. If container is contaminated externally or internally, it is cleaned to ORNL smear tolerance of 500 dis/min beta-gamma or 30 dis/min alpha. The final smear level is recorded by Health Physics and placed in the container's QA file.
3. If the radiation level internally or externally is greater than 1 mR/hr beta-gamma or 500 dis/min alpha, the container is to be decontaminated to the above tolerance. If decontamination efforts fail, the container is tagged out of service and the Department Head is notified in writing of the status. A copy of the notification is placed in the container's QA file. EXCEPTION: Uranium carriers may read up to 10 mrem/hr internally or externally.

4. Fire Shields

The RSPD Foreman will visually inspect all fire shields for cracks in the wood, protective coatings, foam glass, and/or steel covers. Defects in these items are to be recorded in the container's QA file and a blanket work order issued immediately to repair same. A copy of the blanket work order and the copy of the completed work order are to be placed in the container's QA file. An inspection of the repair work is to be made by the RSPD Foreman and a record of acceptance placed in the container's QA file.

Outgoing Type B Containers

1. Shielded Containers

- a. A soap bubble test will be performed by operating personnel and recorded in the container's QA file in Building 3029 before the container can be used for loading encapsulated radioactive material.
- b. An Inspection Engineering report on the internal weld dye penetrant inspection is valid for 6 months prior to shipment. If inspection is over 6 months old, a new dye penetrant inspection of the internal welds must be made and the results recorded in the QA file. All repairs will be inspected and approved by Inspection Engineering and recorded in the QA file.

APPROVED:

<p>SUPERVISOR <i>[Signature]</i></p>	<p>PROCESS GROUP LEADER <i>[Signature]</i></p>	<p>DATE 4/19/82</p>
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OPERATIONS DIVISION
RADIOISOTOPE DEPARTMENT
BUILDING 3029

PROC. NO. 24
PAGE 2 OF 7
DATE 2/26/82

SOURCE DEVELOPMENT LABORATORY

QUALITY ASSURANCE PROCEDURE FOR TYPE B SHIPPING CONTAINERS

- c. Gaskets will be changed every 6 months and recorded in the container's QA file. Gasket material from stores stock must be verified by the store stock number.

2. Fire Shields

Fire shield lids and bolting devices will be inspected before shipment by the Packing Foreman to insure proper fit of the locking mechanism to hold the lid securely in place during transit. A record of this inspection is to be placed in the container's QA file. All repairs are to be made before shipment and the blanket work order with its completed form is to be filed in the container's QA file.

APPROVED:

SUPERVISOR <i>J. L. Moore</i>	PROCESSOR LEADER <i>H. W. Schuch</i>	DATE 2/26/82
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OPERATIONS DIVISION RADIOISOTOPE DEPARTMENT

BUILDING 3029

SOURCE DEVELOPMENT LABORATORY

QUALITY ASSURANCE PROCEDURE FOR TYPE B SHIPPING CONTAINERS

CONTAINER INSPECTION SHEET

PROC. NO. 24
PAGE 6 OF 7
DATE 4/16/82

Date _____ Container Number _____

EXTERNAL INSPECTION

By _____

Smeared _____ dpm Bγ; _____ dpm alpha

Condition Good Fair Poor

Repairs Needed _____

Action Taken _____

INTERNAL INSPECTION

By _____

Smeared _____ dpm Bγ; _____ dpm alpha

Decontaminated: Yes No By _____

CONTAINER TESTING

Soap Bubble Test _____ Gaskets _____

Weld Dye Check _____ Bolts & Lock Washers _____

Repairs Made _____

RE-TESTING

Soap Bubble Test _____

Weld Dye Check _____

CONTAINER CERTIFIED FOR SHIPMENT - Date _____

By _____

APPROVED:

SUPERVISOR

J. H. House

PROJECT GROUP LEADER

A. W. Schuch

DATE

4/16/82

**OPERATIONS DIVISION
RADIOISOTOPE DEPARTMENT**

BUILDING 3029

SOURCE DEVELOPMENT LABORATORY

QUALITY ASSURANCE PROCEDURE FOR TYPE B SHIPPING CONTAINERS

GAS CYLINDER FIRE SHIELD - CHECK-IN SHEET

PROC. NO. 24
PAGE 7 OF 7
DATE 2/26/82

Date _____ Fire Shield Number _____

Shipped From _____

EXTERNAL INSPECTION

Smears _____ dpm beta/gamma; _____ dpm alpha
_____ dpm tritium

External Condition

Lid Bolts _____ Lid _____

General _____

Repairs Needed _____

Action Taken _____

INTERNAL INSPECTION

Smears _____ dpm beta/gamma; _____ dpm alpha
_____ dpm tritium

CYLINDER CONTAINMENT INSPECTION

Bolts _____

Inside Smears _____ dpm beta/gamma; _____ dpm alpha
_____ dpm tritium

Repairs Needed _____

Action Taken _____

FIRE SHIELD CERTIFIED FOR SHIPMENT: DATE _____

BY _____

APPROVED:

<p>SUPERVISOR</p> <p><i>[Signature]</i></p>	<p>PROCESS GROUP LEADER</p> <p><i>[Signature]</i></p>	<p>DATE</p> <p>2/26/82</p>
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Appendix D

INSPECTION REPORTS

INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

To: R. W. Schaich

Date: October 20, 1976

From: S. E. Gheesling

Subject: CLOSE OUT OF STAINLESS STEEL GAS CYLINDER FIRE AND IMPACT SHIELD ORDER

The attached information is all the available Q.A. records on this job. No manufacturing plan was required for Level III jobs when this job was started.

Attached Information:

1. Dimensional Certification Report
2. Hydrostatic Pressure Test Report
3. Weld Inspection Report
4. Job Specification JS-31536-1 used by K-25 for pouring foam.
5. Material requests with verification of grade, heat numbers, etc.
Nos. F 7505, F 7504, F 7524, F 7543, F 7502 and F 7556
6. Requisition R-8703, Associated Steel Company Invoice G-30347 and Material Test Report on plate purchased on above requisition.

Sam E. Gheesling
Field Engineer

SEG:drw

Enclosures

UNION CARBIDE CORPORATION
NUCLEAR DIVISION
P.O. BOX 2, Oak Ridge, Tennessee 37830

DIMENSIONAL CERTIFICATION REPORT

JOB DESCRIPTION Gas Cylinder Fire And Impact Shield		PROGRAM PLAN NUMBER	PAGE 1 of 2
DRAWING NUMBER M 11574		QUALITY LEVEL NUMBER QA-III	ITEM NUMBER
INSP ORDER NUMBER IS-138	WORK ORDER NUMBER K-1776E-A1	TEST NUMBER 165A-40604 1652-40613	SERIAL NUMBER

METHOD OF RECORDING

Decimal Dimensions: Record Actual Dimensions

Fractional Dimensions: Record Actual Readings on any out-of-tolerance fractional dimensions: Record "within Tol" on acceptable fractional dimensions.

Circle all out-of-tolerance dimensions.

QC NO.	INSPECTION RESULT	SPECIFICATION
1	W/in Tol	41 ⁷ / ₈ "
2	W/in Tol	41 ⁷ / ₈ "
3	W/in Tol	29 ³ / ₄ "
4	W/in Tol	12" Actual 11 ¹⁵ / ₁₆ "
5	W/in Tol	14 ³ / ₄ "
6	W/in Tol	11 ³ / ₄ " Actual 11 ⁷ / ₈ "
7	W/in Tol	5"
8	W/in Tol	30 ⁵ / ₈ "
9	W/in Tol	1/2" Actual 7/16"
10	W/in Tol	1/4"
11	Out of Tol	27 ¹ / ₈ " O.D. Actual 27" O.D.
12	W/in Tol	24 ¹ / ₈ " O.D. Actual 24 ¹ / ₁₆ " O.D.
13	W/in Tol	24" I.D. Actual 23 ⁵ / ₁₆ " I.D.
14	W/in Tol	15" O.D.
15	W/in Tol	12" I.D.
16	W/in Tol	5 ¹⁵ / ₁₆ "
17	W/in Tol	1/2" THK X 8 ³ / ₄ " I.D. X 10 ¹ / ₄ " O.D.
18	W/in Tol	11 ³ / ₄ " O.D.
19	W/in Tol	8 ³ / ₄ " I.D.
20	W/in Tol	3 ³ / ₄ "
21	W/in Tol	3 ³ / ₄ " I.D.
22	W/in Tol	2"

DIMENSIONAL INSPECTION RESULTS		DIMENSIONAL INSPECTION DISPOSITION	
PART MEETS DIMENSIONAL CRITERIA ☒ YES ☐ NO		NCR ATTACHED ☐ YES ☐ NO	
DATE 1-10-75	INSPECTOR B. J. Miles	DATE	ACCEPTED BY
REVISION	APPROVED	DATE	APPROVED

UNION CARBIDE CORPORATION
NUCLEAR DIVISION
P.O. BOX 2, OAK RIDGE, TENNESSEE 37830

DIMENSIONAL CERTIFICATION REPORT

DIMENSIONAL CERTIFICATION REPORT				PAGE
JOB DESCRIPTION		PROGRAM PLAN NUMBER		2 of 2 QUALITY LEVEL NUMBER
ART NAME		DRAWING NUMBER		QA-III ITEM NUMBER
SHOP ORDER NUMBER	WORK ORDER NUMBER	HEAT NUMBER	SERIAL NUMBER	

METHOD OF RECORDING

Decimal Dimensions: Record Actual Dimensions

Fractional Dimensions: Record Actual Readings on any out-of-tolerance fractional dimensions: Record "within Tol" on acceptable fractional dimensions.

Circle all out-of-tolerance dimensions.

[illegible]

DIMENSIONAL INSPECTION RESULTS			DIMENSIONAL INSPECTION DISPOSITION		
PART MEETS DIMENSIONAL CRITERIA ☒ YES ☐ NO			PCR ATTACHED ☐ YES ☐ NO		
DATE	INSPECTOR		DATE	ACCEPTED BY	
1-10-75	B. J. Miller				
REVISION	APPROVED	DATE	APPROVED	DATE	

FABRICATION DEPARTMENT
REPORT OF PRESSURE TEST☒ HYDROSTATIC☐ PNEUMATIC

The following information is required as an effort to substantiate the leak tightness required under the specification, to evaluate the quality of the test, and to record for historical purposes the integrity of the item of equipment being tested.

Equipment Tested TWO EACH GAS CYLINDER FIRE + IMPACT SHIELDS
(Name, Model, Serial No., etc.)

Drawing Number M-11574-EM-001E-R0

Pressure at beginning of test 5 psig.

Pressure at conclusion of test 5 psig.

Total time equipment was at test conditions 15 min

Range of test gauge 0-15; subdivided in 1 psi increments.

Pressure source used GAS CYLINDER

Water or gas removed after test: ☒ Yes ☐ No

Remarks:

SOAP BUBBLE TEST

SIGNATURE OF PERSON PERFORMING TEST

H. B. Gay
W. L. Smith
D. W. Robertson

Date

6-10-75

SIGNATURE OF PERSON ACCEPTING TEST

Date

WELD INSPECTION REPORT										DATE <div style="font-size: 1.2em;">3-13-75</div>	
<div style="font-size: 1.2em; font-family: cursive;"> 2. Cylindrical Tank And Support 5. Flange & Lifting 2. Ring 11-2 </div>										REPORT NUMBER <div style="font-size: 1.2em;">KL776E-A1</div>	
										WORK ORDER NUMBER <div style="font-size: 1.2em;">WA-11-F-2</div>	
DRAWING NUMBER <div style="font-size: 1.2em;">11574-EM-DD1</div>										WSP. SPEC. <div style="font-size: 1.2em;">7012</div>	
WSP. SCHED. <div style="font-size: 1.2em;">F</div>											
WELD SPEC. <div style="font-size: 1.2em;">11/PS-302</div>			WELD PROCESS <div style="font-size: 1.2em;">GTA</div>			JOINT TYPE ☒ FILLET ☐ SINGLE WELDED ☐ DOUBLE WELDED					
BASE MATERIAL(S)						FILLER MATERIAL(S)					
TYPE		304-L		304-L		TYPE		308-L			
P. NO.		None		None		IR. NO.		4-2302			
-EAT. NO.		29227		V40611		HEAT NO.		1717			
WPG.		Commercial ESS				WPG.		GMAW			
FORM		Plate		Plate		SIZE		1/16"			
PART											
PIECE											
SIZE		5/16 THK		1/8 GA							
JOINT PREPARATION				CLEANER				INERT GAS			
<div style="font-size: 1.2em; font-family: cursive;"> F. H. H. H. F. H. H. H. F. H. H. H. F. H. H. H. </div>				☒ ACETONE ☐ ALCOHOL WELDER <div style="font-size: 1.2em; font-family: cursive;"> R. H. H. H. </div> CRAFTSMAN				COVER ☒ ARGON CFH _____ ☐ HELIUM CFH _____ ☐ MIXED CFH _____		BACKUP ☒ ARGON CFH _____ ☐ HELIUM CFH _____	
								FIT UP <div style="font-size: 1.2em; font-family: cursive;"> R. H. H. H. </div>		WORK CONDITION <div style="font-size: 1.2em; font-family: cursive;"> R. H. H. H. </div>	
STAGE		ROOT PASS		SECOND LAYER		INTERM.		FINAL			
VISUAL								R. H. H. H.			
PENETRANT											
RADIOGRAPH											
ULTRASONIC REPAIRS											
MACHINE WELDING VARIABLES				VOLTS				AMPS			
								INTERPASS TEMP.			
REMARKS:											
DATE <div style="font-size: 1.2em;">3-13-75</div>				FINAL ACCEPTANCE				DATE			

DATE 3-13-75			
REPORT NUMBER			
DRAWING NUMBER 11574-EM-001		WORK ORDER NUMBER K1776E-A1	
WELD SPEC W-2-9		WELD PROCESS GTA	
WELD TYPE 1115-302		WELD PROCESS GTA	
FILLER MATERIAL(S)		FILLER MATERIAL(S)	
TYPE 304-L	TYPE 304-L		
IR NO.	IR NO.		
HEAT NO. V40604 17599	HEAT NO. 1717		
WFS. ESS. Henry	WFS. Henry		
FORM Plate Angle	SIZE 1/16		
SIZE 1/16	SIZE 1/16		
JOINT PREPARATION Fillet		CLEANER	
WELDER F. H. Hushon		CRAFTSMAN David L. 3-13-75	
COVER		INERT GAS	
☒ ARGON CFN		☒ ARGON CFN	
☐ HELIUM CFN		☐ HELIUM CFN	
☐ MIXED CFN		☐ MIXED CFN	
FIT UP OK		WORK CONDITION OK	
STAGE	ROOT PASS	SECOND LAYER	INTERM.
VISUAL			OK
PENETRANT			
RADIOGRAPH			
REPAIRS			
ULTRASONIC			
MACHINE WELDING VARIABLES	VOLTS	AMPS	INTERPASS TEM.
REMARKS			
INSPECTOR W. H. Hushon			
DATE 3-13-75			
FINAL ACCEPTANCE			
DATE			

TITLE: <u>Hydraulic Fire and Impact Shield</u>					DATE: <u>3-12-75</u>				
SYSTEM: <u>Hydraulic</u>					REPORT NUMBER:				
ELEMENT NUMBER:					WORK ORDER NUMBER: <u>K1711-1</u>				
TITAN 23 525TH 32					DRAWING NUMBER: <u>11574-FH-001</u>				
WELD PROCESS:					SHOP: <u>7012</u>				
INS. SPEC:					INS. SPEC: <u>DA-11-F-2</u>				
WELD PROCESS:					INS. SCHED: <u>F</u>				
JOINT TYPE:					☒ FILLET ☐ SINGLE WELDED ☐ DOUBLE WELDED				
BASE MATERIAL(S)					FILLER MATERIAL(S)				
TYPE	<u>304-L</u>	<u>304-L</u>			TYPE	<u>308-L</u>			
REC.	<u>None</u>	<u>None</u>			IR NO.				
EAT NO.	<u>V40611</u>	<u>V40611</u>			HEAT NO.	<u>1717</u>			
WFS.	<u>ESS.</u>	<u>ESS.</u>			WFS.	<u>None</u>			
FORM	<u>Plate</u>	<u>Plate</u>			SIZE	<u>1/4"</u>			
PART									
SIZE	<u>1 1/2 x 11 GA</u>	<u>16 GA</u>							
PREPARATION: <u>Grind</u>			CLEANER:			INERT GAS:			
☒ ACETONE ☐ ALCOHOL			COVER:			BACKUP:			
WELDER: <u>James P. Ch...</u>			☒ ARGON CFH _____			☒ ARGON CFH _____			
CRAFTSMAN: <u>James P. Ch...</u>			☐ HELIUM CFH _____			☐ HELIUM CFH _____			
FIT UP: <u>OK</u>			WORK CONDITION: <u>OK</u>			PREHEAT TREATMENT:			
STAGE:			ROOT PASS			SECOND LAYER			
VISUAL			PENETRANT			RADIOGRAPH			
REPAIRS:			ULTRASONIC:			DATE:			
MACHINE WELDING VARIABLES:			VOLTS:			AMPS:			
INTERPASS TEMP.:			REMARKS:			DATE:			
SIGNATURE: <u>James P. Ch...</u>			DATE: <u>3-12-75</u>			ACCEPTANCE:			

D-11

TITLE <i>Exhaust Pipe Weld</i>		DATE 3-13-75	
		REPORT NUMBER 1574-EM-001	
DRAWING NUMBER 1574-EM-001		WORK ORDER NUMBER K-177E-A1	
DESIGNED 1-6-7		INS. SPEC. PA-11-E-2	
SPEC. 175-302		INS. SCHED. F	
WELD PROCESS GTA		JOINT TYPE ☐ FILLET ☒ SINGLE WELDED ☐ DOUBLE WELDED	
BASE MATERIAL(S)		FILLER MATERIAL(S)	
306-L 2mm V40611 ESS P.P.T.		TYPE 301-L IR NO. HEAT NO. 1717 MFG. <i>Rock</i> SIZE 1/16	
PREP. METHOD File 30		CLEANER ☒ ACETONE ☐ ALCOHOL	
WELDER <i>David D. 3-13-75</i>		INERT GAS COVER ☒ ARGON CFN _____ ☐ HELIUM CFN _____ ☐ MIXED CFN _____	
CRAFTSMAN <i>David D.</i>		BACKUP ☒ ARGON CFN _____ ☐ HELIUM CFN _____	
FIT UP <i>OK</i>		WORK CONDITION <i>OK</i>	
PREHEAT TREATMENT		POSTHEAT TREATMENT	
SP.		PREHEAT TREATMENT	
ROOT PASS		POSTHEAT TREATMENT	
SECOND LAYER		POSTHEAT TREATMENT	
INTERM.		POSTHEAT TREATMENT	
FINAL		POSTHEAT TREATMENT	
REPAIRS		POSTHEAT TREATMENT	
ULTRASONIC		POSTHEAT TREATMENT	
MACHINE WELDING VARIABLES		INTERPASS TEMP.	
VOLTS		INTERPASS TEMP.	
AMPS		INTERPASS TEMP.	
REMARKS		INTERPASS TEMP.	
SECTION/INCH/1/16		DATE 3-13-75	
FINAL ACCEPTANCE		DATE	

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WELD INSPECTION REPORT

DATE <u>3-4-75</u>																																																										
REPORT NUMBER																																																										
WORK ORDER NUMBER <u>K1776-A1</u>																																																										
SPEC. <u>24 & 53</u>		WELD PROCESS <u>GTA</u>		JOINT TYPE ☐ FILLET ☒ SINGLE WELDED ☐ DOUBLE WELDED																																																						
INSPEC. <u>1105-312</u>		DRAWING NUMBER <u>11574-EM-C01</u>		INSPEC. SPEC. <u>QA-11-F-2</u>																																																						
INSPEC. SCHED. <u>F</u>		INSPEC. SCHED.																																																								
<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <th colspan="4">BASE MATERIALS</th> <th colspan="2">FILLER MATERIALS</th> </tr> <tr> <td>DE</td> <td><u>304-L</u></td> <td></td> <td></td> <td>TYPE</td> <td><u>308-L</u></td> </tr> <tr> <td>NO.</td> <td><u>Pipe</u></td> <td></td> <td></td> <td>IR NO.</td> <td></td> </tr> <tr> <td>CAT NO.</td> <td><u>440604</u></td> <td></td> <td></td> <td>HEAT NO.</td> <td><u>1717</u></td> </tr> <tr> <td>FG</td> <td><u>F55</u></td> <td></td> <td></td> <td>WFE</td> <td><u>Pipe</u></td> </tr> <tr> <td>GRV</td> <td><u>Plate</u></td> <td></td> <td></td> <td>SIZE</td> <td><u>1/2"</u></td> </tr> <tr> <td>LOT</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>ECO</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>CE</td> <td><u>06-3</u></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>					BASE MATERIALS				FILLER MATERIALS		DE	<u>304-L</u>			TYPE	<u>308-L</u>	NO.	<u>Pipe</u>			IR NO.		CAT NO.	<u>440604</u>			HEAT NO.	<u>1717</u>	FG	<u>F55</u>			WFE	<u>Pipe</u>	GRV	<u>Plate</u>			SIZE	<u>1/2"</u>	LOT						ECO						CE	<u>06-3</u>				
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JOINT PREPARATION <u>Fillet</u>		CLEANER ☒ ACETONE ☐ ALCOHOL		INERT GAS																																																						
WELDER <u>W. H. H. H.</u>		COVER ☒ ARGON CFH <u> </u> ☐ HELIUM CFH <u> </u> ☐ MIXED CFH <u> </u>		BACKUP ☒ ARGON CFH <u> </u> ☐ HELIUM CFH <u> </u>																																																						
CRAFTSMAN <u>W. H. H. H.</u>		FIT UP <u>OK</u>		WORK CONDITION <u>OK</u>																																																						
SP.	ROOT PASS	SECOND LAYER	INTERM.	FINAL	PREHEAT TREATMENT	POSTHEAT TREATMENT																																																				
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RADIOGRAPH																																																										
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ULTRASONIC																																																										
WELDING VARIABLES		VOLTS		AMPS		INTERPASS TEMP.																																																				
REMARKS																																																										
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WELD INSPECTION REPORT

DATE 3-19-73				
REPORT NUMBER K-1716E-A				
WORK ORDER NUMBER 11574-EM-001				
SHOP 7012				
WSP. SPEC. QA-11-E-2				
WSP. SCHED. F				
WELD SPEC. WIP5-302		WELD PROCESS GTA		JOINT TYPE ☒ FILLET ☐ SINGLE WELDED ☐ DOUBLE WELDED
BASE MATERIAL(S)			FILLER MATERIAL(S)	
TYPE	300 SS.	300 SS.	304-L	TYPE 308-L
NO.	11677	11677	11677	IR NO.
LOT NO.	n	n	21874	HEAT NO.
WGT.	n	n	21874	WFC.
FORM	Bolt	Nut	21874	SIZE
WGT.				
SIZE	3/16" x 1/2"	3/16" x 1/2"	1/4" Plate	
JOINT PREPARATION Fillet		CLEANER ☒ ACETONE ☐ ALCOHOL		INERT GAS COVER ☒ ARGON CFN ☐ HELIUM CFN ☐ MIXED CFN
WELDER H. H. H.		CRAFTSMAN H. H. H.		BACKUP ☒ ARGON CFN ☐ HELIUM CFN
STAGE ROOT		SECOND LAYER		INTERM.
FINAL		PREHEAT TREATMENT		POSTHEAT TREATMENT
USUAL		REPAIRS		
EXERCISE		RADIOGRAPH		
ULTRASONIC		MACHINE WELDING VARIABLES		VOLTS
REMARKS		AMPS		INTERPASS TEMP.
SECTION: 11574-EM-001 DATE: 3-19-73 FINAL ACCEPTANCE: DATE:				

WELD INSPECTION REPORT

PROJECT TITLE <i>Repaired Fire and Impact Shield</i> ORDER NUMBER <i>11574-EM-01</i> SHOP <i>7012</i>						DATE <i>3-13-75</i>	
						REPORT NUMBER <i>K-177LE-A1</i>	
WELD SPEC. <i>11P5-70L</i>		WELD PROCESS <i>CTA</i>		JOINT TYPE		☐ FILLET ☐ SINGLE WELDED ☐ DOUBLE WELDED	
BASE MATERIAL(S)				FILLER MATERIAL(S)			
TYPE	<i>304-L</i>	<i>304-L</i>		TYPE	<i>308-L</i>		
END.	<i>2001</i>	<i>2001</i>		IR NO.			
HEAT NO.	<i>V40611</i>	<i>V40611</i>		HEAT NO.	<i>1717</i>		
WPG.	<i>E.S.S.</i>	<i>E.S.S.</i>		MFG.	<i>FRANC</i>		
FORM	<i>Plasma</i>	<i>Plasma</i>		SIZE	<i>1/4"</i>		
POST							
WELD							
SIZE	<i>1/4"</i>	<i>1/4"</i>					
JOINT PREPARATION <i>Bevel</i>		CLEANER ☒ ACETONE ☐ ALCOHOL		INERT GAS COVER ☒ ARGON CFH _____ ☐ HELIUM CFH _____ ☐ MIXED CFH _____		BACKUP ☒ ARGON CFH _____ ☐ HELIUM CFH _____	
WELDER <i>Huckman</i>		WELDER <i>Huckman</i>		FIT UP <i>OK</i>		WORK CONDITION <i>OK</i>	
STAGE	ROOT PASS	SECOND LAYER	INTERM.	FINAL	PREHEAT TREATMENT	POSTHEAT TREATMENT	
VISUAL				<i>OK</i>			
PENETRANT							
RADIOGRAPH							
REPAIRS							
ULTRASONIC							
MACHINE WELDING VARIABLES		VOLTS		AMPS		INTERPASS TEMP.	
REMARKS							
INSPECTOR'S SIGNATURE <i>[Signature]</i>		☒ FAB ☐ I.E.		DATE <i>3-13-75</i>		FINAL ACCEPTANCE	
						DATE	

WELD INSPECTION REPORT

DATE 3-11-75				
REPORT NUMBER 817711-A1				
WORK ORDER NUMBER 11574-LM-201				
INSP. SPEC. 7012				
INSP. SCHED.				
WELD PROCESS 55 FILLER 2 65				
JOINT TYPE ☐ GULLET ☐ SINGLE WELDED ☐ DOUBLE WELDED				
BASE MATERIAL(S)			FILLER MATERIAL(S)	
TYPE	304-L	304-L	TYPE	308-L
NO.	11612	None	IR NO.	
EAT NO.	18221	V40611	HEAT NO.	C1717
NO.	ESG	ESG	WFC.	Green
JOINT	Plate	Plate	SIZE	3/32
WGT				
ECR				
SIZE	3/16	1/8		
JOINT PREPARATION Fillet		CLEANER		INERT GAS
TEXTURE Smooth		☒ ACETONE ☐ ALCOHOL		COVER
WELDER Welding		WELDER Qual. Ch. 3-12-75		BACKUP
CRAFTSMAN Welding		CRAFTSMAN		☒ ARGON CFH ☐ HELIUM CFH ☐ MIXED CFH
STAGE		FIT UP OK		WORK CONDITION OK
SP.	ROOT PASS	SECOND LAYER	INTERM.	FINAL
VISUAL				OK
PENETRANT				
RADIOGRAPH				
REPAIRS				
ULTRASONIC				
MACHINE WELDING VARIABLES		VOLTS	AMPS	INTERPASS TEMP.
REMARKS				
SIGNATURE Welding				
DATE 3-11-75		FINAL ACCEPTANCE		DATE

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WELD INSPECTION REPORT

DATE <u>3-12-75</u>				
REPORT NUMBER <u>K177LE-A1</u>				
WORK ORDER NUMBER <u>1514-EH-201</u>				
INSP. SPEC. <u>QA-11-F-2</u>				
INSP. SCHED. <u>F</u>				
WELD PROCESS <u>GTAW</u>				
JOINT TYPE ☒ FILLET ☐ SINGLE WELDED ☐ DOUBLE WELDED				
BASE MATERIAL(S)				
FILLER MATERIAL(S)				
TYPE <u>304-L</u>				
IR NO.				
HEAT NO. <u>1717</u>				
W.C. <u>Primer</u>				
SIZE <u>1/16"</u>				
3/8" 3/16" 1"				
CLEANER				
☒ ACETONE ☐ ALCOHOL				
COVER				
☒ ARGON CFH ☐ HELIUM CFH ☐ MIXED CFH				
BACKUP				
☒ ARGON CFH ☐ HELIUM CFH				
WELDER <u>David Ch. 3-12-75</u>				
CRAFTSMAN				
FIT UP <u>EX</u>				
WORK CONDITION <u>EX</u>				
STAGE				
ROOT PASS SECOND LAYER INTERM. FINAL				
PREHEAT TREATMENT				
POSTHEAT TREATMENT				
REPAIRS				
ULTRASONIC				
MACHINE WELDING				
VOLTS				
AMPS				
INTERPASS TEMP.				
VARIABLES				
REMARKS				
SECTION SIGNATURES				
DATE				
FINAL ACCEPTANCE				
DATE				

JOB SPECIFICATION STANDARD REFERENCE INFORMATION UNION CARBIDE CORPORATION NUCLEAR DIVISION ORGOP, OAK RIDGE, TENNESSEE - PADUCAH, KENTUCKY		NUMBER JS-31535-1 Rev. 1 DATE 3-28-66 REVISED 3-28-68 PAGE 1 of 5
SUBJECT FIRE RESISTANT PHENOLIC FOAM		

SCOPE

This specification shall cover materials and procedures for mixing and applying foamed-in-place fire resistant phenolic foam where specified on the drawings.

MATERIALS AND PROPORTIONS

All materials used in the fire resistant foam shall be as listed below and shall be prepared by blending, screening, etc., as defined. Substitutions of materials may be made only where noted. Total quantity of materials shall be as required to fill the container cavities and provide the finished foam weight as defined on the drawings. Individual weight quantity of each component material shall be such to provide a finished foam material mixture of the proportionate blend specified below.

<u>Material</u>	<u>Vendor - Trade Name</u>	<u>Component Weight per 100 Lb. of Matl. (Lbs.)</u>
<u>Liquid Components</u>		
Phenolic Resin	UCC Plastics Division BRL-2760 (Foam Density 1.8-2.0 Lbs./ft. ³)*	65.8 $\pm$ 0.2
Surfactant	UCC Plastics Division Silicone Surfactant L-530, or equal	2.0 $\pm$ 0.1
Refrigerant 113	DuPont Freon 113, or equal	6.6 $\pm$ 0.1
<u>Powder Components</u>		
Boric Anhydride (B ₂ O ₃), Powder, Reagent Grade, -100 + 200 Mesh	Varlacoid Chemical Company No. 1136, or equal	4.1 $\pm$ 0.1

* Resin foam value as determined by method used at the Marietta Ohio Plant of the UCC Plastics Division.

APPROVED BY: *Paul Zimmerman*

STANDARD REFERENCE INFORMATION

SUBJECT

FIRE RESISTANT PHENOLIC FOAM

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<u>Material</u>	<u>Vendor - Trade Name</u>	<u>Component Weight per 100 Lb. of Matl. (Lbs.)</u>
<u>Powder Components (Contd)</u>		
Boric Anhydride (B_2O_3) Powder, Reagent Grade, -200 Mesh	Varlacoid Chemical Company No. 1137, or equal.	4.1 ± 0.1
Oxalic Acid, $H_2C_2O_4$, Anhydrous Powder, Reagent Grade	Baker and Adamson No. 1135, or equal	8.2 ± 0.1
<u>Reinforcing Component</u>		
Fiberglass Rovings 1/4" Chopped Lengths	Owens-Corning Fiberglas No. 805 (HSI), or equal	9.2 ± 0.1

MATERIAL STORAGE REQUIREMENTSPhenolic Resin

1. Store in airtight storage container.
2. Maximum shelf life is three months from date of manufacture if stored at room temperature.

or

Maximum shelf life is six months from date of manufacture if stored at a temperature of $40^\circ \pm 5^\circ F$.

NOTE: Date of manufacture should be marked on the storage container.

Pre-blended Liquid Components

The three liquid components may be pre-blended or stored separately. If pre-blended, the liquid mixture may be stored in airtight storage containers at a temperature of $40^\circ \pm 5^\circ F$ for a period of time not exceeding one month prior to final blending, provided this additional time does not exceed the maximum storage life for the phenolic resin. If the liquid components are stored separately, the same storage requirements must be observed for the phenolic resin component.

Powder Components

All powders shall be stored in airtight storage containers at room temperature before and after pre-blending to prevent absorption of moisture.

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FIRE RESISTANT PHENOLIC FOAM

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All Other Materials

Store all other component materials in airtight storage containers at room temperature until ready for blending.

PREPARATION OF RECEIVER CONTAINER AND ACCESSORIESContainer

In preparing a container for receiving the foamed-in-place filling, all loose inner pieces shall be securely anchored in place to prevent displacement by the foam, and vent holes to prevent voids in the finished foam and to provide gas relief when exposed to high heat shall be drilled as defined on the drawings. The necessary blocking, framing, bracing, etc., shall be installed to hold in place the container shell, ends, lining, etc., as applicable, and prevent distortion to out-of-tolerance condition during the foaming operation.

Molds

Molds to shape exposed surfaces of foam shall be installed and secured in position just after the final foam raw material is placed so foam can expand into the mold. Air vent holes not exceeding 1/4" in diameter may be made at intervals in a mold to allow for escaping air and thereby prevent void spaces in the finished surface. Molds shall be made of such strength to prevent distortion to out-of-tolerance condition during the foaming operation. A mold release (e.g. Emerson and Cuming mold release compound No. 1228 or DuPont Teflon) shall be applied to mold surfaces which will contact foam material so that the mold can be removed without damaging the finished foam surface.

Cleaning Before Foaming

All sawdust, bits of wood, metal filings, water droplets, grease, oil, and other foreign particles shall be removed from the molds or container cavities before foam raw material is added.

MIXING PROCEDURESPre-Blending

Liquid Components - Pre-blend liquid components in any order by combining the ingredients and stirring to a uniform consistency. Temperature of the phenolic resin shall be $60^{\circ} \pm 5^{\circ}\text{F}$ when it is added to the mix. If final blending is to be delayed, reseal the blended components so atmospheric exposure is reduced to a minimum.

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Powder Components

Screen all components through a sieve (National Bureau of Standards No. 40) and pre-blend to a uniform consistency. Reseal blended components so atmospheric exposure is reduced to a minimum.

Final Blending

1. Add liquid components or pre-blended liquid components to mixer tub and stir to a uniform consistency, about 2 minutes for pre-blended components. Temperature of the phenolic resin or pre-blended liquid components shall be $60^{\circ} \pm 5^{\circ}\text{F}$ when it is added to the mix.
2. Add fiberglass and mix to a uniform consistency.
3. Add the pre-blended powder components rapidly and mix to a uniform consistency, 30 to 60 seconds.
4. Quickly transfer the mixed raw material to the receiver container so that the foaming action takes place within the container.

PLACING AND CURING FOAM MATERIAL

The mixed foam raw material shall be spread evenly over the bottom surface of the receiver container so foam expands in relatively uniform layers. The first pour of bottom section should be tamped immediately after foaming begins to minimize size of void spaces. Air cure at room temperature for at least one hour to allow for full expansion of foam.

After foaming action and curing is completed on a pour, the next pour of material can be spread evenly on top of the previous expanded layer. All sequential pours shall proceed with a minimum delay so that atmospheric exposure of the internal fibers is minimized. The number of pours shall be as specified on the drawings. After the final pour, the foam shall be allowed to cure at least four hours at room temperature before bracing, molds, and accessories are removed.

NOTE: Sequential pours are self bonding to the previous pour with no apparent voids or cleavage planes.

REMOVAL OF BRACING, MOLDS, AND ACCESSORIES AND FINISHING WORKGeneral

All bracing, molds, and any accessories not part of the finished container, as defined on the drawings, shall be removed after foaming and curing operations are completed. Any extruded foam material (e.g. extrusions through

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SUBJECT	REVISION
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air vent holes) shall be carefully trimmed and removed to provide a smooth surface over the exterior and interior surface of the container. Foam material splashed onto exposed surfaces of the container shall be removed.

All mold release, grease, dust, etc., which would prevent a coating from adhering properly shall be removed from the finished foam surfaces, prior to coating, by wiping with a soft cloth saturated with tri-chloroethylene.

Patching Voids in Finished Foamed Surface Material

Voids: spaces in the finished foam surface shall be patched by filling with additional foam raw material and allowing the material to expand and cure. Excessive foam or rough spots left by this process shall be dressed smooth with the surrounding surface to give an overall uniform surface.

Waterproofing

Seal watertight all holes in outer shell and inner liner when applicable, (e.g. vent holes, gaps around caps for fill holes, nail and screw holes, etc., as applicable) with two coats of epoxy** prior to finish coat of paint. Seal watertight all exposed surfaces of foam with two coats of epoxy.

CLEANING AGENTS

Cellosolv, acetone, or other cleaning agents may be used for cleaning utensils or removing particles of splattered foam from metal parts only of container surfaces.

OTHER

The following typical chemical analysis of cured foam may be used as reference data for nuclear calculations.

	<u>Wt. %</u>
Carbon	41.0
Hydrogen	4.5
Boron	3.2
Silicon	2.2
Chlorine	0.5
Nitrogen	nil
Fluorine	nil
Oxygen	48.6 (by difference)

** Epoxy shall be Araldite #502 epoxy with hardener #951 as manufactured by Ciba Products Company, Fairlawn, New Jersey, or equal.

SECRET
11-8-68

APPROVED BY: _____

REQUEST FOR MATERIAL

6L-6-15
STONES LOCATION
MET. CUTTING
EXPEDITE AREA
A B C D E F

NO. <u>7505</u>	DATE <u>7-5-138</u>	TELEPHONE <u>3-6983</u>	DELIVER TO <u>D.K. HOOD</u>	STATION NO.	DATE NEEDED <u>NORMAL</u>
AUTHORIZED SIGNATURE <u>D.K. HOOD</u>	SALES NO. <u>44-07-6947</u>	DEPT. NO. <u>3011</u>	BLDG. NO. <u>7058</u>	DELIVERY POINT	TIME NEEDED

CATALOG NO.	QUANTITY & UNIT	DESCRIPTION	WORK ORDER OR ACCT.	DRAWING NO.	PART NO.
<u>7-774-F335</u>	<u>9</u>	<u>PLATE, STAINLESS STEEL,</u>	<u>K-17762-AV</u>		
<u>3 1030</u>	<u>SQ. FT.</u>	<u>304L, 1/4" THICK, 4 PIECES</u>	<u>TR11672/HT 21874-304L JESSOP</u>		
		<u>18" X 18" SQUARE 12-11172 HT 21874</u>	<u>SA240-HRPP-1/4" R. 10/11/44</u>		
		<u>HT 21111 HOOD 21111 JESSOP</u>			
<u>4-761-4047</u>	<u>24</u>	<u>BAR, STAINLESS STEEL, TYPE</u>	<u>TR11660/HT 56776-304L</u>		
<u>3</u>	<u>IN.</u>	<u>304L, 3/8" X 4" RECTANGULAR,</u>	<u>3/8" X 4" CANTON. ANL</u>		
		<u>HT 11660 HT 56776 GASTON A-479</u>	<u>RDT.M7-3T(4) R. 10/11/44</u>		
		<u>RDT.M7-3T 304L</u>			
<u>4-761-3215</u>	<u>40</u>	<u>SHEET, STAINLESS STEEL, TYPE</u>	<u>HT. M40611 304L ESS.</u>		
<u>1-2-3</u>	<u>SQ. FT.</u>	<u>304L, 0.125 THICK (11 GANGE)</u>	<u>ASTM-A240 GA.125</u>		
		<u>1 SHEET 48" X 120" A-240</u>	<u>factory marking R. 10/11/44</u>		
		<u>304-L V40611 V40613 ESS.</u>			
<u>4-761-3200</u>	<u>80</u>	<u>SHEET, STAINLESS STEEL, 304L,</u>	<u>HT. M40611 304L ESS.</u>		
<u>1-2-3</u>	<u>SQ. FT.</u>	<u>0.063 THICK (16 GANGE) 2 SHEETS</u>	<u>ASTM-A240 GA.0630</u>		
		<u>48" X 120" 304-L HT. V40611 A-240</u>	<u>factory marking R. 10/11/44</u>		
		<u>ESS</u>			
		<u>HFE</u>			
		<u>2-13-75</u>			
		<u>O. N. LOVELL</u>			

DATE DELIVERED	TIME DELIVERED
REMARKS <u>P. F. B. 11/13 3-7-138.</u>	

D-24

REQUEST FOR MATERIAL

DATE 2-6-75		STATION NO.		DELIVER TO NAME D.K. HODD		TELEPHONE 3-6983		STATION NO.		DATE DELIVERED		TIME DELIVERED	
STATION LOCATION		STATION NO.		DELIVERY POINT		WORK ORDER OR ACCT.		DRAWING NO.		PART NO.		TIME RECEIVED	
EXPEDIENT AREA		EXPEDIENT AREA		EXPEDIENT AREA		EXPEDIENT AREA		EXPEDIENT AREA		EXPEDIENT AREA		EXPEDIENT AREA	
EXPEDIENT AREA		EXPEDIENT AREA		EXPEDIENT AREA		EXPEDIENT AREA		EXPEDIENT AREA		EXPEDIENT AREA		EXPEDIENT AREA	
NO. F7505	DATE 2-6-75	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.
15-138	DATE 2-6-75	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.
D.K. HODD	DATE 2-6-75	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.
CATALOG NO.	DATE 2-6-75	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.
04-777-1335	DATE 2-6-75	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.
3	DATE 2-6-75	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.
04-761-4047	DATE 2-6-75	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.
3	DATE 2-6-75	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.
04-784-3215	DATE 2-6-75	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.
1-2-3	DATE 2-6-75	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.
04-774-3200	DATE 2-6-75	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.
1-2-3	DATE 2-6-75	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.	STATION NO.

D.K. HODD 3-6983

REQUEST FOR MATERIAL

DATE 2-6-75		STONES LOCATION MET. CUTTING		EXPLOSION AREA A B C D E F	
F7504		3-6973		STATION NO.	
15-138		3016		DELIVERY POINT	
D.K. 1100		311-07-6942		WORK ORDER OR ACCT.	
AUTHORIZED SIGNATURE		DEPT. NO.		DRAWING NO.	
D.K. 1100		3016		PART NO.	
CATALOG NO.		DESCRIPTION		TIME NEEDED	
04-755-5301	28	ANGLE, STAINLESS STEEL, H.R.,	K-1776E-A1		
3	FT.	1" X 1" X 1/8" (4 PIECES - 7 FT. LG.)	OUT		
	HT	17599 JESSOP WRP 304	2/11/75		
04-755-5502	28	ANGLE, STAINLESS STEEL, H.R.,	"		
3	FT.	1 1/2" X 1 1/2" X 1/8" (4 PIECES - 7 FT. LG.)	"		
		LONG, JESSOP T-304 ELC. WRP A-276 HT-3710.3			
11-4220	7	BAR, STAINLESS STEEL, 304L,	"		
3	FT.	ROUND, 3/8" DIA. X 7 FT. LONG	OUT		
		(1 PIECE)	2/11/75		
11-4035	4	BAR, STAINLESS STEEL, 304L,	"		
3	FT.	RECTANGULAR, 3/8" X 1" X 4 FT. LONG, (1 PIECE)	"		
		Q. A. Level			

DATE DELIVERED

DATE RECEIVED

2-6-75

REQUEST FOR MATERIAL

STOCK NO.		TELEPHONE		DELIVER TO		STATION NO.		STOCK LOCATION	
F7504		3-6983		NAME D.K. HOOD				MET. CUTTING	
25-138		DEPT. NO. 3016		BLOG. NO. 7058				ENCLOSURE AREA	
D.K. 1100		411-07-6847				DELIVERY POINT		A B C D E F	
AUTHENTICATED SIGNATURE		QUANTITY & UNIT		DESCRIPTION		WORK ORDER OR ACCT.		DRAWING NO.	
CATALOG NO.								PART NO.	
04-755-5304	28	ANGLE, STAINLESS STEEL, H.R.,		K-1776E-A1					
3	FT.	1" X 1" X 1/8" (4 PIECES - 7 FT. LONG)		OUT					
	HT	17599 TRESSOT HARP 30W		2/14/75					
04-755-5507	28	ANGLE, STAINLESS STEEL, H.R.,		H					
3	FT.	1 1/2" X 1 1/2" X 1/8" (4 PIECES - 7 FT. LONG)		TRESSOT HARP A-276 HT-3710.3					
04-761-4220	7	BAR, STAINLESS STEEL, 304L,		"					
3	FT.	ROUND, 3/8" DIA. X 7 FT. LONG		OUT					
		(1 PIECE)		2/14/75					
04-761-4035	4	BAR, STAINLESS STEEL, 304L,		"					
3	FT.	RECTANGULAR, 3/8" X 1" X 4 FT. LONG, (1 PIECE)							
		Q. N.		K-1776E-A1		1100			
				T.R. 11660 - 3/8" X 1" - 304L					
				HT 555776 - Cont'd					
				K-1776E-A1					

REQUEST FOR MATERIAL

NO. <u>F 7504</u>		DATE <u>2-6-75</u>		STORED LOCATION <u>MET. CUTTING</u>		EXPEDITER AREA <u>A B C D E F</u>	
REGISTER		TELEPHONE		STATION NO.		DATE RECEIVED	
AUTHORIZED SIGNATURE		Name		DELIVERY POINT		TIME NEEDED	
D.K. HOOD		3-6983		O.K. HOOD		NORMAL	
STAGE NO.		DEPT. NO.		GLOB. NO.		TIME NEEDED	
411-17-6947		3016		7058			
CATALOG NO.	QUANTITY & UNIT	DESCRIPTION		WORK ORDER OR ACCT.	DRAWING NO.	PART NO.	
04-755-5337	28	ANGLE, STAINLESS STEEL, H.R.,		K-1776E-A1			
3	FT.	1" X 1" X 1/8", (4 PIECES - 7 FT. EACH)		OUT 2/14/75			
04-755-5507	28	ANGLE, STAINLESS STEEL, H.R.,		"			
3	FT.	1 1/2" X 1 1/2" X 1/8", (4 PIECES - 7 FT. EACH)		"			
		LONG, 2 1/2" X 7" X 1/8" X 276 HT 23379					
04-761-4220	7	BAR, STAINLESS STEEL, 304L,		"			
3	FT.	ROUND, 3/8" DIA. X 7 FT. LONG		OUT 2/14/75			
		(1 PIECE)					
04-761-4035	4	BAR, STAINLESS STEEL, 304L,		"			
3	FT.	RECTANGULAR, 3/8" X 1" X 4 FT.		1A-11660 HT 56776 OUT			
		LONG, (1 PIECE)		A-479 PUT 567-2T 567-1			
		Q. A. Level					
FIELD SIGNATURE		DATE DELIVERED		TIME DELIVERED			
		2-6-75					

2-13-75
STONKS LOCATION
MET. CUTTING
EXPEDITER AREA
A B C D E F

D-29

62-95874-1000

2-13-75
STUNT LOCATION
NET, CUTTING
EXHIBIT, AREA
A B C D E F

[illegible]

20
21

REQUEST FOR MATERIAL

DATE
2-24-75
STORES LOCATION
MET. CUTTING
EXPEDITER AREA
A B C D E F

NO. F 7543		BADGE NO.		TELEPHONE	DELIVER TO HOUSTON	STATION NO.	DATE RECEIVED
REQ. CATER IS-138				3-1539	Name K.E. KIRKSEY		NORMAL
AUTHORIZED SIGNATURE K.E. KIRKSEY		BADGE NO. 443-24-7287		DEPT. NO. 3016	BLOG. NO. 7058	DELIVERY POINT	TIME NEEDED
CATALOG NO.	QUANTITY & UNIT	DESCRIPTION			WORK ORDER OR ACCT.	DRAWING NO.	PAI. NO.
04-777-1330	2	PLATE, STAINLESS STEEL, TYPE K-1776-A1					
3	50 FT.	304L, H.R., 3/16 THICK, (2 PIECES) IR-11672-LESSOR 304L			HT 18081-50240-HRAN		
		3" WIDE X 48" LONG			3/16" 04-777-1025		
		H H E					
		2-25-1/5					
		Q. A. Level III					
		(MANUFACTURERS IDENTIFICATION REQUIRED)					
F.O. JOB LOCATION					DATE DELIVERED	TIME DELIVERED	
					PLANNER	KIRKSEY 3 144-	

D-31

2-24-75
STORES LOCATION
MET. CUTTING
EXPEDITED AREA
A B C D E F

NO. F7543		EXPEDITER AREA A B C D E F					
REQUESTER IS-138	BADGE NO.	TELEPHONE 3-1539	DELIVER TO HOUSTON TX Name K.E. KIRKSEY		STATION NO.	DATE RECEIVED NORMAL	
AUTHORIZED SIGNATURE K.E. KIRKSEY	BADGE NO. 413-24-7287	DEPT. NO. 3016	BLDG. NO. 7058		DELIVERY POINT	TIME NEEDED	
CATALOG NO.	QUANTITY & UNIT	DESCRIPTION			WORK ORDER OR ACCT.	DRAWING NO.	PART NO.
04-777-1330	2	PLATE, STAINLESS STEEL, TYPE			K-1776B-A1		
3	SQ. FT.	304L, H.R., 3/16 THICK, (2 PIECES)					
		3" WIDE X 48" LONG					
Q. A. Level III							
(MANUFACTURERS IDENTIFICATION REQUIRED)							
FIELD JOB LOCATION					DATE DELIVERED	TIME DELIVERED	
					DEC 10 1963		

REQUEST FOR MATERIAL

2-6-70
PIPE FITTINGS
RECEIVED AND
A B C D E F

F7502		T.S.-138		D.K. HOOD		3-6983		D.K. HOOD		7058	
BADGE NO.		TELEPHONE		DELIVER TO		STATION NO.		DATE RECEIVED		TIME RECEIVED	
AUTHORISED SIGNATURE		BADGE NO.		DEPT. NO.		BLOG. NO.		DELIVERY POINT		TIME NEEDED	
07-257-8310		2		PLUG, SCREWED, STAINLESS		K-1776-A1					
3		EA.		STEEL, 1/2" 103							
07-439-3070		5		PACKING, SHEET, NEOPRANE,		H					
1-2-3		SQ. FT.		36" WIDE X 18", 1/2" THICK,							
				(1 PIECE)							
07-938-7160		3		PACKING, SHEET, RUBBER, SPONGE		H					
1-2-3		SQ. FT.		1/2" THICK X 36" WIDE X 12",							
				(1 PIECE)							

DATE DELIVERED
C.E. RINE 3-11-70

D-38

REQUEST FOR MATERIAL

NO. F7556 Y4-K 1000 138 1-2

STATION NO. 11-07-6947 TELEPHONE 3-6983 DELIVER TO NAME P.K. 1400 STATION NO. 11-07-6947 DELIVERY POINT 7058 TIME NEEDED NORM.

CATALOG NO. 04-764-2915 QUANTITY & UNIT 12 DESCRIPTION BAR STAINLESS STEEL, ROLLID WORK ORDER OR ACCT K-1771E-RI DRAWING NO. PART NO.

1-2 11. (1 PIECE) TYPE 304L, 1" DIA. X 12' LONG FOR TIE BARS ASTM A276 B7118

U. A. 1000

(MANUFACTURERS IDENTIFICATION)

OF MATERIAL REQUIRED

FIELD JOB LOCATION DATE DELIVERED TIME DELIVERED

DATE 10-1-70

BY C.E. BLAKE

PHONE 713 926-4401

1975 FEB 12 12:53 09

30347

**PLEASE REFER TO
THIS NUMBER ON ALL
CORRESPONDENCE.**

P. O. BOX 9350 - 7211 AVENUE "B" - HOUSTON, TEXAS 77011
STAINLESS SPECIALISTS

ORDER DATE	DATE SHIPPED	PART	QTY.	PR.	COLL.	VIA	O. D. J.	TERMS
1-1-55	1-28-55	X	2			H.F. ✓	Houston 37A	4-10-55

S [] **NOT TO BE USED AS A BASIS FOR UNLESS SPECIFIED**

Union Carbide Corp.
Nuclear Div.
P. O. Box 7
Oak Ridge, Tenn. 37830

2008
2009

[illegible]

• 6:2. 0 _____ IF PAID BY _____ SALES TAX 0 _____ NOV 1

UNION CARBIDE CORPORATION
NUCLEAR DIVISION

 300 RICE TERRACE, SUITE 100
 ALBUQUERQUE, NEW MEXICO 87102

Also known as: Union Carbide Corporation, Union Carbide Energy Services

IS-138
PURCHASE REQUISITION

- ☐
- TELEPHONE RELEASE
-
- ☐
- LETTER RELEASE
-
- ☐
- PURCHASE ORDER

DATE: 3/9/75		BY: RHL	
TO: J.E. Smith, Project Engineer, Union Carbide Corporation, Suite 100, 300 Rice Terrace, Albuquerque, New Mexico 87102		FROM: [Blank]	
SUBJECT: [Blank]		PURPOSE: [Blank]	
1. Southern Railway to New, Tennessee 2. Kentucky and Tennessee Railway to New, Tennessee		ABOVE ORDER AND RELEASE NO. MUST APPEAR ON ALL PACKAGES, B-T, AND FREIGHT BILLS	
R 8703 REPUBLIC STEEL CANTON, OHIO		1. Amount of Contract: \$ 0.00 2. Amount of Order: \$ 0.00 3. Amount of Balance: \$ 0.00	

ITEM NO.	QUANTITY	DESCRIPTION	UNIT	PRICE	TOTAL PRICE
01	5	PLATE, STAINLESS STEEL, $\frac{5}{16}$ " THICK, (1 PIECE 36" X 18"), ASTM A-240, TYPE 304L OR 347 HOT ROLLED.	Sq. Ft.		
	14	BAR, RECTANGULAR, $\frac{3}{16}$ " X 3", STAINLESS STEEL, ASTM A-276 OR A-479, TYPE 304L OR 347 HOT FINISHED, (1 PIECE), 14 FT LONG.	FT.		
(MANUFACTURERS IDENTIFICATION REQUIRED)					

THE CHECKED BELOW IS APPLICABLE TO THIS ORDER. IF BLOCK "A" IS CHECKED, THE SELLER SHALL SIGN & COMPLETE IN THE SPACE PROVIDED.	
☐ A. TO THE SELLER, PLEASE SIGN & RETURN ONE COPY OF ACCEPTANCE OF THIS ORDER AT ONCE TO THE ABOVE ADDRESS. IF YOU DO NOT, ALL OF THE AGREEMENTS OF THE PARTIES RELATIVE TO THE SUBJECT MATTER ARE CONTAINED IN THIS PURCHASE ORDER.	☐ B. TO THE SELLER, THIS PURCHASE ORDER IS ISSUED.
BILLING INSTRUCTIONS (REFER TO PURCHASE ORDER TERMS AND CONDITIONS) ☐ INVOICE NOT REQUIRED - DO NOT MAIL. ☐ FURNISH ORIGINAL INVOICE TO UNION CARBIDE CORPORATION - NUCLEAR DIVISION. ACCOUNTS PAYABLE. P.O. BOX 7, ONE RICE TERRACE, SUITE 100, ALBUQUERQUE, NEW MEXICO 87102.	UNION CARBIDE CORPORATION - NUCLEAR DIVISION EST. COST \$75.00

D-37

Associated Fuel Company of Houston:

OUR ORDER NO. 8379

Houston

Texas

NO. ASTM A-240

8/22 1969

TYPICAL TESTS: Type 304 Stainless Plate #1 Finish

Heat #	HAZ	SIZE	Pieces	YIELD ST	TENSILE ST	ELONG %	END	PER. ALL
39245	77	1/4 X 84 X 24	5	37,000	—	76,600	52.0	OK 56.4
39227	86	5/16 X 84 X 24	3	42,600	—	78,500	57.0	" 58.5
39142	81	1/2 X 84 X 24	3	41,200	—	79,800	61.0	" 59.3
FULL TEST REPORTS FURNISHED BY ASSOCIATED STEEL CO. OF HOUSTON CUSTOMER <u>Ames Carbide Nuclear</u> YOUR P.O. <u>225-252 REX 10</u> DATE <u>2-14-75</u> PICK NO. <u>1</u> OUR INV. NO. <u>637247</u>								

TYPICAL TESTS:

IDENTIFICATION	HAZ	CARB	MANG	PHOS	SIL	SIL	CHROME	NICKEL	Co.	Cu.	Mo.
301L	39245	.03	1.62	.022	.012	.45	18.03	8.70	.11	.20	.18
"	39227	.02	1.80	.012	.005	.52	18.00	9.40	.03	.02	.05
"	39142	.03	1.67	.030	.011	.52	18.48	9.35	.11	.09	.28

STATE OF INDIANA
COUNTY OF HENRY

Subscribed and Sworn To Before Me This

22nd

day of

August

1969

Donny M. Capula
James B. Capula
 Notary Public
 My Commission Expires
 May 3, 1971

Ingersoll STEEL DIVISION
 Borg-Warner Corporation
 NEW CASTLE - INDIANA

D-38

Houston

Texas

NO. AST: A-240

TYPICAL TESTS: Type 304 Stainless Plate Fl Finish

OUR ORDER NO. 8329

15-138

8/23

1969

ENT #	WELD	SIZE	Pieces	TENS	MAX	TENSILE	YIELD	END	RED AFT
39245	77	1/2 X 84 X 3/4	5	37,000	---	74,600	52.0	OK	56.4
39227	81	5/16 X 84 X 3/4	3	42,600	---	78,500	57.0	"	58.5
39112	81	1/2 X 84 X 3/4	3	41,200	---	79,600	61.6	"	57.3
SENT TEST REPORT REQUESTED BY ASSOCIATED STEEL CO. OF INDIANA CUSTOMER: <u>Indiana Lumber Products</u> YOUR P.O. <u>222-1252</u> DATE <u>2-11-75</u> ITEM NO. <u>023841</u>									

TYPICAL TESTS:

CERTIFICATION	HEAT	CARB	MANG	PHOS	SUL	SIL	CHROME	NICKEL	Co.	Cu.	Mo.
304L	39245	.03	1.62	.022	.012	.45	18.03	8.70	.11	.20	.1
"	39227	.02	1.80	.012	.005	.52	18.00	9.40	.03	.02	.0
"	39112	.03	1.67	.020	.011	.52	18.48	9.85	.11	.09	.3

STATE OF INDIANA
COUNTY OF HENRY

Subscribed and Sworn To Before Me This

22nd

day of

August

1969

JUL

Ingersoll STEEL DIVISION
Borg-Warner Corporation My Commission Expires
May 3, 1976

D-30

Associated Steel Company of Houston

15-138 K8712
OUR ORDER NO. 9329

Houston

Texas

NO. ASTM A-240

SPEC. TESTS: Type 304 Stainless Plate 1/2" Finish

8/23 1969

SIZE	HAZ	SIZE	Pieces	YIELD	MAX	TENSILE	ELONG	ELONG	RED
				STRESS	LOAD	STRESS	%	INCHES	APT. %
3/4" x 5'	77	1/4" x 5'4" x 3/4"	5	37,000	—	76,600	72.0	OK	56.4
3/4" x 5'	86	5/16" x 5'4" x 3/4"	3	41,600	—	78,500	52.0	"	58.5
3/4" x 5'	81	1/2" x 5'4" x 3/4"	3	41,200	—	77,600	61.6	"	57.3
<p>WILL TEST REPORTS BE REQUIRED BY APPROVED STEEL CO. OF HENRY</p> <p>CHARTERED MEMBER (Seal of American Society of Mechanical Engineers)</p> <p>YOUR P.O. 225-125 220 770</p> <p>DATE 2-11-75</p> <p>ITEM NO. 025347</p> <p>ENG. REC. FILE</p>									

SPEC. TESTS:

IDENTIFICATION	HEAT	CARD	HAZ	PROS	SEL	SEL	CHROME	NICKEL	Co.	Cu.	Mo.
304L	39245	.03	1.62	.022	.012	.45	18.03	9.70	.11	.20	.15
"	39237	.02	1.80	.012	.005	.52	18.00	9.40	.03	.02	.05
"	39144	.03	1.67	.020	.011	.52	18.48	9.35	.11	.09	.25

STATE OF INDIANA
COUNTY OF HENRY

Subscribed and Sworn To Before Me This

22nd

day of

August

1969

FILE

Dorothy M. Cigular
Daniel P. Cigular

NOTARY PUBLIC

My Commission Expires
May 3, 1973Ingersoll STEEL DIVISION
Borg-Warner Corporation
HONOLULU HAWAII

Appendix E

APPROVAL DOCUMENT

E-3

INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

March 4, 1983

TC 83-1

To: R. W. Mouring, R. W. Schaich
From: Transportation Committee
Subject: Approval of SARP (ORNL/ENG/TM-5, Rev. 1) for
the ORNL Gas Cylinder Fire and Impact Shield

The ORNL Transportation Committee has reviewed your submission of the subject SARP, with particular attention to the revisions. The results of the evaluation show that the package meets the requirements of DOE Order 5480.1, Chapter III, and the SARP is approved for submission to DOE for request of a revised Certificate of Compliance for approval for use as described in the offsite shipment of tritium gas.

E.M. King

E. M. King, Chairman
Transportation Committee

EMK:bb

cc: Transportation Committee

DOE Form EV-618
(11-77)
18 CFR 71U.S. DEPARTMENT OF ENERGY
CERTIFICATE OF COMPLIANCE
For Radioactive Materials Package

1a. Certificate Number	1b. Revision No.	1c. Package Identification No.	1d. Page No.	1e. Total No. Pages
5552	4	USA/5552/B (DOE-OR)	1	2

2. PREAMBLE

- 2a. This certificate is issued to satisfy Sections 173.203b, 173.204, 173.205, and 173.206 of the Department of Transportation Hazardous Materials Regulations (49 CFR 170-180).
- 2b. The packaging and contents described in item 5 below, meets the safety standards set forth in Subpart C of Title 18, Code of Federal Regulations, Part 71, "Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions."
- 2c. This certificate does not relieve the shipper from compliance with any requirements of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. The certificate is based on the basis of a safety analysis report of the package design or application-

(1) Prepared by (Name and address):	(2) Title and Identification of report or application:	(3) Date:
Oak Ridge National Laboratory P.O. Box X Oak Ridge, Tennessee 37830	Safety Analysis Report for Packaging for the ORNL Gas Cylinder Fire and Impact Shield.	April 1983

Report No.: ORNL/ENG/TM-5, Rev. 1

4. CONDITIONS

This certificate is conditional upon the fulfilling of the requirements of Subpart D of 18 CFR 71, as applicable, and the conditions specified in item 5 below.

5. Description of Packaging and Authorized Contents, Model Number, Fields Class, Other Conditions, and References:

a. Packaging:

- (1) Model: Gas Cylinder Fire Impact Shield.
- (2) Description: Packaging for Type B quantities of radioactive gases - tritium.
- The inner containment vessels consist of the following cylinders:

<u>Volume - l.</u>	<u>Tare Wt. - kg (lb)</u>
2	22.7 (50)
5	34.5 (76)
16	48.1 (106)

and other vessels of equivalent construction with capacities of 16 liters or less. The gas cylinders are supported by padded inserts to prevent lateral or vertical motion within the inner 30.5 cm (12 in.) dia. x 77.8 cm (30-5/8 in.) high, 16-gauge steel vessel. The 0.6 cm (1/4 in.) thick gasketed lid is held in with 12 1 cm (3/8 in.) dia. bolts. The outer shell

6a. Date of Issuance: May 13, 1983

6b. Expiration Date: May 31, 1985

FOR THE U.S. DEPARTMENT OF ENERGY

7a. Address for DOE Issuing Office:

U.S. Department of Energy
P.O. Box 2
Oak Ridge, Tennessee 37830

7b. Signature, Name, and Title for DOE Approving Official

William H. Travis
William H. Travis, Director
Safety & Environmental Control Division

je 2, C of C 5552, Rev. 4

consists of 16-gauge 304L Stainless Steel drum 61.3 cm (24-1/8 in.) dia. x 106.4 cm (41-7/8 in.) high with a 0.3 cm (1/8 in.) thick removable head held in place by 8 1.5 cm (5/8 in.) dia. bolts and nuts and equipped with lock washers. Sealed vent holes are provided in the outer drum. The space between the inner vessel and outer drum is filled with a high temperature phenolic foam containing glass fibers meeting DOE Specification SP-9. The maximum gross weight of the package is 340 kg. (750 lb.).

(3) Drawings:

The packagings are as described and fabricated in accordance with Oak Ridge National Laboratory Drawings:

M-11574-EM-001-E-6
XSE-11572-007-E
XSE-11572-012-0
XSE-11572-013-0
XSE-11572-014-0
XSE-11572-015-0

b. Contents:

(1) Type and Form of Material:

Uncompressed tritium gas.

(2) Maximum quantity of gases not to exceed Type B quantities of radioactive material consisting of:

Not more than 30,000 Ci of tritium.

(3) Maximum pressures of gases not to exceed:

Four-fifths atm (11.8 psia) for tritium.

(4) Maximum decay heat load not to exceed five watts.

c. Prior to each shipment, the package must be inspected and leak tested in accordance with the procedures specified in Appendix C to Report ORNL/ENG/TM-5, Rev. 1, April 1983.

Appendix F

FRICTION AND PENETRATION TESTS

F-3

C O P Y

INTERNAL CORRESPONDENCE

NUCLEAR DIVISION

POST OFFICE BOX X, OAK RIDGE, TENNESSEE 37830

To (Name) File

Division

Location

Date August 27, 1975

Originating Dept.

Answering letter date

Copy to

Subject Coefficient of Friction Between
a Stainless Steel Cask and High-
way Vehicle Bed.

On the above date G. G. Stiff and I conducted some simple tests to determine a value applicable to the down calculation for the coefficient of friction between a stainless steel cask and highway vehicle beds. A piece of scrap one inch thick stainless plate, weighing 16.5 lbs was connected to a spring scale as illustrated in the schematic on the attached data sheet. The plate surface in contact with the vehicle beds was typical of hot rolled and annealed stainless plate. The short sides of the plate had been machined and deburred hence there were no edges to dig into the bed. The plate was placed on actual dry vehicle beds and the force required to cause motion read. Three (3) readings were taken for each condition. The lower value was recorded except where there were variation in excess of one-half pound. In these cases the range was recorded. After completion of dry tests the bed was saturated with tap water and the test repeated for the wet surface. Eleven different beds were tested and the results are tabulated on the attached data sheet. These data support the use of any number .4 or less for tie down calculations.

John Evans
John Evans
Experimental Engineering

JE:abc

DATA SHEET TEST SCHEMATIC

EQUATION $\mu = \frac{F}{N}$ = COEFFICIENT OF FRICTION

DATA

TRUCK BED DESCRIPTION	Fig. No.	FORCE		COEFFICIENT OF FRICTION	
		DRY	WET	DRY	WET
WOOD WITH STEEL STRIPS	1	7.0	10.5	0.48	0.72
GALVANIZED STEEL	-	8.0	9.0	0.55	0.62
OLD STEEL-RUSTY	2	7.5	8.5	0.52	0.57
OLD STEEL-RUSTY SPOTS	2	6.5	8.0	0.45	0.55
NEW PAINTED STEEL	2	6.25	8.25	0.43	0.57
DOUGLAS FIR PLYWOOD	-	11.5	11.5	0.79	0.79
OAK TIMBERS WITH GRAIN	-	8.0	10.5	0.55	0.72
CHECKERED STEEL-PAINTED	-	8.5	8.5-10.0	0.57	0.57-0.69
CHECKERED STEEL-LIGHT RUST	-	6.0	7.0	0.41	0.48
OAK TIMBERS WITH GRAIN	-	7.0	7.5	0.48	0.52
OAK TIMBERS ACROSS GRAIN	-	8.5-10.0	8.0-12.0	0.57-0.69	0.55

Fig. 1

Fig. 2

F-5

INTERNAL CORRESPONDENCE

NUCLEAR DIVISION

POST OFFICE BOX 1 OAK RIDGE TENNESSEE 37830

To: Name File

Division

Location

Date January 29, 1976

Originating Dept Development Engineering

Requoting letter date

Subject

Copy to K. K. Chipley
E. M. King
J. M. Robinson
L. B. Shappert

On December 22, 1975, I performed the "Penetration" Test described in Annex 1 of AEC MC-0529 on the existing packages and models listed on the attached data sheet. In all cases the resulting damage was a small dent. It is now obvious that this test will not reduce the effectiveness of steel or stainless steel jacketed packages and that the resulting damage is insignificant.

A handwritten signature in cursive script that reads "John Evans".
John Evans

JE:gl

Attachment

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