SAFETY ANALYSIS REPORT — PACKAGES
232-H BYPRODUCT TRAILER
(Packaging of Radioactive Material)

FINAL REPORT

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SAFETY ANALYSIS REPORT — PACKAGES 232-H BYPRODUCT TRAILER

ABSTRACT

Helium containing some tritium is shipped at low pressure in banks of cylinders mounted on a truck trailer in compliance with 49 CFR 178.350, Specification 7A. The shipping package is not a radiological hazard under normal or accident conditions.

DESCRIPTION OF SHIPMENT

Helium containing some tritium is shipped from the Savannah River Plant in thirty seamless steel cylinders mounted on a truck trailer. (The assembly is known as the Byproduct Trailer.) Valves divide the cylinders into four banks, each considered a separate Type 7A container, having nominal volumes of 1700, 2000, 1700, and 2000 liters. Shipping package components are shown in figures 1 through 4.

Helium may contain varying amounts of argon, tritium, protium (hydrogen-1), deuterium, nitrogen, and trace gaseous components of the waste stream from the tritium separations facility. The following restrictions apply to the use of this container.

Maximum tritium content per bank (Type 7A container)	1000 curies
Maximum total pressure during shipment	900 torrs at 180°F

Each bank contains a Type A quantity of nonfissile, Group VII materials, as defined in 49 CFR 173.389, and complies with appropriate sections of that regulation. No exemptions are claimed.

COMPARISON WITH REGULATIONS

The packaging standards required of shippers are contained in 49 CFR 170-179. All pertinent sections are quoted in italics, then discussed in roman type.

Sec 178.350 *Specification 7A; general packaging, Type A.*

Sec 178.350-1 *General requirements. (a) Each packaging must meet all applicable requirements of 173.24.*

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173.24 *Standard requirements for all packages.*

- (a) *Each package used for shipping hazardous materials under this chapter shall be so designed and constructed, and its contents so limited, that under conditions normally incident to transportation:*

- (1) *There will be no significant release of the hazardous materials to the environment;*

No significant release of radioactive material is interpreted to mean no release which would expose any persons to a dose above that received by continuous exposure to the maximum permissible concentration allowed for the public. A tritium release rate of 1.08×10^{-7} atm cc/sec has been established by the International Atomic Energy Agency in their Safety Series No. 6.

- (2) *The effectiveness of the packaging will not be substantially reduced;*

The steel containers have been shipped for 18 years without loss of effectiveness. To ensure that the package continues to retain its effectiveness, an inspection program has been initiated. This program includes a visual inspection of the trailer and a leak test of the closure valves prior to every shipment. The package will be pressure-tested at 250 psig and leak-tested at 15 psig every 5 years. The trailer, consisting of the 4 banks of type 7A packages, will be leak-tested with helium gas to confirm that the tritium leak rate of each bank is less than 1×10^{-7} atm cc/sec (see Byproduct Trailer QA file).

- (3) *There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure, or through an explosion, significantly reduce the effectiveness of the packaging.*

The contents of the package, primarily helium and argon, will not have hydrogen isotope or oxygen concentrations within the explosive limits. [The explosive limit is greater than 4% hydrogen.]

- (b) *Materials for which detailed specifications for packaging are not set forth in this part must be securely packaged in strong, tight packages meeting the requirements of this section.*

Not applicable.

(c) *Packaging used for the shipment of hazardous materials under this chapter shall, unless otherwise specified or exempted therein, meet all of the following design and construction criteria:*

(1) *Each specification container shall be marked in an unobstructed area with letters and numerals identifying that specification (e.g., DOT-6J, DOT-6L, etc.).*

Each container is marked as required. See 178.350-3 for actual markings.

(i) *The marking is a certification that the packaging complies with all specification requirements.*

The package shall be marked accordingly.

(ii) *The name and address or the symbol of the manufacturer or the user, who assumes responsibility for compliance with the specification requirements, shall be included. Symbol letters must be registered with the Bureau of Explosives. Duplicate symbols are not authorized.*

The packaging complies with this requirement. See 178.350-3(a).

(iii) *The markings shall be stamped, embossed, burned, printed, or otherwise marked on the packaging to provide adequate accessibility, permanency, and contrast so as to be readily apparent and understood.*

The markings, shown in Sec 178.350-3(a), are painted onto the exterior of each exposed tube on the trailer.

(iv) *Unless otherwise specified, letters and numerals shall be at least 1/2-inch high.*

Letters and numerals are 1/2 inch high.

(v) *Packaging which does not comply with the applicable specification listed in Parts 178 and 179 of this chapter must not be marked to indicate such compliance.*

Not applicable.

- (2) *Steel used shall be low carbon, commercial quality steel. Stainless, open hearth, electric, basic oxygen, or other similar quality steels are acceptable. Steel sheets or specified gages shall comply with the following: [Table not reproduced.]*

These cylinders were made of rolled seamless steel tubing having the composition specified in 178.36-5 and analysis certified as shown in figures 7 through 9.

- (3) *Lumber used shall be well seasoned, commercially dry, and free of decay, loose knots, knots that*

Lumber is used only for the front impact absorber and is "Wolmanized"-treated long leaf yellow pine. The lumber is protected from the weather by a stainless steel cover.

- (4) *Welding and brazing shall be performed in a workman-like manner using suitable and appropriate techniques, materials, and equipment.*

Welding and brazing are performed in accordance with 178.36-9 and Du Pont Spec 4482, P 40.011A.

- (5) *Packaging materials and contents shall be such that there will be no significant chemical or galvanic reaction among any of the materials in the package.*

The cylinder contents will not cause any significant chemical or galvanic reaction with the cylinder.

- (6) *Closures shall be adequate to prevent inadvertent leakage of the contents under normal conditions incident to transportation. Gasketed closures shall be fitted with gaskets of efficient material which will not be deteriorated by the contents of the container.*

One Powell valve (figures 10 and 11) isolates the gas in the cylinders during shipping. A second Powell valve provides a backup seal for the cylinder valves. Before shipping, the valve which seals each bank of cylinders is leak-tested across the seat to show that the individual leak rates are less than 5×10^{-5} atm cc/sec. Because tritium concentration is only 0.02 mol % max, the tritium leakage through the first valve will be $<1 \times 10^{-8}$ atm cc/sec and the leakage through the second valve will be even less.

- (7) Nails, staples, and other metallic devices shall not protrude into the interior of the outer packaging in such a manner as to be likely to cause failures.

None exist.

- (8) The nature and thickness of the packaging shall be such that friction during transport does not generate any heating likely to decrease the chemical stability of the contents.

The cylinders are fixed to the truck bed.

- (9) Polyethylene used must be of a type compatible with the lading and must not be permeable to an extent that a hazardous condition could be caused during transportation and handling.

Polyethylene is not used as a material of construction on the byproduct trailer.

- (d) For specification containers, compliance with the applicable specifications in Parts 178 and 179 of this chapter shall be required in all details, except as otherwise provided in this chapter.

Sec 178.350-2 *Specific Requirements*

- (a) Each packaging must be so designed and constructed that it meets the standards for Type A packaging [see 173.389(j) and 173.398(b)].

173.389(j) "Type A packaging" means packaging which is designed in accordance with the general packaging requirements of 173.24 and 173.393, and which is adequate to prevent the loss or dispersal of the radioactive contents and to retain the efficiency of its radiation shielding properties if the package is subject to the test prescribed in 173.398(b).

173.24 already quoted.

173.393 *General Packaging and Shipping Requirements*

- (a) Unless otherwise specified, all shipments of radioactive materials must meet all requirements of this section, and must be packaged as prescribed in 173.391 through 173.396.

173.391 *Small Quantities of Radioactive Materials and Radioactive Devices*

- (a) *Radioactive materials in normal form not exceeding ----- 25 curies of Group VII radionuclides; --- are exempt from specification packaging, marking, and labeling, and are exempt from provisions of 173.393, if the following conditions are met.*

The byproduct trailer banks of cylinders may contain more than 25 curies of tritium.

173.392 *Low Specific Activity Materials*

Not applicable.

173.394 *Radioactive Material in Special Form*

Not applicable.

173.395 *Radioactive Material in Normal Form*

- (a) *In addition the applicable requirements of 173.24 and 173.393, a Type A quantity of normal form radioactive material must be packaged as follows:*

- (1) *Specification 7A (178.350 of this subchapter) Type A general packaging. Each shipper of a specification 7A packaging must maintain on file for at least one year after the latest shipment, and be prepared to provide the Department, a complete certification and supporting safety analysis demonstrating that the construction methods, packaging design, and materials of construction are in compliance with the specification. This requirement is effective December 31, 1975.*

Package design, materials of construction, and fabrication details are shown on drawings contained in Du Pont VPF 4729. This document is the supporting Safety Analysis Report. Annual inspections and preusage inspections are performed according to DPSOLs 232-H-912 and -909.

- (2) *Specification 55 metal encased shielded container. Use of existing container authorized; construction not authorized after March 31, 1975. For liquid contents the provisions of 173.393(g) must also be met.*

(3) Any Type B packaging pursuant to para (b) of this section.

(4) Foreign-made packagings which bear the marking "TYPE A."

(2), (3), and (4): Not applicable.

(b) Type B quantities of radioactive materials in normal form must be packaged as follows:

- (1) Spec. 6M (178.104) metal packaging. Authorized only for solid or gaseous radioactive materials which will not decompose at temperatures up to 250°F.
- (2) Any other Type B packaging approved by the U.S. Energy Research and Development Administration.
- (3) Any other Type B packaging which meets the pertinent requirements in the 1967 regulations of the International Atomic Energy Agency, and for which the foreign competent authority certificate has been re-validated by the Department.
- (4) Spec. 20WC (178.194 of this subchapter) wooden outer protective jacket, when used with a single, snug-fitting inner specification 2R (178.34 of this subchapter) or specification 55 inner packaging. Only use of existing specification 55 container authorized; construction not authorized after March 31, 1975. For liquid contents the provisions of 173.393(g) must also be met, with respect to the inner packaging.

(b): Not applicable.

(c) Large quantities of radioactive materials in normal form must be packaged as follows:

- (1) Spec. 6M (178.104) metal packaging. Authorized only for solid or gaseous radioactive materials which will not decompose at temperatures up to 250°F. Radioactive thermal decay energy must not exceed 10 watts.
- (2) Any other Type B packaging for large quantities of radioactive materials which meets the pertinent requirements in the regulations of the U.S. Energy Research and Development Administration (10 CFR Part 71) and is approved by the U.S. Energy Research and Development Administration.

- (3) *Any other Type B packaging which meets the pertinent requirements for large quantities of radioactive materials in the 1967 regulations of the International Atomic Energy Agency, and for which the foreign competent authority certificate has been revalidated by the Department.*

(c): Not applicable.

173.396 *Fissile Radioactive Material*

Not applicable.

173.393 *General Packaging and Shipping Requirements*

- (b) *The outside of each package must incorporate a feature such as a seal, which is not readily breakable and which, while intact, will be evidence that the package has not been illicitly opened.*

A leaded wire seal is placed on the cabinet door which encloses the manifold.

- (c) *The smallest outside dimension of any package must be 4 inches or greater.*

The OD of each cylinder is 9-5/8 inches.

- (d) *Each radioactive material must be packaged in packaging which has been designed to maintain shielding efficiency and leaktightness, so that, under conditions normally incident to transportation, there will be no release of radioactive material ----.*

See 173.24(c),(6) regarding leaktightness.

- (e) *The packaging must be so designed, constructed, and loaded so that during transport:*

- (1) *The heat generated within the package because of the radioactive materials present will not, at any time during transportation, affect the efficiency of the package under the conditions normally incident to transportation, and ...*

The heat from decay of 1000 curies of tritium is negligible (0.034 watt).

- (2) *The temperature of the accessible external surfaces of the package will not exceed 122°F in the shade when fully loaded, assuming still air at ambient temperature. If the package is transported in a transport vehicle consigned for the sole use of the consignor, the maximum accessible external surface temperature shall be 180°F.*

The external surface temperature of the package is less than 180°F.

- (f) *Pyrophoric materials,*

Not applicable.

- (g) *Liquid radioactive material*

Not applicable.

- (h) *There must be no significant removable radioactive surface contamination on the exterior of the package (see 173.397).*

Before shipping, the transferrable contamination on the exterior will be less than 500 d/m/100 cm² β-γ.

- (i) *Except for shipments described in paragraph (j) of this section, all radioactive materials must be packaged in suitable packaging (shielded, if necessary) so that at any time during the normal conditions incident to transportation the radiation dose rate does not exceed 200 millirems per hour at any point on the external surface of the package, and the transport index does not exceed 10.*

There are no gamma emitting isotopes in this package and the weak beta radiation does not have enough energy to penetrate the cylinder walls; consequently, radiation dose rate will be insignificant.

- (j) *Packages for which the radiation dose rate exceeds the limits specified in paragraph (i)*

Not applicable.

- (k) *Cancelled.*

(1) Packages consigned for export

Not applicable.

(m) Prior to the first shipment of any package, the shipper shall determine by examination or appropriate test that:

(1) The packaging meets the specified quality of design and construction;

The steel containers have been used for this purpose for 18 years without loss of effectiveness. Each shipment after 12/31/75 will be given a preusage inspection to confirm present quality of construction.

(2) The effectiveness of the shielding and containment, and, where necessary, the heat transfer characteristics of the package are within the limits applicable to or specified for the package design.

Containment is in cylinders originally rated for a working pressure of 2400 psig. The shipment is pressurized only to atmospheric pressure at 25°C and the cylinders are sealed with two Powell valves, in series, the first of which is leak-tested to $<5 \times 10^{-5}$ atm cc/sec.

(n) Prior to each shipment of any package, the shipper shall insure by examination or appropriate test that:

(1) The package is proper for the contents to be shipped.

A preusage inspection by SRP shall confirm (DPSOL 232-H-909).

(2) The packaging is in unimpaired physical condition except for superficial marks.

Periodic (DPSOL 232-H-912) and preusage inspections (DPSOL 232-H-909) by SRP shall confirm.

(3) Each closure device of the packaging, including any required gasket, is properly installed and secured and free of defects;

Leak test (DPSOL 232-H-906) and preusage inspection (DPSOL 232-H-909) shall confirm.

(4) For a fissile material, and moderator and neutron absorber, if required, is present in proper condition;

Not applicable.

- (5) *Any special instructions for filling, closing, and preparation of the package for shipment have been followed;*

SRP shall comply through its procedure system (DPSOLs 232-H-904, -906, -907, -908, and -909).

- (6) *Each closure, valve, and any other opening of the containment system through which the radioactive content might escape is properly closed and sealed;*

SRP shall comply through its procedure system and preusage inspection.

- (7) *Each package containing liquid in excess of a Type A quantity*

Not applicable.

- (8) *If the maximum normal operating pressure of a package is likely to exceed 0.35 kg/cm^2 (gage), the internal pressure of the containment system will not exceed the design pressure during transportation and*

($0.35 \text{ kg/cm}^2 = 5 \text{ psig}$)

Normal loading pressure is 760 torrs or 0 psig at 25°C. Maximum pressure that would develop inside the package if the surface temperature reached 180°F from environmental conditions is 2.9 psig.

- (9) *External radiation and contamination levels are within the allowable limits.*

- o External radiation — not applicable.
- o External contamination — before shipping, the smearable contamination on the exterior will be less than $500 \text{ d/m/100 cm}^2 \beta\text{-}\gamma$.

- (o) *No person may offer for transportation a package of radioactive material until the temperature of the packaging system has reached equilibrium (see also paragraph (e) of this section) unless, for the specific contents, he has ascertained that the maximum applicable surface temperature limits cannot be exceeded.*

Not applicable.

173.398(b) Special Tests, Standards for Type A Packaging

- (1) *Type A Packaging must be so designed and constructed that, if it were subject to the environmental and test conditions prescribed in the paragraph:*

- (i) *There would be no release of radioactive materials from the package;*
- (ii) *The effectiveness of the packaging would not be substantially reduced; and,*
- (iii) *There would be no mixture of gases or vapors in the package which could, through any credible increase of pressure or an explosion, significantly reduce the effectiveness of the package.*

(2) *Environmental conditions:*

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

$$\frac{P_2}{T_2} = \frac{P_1}{T_1} \text{ (assume ideal gas)}$$

where:

P_1 = loading pressure, 1 atm absolute

T_1 = loading temperature, 537°R or 77°F

P_2 = pressure at T_2 , atm absolute

T_2 = 640°R or 180°F

$$P_2 = \frac{1 \text{ atm} \times 640^\circ\text{R}}{537^\circ\text{R}} = 1.2 \text{ atm absolute}$$

This small increase in pressure would not significantly increase the leakage rate from the tanks.

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

This package contains no liquids nor other materials harmfully affected by a temperature of -40°F. The strength of the package is adequate for -40°F service. The cylinders are DOT specification 3A and the manifold and valves are fabricated from type 304 SST material.

- (iii) *Reduce pressure. Ambient atmospheric pressure of 0.5 atmosphere (abs; 7.3 psia).*

Since the containers were originally certified by hydrostatic pressure test to 4000 psig, 0.5 atm (abs) ambient pressure would have little effect on the stress level in the cylinders. Also, a pressure differential of 8.9 psi on the Powell valves is much less than the recommended operating range of the valve (full vacuum to 100 psi).

(iv) *Vibration. Vibration normally incident to transportation.*

The byproduct trailer has been shipped for 18 years and nondestructive tests have indicated that no structural damage has occurred during this time.

(3) *Test Conditions: The packaging shall be subject to all of the following tests unless specifically exempted therefrom, and also the consecutive application of at least two of the following tests from which it is not specifically exempted:*

(i) *Water Spray. A water spray heavy enough to keep the entire exposed surface of the package except the bottom continuously wet during a period of 30 minutes. Packages for which the outer layer consists entirely of metal, wood, ceramic, or plastic or combinations thereof, are exempt from the water spray test.*

A water spray will not affect the materials in this package.

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

Since these cylinders are part of the trailer, a four-foot drop would constitute an incredible handling mishap. It is our opinion that the mishap described in the following paragraph is much more realistic and likely to occur.

A byproduct trailer experienced a handling mishap which could be characterized in severity between the 4-foot fall for normal conditions of transport and an accident. A tractor, upon contact with the trailer, was too high to engage the fifth wheel coupling. This resulted in the tractor pushing the trailer to the rear. The rigid landing gear collapsed, allowing the front of the trailer to free fall four feet onto the asphalt pavement (see figures 5 and 6). Investigation revealed that the bolts holding the landing gear to the frame had sheared, and one tiedown strap for the cylinders had failed.

The shipping package and the 30 cylinders with attached manifolds were undamaged, as later confirmed by a leak test of the package. Calculations shown in appendix A indicate that, with the addition of impact absorbers to the front and rear of the trailer (figures 2 and 4), the package will have the ability to withstand a 4-foot drop onto its weakest position without loss of radioactive contents. Impact absorbers, recommended in appendix A and shown in detail in appendix B were installed on the three trailers.

- (iii) *Corner Drop.* A free drop on each corner of the package in succession, or in the case of a cylindrical package onto each quarter of each rim, from a height of 1 foot onto a flat essentially unyielding horizontal surface. This test applies only to packages which are constructed primarily of wood or fiberboard

Not applicable.

- (iv) *Penetration.* Impact of the hemispherical end of a vertical steel cylinder 1-1/4 inches in diameter and weighing 13 pounds, dropped from a height of 40 inches onto the exposed surface of the package which is expected to be most vulnerable to puncture. The long axis of the cylinder shall be perpendicular to the package surface.

By comparison with tests made on drums of 16 and 18 gage metal, the required penetration test would not result in significant damage.

- (v) *Compression.* For packages not more than 10,000 pounds in weight, a compressive load equal to either five times the weight of the package or 2 pounds per square inch multiplied by the maximum horizontal cross section of the package, whichever is greater. The load shall be applied during a period of 24 hours, uniformly against the top and bottom of the package in the position in which the package would normally be transported.

This trailer weighs 27,500 pounds and is not subject to compression during normal transport, therefore the test is not applicable.

Sec. 178.350-3 Marking

- (a) *Marking on the outside of each packaging as follows:*

"USA DOT-7A Type A"
USERDA-SR

and "RADIOACTIVE MATERIAL"

The packaging complies with this requirement.

(b) Marking to conform with 173.24.

The packaging complies with this requirement.

FIGURE 1. BYPRODUCT TRAILER, FRONT VIEW (DPSPF 20483-6)

FIGURE 2. BYPRODUCT TRAILER, REAR VIEW SHOWING MANIFOLD AND IMPACT ABSORBER (DPSPF 20483-1)

FIGURE 3. BYPRODUCT TRAILER, CYLINDER BANK MANIFOLD
PRIOR TO INSTALLATION OF IMPACT ABSORBER (DPSPF
13760-2)

FIGURE 4. BYPRODUCT TRAILER, FRONT IMPACT
ABSORBER (DPSPF 20184-2)

FIGURE 5. BYPRODUCT TRAILER AFTER HANDLING MISHAP
(DPSPF 15212-7)

FIGURE 6. FRONT VIEW OF TRAILER AFTER HANDLING MISHAP
(DPSPF 15212-8)

C O P Y

STEEL GAS CYLINDERS

Manufactured for Eidal Manufacturing Company
Location at Albuquerque, New Mexico
Manufactured by The Marison Company
Location at Elgin, Illinois
Consigned to Eidal Manufacturing Company
Location at 336 East Woodward Road, Albuquerque, New Mexico
Quantity 332 Size 9-5/8 inches outside diameter
This is a complete report of the manufacture of the cylinder.
Marks stamped into the shoulder of the cylinder are:
Specification ICC-3A 2400
Serial Nos. 454 to 785
Inspector's Mark (L)
Identifying Symbol EIDAL
Test Date 7/54
Tare Weights (Yes or No) No

These cylinders were made by the process of hot drawn and rolled seamless steel tubing and the spinning of both ends, with both ends drilled and tapped for a 3/4" taper pipe thread.

The steel used was identified by the following heat numbers 622381, 641998, 612285, 13239, 23417, 13460

The steel used was verified as to chemical analysis and record thereof is attached hereto. The heat numbers were not marked on the material.

All material, such as plates, billets and seamless tubing, was inspected and each cylinder was inspected both before and after closing in the ends, all that was accepted was found free from seams, cracks, laminations, and other defects which might prove injurious to the strength of the cylinder. The processes of manufacture and heat treatment of cylinders were supervised and found to be efficient and satisfactory.

The cylinder walls were measured and the minimum thickness noted was .300 inch. The outside diameter was determined by a close approximation to be 9-5/8 inches. The wall stress was calculated to be 54,785 pounds per square inch under an internal pressure of 4000 pounds per square inch.

Hydrostatic tests, flattening tests, tensile tests of material, and other tests, as prescribed in specification No. ICC- 3A were made, except as noted, in the presence of an inspector and all material and cylinders accepted were found to be in compliance with the requirements of that specification. Records thereof are attached hereto.

Each cylinder has been equipped with safety devices _____

I hereby certify that all of these cylinders proved satisfactory in every way and comply with the requirements of Interstate Commerce Commission specification No. ICC- 3A except as noted.

Exceptions: _____

T. H. COCHRANE LABORATORIES
Milwaukee 4, Wisconsin

(Original Signed by R. R. Blackwood)

C O P Y

Milwaukee 4, Wisconsin Sept. 7, 1954

RECORD OF CHEMICAL ANALYSIS OF STEEL FOR CYLINDERS

Numbered 454 to 785 Inclusive.

Size 9-5/8 Inches Outside Diameter by 21 feet Long.

Made by The Marison Company Elgin, Illinois

For Eidal Manufacturing Company Albuquerque, New Mexico

Test Bar No.	Heat No.	Check Analysis No.	Cylinders Represented Serial Nos.	Chemical Analysis, %							
				C	Mn	S	P	Si	Cr	Ni	Mo
	622381		454 to	.43	1.48	.016	.025				
	612285		597	.40	1.50	.022	.017				
	641998		inclusive	.41	1.40	.022	.024				
The above chemical analyses were made by the Jones & Laughlin Steel Corp., a certified copy of which is in our files.											
	13239		598 to	.40	1.53	.023	.018				
	23417		785	.40	1.51	.025	.021				
	13460		inclusive	.40	1.50	.023	.016				
The above chemical analyses were made by the National Tube Division of the United States Steel Corp., a certified copy of which is in our files.											
		A-1585	454 to 555 inclusive	.41	1.58	.015	.017				
		A-1749	556 to 597 inclusive	.43	1.58	.015	.020				
		A-2676	598 to 688 inclusive	.44	1.56	.017	.025				
		A-2677	689 to 785 inclusive	.38	1.56	.017	.020				
The above chemical analyses were made by the T. H. Cochrane Laboratories.											

T. H. COCHRANE LABORATORIES

Milwaukee 4, Wisconsin

(Original Signed by R. R. Blackwood)

C O P Y

Milwaukee 4, Wis. Sept. 7, 1954

RECORD OF TENSILE TESTS OF MATERIAL IN CYLINDERS

Numbered 454 to 785 Inclusive.

Size 9-5/8 Inches Outside Diameter by 21 feet Long.

Made by The Marison Company Elgin, Illinois

For Eidal Manufacturing Company Albuquerque, New Mexico

Test Bar No.	Cylinders Represented by Test	Yield Point in Pounds per Square Inch	Tensile Strength in Pounds per Square Inch	Elongation (Percent in 8 inches)	Reduction of Area (Percent)	Flattening Test
TB #1	454 to 555	64,140	107,515	12.9	50.1	
TB #2	Inclusive	65,350	110,975	12.2	50.1	OK
TB #1	556 to 597	62,795	105,810	13.3	49.4	
TB #2	Inclusive	62,150	107,750	13.3	49.5	OK
TB #1	598 to 688	70,205	113,570	12.9	47.1	
TB #2	Inclusive	69,275	111,445	12.1	46.3	OK
TB #1	689 to 785	65,735	105,745	14.9	51.0	
TB #2	Inclusive	67,135	107,470	12.5	49.9	OK
		Yield Point Determined by Extensometer				

T. H. COCHRANE LABORATORIES

Milwaukee 4, Wisconsin

(Original signed by R. R. Blackwood)

1" SCHEDULE
40 PIPE

[illegible]

FIGURE 10. POWELL VALVE

LIST OF MATERIAL				FIG. NO.	STANDARD
DESCRIPTION 1/2" - INSIDE SCREW BELLOSEAL GLOBE VALVE WITH UNION DISC AND BUTT WELD NIPPLES				SPECIAL 1976 MOD.	
				ASSEMBLY NO. E-39426	
LINE	PART NAME	NO. REQ.	MATERIAL	REMARKS	
1	HANDWHEEL NUT	1	STEEL	CADMIUM PLATED	
2	HANDWHEEL	1	ALUMINUM		
3	STEM	1	TYPE 316 STAINLESS STEEL	HEAT TREAT 300-325 BRINELL	
4	BOHRET PUSHING	1	TYPE 304 STAINLESS STEEL		
5	BOHRET HOUSING	1	TYPE 304 STAINLESS STEEL		
6	BELLOWS	1	TYPE 321 STAINLESS STEEL		
7	BELLOWS ADAPTER	1	TYPE 304 STAINLESS STEEL		
8	DISC HOLDER	1	TYPE 304 STAINLESS STEEL		
9	GUIDE PIN	1	TYPE 303 STAINLESS STEEL		
10	DISC	1	NIL-F		
11	DISC NUT	1	TYPE 303 STAINLESS STEEL		
12	FOUNT BASE	1	TYPE 304 STAINLESS STEEL		
13	GASKET	1	NIL-F		
14	POXY	1	TYPE 304 STAINLESS STEEL		
15	WELD NIPPLES	2	TYPE 304 STAINLESS STEEL	STAINLESS PIPE	
16					
17					
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21	NOTE: 100% OF ALL GASKETS ARE TYPE #10 and #13				
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COMPILED BY L.J.S. DATE 3/14/57			CUSTOMER	ORDER NO.	SHEET
APPROVED BY E.J.A. DATE 3/14/57			DU PONT INQUIRY H-30-5321	DATE	1 OF 1

FIGURE 11. BILL OF MATERIALS FOR POWELL VALVES

E. I. DU PONT DE NEMOURS & COMPANY

WILMINGTON, DELAWARE 19898

ENGINEERING DEPARTMENT

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IC #33 (860477)

January 8, 1976

J. F. PROCTOR, MANAGER
PROCESS SECTION
MANUFACTURING DIVISION
ATOMIC ENERGY DIVISION
POLYMER INTERMEDIATES DEPARTMENT

ATTENTION: J. W. LANGHAAR (5)

WORK REQUEST 860477 - SAVANNAH RIVER PLANT
232-H BYPRODUCT TRAILER

Analysis of the package for a 4 foot drop per your request (Ref: J.F. Proctor to L.F. Shafranek, November 14, 1975) indicated that the ends of the package were vulnerable to possible damage when they were the impacting surfaces. To prevent this damage in a direct hit and to help rotate the package in an oblique hit, the protecting structures shown in attached Figures 1-3 were suggested and are to be added to the packaging. Also attached is a summary of the analysis demonstrating the package's ability to survive a 4 foot fall without leaking or being reduced in effectiveness.

DESIGN DIVISION
Atomic Engrg. Section

J. R. Cherney
J. R. Cherney
Senior Process Engineer

JRC/cak
Attach.

DROP ON BACK END OF TRAILER:

The following equation from the Cask Designer's Guide is used to demonstrate the energy absorbing features of the pipe.

$$E = \frac{S_y t^2 L}{R} \left[\Delta + .4 \frac{\Delta^2}{R} \right]$$

E = energy absorbed, in #

S_y = yield strength of steel 25,000 psi (304L)

t = cylinder thickness .237 in.

L = cylinder length 352 in.

R = mean radius 2.1315 in.

Δ = deformation 3.125 in.

$$E = \frac{25,000 (.237) (.237) (352)}{2.1315}$$

$$\left[3.125 + \frac{.4 (3.125)^2}{2.1315} \right]$$

$$E = 1,149,657 \text{ in \#}$$

$$E \text{ for 48" fall} = 23,000 (48)$$

$$= 1,104,000 \text{ in \#}$$

WEIGHTS:

Wood Front	~ 108#
Pipes on Back	~ 500#
Cylinders	21,480#
Plates	~ 680#
Manifold Box	~ 230#
Total	22,998# $\approx$ 23,000#

DROP ON FRONT END OF TRAILER:

$$E = \sigma A \delta$$

$$E = Wh$$

Where

E = energy, in #

σ = crush strength of yellow pine 1,650 psi

A = area crushed 1,507.1 in²

δ = deformation in.

W = package weight 23,000#

h = drop height 48 in.

$$\delta = \frac{(23,000) (48)}{(1,650) (1,507.1)}$$

$$\delta = .44 \text{ in.}$$

The available depth of wood to be crushed is 3.625 in.

DROP ON SIDES

The 4' drop on either side results in crushing of the 3/8" plates to which the cylinders are attached. The front plate is 36" by 82" by 3/8" and the rear plate is 42" by 82" by 3/8". It was assumed that the commercial steel has a tensile strength of 70,000 psi and a yield strength of 35,000 psi.

Drop on long side on bottom:

$$Wh = \sigma A \delta$$

W = weight of package 23,000#

h = drop height 48 in.

σ = yield of steel 35,000 psi

A = area of crush 61.5 in²

δ = deformation in.

$$\delta = \frac{(23,000)(48)}{35,000(61.5)}$$

$$\delta = .51" \quad 1.125" \text{ clearance exists between cylinder and plates}$$

Drop on short side:

$$A = 29.25 \text{ in}^2$$

$$\delta = 1.08" \quad 2.0625" \text{ clearance}$$

Drop on long side on top:

The clearance between the cylinder walls and the edge of the 3/8" plate in this orientation is .0625". The energy of the fall will be absorbed by crushing the plate and deforming the row of 7 cylinders. This is also typical of the energy absorption in any oblique drop.

$$E_1 = \sigma A \delta$$

$$E_1 = \text{energy absorbed by crushing plate}$$

$$\sigma = 35,000 \text{ psi}$$

$$A = 61.5 \text{ in}^2$$

$$\delta = .0625"$$

$$E_1 = (35,000) (61.5) (.0625)$$

$$= 134,531 \text{ in } \#$$

The energy remaining to be absorbed when the cylinders come into contact is 1,104,000 - 134,531 in #.

$$E_2 = \sigma A \delta + \frac{S_y t^2 L}{R} \left[\delta + .4 \frac{\delta^2}{R} \right]$$

Where E_2 = energy absorbed by crushing plates and deforming cylinders, in #.

$$\sigma = 35,000 \text{ psi}$$

$$A = 61.5 \text{ in}^2$$

$$\delta = .25 \text{ in.}$$

$$S_y = 62,000 \text{ psi}$$

$$t = .3 \text{ in.}$$

$$L = 1,764 \text{ in.}$$

$$R = 4.6625 \text{ in.}$$

$$E_2 = (35,000) (61.5) (.25) + \frac{(62,000) (.09) (1764)}{4.6625} \left[.25 + \frac{(.4) (.25)^2}{4.6625} \right]$$

$E_2 = 1,077,226 \text{ in } \#$ which is greater than that remaining.

SHEAR OF NOZZLES BY PLATES

plate 3/8 steel (yield 35,000, tensile 70,000)

nozzle 2" OD x .3 wall steel (yield 62,000, tensile 105,000)

Force to cause bearing failure in plate

$$\begin{aligned} F &= \sigma A \\ &= (70,000) (.375) (2) \\ F &= 52,500\# \end{aligned}$$

Force to shear nozzle

$$\begin{aligned} F &= \tau A \\ &= (52,500) \left(\frac{\pi}{4} \right) (2^2 - 1.4^2) \end{aligned}$$

F = 84,116# Thus, the plate fails by bearing before the nozzles shear off.

APPENDIX B

The original sketchers in appendix B were replaced with the following drawings in revision 2:

S5-2-8843
S5-2-8844
S5-2-8942
S5-2-8163

PLAN

SIDE VIEW

GENERAL NOTE

- 1 For trailer specifications and details see VPF 4729
- 2 Each bank of cylinders, on both sides of trailer shall be marked "USA DOT-7A TYPE A", "USERDA-SR", "RADIOACTIVE MATERIAL". Letters and numerals shall be at least $\frac{1}{2}$ " high, applied with contrasting color paint.
- 3 Doors of rear cabinet shall be seal wired in accordance with USNRC Regulatory guide 515 prior to each shipment.

REAR VIEW

APPENDIX B FIGURE 1. BYPRODUCT TRAILER, TRITIUM FACILITY -
ASSEMBLY. (Du Pont dwg 55-2-8843, Rev 1, May 1977.)

Wood to be cut half through
thickness at each intersection

Scale: $1\frac{1}{2}" = 1'-0"$

SECTION (A) (A)
(TYPICAL SADDLE CONNECTION)

1091

107)

- 1 Support legs and braces where applicable are welded to the $\frac{3}{8}$ " thick rear tube sheet of the trailer with $\frac{3}{16}$ " fillet welds. The weld extends around 180° of each leg or brace and is so positioned that no liquid will accumulate in the area between the leg or brace and the tube sheet.
- 2 All steel to be Type 304-L SST.
- 3 All 4" legs and braces are to be Sch. 10 Type 304-L SST pipe.
- 4 All legs and braces are sealed with a $\frac{3}{8}$ " thick plate welded inside each leg and brace in the area where it is attached to the $\frac{3}{8}$ " thick tube sheet.

NOTES:

1. Paint all new steel one coat primer, two finish coats aluminum paint in accordance with Spec 3557, Section BR-4.
2. Weld joints to be inspected by magnetic particle or liquid penetrant examination.
3. Frame butt weld to be inspected by 100% X Ray.
4. All welding to be per shielded metal ARC process using AWS class E 7018 Electrodes.
5. All new material to be fabricated from ASTM A-36 plate.

DETAIL (T) S5-2-8843
(FRAME SPLICE)
Scale: 1 1/2" = 1'-0"

SECTION (A) (A)
Scale: 3" = 1'-0"

DETAIL (U) S5-2-8843
(TYPICAL CYLINDER PLUG)
Scale: 6" = 1'-0"

APPENDIX B FIGURE 3. BYPRODUCT TRAILER, TRITIUM FACILITY -
DETAIL. (Du Pont dwg S5-2-8942, Rev 1, May 1977.)

1. All pipe and fittings are to be $\frac{1}{2}$ " Sch. 40, 304 SS in accordance with Spec. 4482, P40.01 unless otherwise specified.
2. Welding to be per SW1W and Spec. 3565.
3. Valves are $\frac{1}{2}$ " 3V 255, Powell, double bellows.
4. Cap millage cap shown on D-139955 and D-115441 except nut (D-139955-B) has no $\frac{1}{2}$ " Dia hole and gasket (D-139955-D) has no hole.
5. Trailers built by Eidal Manufacturing Co., Albuquerque, N.M. Details are shown in VPF 4729.

APPENDIX B FIGURE 4. BYPRODUCT TRAILERS, GAS MANIFOLD PIPING -
DETAILS. (Du Pont dwg S5-2-8163, Rev 0, January 1976.)