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Amersham

Amersham Corporation
Safety Analysis Report
Keg Design Containers
Type B Package

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1. General Information

1.1 Introduction

Amersham Corporation is applying for a Certificate of Compliance to use the family of containers described in this application for the storage and shipping of up to 25 Curies of Amersham manufactured ^{241}americium/beryllium competent authority approved special form sources. These containers are stainless steel kegs into which water extended polyester (WEP) has been cast as the radiation and thermal shield.

There are three primary container designs in this family of containers; Amersham Corporation model numbers 3206B, 3218 and 3235. Model number 3206B and a sub-design, 3206A, have already been approved by the United Kingdom Competent Authority for the Transport of Radioactive Materials as Type B(U) containers. The United Kingdom Competent Authority Certificate for 3206A has been revalidated by the U.S. Department of Transportation and an application for revalidation of the model 3206B container was submitted to the United States Competent Authority on July 14, 1982.

1.2 Package Description

1.2.1 Packaging

The keg design containers measure 20.35 inches long by 16.81 inches in diameter. The gross weight of each container is approximately 165 pounds (75 kg).

Only Amersham manufactured dual-encapsulated stainless steel sources which have been special form approved by a competent authority will be used in the containers.

Model 3206B and 3235 containers each have one specially designed receptacle. Model 3218 containers have two receptacles; the larger centrally located receptacle will house the high activity source assembly. The smaller receptacle will be used only for a reference or calibration source.

The source capsule(s) which will be shipped in the container will either be loaded into machined stainless steel holders (which will be referred to as source holders) or threaded onto "nose plugs". A "nose plug" is a machined stainless steel holding device which attaches to the threaded source capsule by means of mating threads. The source capsule is further secured to the nose plug by crimping a locking ring into the notched areas in the source capsule and nose plug.

High Activity Source Receptacle

Once the source capsule has been loaded into the source holder or attached to the nose plug, the assembly is fixed inside a stainless steel insert, the design of which is determined by the needs of each customer.

The insert is machined from 316 or 304 stainless steel solid bar stock. The diameter of the insert will range from 2 to 3 inches depending on which holding device will be placed into the insert. The length of the insert is also dependent on the type of holding device that will be used. The wall thickness of the insert will not be less than 0.2 inches.

An end plate will be circumferentially welded onto the end of the insert. Four fillet welds, each at least 6 mm (.236 inches) long will be used to attach the end plate to the insert. The end plate, which will have a minimum thickness of 3 mm (0.118 inches), will have been drilled and tapped to allow insertion of stainless steel fastening bolts which will securely attach the insert to an outer support tube.

The support tube will be manufactured from 321 stainless steel. The size will vary depending on the type of holding device and insert which will be used. The outer diameter of the support tube will range from 2.375 inches to 3.0 inches. The wall thickness will range from 0.104 to 0.109 inches. The length of the support tube will range from 11.75 to 13.25 inches. On one end of the support tube, a 2 mm thick machined steel plate will be welded. This plate will be welded in nine positions using fillet welds, each of which will be a minimum of 6 mm long.

Numerous M6 stainless steel nuts will be welded to the outside surface of the plate. The bolts that are inserted through the holes in the insert will thread into these M6 nuts on the support tube.

The end of the support tube opposite the plate will be completely welded to the end wall of the keg.

A stainless steel encased WEP plug will be inserted into the support tube to provide shielding when a source is present in the container. The walls of the plug will be a minimum of 0.07 inches thick and will be manufactured from 304 stainless steel tubing. The end plates will be from 0.04 to 0.05 inches thick. The outer diameter of the plugs will range from 2.0 to 2.75 inches.

The shielding plug will be held in position by a knurled stainless steel screw cap. This cap is manufactured from 303 stainless steel and is machined to fit the threaded support tube. The screw cap will not fully close unless the source and shielding plug are correctly installed within the stainless steel insert.

A stainless steel latch bar is locked in place over the screw cap with a key operated padlock. This prevents the screw cap from coming unthreaded and prevents unauthorized access to the source. The latch bar is manufactured from 304 or 316 stainless steel and consists of a latch and bracket assembly which is welded to the end of the keg. The latch bar will be a minimum of 3 mm thick and 30 mm wide. The length of the bar will vary in accordance with the outside diameter of the screw cap.

Reference or Calibration Source Receptacle

Once the source capsule has been loaded into the source holder or attached to the nose plug, the assembly is fixed inside of a stainless steel insert.

The design of the insert is determined by the needs of each customer. This insert is machined from either 304 or 316 stainless steel solid bar stock. The outside diameter of the insert is 2.375 inches. The length of the insert will be dependent upon the design length of the reference source assembly; the maximum length will be 6.0 inches. The minimum wall thickness of the insert will be 0.2 inches. Upon completion of the machining, the insert is circumferentially welded into the outer wall of the container, with a minimum weld thickness of 1/8 inch. The insert is also machined to accept a stainless steel screw cap.

The screw cap is manufactured from 303 stainless steel and is machined to fit the threaded insert. The screw cap will not fully close unless the source is correctly installed within the stainless steel insert.

The stainless steel latch bar is locked in place over the screw cap with a key operated padlock. This prevents the screw cap from becoming unthreaded and prevents the unauthorized access to the source. The latch bar is manufactured from 304 or 316 stainless steel and consists of a latch and bracket assembly, which is welded to the end of the keg. The latch bar will be a minimum of 3 mm thick by 30 mm wide. The length of the bar will vary to accomodate the outside diameter of the screw cap.

Shielding

The shielding material used in the container is water extended polyester (WEP). WEP consists primarily of polyester resin, water, and ethylene glycol. A catalyst is used to react these constituents and the resulting emulsion is placed into a keg after the support tube (and in 3218 containers, the insert for the reference source) have been installed. There it hardens into a solid mass with an outward appearance much like plaster of paris. A minimum of 125 pounds of WEP is used in each container; this provides a 6.97 inch (177 mm) thick shield primarily intended for neutron absorption. However, the WEP also adds structural strength to the container and acts as thermal insulation.

Outer Container

The outer shell of the container consists of a 50 liter stainless steel keg. The 0.079 inch (2 mm) stainless steel wall thickness supplies a solid outer protective cover to the container and acts as a effective structural overpack for the WEP.

The container is supported by two stainless steel 3 mm thick x 30 mm wide legs which are welded to the stainless steel shell.

The container is capable of being lifted by the intricately molded stainless steel hand-holds, which are a part of the stainless steel shell.

1.2.2 Operational Features

As described in 1.2.1, the source is secured in a nose plug or source holder which is fixed into a stainless steel insert. A stainless steel encased WEP shielding plug is placed into the cavity after the high activity source. The closure on each receptacle is a stainless steel screw cap. The screw cap is prevented from opening by a stainless steel latch bar which is secured by a padlock.

1.2.3 Contents of Packaging

The keg design containers are designed for the transport of Amersham manufactured ^{241}americium/beryllium special form capsules in quantities up to 25 curies. Any source capsule to be used in these containers will be an Amersham capsule approved by a competent authority in accordance with the requirements for special form capsules in 49 CFR Part 173 and/or IAEA Safety Series No. 6, 1973 Edition.

Revision 0
25 August 1982

1.3 Appendix

Keg Design Single 2" Port Container, Model 3206B, Drawing OA-22533 (1.3.1).

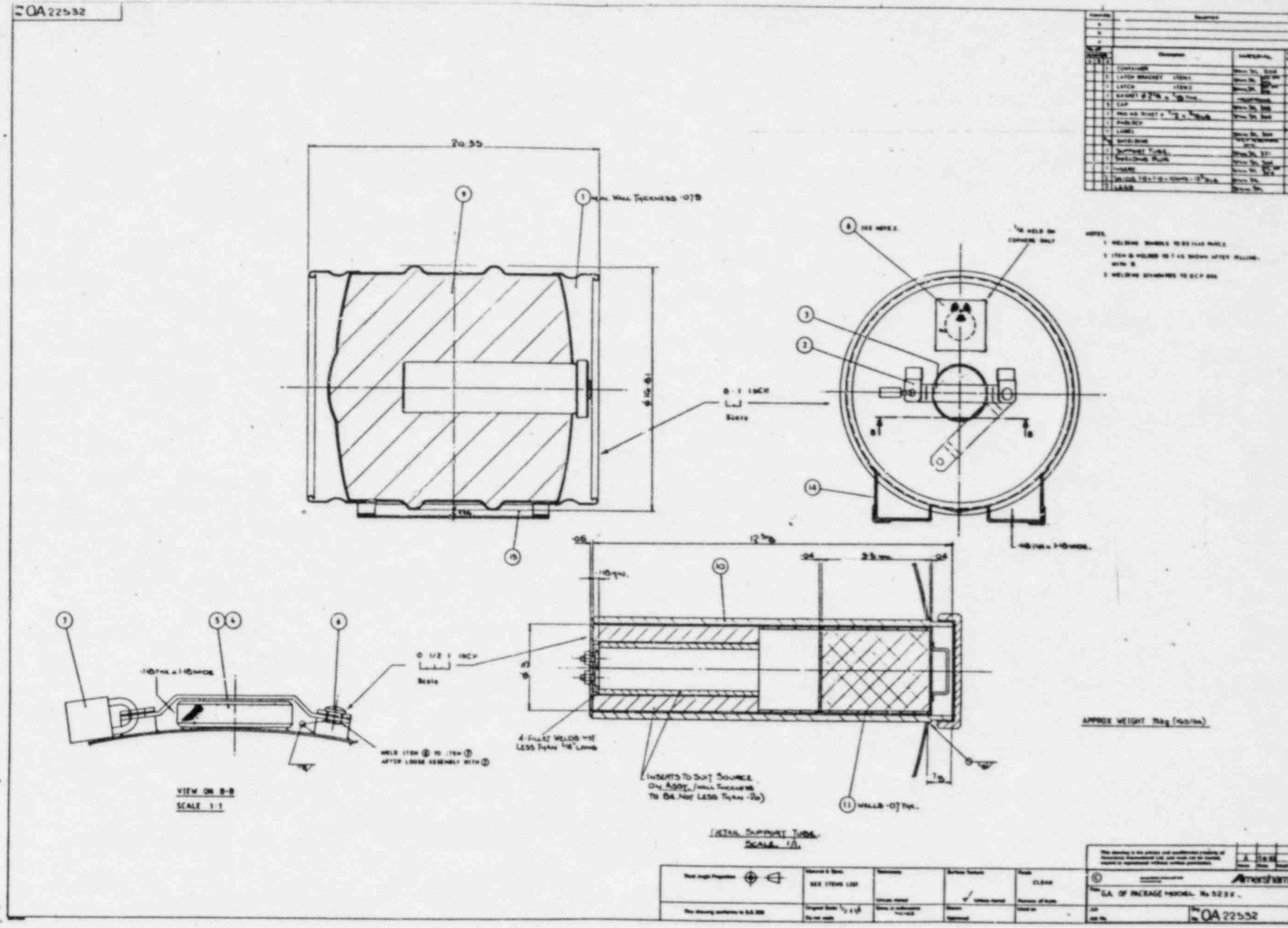
Keg Design Single 3" Port Container, Model 3235, Drawing OA-22532 (1.3.2).

Keg Design Dual Port Container, Model 3218, Drawing OA-22534 (1.3.3).

Revision 0
25 August 1982

1.3 Appendix

1.3.2 Keg Design Single 3" Port Container, Model 3235, Drawing OA-22532


OA 22532
20.35
MIN. WALL THICKNESS ·078
0 1 INCH
Scale
CONTAINER
LATCH BRACKET
LATCH
GASKET
CAP
PADLOCK
LABEL
SHIELDING
SUPPORT TUBE
SHIELDING PLUG
INSERT
SEE NOTES
NOTES
APPROX WEIGHT 75kg (165lbs)
0 1/2 1 INCH
Scale
WELD ITEM ② TO ITEM ①
AFTER LOOSE ASSEMBLY WITH ③
VIEW ON B-B
SCALE 1:1
4-FILLET WELDS NOT LESS THAN 1/8" LONG
INSERTS TO SUIT SOURCE ON ASSY. (WALL THICKNESS TO BE NOT LESS THAN ·20)
WALLS ·07 THK.
DETAIL SUPPORT TUBE
SCALE 1/1
SEE ITEMS LIST
CLEAN
Amersham
G.A. OF PACKAGE MODEL No 5233.
OA 22532

1.3 Appendix

1.3.3 Keg Design Dual Port Container, Model 3218, Drawing OA-22534

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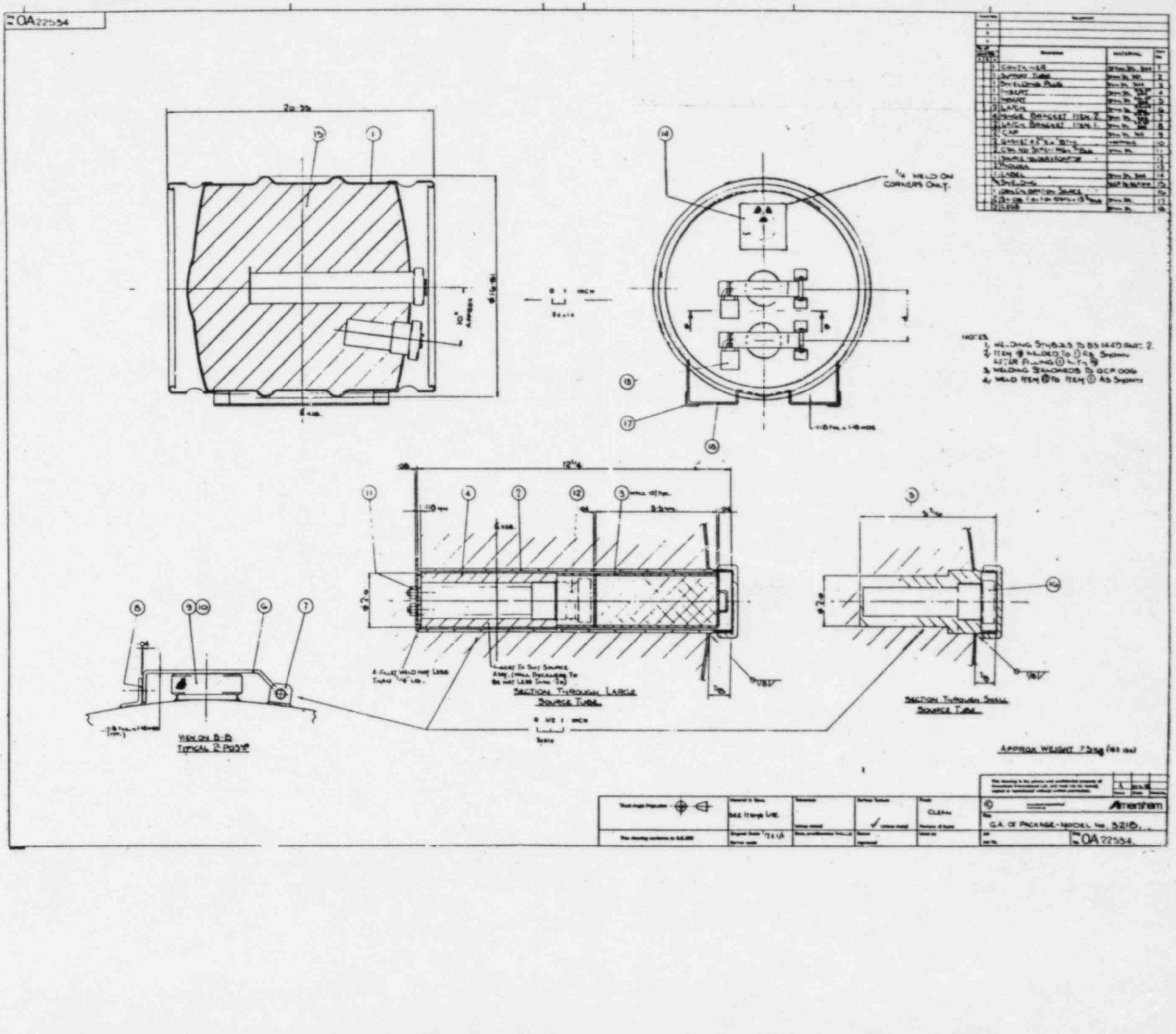
25 August 1982



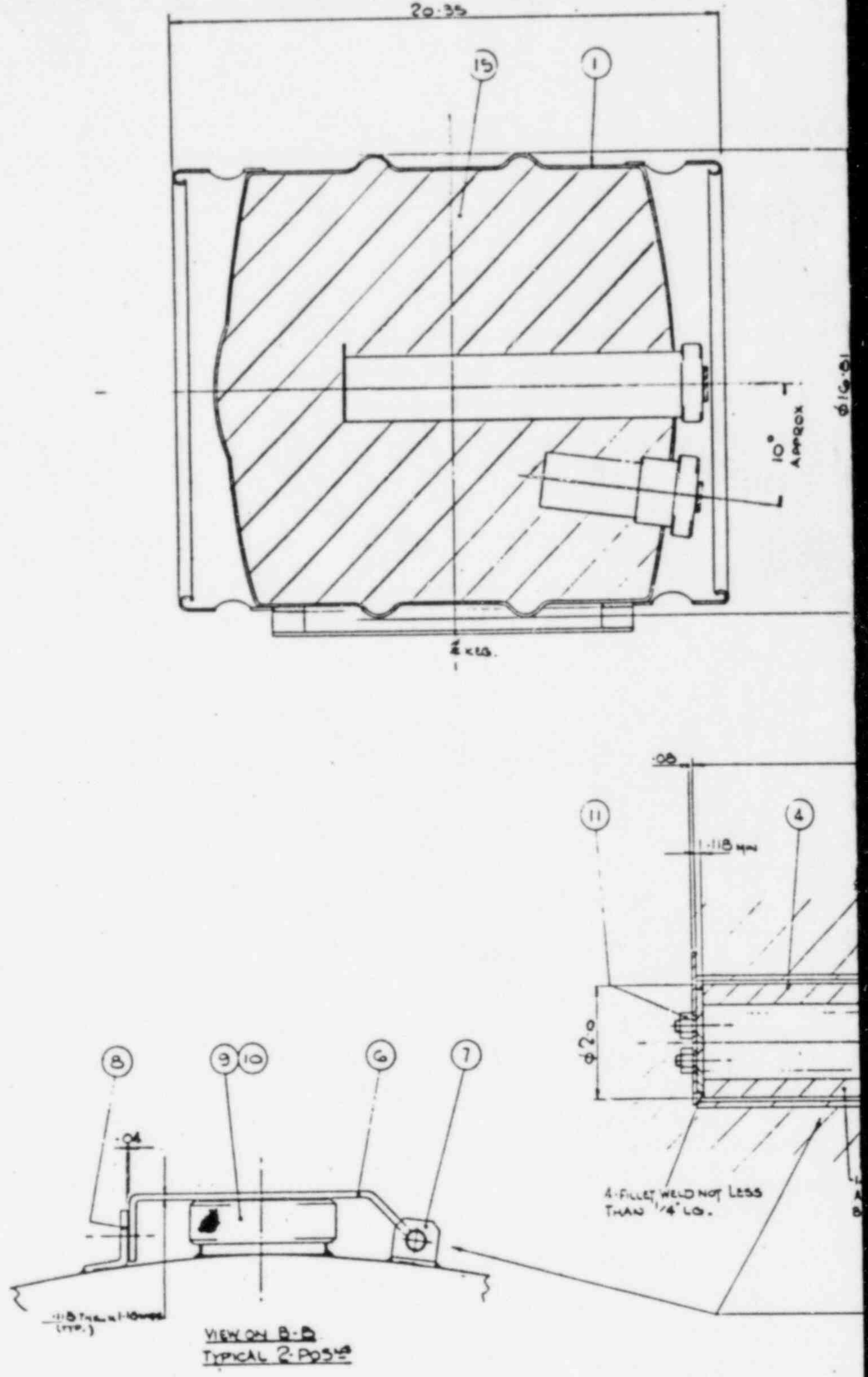
OA22554
NOTES.
1, WELDING SYMBOLS TO BS 1449 PART 2.
3, WELDING STANDARDS TO QCP 006
1/4 WELD ON CORNERS ONLY.
SECTION THROUGH LARGE SOURCE TUBE.
SECTION THROUGH SMALL SOURCE TUBE.
VIEW ON B-B TYPICAL 2 POSN
APPROX WEIGHT
SCALE
CONTAINER
CAP
LABEL
SHIELDING
CLEAN
Amersham
G.A. OF PACKAGE - MODEL No. 3210.
OA 22554.

1.3 Appendix

1.3.3 Keg Design Dual Port Container, Model 3218, Drawing 0A-22534

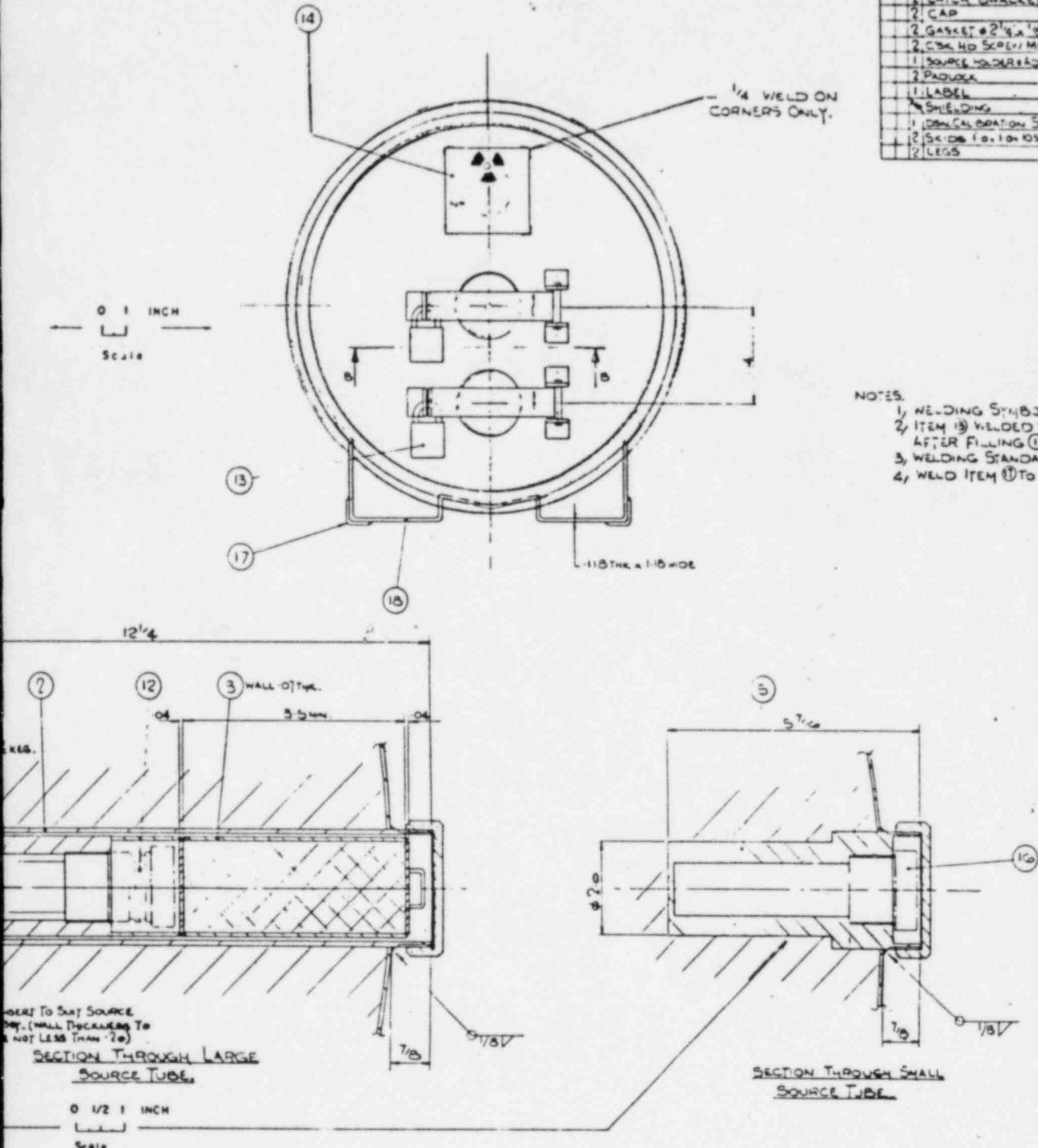
Revision 0
25 August 1982

OA22534



20·35
15
1
10° APPROX
.08
11
4
1·118 MIN
φ2·0
8
9
10
6
7
·04
A-FILLET WELD NOT LESS THAN 1/4" LG.
VIEW ON B-B
TYPICAL 2-POSNS

No. off (a)	(b)	(c)	Description	MATERIAL	Item No.
		1	CONTAINER	STAIN. STL. 304	1
		1	SUPPORT TUBE	STAIN. STL. 321	2
		1	SHIELDING PLUG	STAIN. STL. 304	3
		1	INSERT	STAIN. STL. S.G.W. 304	4
		1	INSERT	STAIN. STL. S.G.W. 304	5
		2	LATCH	STAIN. STL. S.G.W. 304	6
		4	HINGE BRACKET ITEM 2.	STAIN. STL. S.G.W. 304	7
		2	LATCH BRACKET ITEM 1.	STAIN. STL. S.G.W. 304	8
		2	CAP	STAIN. STL. 303	9
		2	GASKET ø2¼ x ⅛ THK	NEOPRENE	10
		2	CSK HD SCREW M6 x 5 LG	STAIN. STL.	11
		1	SOURCE HOLDER & ADAPTOR		12
		2	PADLOCK		13
		1	LABEL	STAIN. STL. 304	14
			SHIELDING	[illegible] TO QCP 010	15
		1	[illegible] CALIBRATION SOURCE		16
		2	SKIDS 1.0 x 10 x 10SWG x 13 LG	STAIN. STL.	17
		2	LEGS	STAIN. STL.	18



NOTES.
1, WELDING SYMBOLS TO BS 1449 PART. 2.
2, ITEM 15 WELDED TO 1 AS SHOWN AFTER FILLING 1 WITH 15
3, WELDING STANDARDS TO QCP 006
4, WELD ITEM 17 TO ITEM 1 AS SHOWN

APPROX WEIGHT 75kg (165 lbs)

Third Angle Projection	Material & Spec. SEE ITEMS LIST.	Tolerances Unless stated	Surface Texture ✓ Unless stated	Finish CLEAN Remove all burrs
	Original Scale 1/2 & 1/1		Drawn / Approved	Used on

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Amersham

Title: G.A. OF PACKAGE-MODEL No. 3218.

Drg No. OA 22534.

2. Structural Evaluation

2.1 Structural Design

2.1.1 Discussion

The model 3206B and 3235 containers consist of a stainless keg with nine major components: a source capsule, a nose plug or source holder, stainless steel insert, welded stainless steel support tube, WEP, WEP filled shielding plug, stainless steel threaded screw cap, stainless steel latch bar, and a padlock.

The model 3218 container consists of a stainless keg with fifteen major components: two source capsules, two nose plugs, two stainless steel inserts, one stainless steel support tube, WEP, one WEP filled stainless steel shielding plug, two threaded screw caps, two stainless steel latch bars, and two padlocks.

The Amersham manufactured competent authority special form approved source capsule(s) is the primary containment vessel. It is held in place as described in Section 1.2.1. The closure device used on all of the keg design containers is a screw cap which is threaded onto the end of the support tube or onto the insert on the reference source receptacle of model 3218.

The screw cap is held in place by a latch bar assembly which is welded directly onto the keg on one end and is secured on the other end with a key-operated padlock.

2.1.2 Design Criteria

The keg design containers are designed to comply with the requirements of 10 CFR Part 71 and IAEA Safety Series No.6, 1973 Revised Edition for Type B(U) packaging.

2.2 Weights and Centers of Gravity

The keg design containers each weigh approximately 165 pounds (75 Kg). The shielding is approximately 125 pounds (57 Kg) of WEP. The center of gravity of each container is located in the center of the keg approximately 8.4 inches (213 mm) from the bottom of the container.

2.3 Mechanical Properties of the Materials

The outer shell, as well as all internal tubes, shielding plug, screw cap(s) and the latch bar(s) are made of stainless steel. These components have a yield strength of 40,000 psi and a tensile and compressive strength in excess of 80,000 psi. The sources are made out of stainless steel, which also has a yield strength of 40,000 psi. (Reference: Machinery Handbook 21st Edition, Page 444).

2.4 General Standards For All Packages

2.4.1 Chemical and Galvanic Action

The materials used in the construction of the keg design containers are stainless steel and WEP. There will be no chemical or galvanic action between any of these components.

2.4.2 Positive Closure

The source(s) in the keg design containers cannot be exposed without opening the key-operated padlock(s), releasing the latch bar(s), unscrewing the screw cap, removing the stainless steel encased shielding plug (in the high activity source receptacle), and removing the source(s) from its fixed position within the receptacle. This system insures a positive closure.

2.4.3 Lifting Devices

The keg design containers have four integrally formed stainless steel hand holds. Each hand hold is a 0.1 inch thick, 0.8 inch deep, semi-circle formed on a 0.6 inch inside diameter. The maximum weight that is capable of being lifted is calculated using the assumption that the container would be lifted by a 0.25 inch thick steel wire, wrapped around 30% of the 0.8 inch outer diameter of the handle semi-circle.

Region of handle in contact with wire = $(0.5 \times \pi \times 0.8)$ inch x .3 = 0.3768 in .

The lifting wire will contact the handle with ½ its circumference, therefore the wire effective width is equal to $(0.5 \times \pi \times .25$ in) = 0.3925 in .

Using the above assumptions, the effective area subjected to the yielding forces of the handle is (0.3768 in x 0.3925 in) = 0.1479 in^2.

The yield strength of the steel in the handle is 40,000 psi. The maximum weight capable of being lifted is 40,000 lb/in x 0.1479 in which equals 5916 lbs. A single handle is capable of carrying over 35.8 times the weight of the container; therefore, the lifting system is capable of lifting more than three times the weight of the package and exceeds the requirements as prescribed in 10 CFR 71.31(c).

2.4.4 Tie Down Devices

Both the lifting handles and the support legs can be used as tie down devices.

Lifting Handles

As described previously, the keg design containers have 4 integrally formed stainless steel hand holds. Each hand hold is a 0.1 inch thick, 0.8 inches deep, semi-circle formed on a 0.6 inch inside diameter. The maximum weight that is capable of being tied down using two handles is calculated using the assumption that the container would be tied down by a 0.25 inch thick steel wire, wrapped around 30% of the 0.8 inch outer diameter of the handle semi-circle.

Region of handle in contact with wire = $(0.5 \times \pi \times 0.8)$ inch $\times 0.3 = 0.3768$ inch

The tie down wire will contact each handle with ½ its circumference, therefore the wire effective width per handle is equal to $(0.5 \times \pi \times 0.25$ inch$) = 0.3925$ inch.

Using the above assumptions, the effective area subjected to the yielding force of each handle is (0.3768 inch x 0.3925 inch) = 0.1479 in^2.

The yield strength of the steel in the handle is 40,000 psi. The maximum weight capable of being tied down (per handle) is 40,000 lb/in^2 x 0.1479 in^2 which equals 5916 lbs. Using two handles to secure the container, the maximum weight that could be tied down would be 5916 x 2 or 11,832 lbs. Therefore, the container handles are capable of holding down 71.6 times the weight of the container and comply with the requirements in 10 CFR 71.31(d).

Support Legs

Each support leg is welded to the container in several places. The total length of the welds is 8.2677 inches long (210 mm) and at least 0.07874 inches (2 mm) wide. Therefore, the actual area subjected to the loading conditions is 0.6509 in^2 (420 mm^2).

The yield strength of the steel in the support leg is 40,000 psi. Therefore, the maximum weight capable of being supported by a single leg is 40,000 lb/in^2 x 0.6509 in^2 which equals 26,029 lbs.

2.5 Standards for Type B and Large Quantity Packaging

2.5.1 Load Resistance

The package is considered a simple beam supported at both ends with the outer container the sole structural member. If a uniform load of 5 times the package weight is evenly distributed along its length, the maximum stress generated can be computed from:

$$\alpha = \frac{FL}{8Z}$$

Where α: Maximum stress generated

F: Total load (825 pounds)

L: Length of beam (20.35 inches)

Z: Section modulus (465.51 in^2)

This package is assumed to be a cylindrial shell 16.81 inches in diameter and 20.35 inches long with a wall thickness of .0788 inches (2 mm). From this relationship, the maximum stress generated in the beam is 4.51 pounds per square inch, which is far below the yield strength of stainless steel (40,000 psi).

2.5.2 External Pressure

The keg design containers are open to the air so there would be no differential pressure to act upon the package. The prototype source is pressure tested to at least 290 psi. Therefore, it can be subjected to an external pressure of 25 psi without adverse affect.

2.6 Normal Conditions of Transport

2.6.1 Heat

The thermal evaluation of the keg design containers is presented in Chapter 3. From this evaluation, it can be concluded that the containers can withstand the normal heat conditions of transport.

2.6.2 Cold

The metals used in the manufacture of the keg design containers can withstand a temperature of -40°C. Since the WEP is made largely of ethylene glycol and polyester resin, no significant effects occur at -40°C. Therefore, these containers can withstand the normal transport cold condition.

2.6.3 Pressure

The keg design containers are open to the atmosphere and therefore there will be no pressure differential acting upon them. The special-form approved source capsules can easily withstand a pressure reduction of 0.5 atmospheres.

2.6.4 Vibration

The source securing system (key-operated padlock, latch bar, screw cap, shielding plug, and nose plug or source holder) could not feasibly allow the source to become exposed due to vibration induced during transportation. All internal and external components are welded and the internal support tube is solidly encased in WEP. Therefore, the keg design containers can withstand the vibrations normally incident to transport.

2.6.5 Water Spray

A water spray test was not performed on the keg design containers. All materials used in the construction of these containers are highly water resistant. Exposure to water will not affect the structural integrity or reduce the shielding effectiveness of the package.

2.6.6 Free Drop

The drop analysis presented in Section 2.7.1 demonstrates that the keg design containers will withstand the normal free drop condition without loss of structural integrity or shielding effectiveness.

2.6.7 Corner Drop

Not applicable.

2.6.8 Penetration

A penetration test was performed on model 3227A, a submodel of model 3235. The surface deemed most probable to be damaged in transit was the top of the container. The top received a slight dent. There was no loss of shielding nor structural integrity as a result of the test. A description of the test results is given in Section 2.10. Because the outer shell of models 3206B, 3218 and 3235 are identical, it is concluded that all models will satisfactorily withstand the penetration test conditions.

2.6.9 Compression

A load of five times the package weight (825 pounds), is greater than two pounds per square inch times the maximum cross sectional area. The keg design containers are assumed to be flat ended cylinders, 16.81 inches in diameter, 20.35 inches long and 0.0788 inches (2 mm) wall thickness.

The compression analysis is done using the assumption that 5 times the weight of the package will be loaded onto the ends of the container. This is appropriate since the container would normally be subjected to a compressive load only in this orientation.

The maximum stress on the front or rear of the cylinder is given by:

$$\alpha = \frac{0.24\ F}{t^2}$$

(Reference: Machinery Handbook 21st Edition, Page 436)

Where α: Maximum stress generated in pounds per square inch

F: Total load (825 pounds)

t: Thickness of plate (0.0788 inches)

The maximum stress generated is found to be 31,887 psi which is below the compressive strength of stainless steel which is approximately 80,000 psi. (Reference: Machinery Handbook 21st Edition, Page 444).

Also the solidly cast WEP would supply additional support (3125 psi) to the compressive capacity of the containers. (Reference: Ashland Chemicals Technical Bulletin 1166-1).

2.7 Hypothetical Accident Conditions

2.7.1 Free Drop

A prototype of a model 3206B (sub-model 3206A) container was subjected to drop tests through a distance of 9 meters onto a target plate. The container was dropped from a height of 9 meters four times. The container received only superficial damage. The only damage was the failure of the padlock base. The shackle of the padlock remained intact. There was no release of the contents.

2.7.2 Puncture

The prototype 3206A container was subjected to a total of four free drops from a height of one meter onto a steel bar fifteen centimeters in diameter and twenty centimeters in height. The container was dropped on its end, on its side and twice on its closing mechanism. The tests inflicted only superficial damage to the container. There was no release of the contents. After both the free drop and puncture tests were completed, the container was examined. The screw cap, stainless steel shielding plug, dummy source and padlock shackle were intact. It is concluded that the conditions of the drop test and puncture test do not cause any loss of structural integrity or shielding effectiveness.

2.7.3 Thermal

The thermal analysis is presented in Section 3.5. It is shown that the melting temperatures of the materials used in the construction of the keg design containers, with the exception of the WEP, are all in excess of the 1475°F (800°C). It has been found that if a similar container is subjected to the thermal test conditions in 10 CFR Part 71, the thickness of the WEP is reduced by approximately 12 mm. Even if all the WEP was removed, however, the exposure rate at three feet would not exceed 1000 millirems per hour.

Since the primary source capsule is prohibited from moving by its holder or nose plug, insert, welded support tube, shielding plug and screw cap, the radioactive source will remain in the container. Thus, it is concluded that the keg design containers satisfactory meet the hypothetical accident - thermal condition of 10 CFR Part 71.

2.7.4 Water Immersion

Not applicable.

2.7.5 Summary of Damage

The tests designed to represent the hypothetical accident conditions caused minor deformation but no reduction in structural integrity of the container. The reduction in the thickness of the WEP during the thermal test would not substantially reduce the shielding effectiveness. The dose rate would not exceed 1000 millirems per hour at three feet from any external surface of the container.

Based on the performance of the containers which were tested, it is expected that all the keg design containers would more than meet the regulatory requirements. A discussion of the probable effects of the tests on other keg design models is included in Section 2.10.

2.8 Special Form

The keg design containers are intended for use with Amersham manufactured special form sources.

All sources used will be tested to the criteria for special form radioactive material contained in IAEA Safety Series No. 6, 1973 Edition and/or 49 CFR Part 173 and approved as special form by a competent authority.

2.9 Fuel Rods

Not applicable.

2.10 Appendix

Drop and Puncture Test Results. (2.10.1)

Penetration Test Results. (2.10.2)

Damage Comparison Analysis of Keg Design Containers. (2.10.3)

2.10 Appendix

2.10.1 Drop and Puncture Test

A prototype container of model 3206B was subjected to the 9 meter and punch tests described in the IAEA Safety Series No. 6, 1973 Revised Edition. This prototype container was also subjected to two additional punch tests using a ½ size punch. This additional testing was a much more severe trial of the closing mechanism of the container.

The original drawing of model 3206B was number OA-22288. The container has since been redrawn and the current drawing number for the container is OA-22533.

The actual test report that was issued by the AERE, Harwell group who tested the container is reproduced on the following pages.

2.10.1 Drop and Puncture Test Results

AERE Test Report No. 458

DROP AND PUNCH TEST OF DESIGN NO. 3206

by L. R. Cohen

ABSTRACT

A prototype neutron source container (Design No.3206) comprising a 9 gallon stainless steel keg filled with water extended polyester resin (WEP), was subjected to a number of 9 metre drops and punch tests to demonstrate its integrity.

Transport Containers Section,
Engineering Projects Division,
Building 424,
AERE, Harwell

Engineering Department
Amersham International
Amersham,
Bucks.

9th September 1981

Test No. 458

DROP AND PUNCH TEST OF DESIGN NO. 3206

1. Introduction

The neutron source container, Design No. 3206, to be produced by Amersham International for oil well logging, comprises a WEP-filled modified 9 gallon stainless steel beer keg. One prototype assembly was subjected by AERE Harwell to a number of 9 metre drops and punch tests to demonstrate the ability of the assembly to withstand the IAEA(1) mechanical test. The test schedule, agreed with the Dept. of Transport, is given in Appendix 1. The tests were witnessed by representatives of Amersham International and the Dept. of Transport.

2. Packaging Make-up (See Fig. 1)

OUTER Design No. 3206 Keg. Drg. No. OA 22288
Overall dimensions 420 mm dia x 520 mm high
Total weight = 75 kg

3. Method of Test

(a) For the 9 metre drops
The container, slung at the required impact attitude, was raised by the crane to a height of 9 metres over the AERE drop test target then released to fall on to the target plate.

(b) For the punch tests
The container, slung at the required impact attitude, was raised by the crane to a height of 1 metre over the vertically mounted steel punch then released to fall on to the punch.

4. Results

4.1 Drop 1: From 9 metres on to base of keg.(Fig. 2)
Apart from some crushing of the rim of the base chimb to a total depth of approximately 25 mm (Fig. 3) there was no noticeable damage to the keg.

4.2 Drop 2: Punch Test on base of keg.(Fig. 4)
After a slight vertical rebound of about 75 mm the keg landed again on the punch and rolled over on to its feet (Fig. 5). No sign of any impression made by the punch could

4.2 contd...

be seen. The feet at the lid end of the keg were seen to have been bent over slightly. No other noticeable damage had occurred.

4.3 Drop 3: From 9 metres on to side of keg. (Fig. 6).
There was a vertical rebound of some 1300 mm. Apart from a slight flattening of the impacted side of the keg (Fig. 7), measured at approximately 12 mm, and a slight failure of a weld attaching the base chimb to the keg body (Fig. 8) there was no new noticeable damage to the keg.

4.4 Drop 4: Punch test on impacted side of keg. (Fig. 9).
A very slight impression of the end of the punch could be seen midway along the previously impacted side of the keg (Fig. 10). No other new damage was noticeable.

4.5 Drop 5: From 9 metres on to lid end of keg (Fig. 11)
There was a vertical rebound of about 300 mm. The protective chimb at the lid end was seen to have been crushed slightly, about 25 mm (Fig. 12), and the padlock had been broken by the impact. The lid screwed cap was, however, undamaged with some 12 mm of clearance remaining between the top of the cap and the end of the crushed chimb.

4.6 Drop 6: Punch test on lid closure (Fig. 13)
The punch struck the edge of the welded lid disc close to the padlock bracket and caused no noticeable damage other than a slight marking of the edge of the lid disc (Fig 14).

4.7 Drop 7: Punch test on lid closure - repeat of Drop 6 (Fig. 15)
The punch struck the screwed cap and the padlock bracket causing some slight bending of the bracket and slightly marking the rim of the screwed cap. The body of the previously damaged padlock became completely detached, leaving just the shackle part of the padlock in the cap-securing bracket (Fig. 16). The screwed cap was completely retained and no other noticeable damage had occurred.

4.8 Drop 8: From 9 metres on to lid-end apex corner of keg (Fig. 17)
There was a vertical rebound of some 900 mm after which the container came to rest on its base end. Apart from the crushed chimb in the impact area (Fig. 18) and a slight further bending of the padlock bracket, there was no new noticeable damage to the keg.

4.9 Drop 9: Half scale punch test on side of keg (Fig. 19)
The drop was arranged so that the punch impacted the centre of the previously impacted side of the keg. A slight impression of the end of the half scale punch could be seen in the centre of the impression made earlier by the full scale punch (Fig. 20). No other new damage was noticeable.

4.10 Drop 10: Half scale punch test on lid closure (Fig. 21)
The lid of the inverted keg was impacted by the half scale punch, denting the top of the screwed cap and the padlock bracket (Fig. 22). No other damage to the keg was noticeable.

5. Inspection at Laboratory

On returning the assembly to the laboratory for inspection it was found that a small amount of prising with a bar was required to raise the bent end of the padlock bracket sufficiently to withdraw the remains of the padlock shackle. The padlock bracket was then able to be swung to one side to allow the screwed cap to be unscrewed with a spanner. On removing the screwed cap (Fig. 23) it was found that the cavity tube was undamaged. With the exception of a crack in the small piece of WEP used to extend the shielding of the cavity tube insert, no noticeable damage had occurred to the tube insert or the shield plug. The only visible WEP in the keg body was at the two filling/vent holes in the lid disc. No cracks or obvious damage to the WEP filling could be seen in either hole.

6. Conclusions

The stainless steel WEP filled keg (Design No. 3206) satisfactorily withstood the combined effects of four 9 metre drops, four punch tests and two half scale punch tests without loss of thermal or radiation shielding. The screwed cap remained securely in place on the keg cavity liner, retaining the keg contents. (In service the source capsule, approved to Special Form Capsule standard, will provide the principal containment).

References

1. IAEA Regulations for the Safe Transport of Radioactive Materials. Safety Series No. 6. 1973 Revised Edition.

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2.10.1 Drop and Puncture Test Results

Figure 1

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2.10.1 Drop and Puncture Test Results

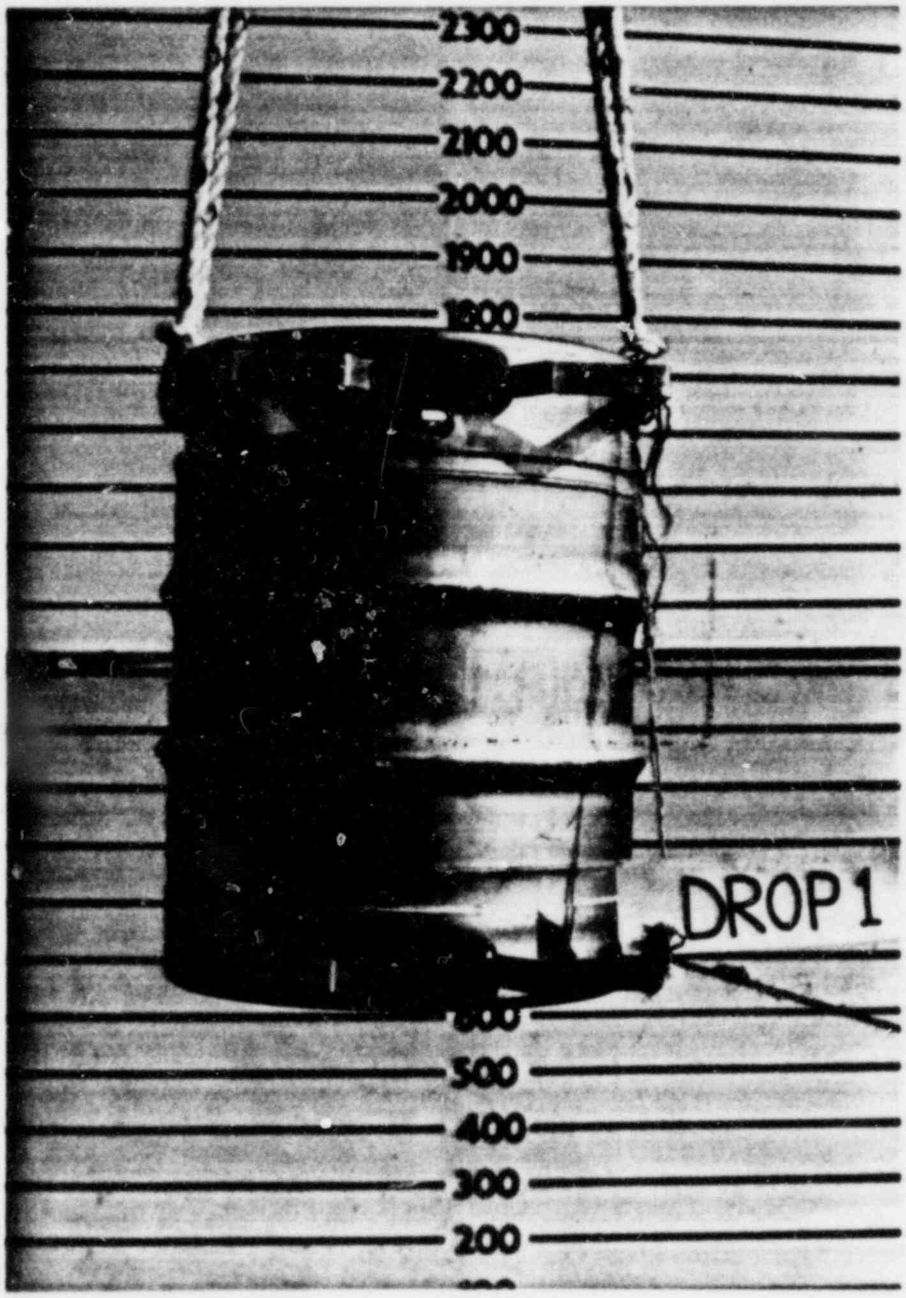

Figure 2

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2.10.1 Drop and Puncture Test Results

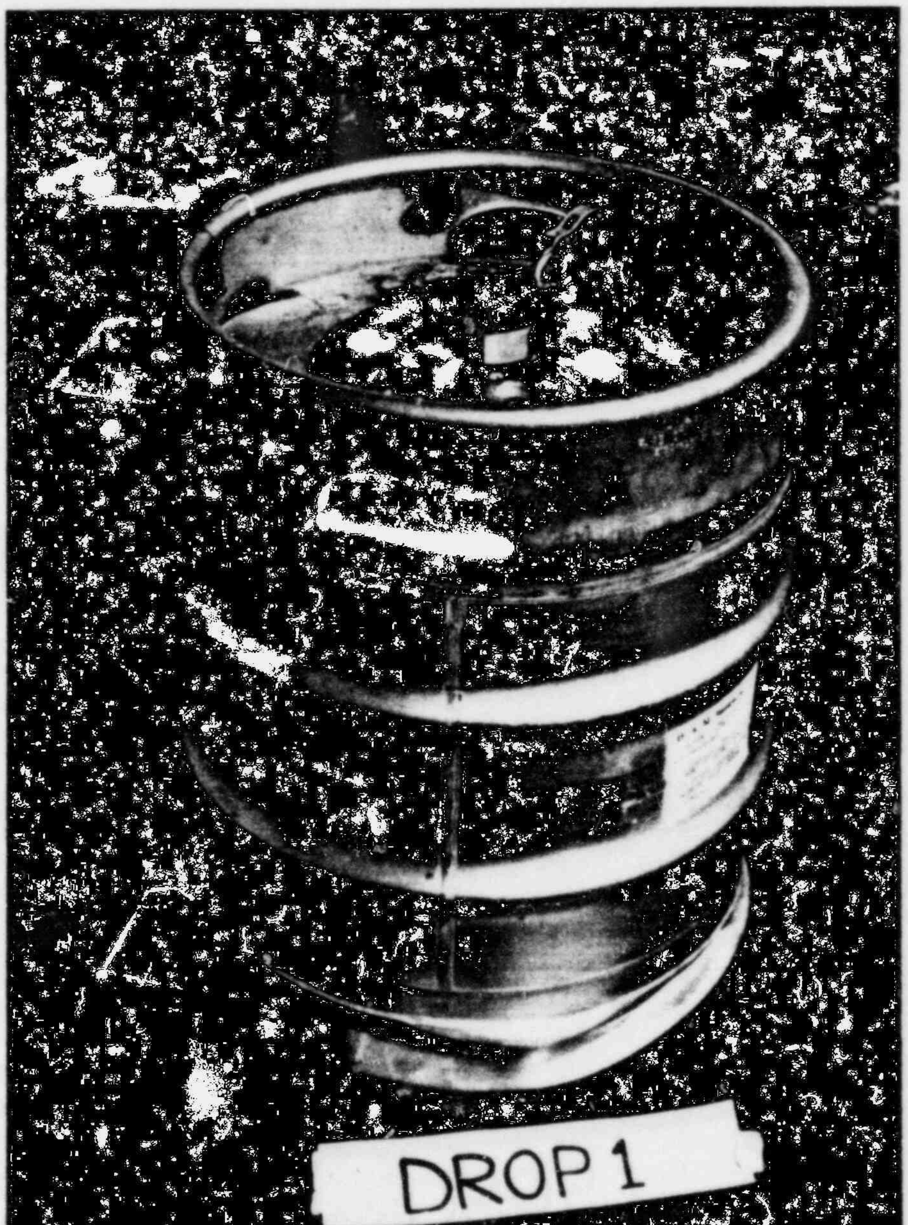

Figure 3

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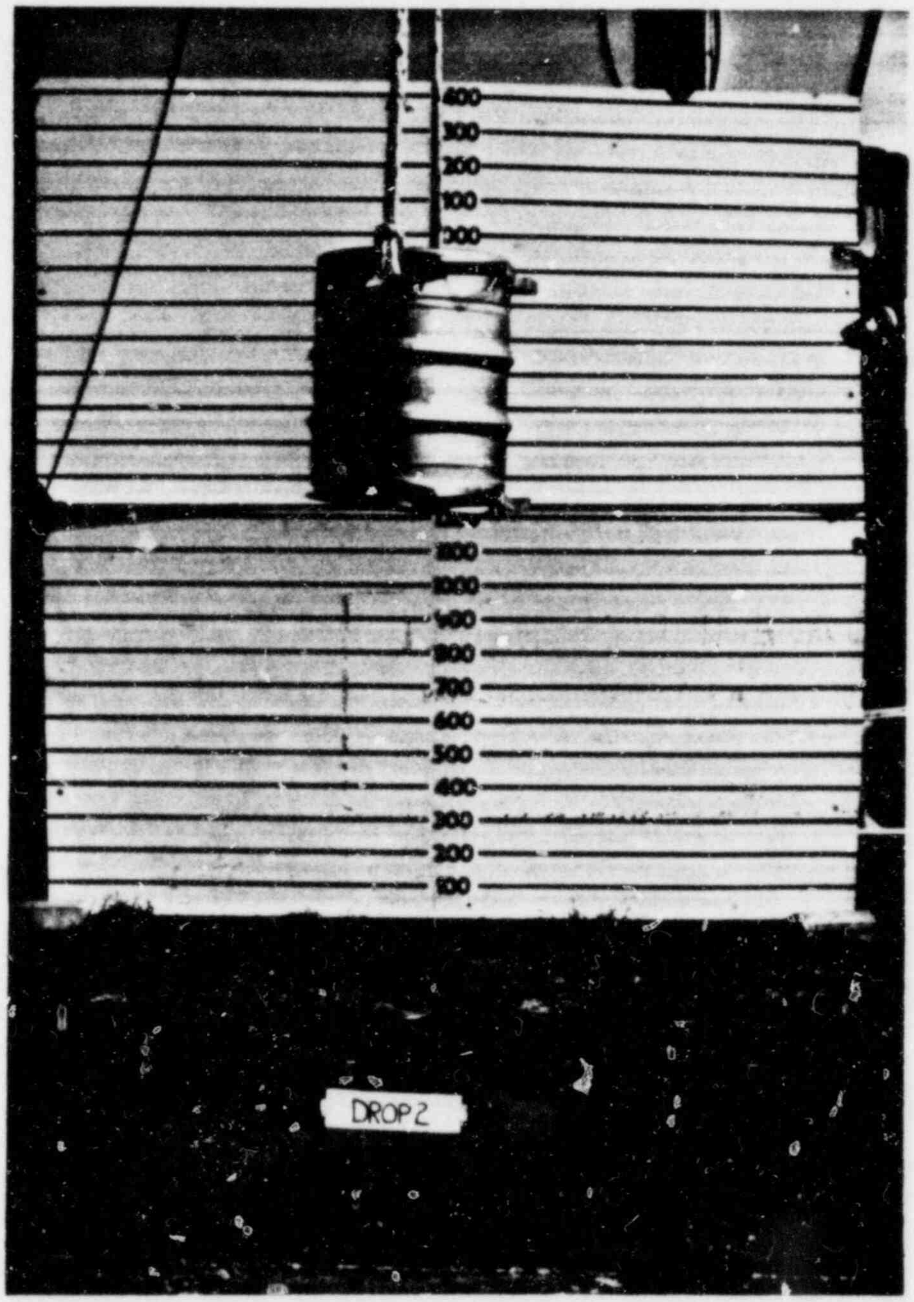

Figure 4

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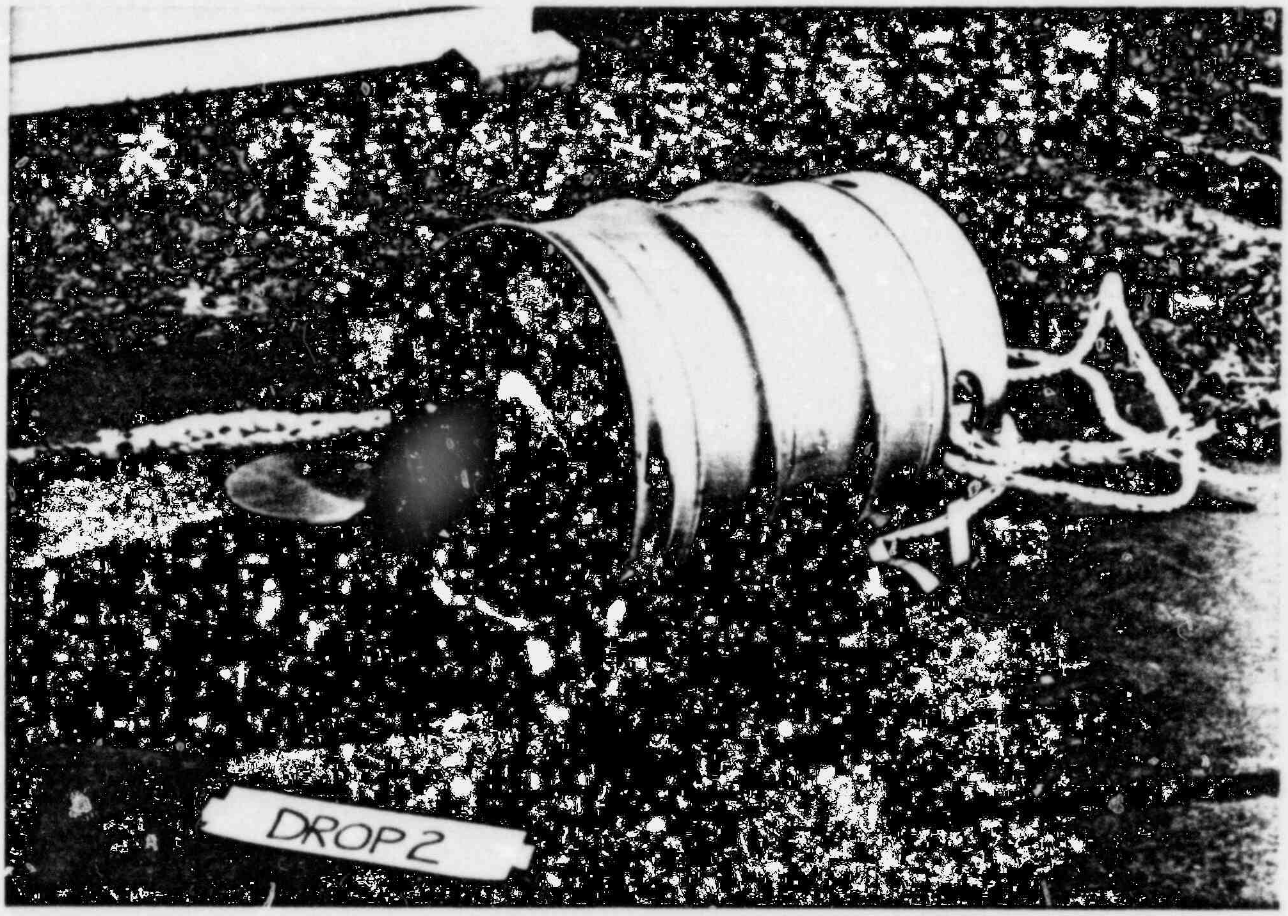

Figure 5

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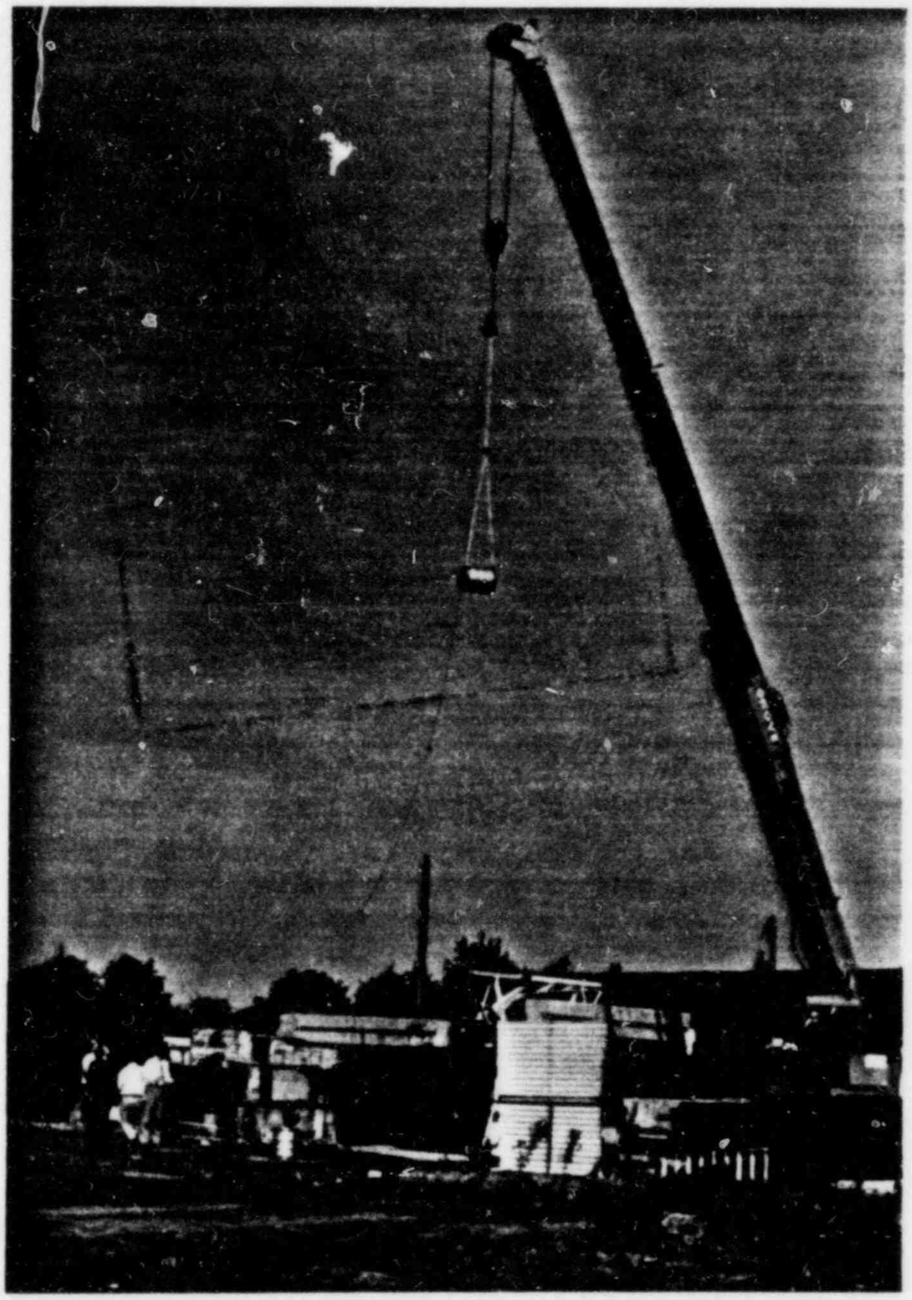

Figure 6

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2.10.1 Drop and Puncture Test Results

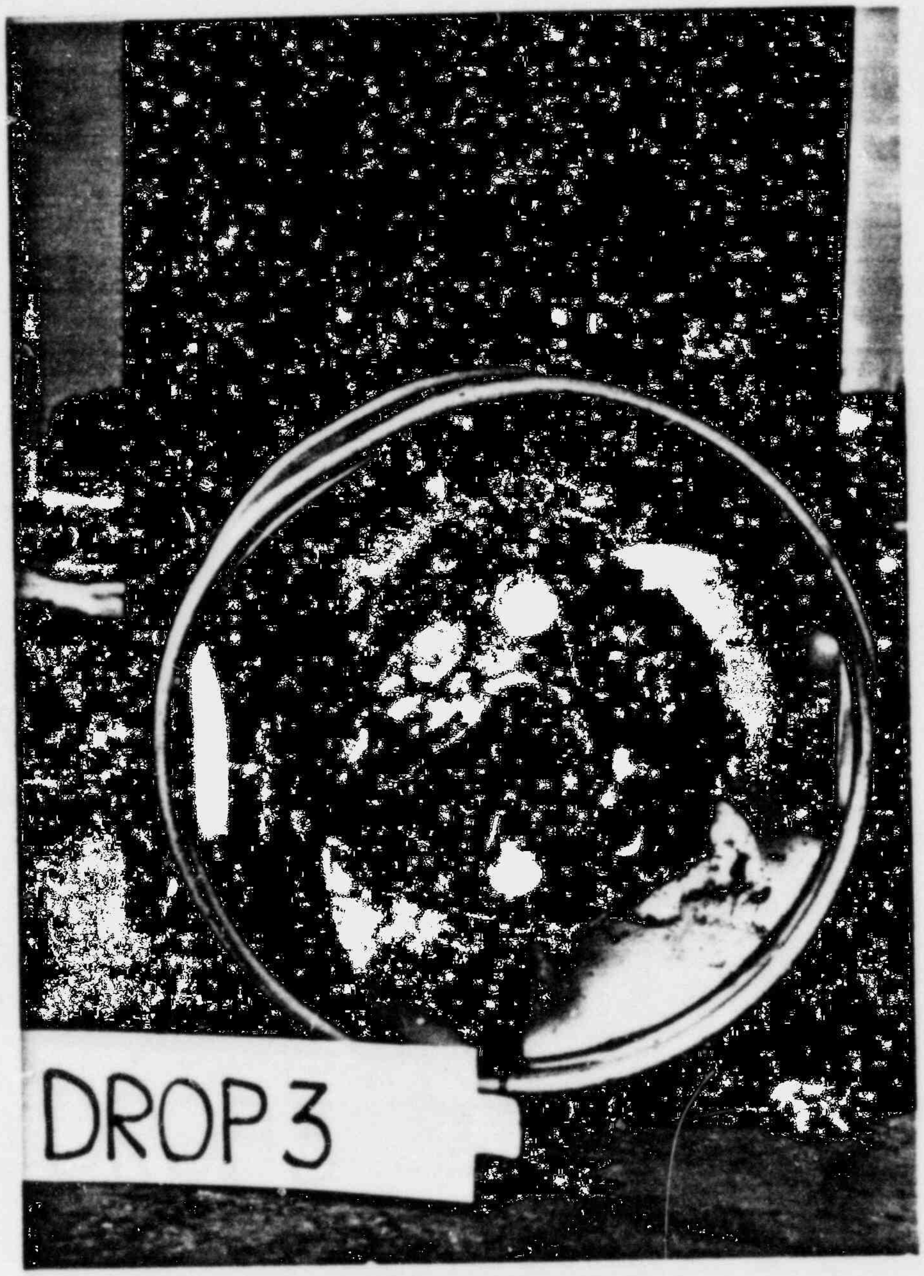

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Figure 8

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2.10.1 Drop and Puncture Test Results

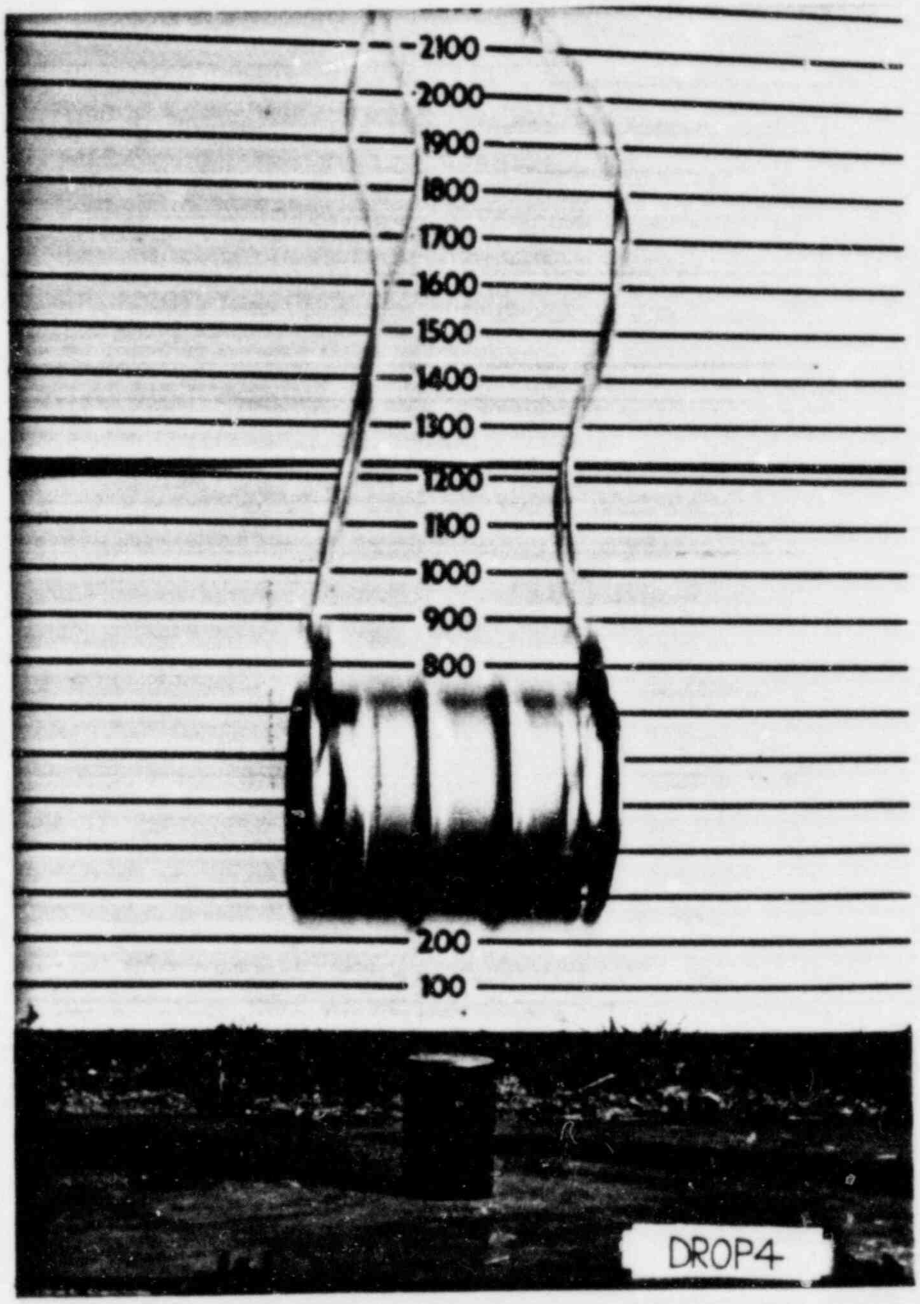

Figure 9

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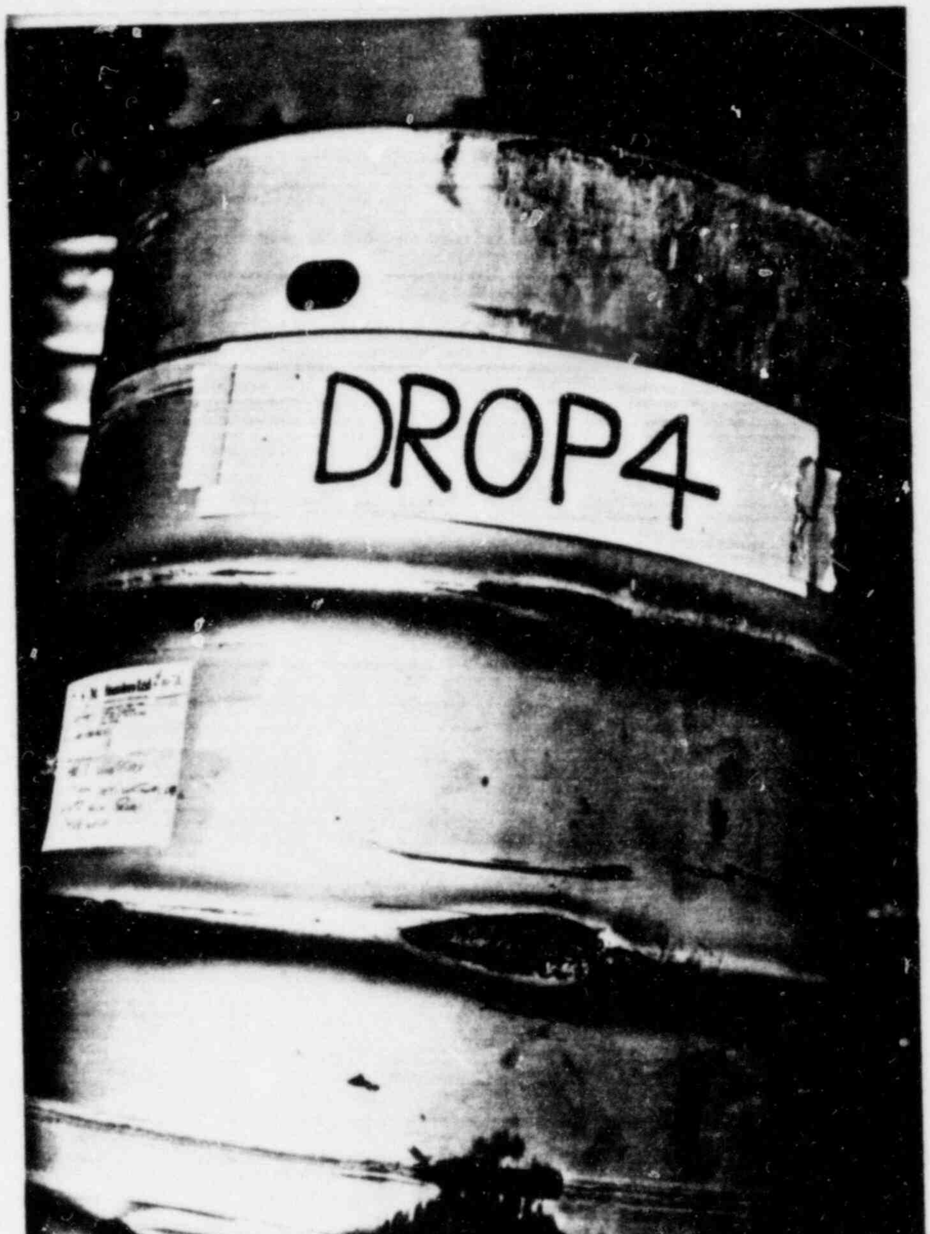

Figure 10

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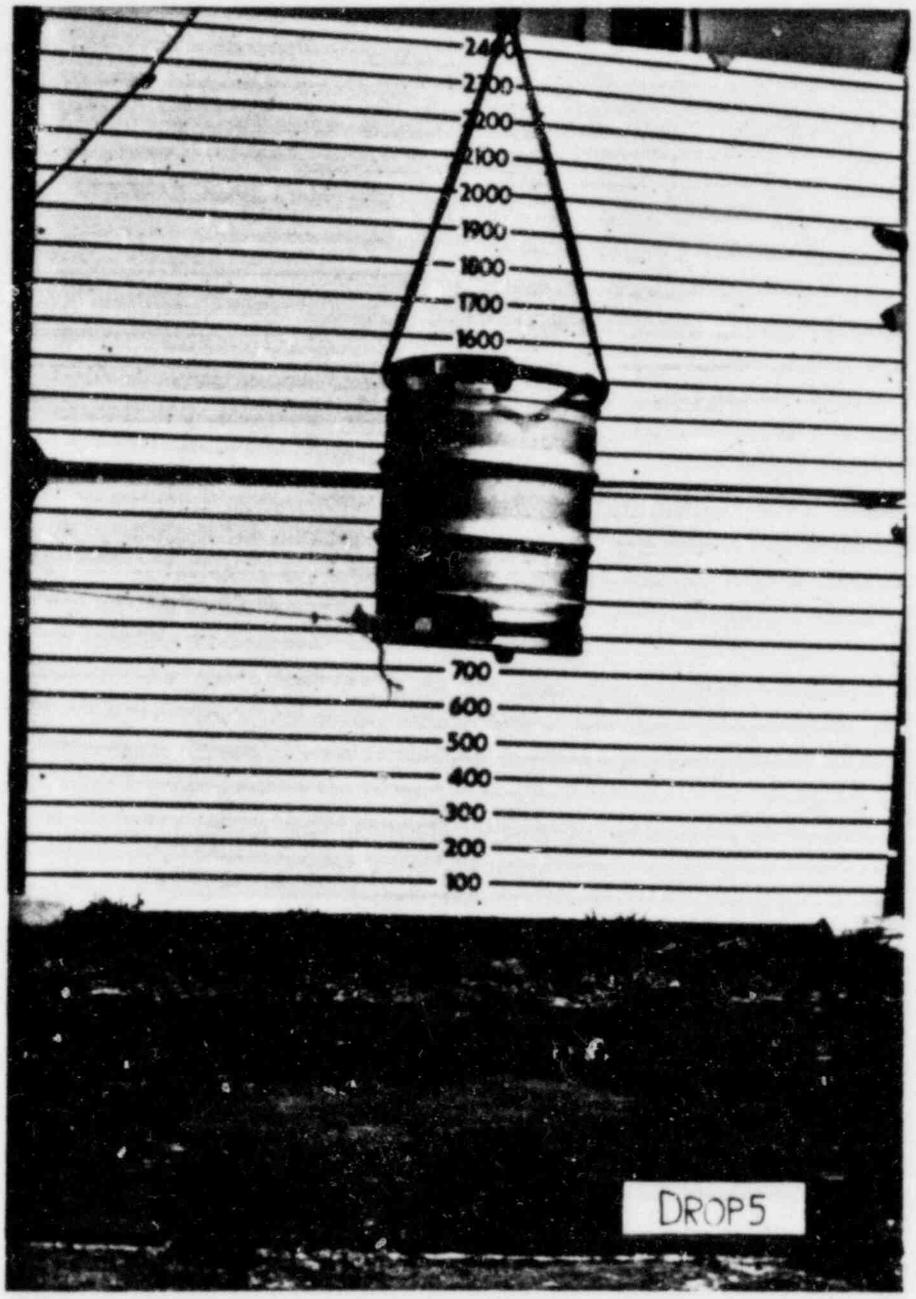

Figure 11

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Figure 12

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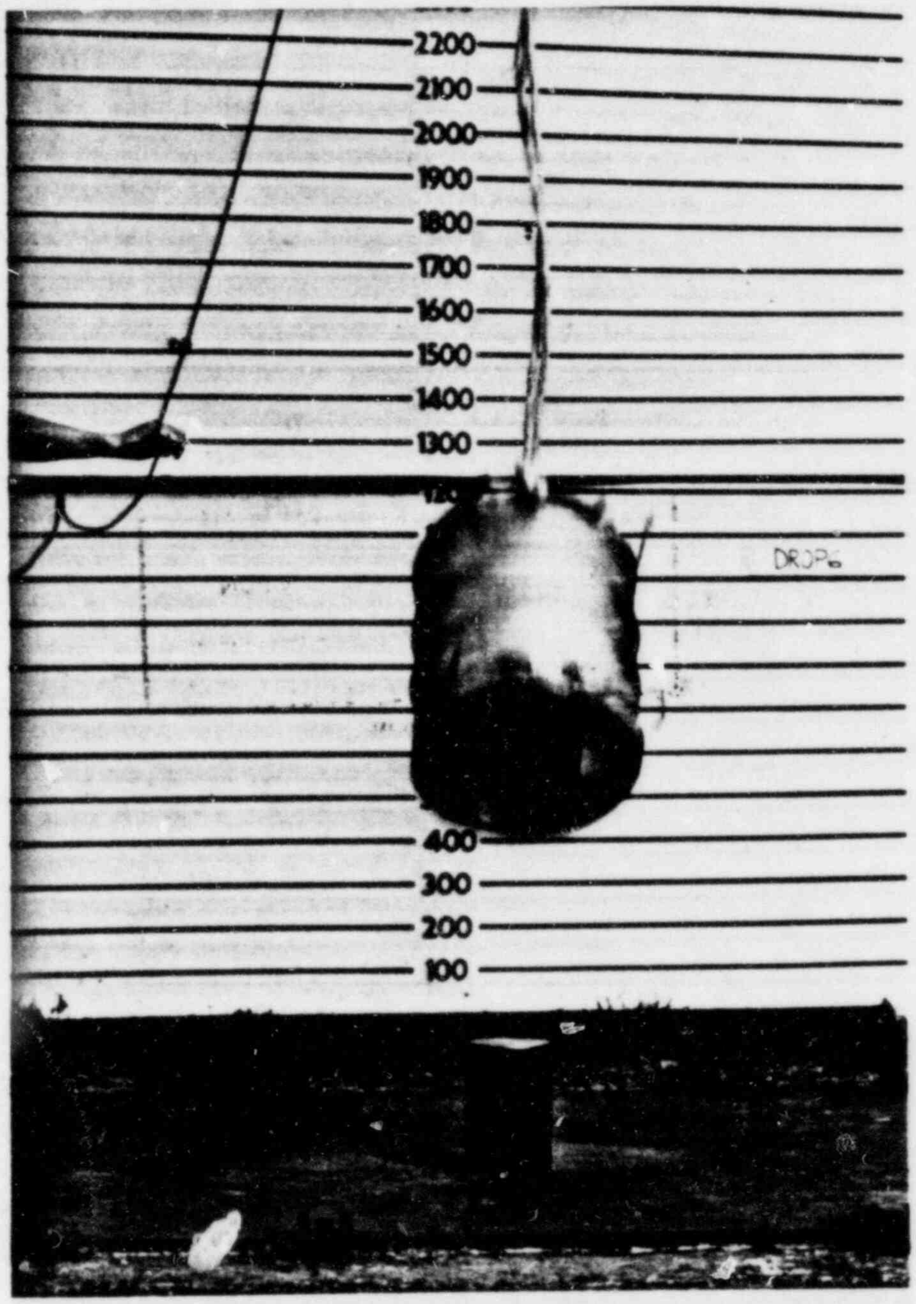

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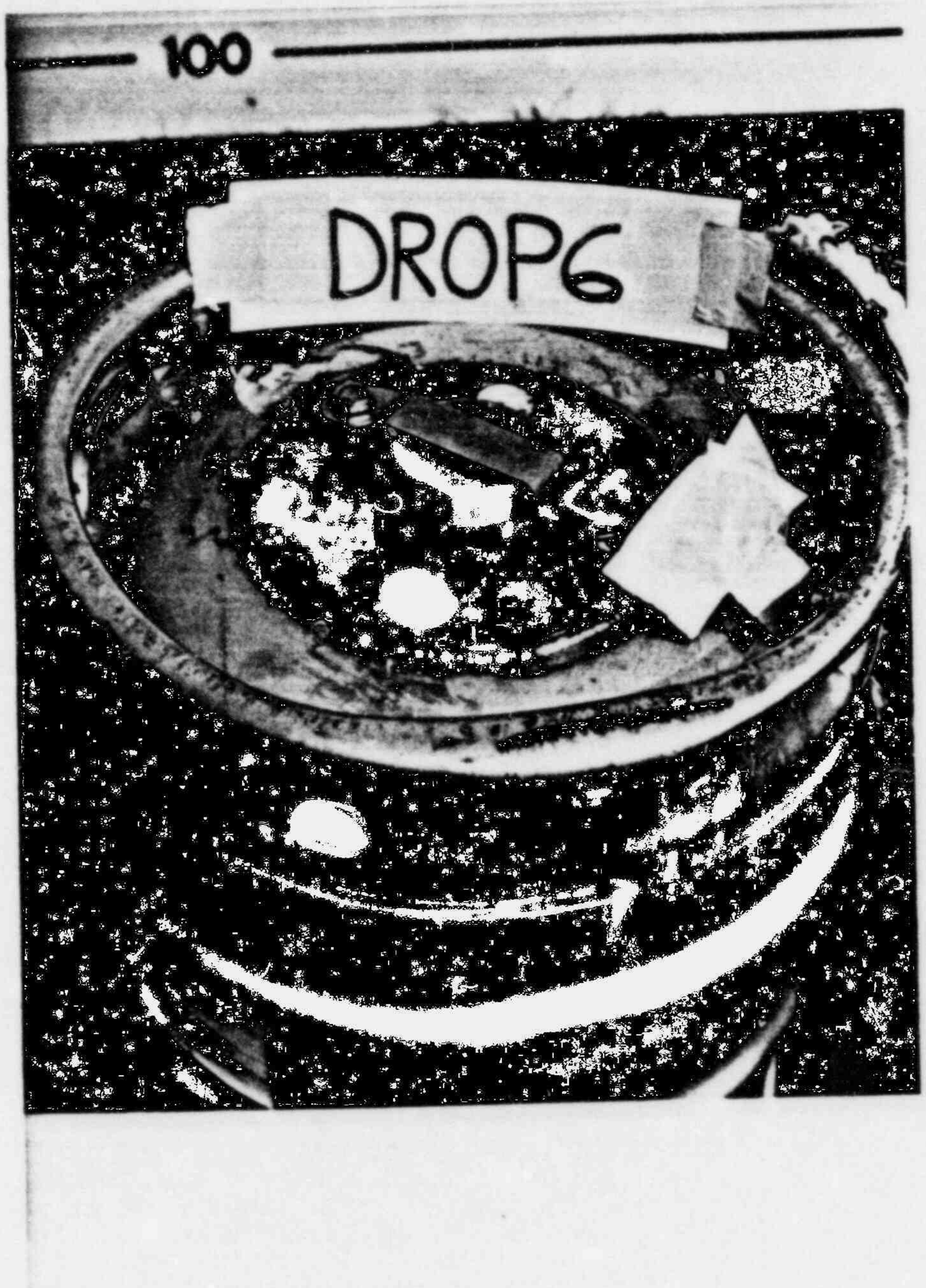

Figure 14

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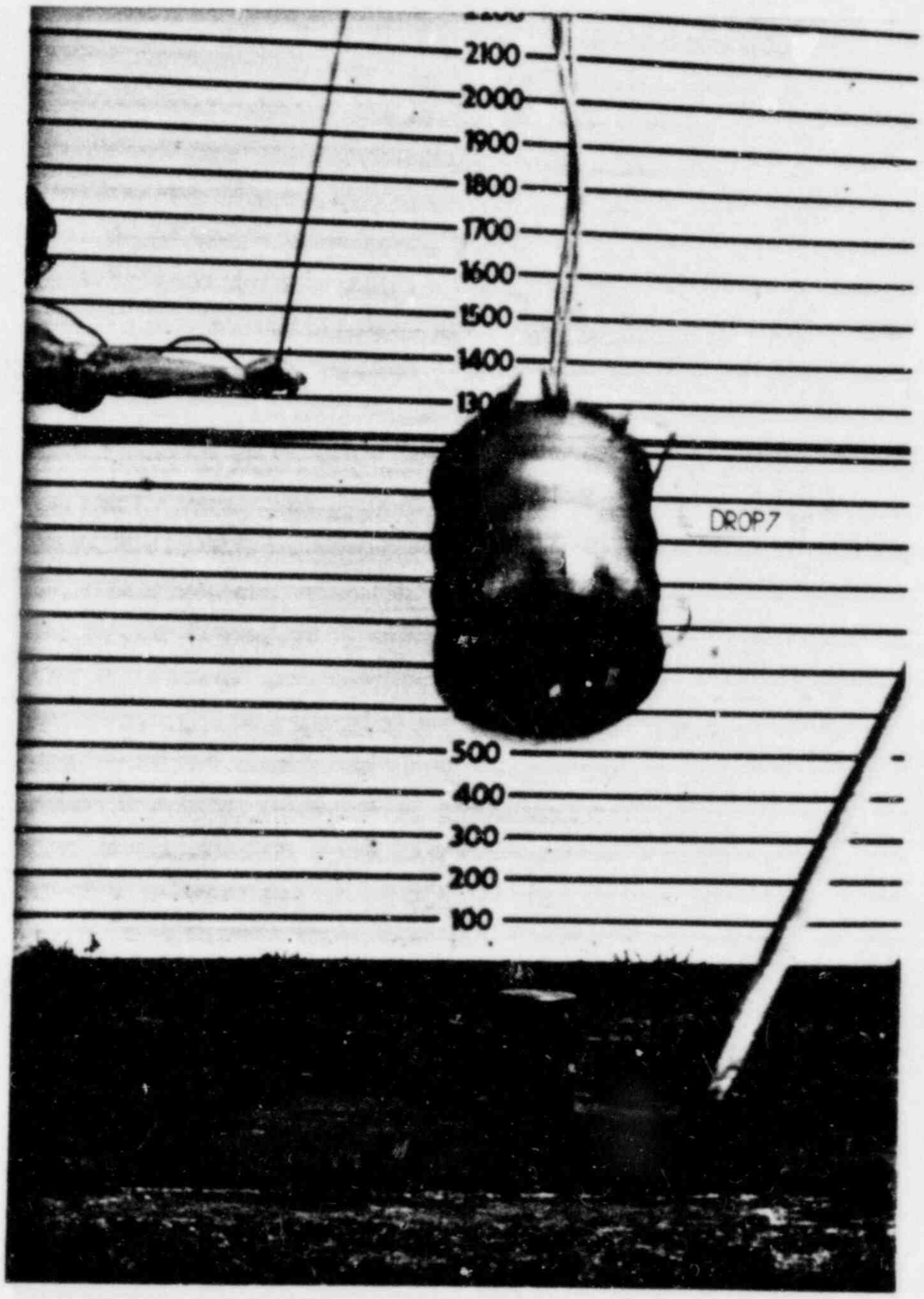

Figure 15

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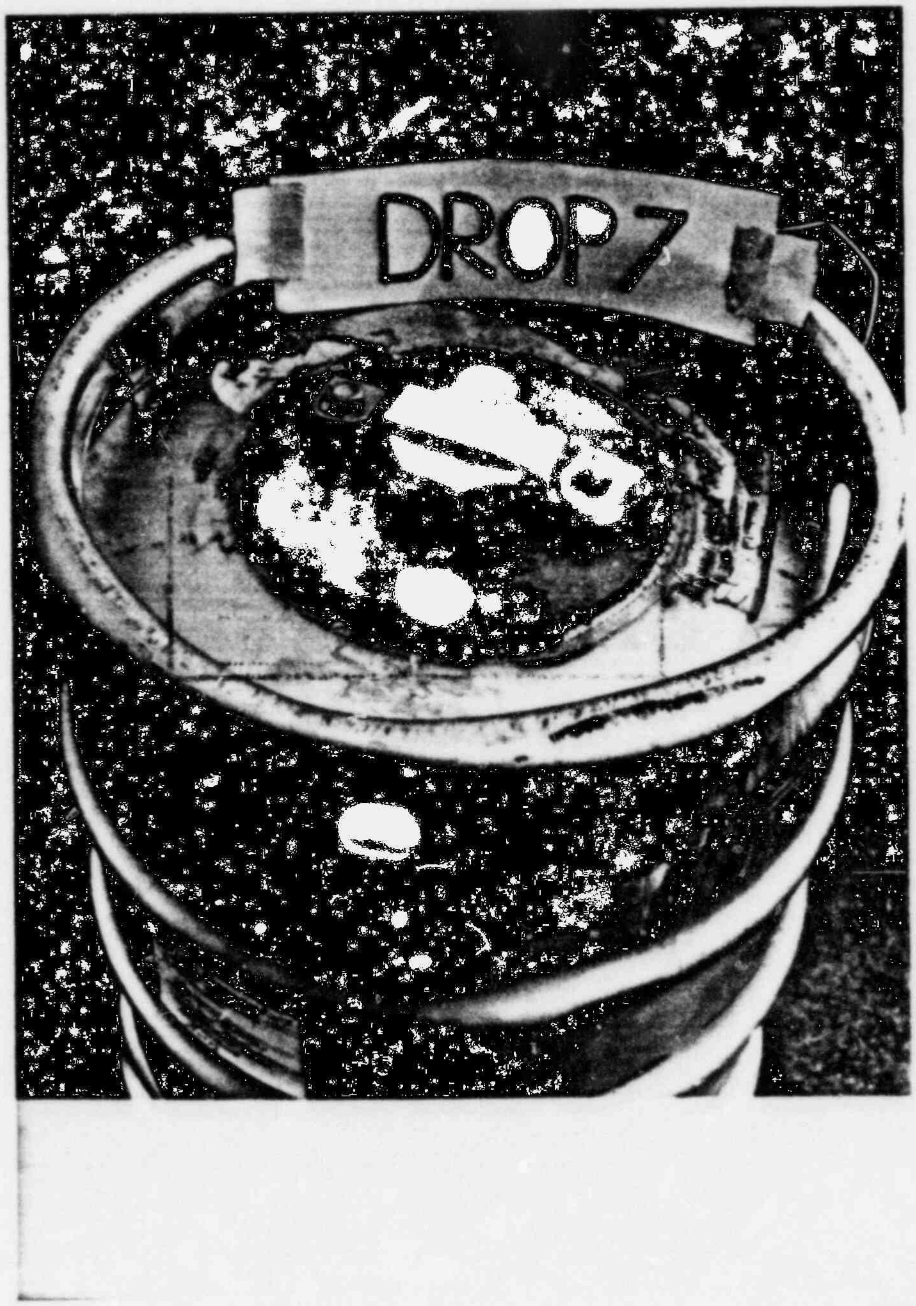

Figure 16

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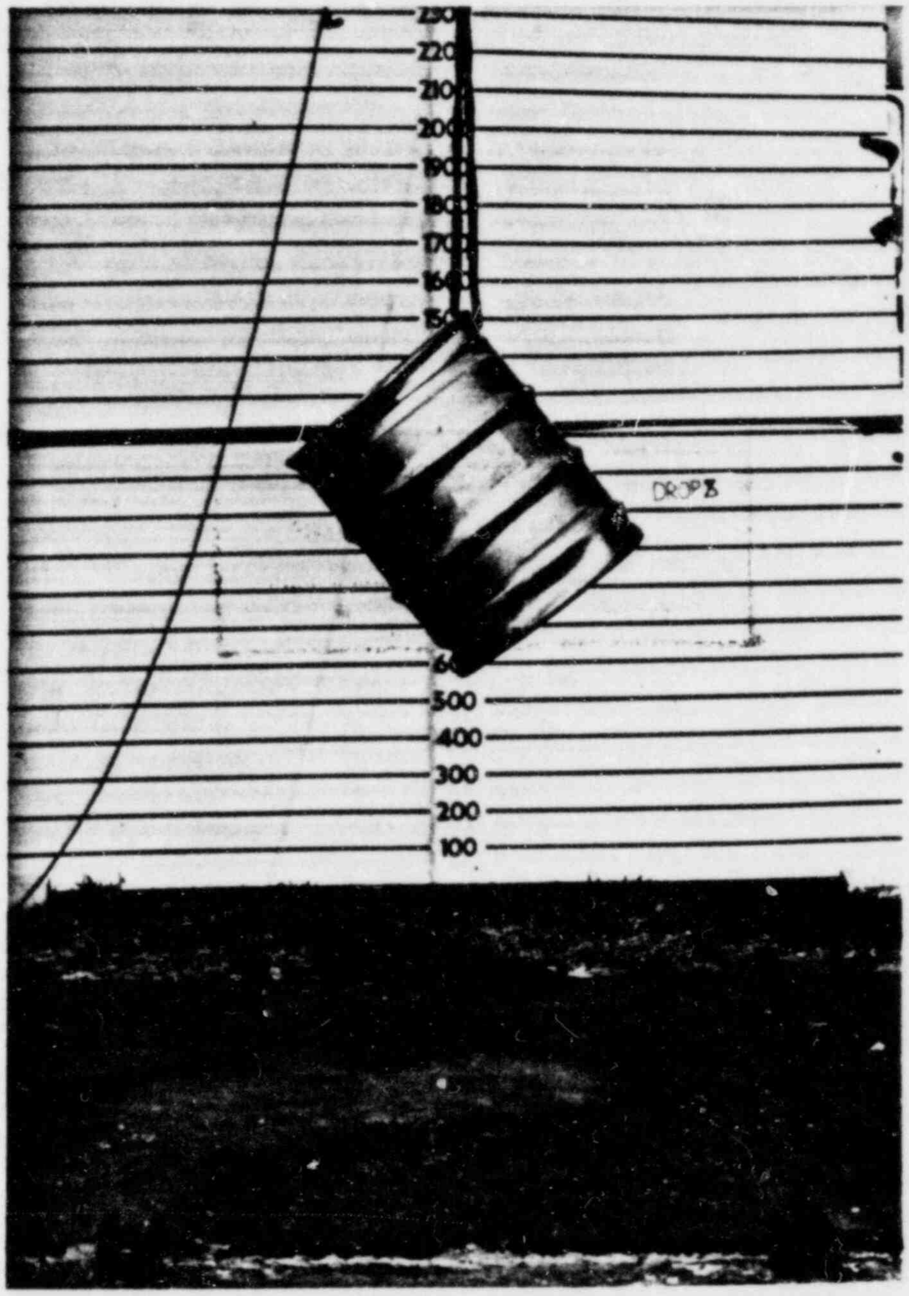

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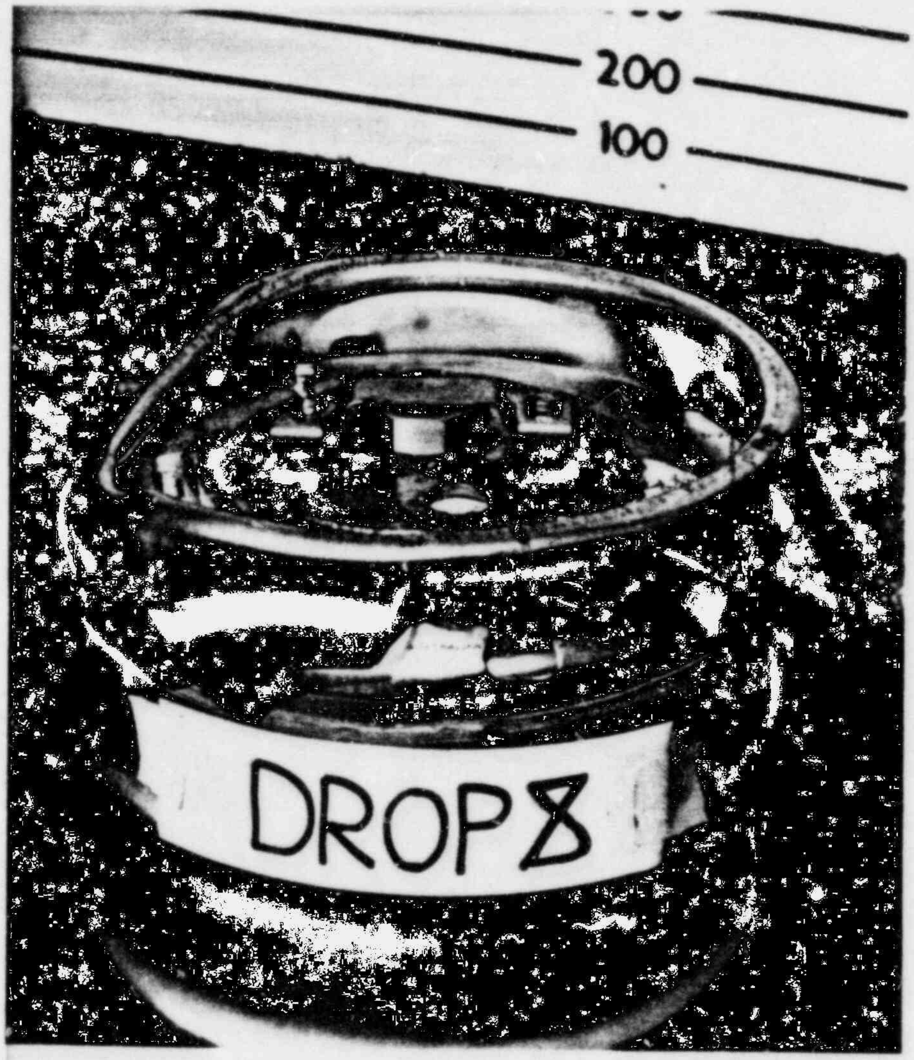

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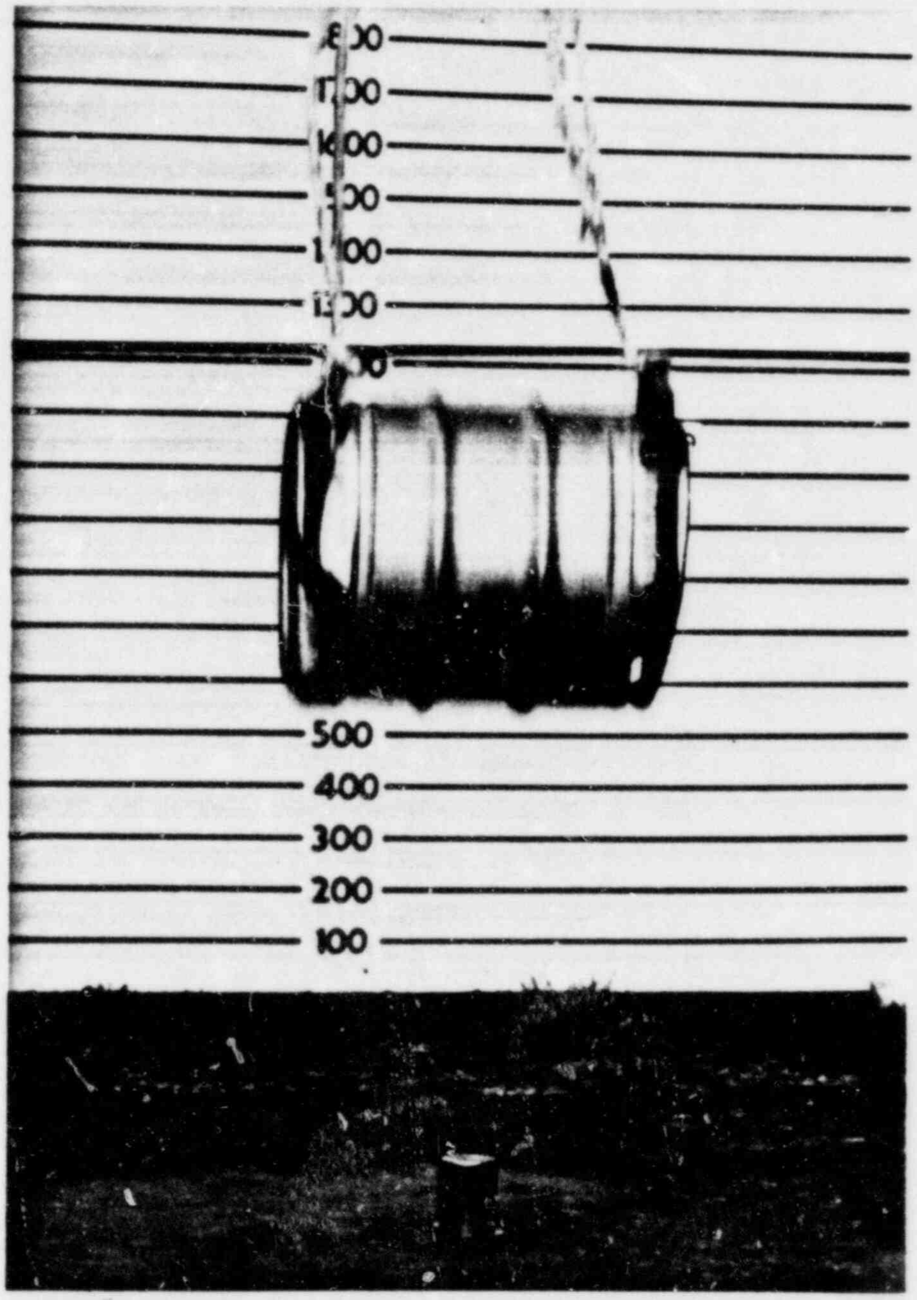

Figure 19

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2.10.1 Drop and Puncture Test Results

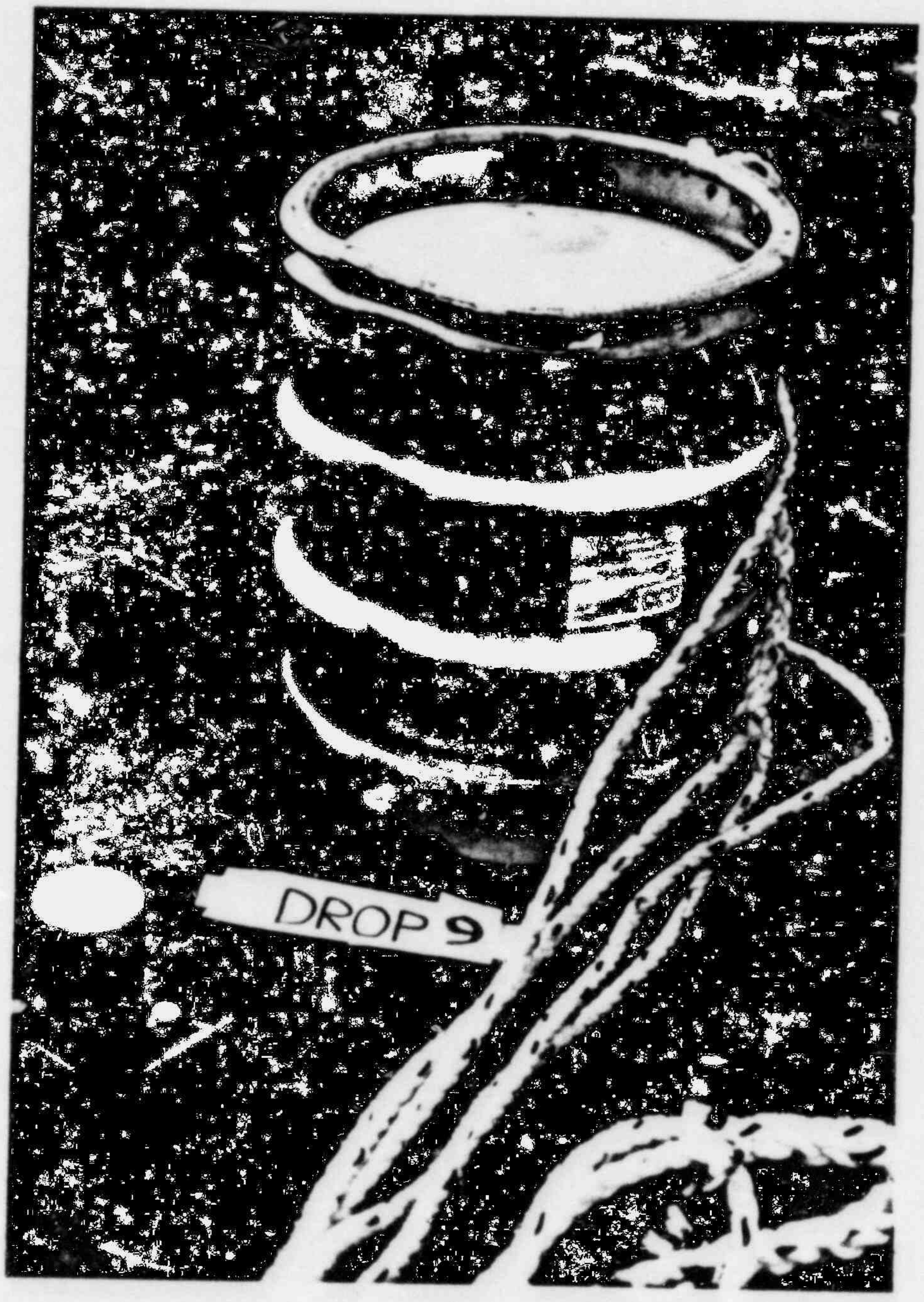

Figure 20

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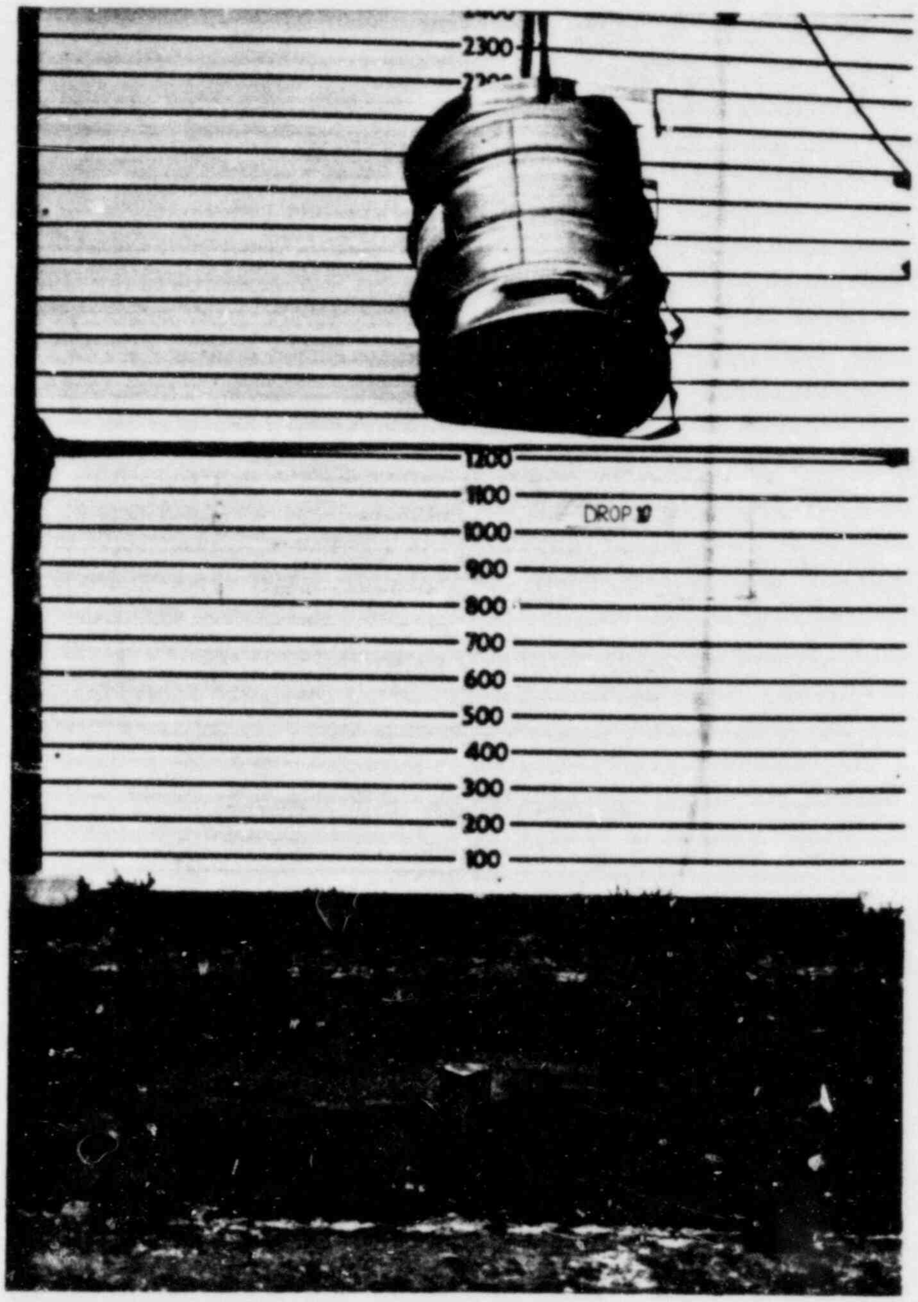

Figure 21

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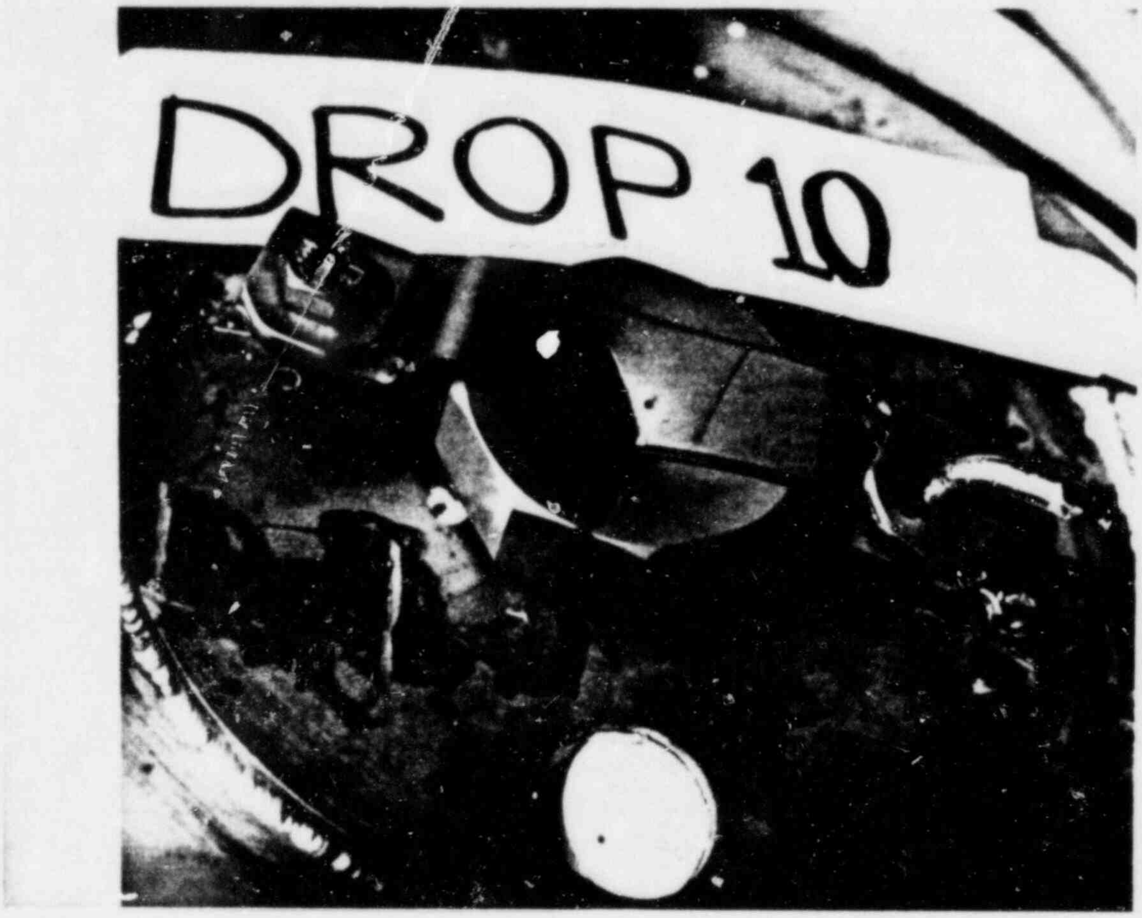

Figure 22

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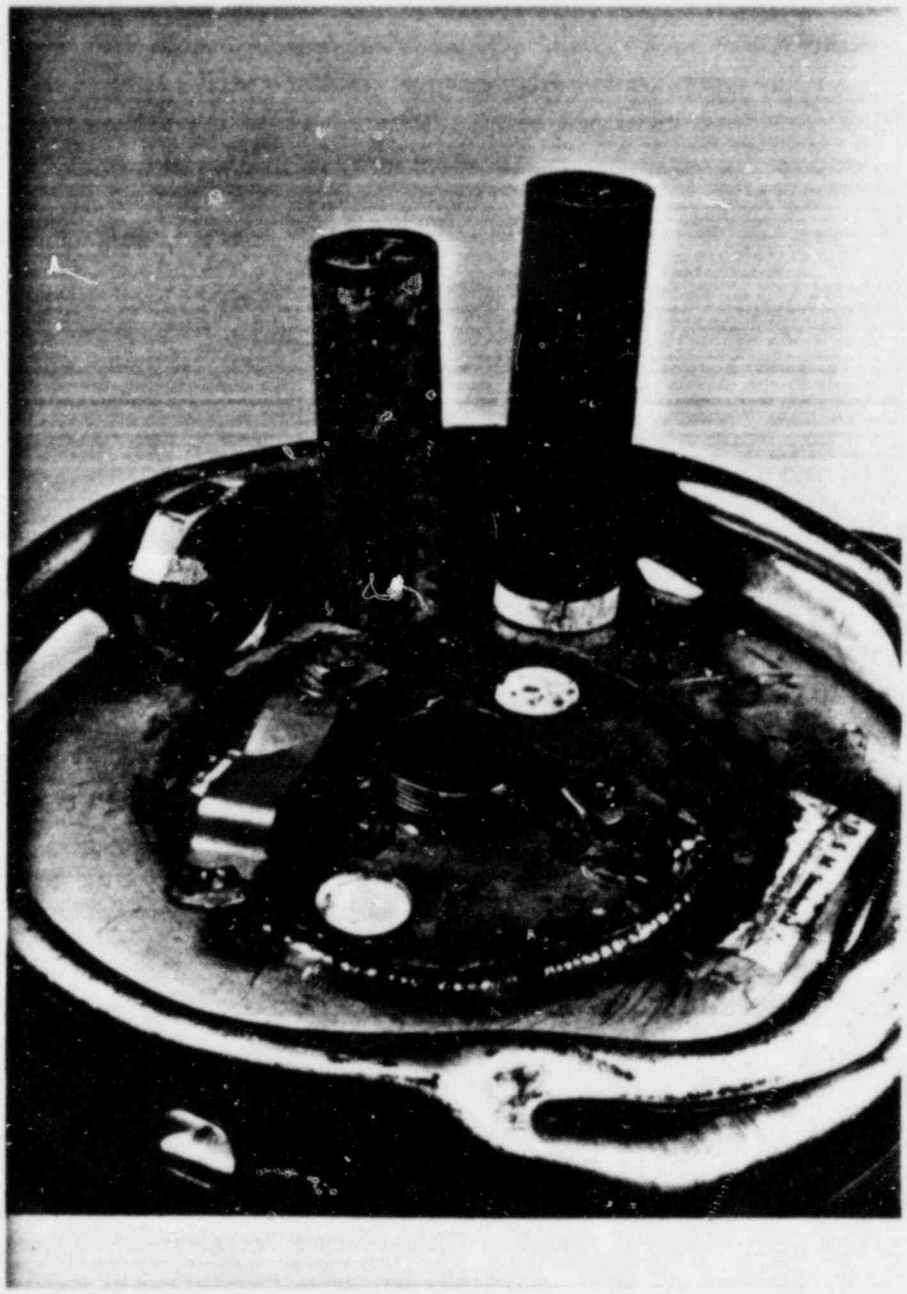

Figure 23

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2.10.2 Penetration Test Results

Memo To: File - 3227A Keg

From: F.V. Susterich

Date: August 25, 1982

Subject: Model 3227A Container - Penetration Test

On July 11, 1982 a penetration test was performed on model 3227A, a submodel of model 3235, serial number 1.

A steel cylinder 1.25 inches (32 mm) in diameter and 13 pounds (6 Kg) in weight was dropped from a height of 40 inches (1 meter) onto the right side of the keg. Upon completion of the test, the keg was inspected for damage. Only minor deformation was observed as a result of the impact. The structural integrity of the container model 3227A was sustained and no loss of shielding effectiveness resulted.

Therefore, it is concluded that the model 3227A container satisfies the requirements for the penetration test as described in 49 CFR Part 173.398 and IAEA Safety Series No. 6, 1973 Edition.

Photographic record attached. (Figure 1)

Witnessed by: Don Pen[illegible]

2.10 Appendix

2.10.2 Penetration Test Results

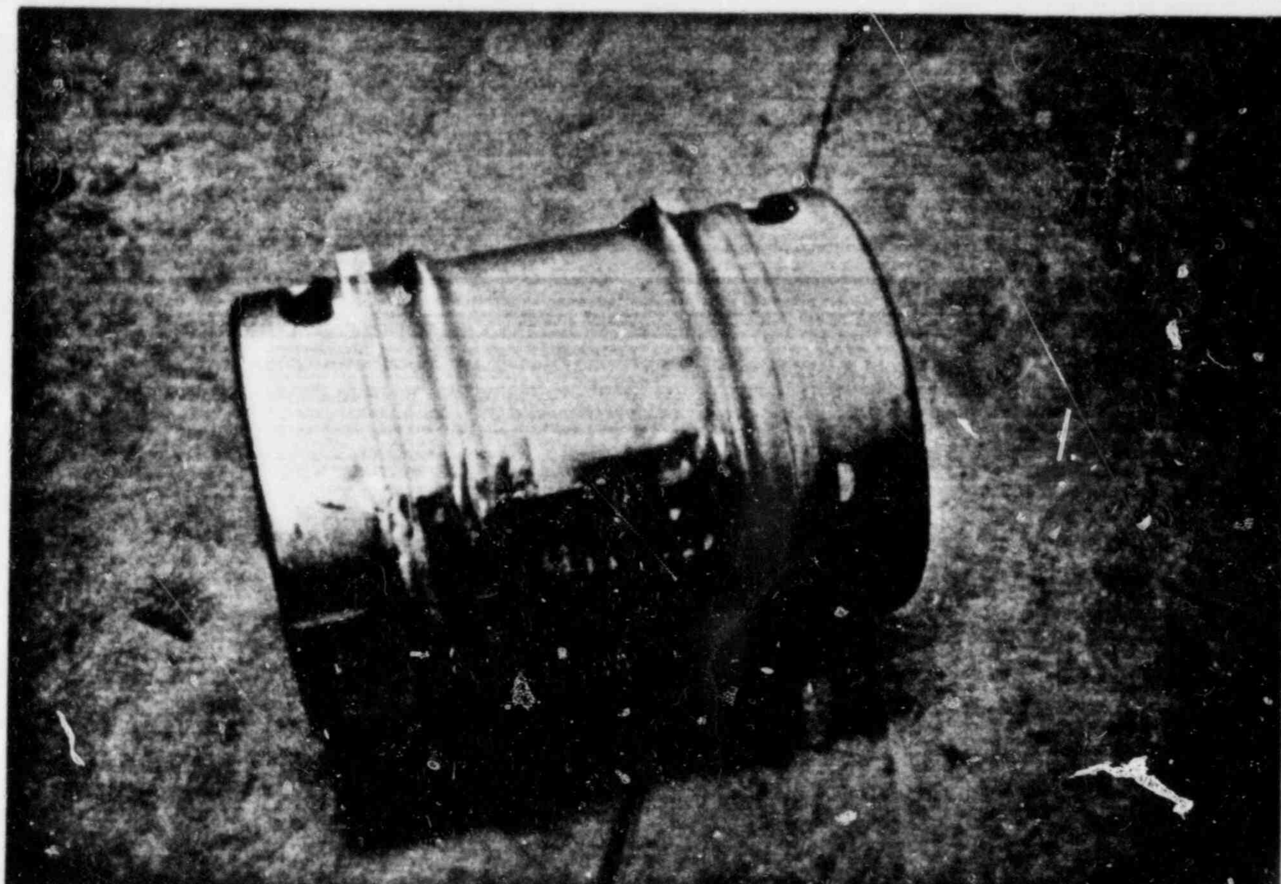

Figure 1

2.10.3 Damage Comparison Analysis of Keg Design Containers

1. General Similarities

All models of Amersham kegs are based on a standard stainless steel keg with identical legs and skids attached for easy horizontal handling. The shielding material, WEP, is cast into this shell around the source support tubes. The source is retained in the support tube by a screwed cap which is locked in the secure position by a latch bar. A shielding plug is used to retain the prime source in the fully shielded position. Any secondary (monitoring) source is of low enough activity not to require this facility.

2. Model 3235 Compared with Model 3206B

The only difference is in the bore (inner diameter) of the source support tube. This is increased to Ø3". (There is also an increase in tube wall thickness which is a result of material availability). The testing of model 3206 showed no shielding damage close to the support tube and the increase in diameter being well embedded and associated with a stronger tube, is not expected to weaken the overall design. The feature which is weakened by this increased diameter is the screw cap. In the model 3206 testing with a stiffer (smaller diameter) cap, the latch bar was pinched but not fractured. Extra damage to model 3235 is likely to be confined to greater indentation of the cap and latch, but with less pinching of the latch bar. Failure of the closure system is not anticipated: indeed the extra indentation is likely to jam this system into a safe, closed, condition.

3. Model 3218 Compared with Model 3206B

Model 3218 has the same prime source support tube as model 3206B, but because of the need to accommodate a second, monitoring, source support tube (or insert), the latching arrangement is changed from a swinging arm to a hinged bar. The second support tube is machined from solid bar stock and is accommodated beneath the central, prime tube, but close enough to it that additional damage to the WEP is most unlikely. The screw caps are the same as model 3206B, and the latch bar is of the same dimensions. The main difference is the replacement of a single stainless steel rivet with a similar diameter hinge pin. The total lack of significant damage to model 3206B in the specified testing suggest that damage to this revised pivot arrangement will also be minimal.

4. Tabular Comparison

The similarities and differences among the three models of the keg design containers are summarized in the following table.

2.10.3 Damage Comparison Analysis of Keg Design Containers

Feature	Model 3206B	Model 3235	Model 3218 Prime Source	Monitoring Source
Container body sides, base legs and skids	*	*	*	
Shielding material	*	*	*	
Latch bar, brackets, padlock	*	*	Same for each position, but different from *	
Overall weight	165 lb	165 lb	165 lb	
Support (source) tube bore	Ø2"	Ø3"	Ø2"	Ø1.5" maximum
Support (source) tube thickness	0.109"	0.188"	0.109"	0.45" approximately
Tube cap	*	* except Ø3"	*	*
Support tube base	*	* except Ø3"	*	0.12 approximately
Insert steel thickness	*	*	*	Not applicable
Shielding under cap	*	*	*	Not applicable
Shielding plug	*	* except Ø3"	*	Not applicable
Support tube range of lengths	*	*	*	6" maximum
* Same design as model 3206				

3. Thermal Evaluation

3.1 Discussion

The keg design containers are completely passive devices and have no mechanical cooling system nor relief valves. All cooling of the package is through free convection and radiation. The heat source is 25 curies of ^{241}americium/beryllium. The corresponding decay heat is 0.825 watts.

3.2 Summary of Thermal Properties of Materials

The melting point of the stainless steel used in the keg design containers is 2500°F.

The WEP has a minimum operating range of -40°C to 110°C. A small portion (12 mm average) will vaporize at the thermal test temperature (800°C). The small portion vaporized will result in gaseous by-products which will burn in a high heat (flame) environment.

3.3 Technical Specification of Components

Not applicable.

3.4 Normal Conditions of Transport

3.4.1 Thermal Model

The heat source in the keg design containers is a maximum of 25 curies of ^{241}americium/beryllium which decays with a total energy liberation of 33 milliwatts per curie. Assuming that all of the decay energy is transformed into heat, the heat generation rate for the maximum curies of ^{241}americium/beryllium is 0.825 watts.

To demonstrate compliance with the requirements of paragraphs 231 and 232 of IAEA Safety Series No. 6, 1973 Edition, for Type B(U) packaging, an analysis is presented in Section 3.6.1. The thermal model employed is described in that section.

To demonstrate compliance with the requirements of paragraph 240 of IAEA Safety Series No. 6, 1973 Edition for Type B(U) packaging, an analysis is presented in Section 3.6.2. The thermal model employed is described in that section.

3.4.2 Maximum Temperatures

The maximum temperatures encountered under normal conditions of transport will have no adverse effect on the structural integrity or shielding. As presented in Section 3.6, the maximum temperature in the shade would be less than 38.7°C and the maximum temperature when insolated would be less than 68.5°C.

3.4.3 Minimum Temperatures

The minimum normal operating temperature of the models 3206A, 3206B, 3218 and 3235 is -40°C (-40°F). This temperature will have no adverse affect on the package.

3.4.4 Maximum Internal Pressures

Normal operating pressures generate negligible internal pressures. The container itself is vented so any pressures encountered (even during the thermal testing) would not result in a loss of the container's ability to contain the source.

3.4.5 Maximum Thermal Stress

The maximum temperatures that occur during transportation are low enough to ensure that thermal gradients will cause no significant thermal stresses.

3.4.6 Evaluation of Package Performance for Normal Condition of Transport

The thermal conditions of normal transport are insignificant from a functional viewpoint for these containers. The applicable conditions of the IAEA Safety Series No. 6, 1973 Edition for Type B(U) packages have been shown to be satisfied by the containers. Additional evidence of the containers' acceptability is that model 3206B and sub-model 3206A have been approved as an IAEA Type B(U) containers.

3.5 Hypothetical Accident Thermal Evaluation

3.5.1 Thermal Model

A smaller WEP filled container (A5N) was subjected to the thermal test conditions and was used as the model for these requirements. The test results demonstrate that the temperature inside the container near the source would be no more than 150°C . At 800°C the only measurable effect on the container was the vaporization of approximately 12 mm of WEP. This vaporized material would escape through the container vent hole. A description of the test is given in Section 3.6.

3.5.2 Package Conditions and Environment

The prototype container (sub-model 3206A) sustained no significant damage during the free drop and puncture tests. The package used in this analysis was considered undamaged.

3.5.3 Package Temperature

As indicated in Section 3.5.1, the keg design containers were compared to a like-filled container (A5N) which was subjected to the 800°C test condition.

The results indicated that the source would be subjected to a maximum of 150°C. Examination of the melting temperatures of the materials used in the construction of the containers indicates that there would be minimal damage to the container at this temperature. The experimental evidence indicates that there will be a reduction of approximately 12 mm of shielding (WEP). This minor reduction will not allow the radiation dose rate to exceed 1000 millirems per hour at three feet from the container.

3.5.4 Maximum Internal Pressures

The containers are open to the atmosphere. Therefore, there will be no pressure buildup within the package. Since the source itself is special form, the source must withstand temperatures up to 1475°F. Also, the sources are tested to ANSI Standard N542, so they must withstand pressures of at least 290 psi. It can be concluded that any possible internal pressure that could be generated at 800°C would not effect the source or the container.

3.5.5 Maximum Thermal Stress

There are no significant thermal stresses generated during the thermal test.

3.5.6 Evaluation of Package Performance

The keg design containers will undergo no loss of structural integrity and will have only a slight reduction in shielding capability when subjected to the thermal accident conditions. The pressure and temperatures have been demonstrated to be within acceptable limits.

3.6 Appendix

Keg design containers Type B(U) thermal analysis: Paragraphs 231 and 232 of IAEA Safety Series No. 6, 1973 Edition. (3.6.1)

Keg design containers Type B(U) thermal analysis: Paragraphs 240 of IAEA Safety Series No. 6, 1973 Edition. (3.6.2)

Furnace test of A5N container (WEP filled). (3.6.3)

3.6 Appendix

3.6.1 Keg Design Containers Type B(U) Thermal Analysis: Paragraphs 231 and 232 of IAEA Safety Series No. 6, 1973 Edition

This analysis demonstrates that the keg design containers will not exceed 50°C with the package in the shade and at an ambient temperature of 38°C.

To assure convervatism, the following assumptions were used:

a) The decay heat load is assumed to be 0.825 watts.

b) The entire decay heat is deposited upon the exterior surface of the container.

c) The interior of the keg design container is perfectly insulated and heat transfer occurs only from the exterior surface to the atmosphere.

d) Since the container is elevated off the ground, the heat is dissipated from the entire surface of the container.

e) The only heat transfer is free convection.

Using these assumptions, the maximum wall temperature is found from:

$$q = hA\,(T_w - T_a)$$

Where q: Heat deposited per unit time in the face of interest (0.825 watts).

h: Free convection heat transfer coefficient $[1.38\,(\Delta T)^{1/4}\ W/m^2 - °C]$.

A: Area of surface of container ($0.9797 m^2$).

T_w: Maximum temperature of the wall of the package.

T_a: Ambient temperature (38°C).

From this relationship, the maximum temperature of the shell is 38.7°C. This satisfies the requirements of Paragraphs 231 and 232 of IAEA Safety Series No. 6, 1973 Edition.

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3.6 Appendix

3.6.2 Keg Design Container Type B(U) Thermal Analysis: Paragraph 240 of IAEA Safety Series No. 6, 1973 Edition

This analysis demonstrates that the maximum surface temperature of the keg design containers will not exceed 82°C when the package is in an ambient temperature of 38°C and insolated in accordance with Paragraph 240 of IAEA Safety Series No. 6, 1973 Edition.

The calculational model consists of taking a steady state heat balance over the surface of the package. The following assumptions were used:

1) The container is insolated at a rate of 387.5 W/m^2 (400 g cal/cm^2-12 hr) on the complete cylindrical surface and 193.75 W/m^2 (200 g cal/cm^2-12 hr) on each end.

2) The decay heat load is added to the solar heat load.

3) The package has a stainless steel surface. The solar absorptivity is assumed to be 0.9. The solar emmissivity is assumed to be 0.8.

4) The package is assumed to undergo free convection from the total surface area of the container. The package will also undergo radiation from the total surface area of the container. The inside face of the container is considered to be insulated so there is no conduction into the package. The walls of the container are considered to be sufficiently thin so that no temperature gradients exist in the walls.

5) The package is approximated as a cylindrical solid 20.35 inches long and 16.81 inches in diameter. The surface area of the cylinder is $0.6933m^2$ and the total surface area of the sides is $0.2864m^2$.

6) Solar heat loading will be considered on the top half of the cylinder area and on both sides of the container.

The maximum surface temperature is established from a steady state heat balance relationship

$$q\ in = q\ out = q_c + q_r$$

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Where q_c: Convection heat transfer.

q_r: Radiative heat transfer.

The heat load applied to the package is:

$$q_{in} = \alpha q_s + q_d$$

Where α: Absorptivity (0.9).

q_s: Solar heat load (319.552 watts).

q_d: Decay heat load (0.825 watts).

The convective heat transfer is:

$$q_c = [(hA)_{cylinder} + (hA)_{sides}] (T_w - T_a)$$

Where h: Convective heat transfer coefficient.

A: Area of surface of interest.

T_w: Temperature of wall.

T_a: Ambient temperature.

The heat transfer due to radiation is :

$$q_r = \sigma \varepsilon A (T_w^4 - T_a^4)$$

Where σ: Stefan Boltzmann constant (5.699×10^{-8} W/m^2 - °K^4).

ε: Emissivity (0.8).

Iteration of this relationship demonstrates that the wall temperature of the keg design containers is 68.5°C which satisfies the requirement of Paragraph 240 of IAEA Safety Series No. 6, 1973 Edition.

3.6.3 Furnace Test of A5N Container (WEP filled)

Test No 336

11 August 1976

Furnace Test of A5N Container (WEP filled)

Introduction

Water extended polyester (WEP) is a material currently under consideration by the Radiochemical Centre, Amersham as a replacement for paraffin wax as a neutron absorbing shield for use in containers designed for the transport of neutron sources. Experimental work on WEP has shown it to have good thermal insulating properties such that if proved successful to the IAEA test standard a WEP insulated container could qualify as a Type "B" packaging in its own right without the need for the additional thermal shielding that is required for a paraffin wax container. In order to obtain more data on WEP an experimental programme was set up whereby an existing A5N container was drained of its paraffin wax and refilled with WEP so that it could be subjected to a furnace test to IAEA standard with neutron dose rate measurements being carried out at Amersham before and after the test. This report covers the furnace test only.

Container details

Design No 0220 A5N Neutron Source Container 178 mm diameter x 230 mm. Drawing No BRC 276 with paraffin wax replaced by WEP.
Weight of assembly 11 Kg.

Instrumentation

Chromel Alumel 1.5 mm diameter thermocouples were fitted to the container body and insulation as shown on Figure 2 with their cold junctions attached to a multichannel recorder.

Method of test

The container, mounted horizontally on a steel grille, was placed in the ALRE oil fired furnace at a temperature of 800°C for a period of 30 minutes after which it was withdrawn and allowed to cool naturally in air for a further 3 hours.

Results

A great deal of flame issued from the container outer shell vents during the furnace period but these flames diminished and died out completely within 5 minutes of the container being withdrawn from the furnace. There was then a little smoke from the vent holes but this too soon died out.

At the end of the 3 hour cooling period it was seen that no noticeable distortion of the container body had occurred, the only noticeable difference being that much of the paint had flaked off the outside and top.

A visual inspection then showed that the WEP had shrunk considerably during the test leaving a gap of some 12 mm between the WEP and the inside wall of the container body and similarly at the top and bottom ends of the container. (This figure of 12 mm was a loose approximation as measurements could only be made in the areas under vent and thermocouple holes and should be confirmed later by sectioning the container shell.)

On removing the flange lid, it was seen that the flat rubber gasket had charred completely through but was still in position as a charred mass. The WEP in the cavity shielding plug had shrunk by about 12 mm in length and the outside of the plug was discoloured at the top end.

The dummy source capsule, on removal, was seen to be still clean, bright and intact and when subjected to a bubble leak test in glycol was seen to be still leaktight to a 10^{-5} litre torr/sec standard.

On reweighing the assembly after test it was found that a loss of weight of 2.4 Kg had resulted, its new weight being 8.6 Kg.

Conclusions

It can be seen from the Time/Temperature curve (Fig 1) that with the exception of its outermost and innermost extremities the WEP reached a maximum temperature during the whole test period of a little over 100°C. The slightly higher temperature reached at the cavity wall and the very much higher temperature measured a short distance inside the outer steel shell were due to the shrinkage of the WEP, particularly the latter where the shrinkage was sufficient to expose the measuring thermocouple to the hot gases of combustion.

While it can be seen that Water Extended Polyester has good thermal insulating properties, caution must be exercised in its use in transport containers due to its tendency to shrink when exposed to a high temperature and to therefore lose 20% or more of its shielding mass.

Figures

1. Time/Temperature curve
2. Arrangement of thermocouples

L R Cohen
Transport Containers Section
Engineering Division
Building 424
AERE Harwell

A5N WEP CONTAINER

Test No 336   Material Water Extended Polyester   Date 11 August 1976

Thermo couple No	Minutes																	
	0	5	10	15	20	25	30	35	40	45	50	60	80	100	120	150	180	210
1	25	25	27	58	97	108	115	121	130	130	128	125	110	100	94	87	80	75
2	25	25	27	30	45	59	70	77	85	90	95	100	101	100	95	90	83	78
3	25	25	25	25	25	29	35	42	50	58	67	80	94	97	96	90	85	79
24	25	25	25	25	28	35	47	58	70	76	82	91	96	95	88	88	82	77
5	25	25	26	35	45	59	85	104	109	110	110	105	98	92	88	83	78	73
6	25	50	96	125	250	550	542	276	200	159	136	113	86	71	66	58	57	52
7	25	686	750	748	760	767	774	284	214	165	139	106	74	58	53	46	45	40
9	25	25	32	73	100	110	117	125	130	130	127	125	110	99	94	86	80	75
10	25	25	26	35	50	61	72	79	86	91	96	100	101	100	95	90	84	78
11	25	25	25	25	25	29	36	45	50	60	68	80	93	97	95	90	85	79
22	25	30	45	82	100	105	115	125	130	130	127	121	107	98	88	85	78	73
Furnace	680	800	812	826	832	830	832											

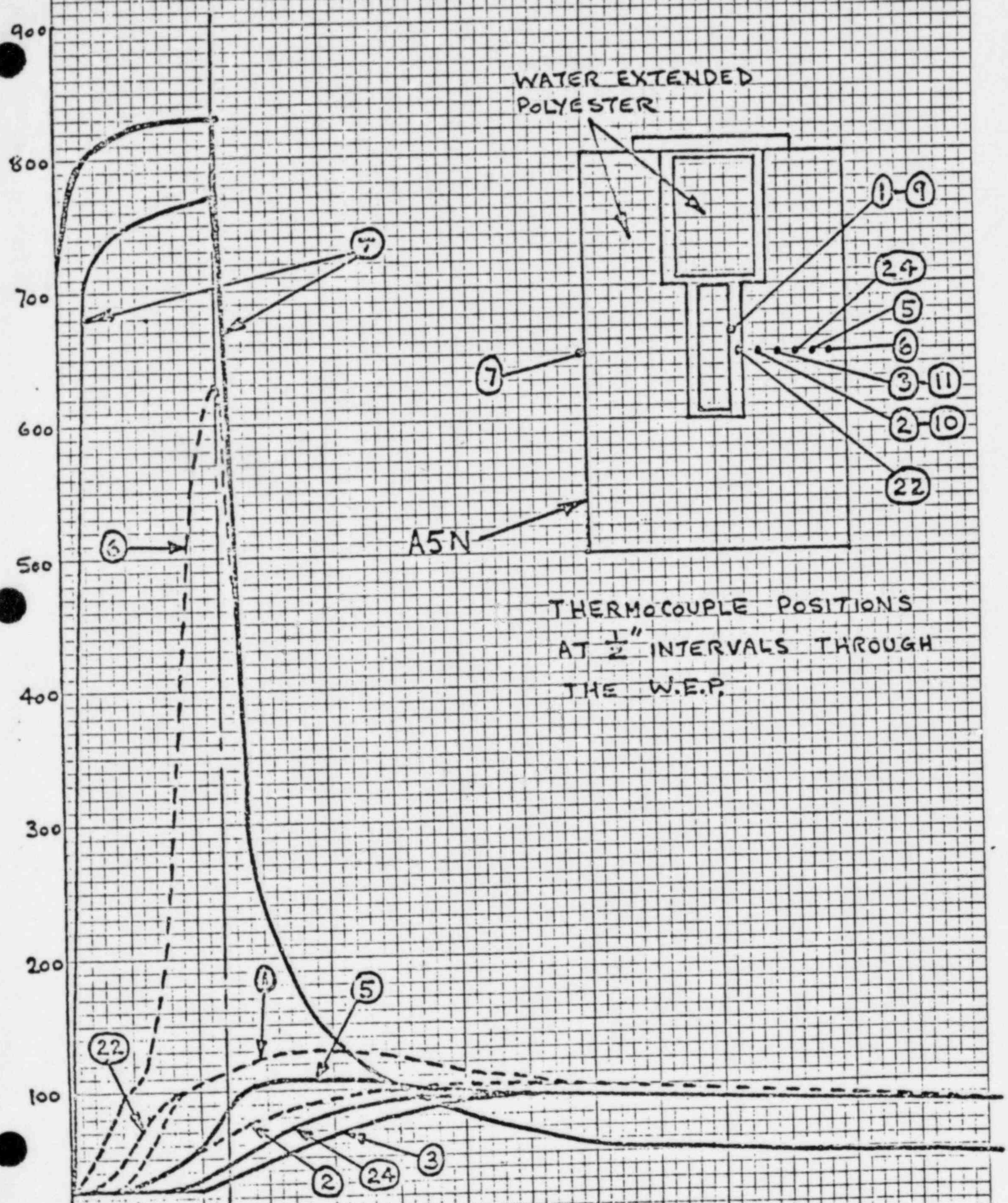
Weight of WEP Container (before) 24 lbs
(after) 19 lbs

Ambient 25°-26°C

Wind Nil

General Dry, sunny and warm

Figure 1



900
800
700
600
500
400
300
200
100
0
0
25
50
75
100
125
150
175
WATER EXTENDED
POLYESTER
1
9
24
5
6
3
11
2
10
22
7
A5N
THERMOCOUPLE POSITIONS
AT 1/2" INTERVALS THROUGH
THE W.E.P.

4. Containment

4.1 Containment Boundary

4.1.1 Containment Vessel

The containment system for the keg design containers is the special form capsule. The source capsule is manufactured to the purchaser's specifications on type of stainless steel.

4.1.2 Containment Penetrations

There are no penetrations of this containment.

4.1.3 Seals and Welds

The containment capsule is seal welded by a tungsten inert gas process according to IAEA and/or USA special form requirements.

4.1.4 Closure

Not applicable.

4.2 Requirements for Normal Conditions of Transport

4.2.1 Release of Radioactive Material

Any source used in these containers will have satisfied the stringent requirements for special form radioactive material as delineated in IAEA Safety Series No. 6, 1973 Edition and/or the USA regulations in 49 CFR Part 170-178. Therefore, there will be no release of radioactive material under normal conditions of transport.

4.2.2 Pressurization of the Containment Vessel

As the sources that will be used in these containers are tested to ANSI Standard N542, level 3, each must be shown to successfully withstand pressures of at least 290 psi. Even during the most extreme hypothetical thermal accident conditions, the pressure exerted would not approach 290 psi. Therefore, the containment will withstand the pressure variations of normal transport.

4.2.3 Coolant Contamination

Not applicable.

4.2.4 Coolant Loss

Not applicable.

4.3 Containment Requirements for the Hypothetical Accident Conditions

4.3.1 Fission Gas Products

Not applicable.

4.3.2 Release of Contents

Subjecting the keg design containers to the hypothetical accident conditions of 10 CFR Part 71 will result in no loss of containment (Reference sections 2.7 and 3.5).

4.4 Appendix

Not applicable.

5. Shielding Evaluation

5.1 Discussion and Results

The keg design containers are shielded with a minimum of 125 pounds of WEP. The WEP is cast around the stainless steel source receptacle(s).

A radiation profile was performed on a model 3206A container, (serial number 001) containing a 19.0 Curie ^{241}americium/beryllium source with a neutron output of 3.8 x 10^7 neutrons/second over 4π radians. The results of this survey are presented in Section 5.5.1. Extrapolation of this data, assuming a maximum output of 4.5 x 10^7 neutrons/second over 4π radians and up to 25 Curies of ^{241}americium mixed with beryllium, is presented in Table 5.1. The mixing profile and source shape will determine the amount of ^{241}americium required to achieve the desired neutron output. The maximum dose rates expected are within the regulatory requirements.

A radiation profile was also performed on a model 3218A container (serial number 002) containing a 19.0 Curie ^{241}americium/beryllium source with a neutron output of 3.7 x 10^7 neutrons/second over 4π radians in the high activity source receptacle, and a 500 millicurie ^{241}americium/beryllium source with a neutron output of 1.3 x 10^6 neutrons/second over 4π radians in the reference source receptacle.

The results of this survey are presented in Section 5.5.2. The maximum amount of ^{241}americium/beryllium that will be present in this container will be 20.5 Curies with a neutron output of 4.4 x 10^7 neutrons/second over 4π radians. The activity of the calibration or reference source will not exceed 500 millicuries with a neutron output of 1.3 x 10^6 neutrons/second over 4π radians. Again, the mixing profile and source shape will determine the amount of ^{241}americium/beryllium required to achieve the desired neutron output. An extrapolation of the experimental data for the maximum activities listed above result in values that are equal to or less than those in Table 5.1. Therefore, dose rates will be within regulatory requirements for this container also.

Table 5.1

Summary of Maximum Dose Rates (mrem/hr)

	Package Surface			At One Meter		
	Front	Top	Rear	Front	Top	Rear
Normal Conditions						
Gamma	19.7	19.7	13.2	.6	.6	.6
Neutron	141.5	141.5	82.3	8.9	8.9	4.7
TOTAL	161.2	161.2	95.5	9.5	9.5	5.3
Hypothetical Accident Conditions						
Gamma	21.7	21.7	14.5	0.7	0.7	0.7
Neutron	188.6	188.6	109.7	12.9	12.9	7.5
TOTAL	210.3	210.3	124.2	13.6	13.6	8.2
10 CFR Part 71 Limit	--	--	--	1,000	1,000	1,000

5.2 Source Specification

The sources used were ^{241}americium oxide/beryllium sources which were dual encapsulated in welded stainless steel capsules, and approved as special form by a competent authority.

5.2.1 Gamma Source

The ^{241}americium used to excite the beryllium to expel a neturon has a major gamma energy of 60 KeV. The maximum amount requested in this application is 25.0 curies. The maximum weight of ^{241}americium is 8.35 grams.

5.2.2 Neutron Source

As stated in Section 5.2.1, ^{241}americium is used to excite the beryllium to expel neutrons. The maximum neutron emission is 4.5×10^7 neutrons per second over 4π radians.

5.3 Model Specification

The basic information on radiation dose rates was generated experimentally. Estimations of the expected values for different sources at specific distances were calculated from the experimental data.

5.4 Shielding Evaluation

Shielding evaluations were performed on model 3206A (serial number 001) and 3218A (serial number 002). The results of these surveys (see Section 5.5) demonstrate that the dose rates associated with these packages are within the regulatory requirements.

A calculated radiation profile was calculated for packages of these designs, based on the reduction in shielding that would be expected to occur in the thermal test (Table 5.1). Even if all of the shielding was vaporized, the dose rate would not exceed the 10 CFR 71 limit of 1,000 millirems per hour at three feet from the surface of the container.

5.5 Appendix

Keg Design Single Port Container Radiation Profile. Drawing # 297.03. (5.5.1)

Keg Design Dual Port Container Radiation Profile. Drawing # 297.04. (5.5.2).

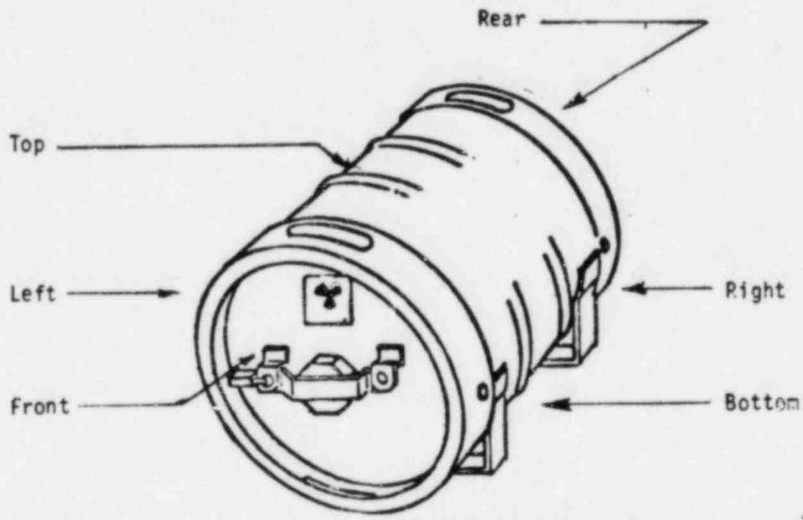
Revision 0
25 August 1982

5.5 Appendix

5.5.1 Keg Design Single Port Container Radiation Profile Drawing #297.03

REVISIONS

LTR	ZONE	DESCRIPTION	BY	DATE	APPVD
		Radiation Profile Model 3206A Serial Number 001			



Containing 19 Curies of Americium-241/Beryllium. Output: 3.8×10^{7} Neutrons/Second

Maximum Dose Rates (mrem/hr)

	@ Surface			@ 1 Meter		
	Gamma	Neutron	Total	Gamma	Neutron	Total
Top	15	120	135	0.5	7.5	8.0
Front	15	120	135	0.5	7.5	8.0
Right	15	120	135	0.5	7.5	8.0
Rear	10	70	80	0.5	4.5	5.0
Left	15	120	135	0.5	7.5	8.0
Bottom	15	120	135	0.5	7.5	8.0

TOLERANCES IN INCHES UNLESS NOTED OTHERWISE	SHEET 1	OF 2
.X±	CHKD.	DATE
.XX±	CHKD.	DATE
.XXX±	APPVD.	DATE
.X°±	APPVD.	DATE
DRAWING SIZE		

SCALE None
DATE 25 August 82
USAGE Single Source Container
DRAWN BY D.E.
REVISED
TITLE Keg Design Single Port Container Radiation Profile
PROJECT NO. 297/82 FVS
DRAWING NO. A 297.03

Amersham Corporation
2636 S Clearbrook Drive
Arlington Heights, Illinois 60005
(312) 593-6300

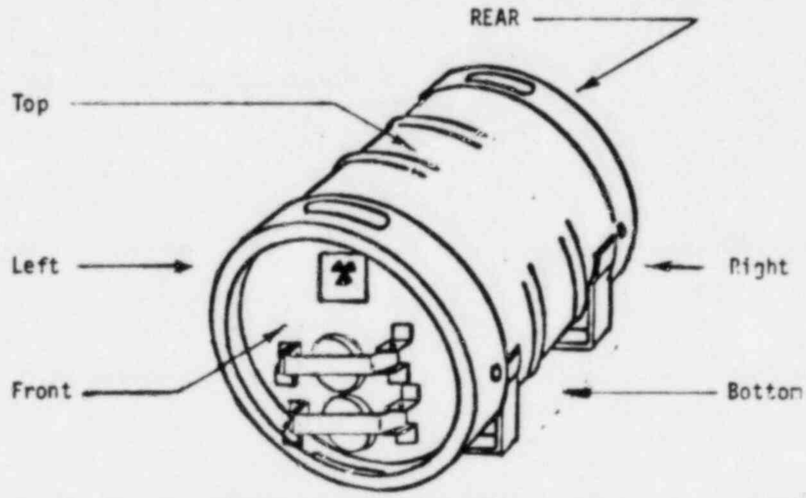
Amersham

5.5 Appendix

5.5.2 Keg Design Dual Port Container Profile Drawing #297.04

REVISIONS

LTR	ZONE	DESCRIPTION	BY	DATE	APPVD
		Radiation Profile Model 3218A Serial Number 002			



Containing 19.5 Curies of Americium-241/Beryllium. Output 3.8×10^7 Neutrons/Second.

Maximum Dose Rates (mrem/hr)

	@ Surface			@ 1 Meter		
	Gamma	Neutron	Total	Gamma	Neutron	Total
Top	19.5	109.3	128.8	1.1	7.3	8.4
Front	15.5	99.3	114.8	0.7	7.3	8.0
Right	19.5	109.3	128.8	1.1	7.3	8.4
Rear	7.5	54.3	61.8	0.6	6.3	6.9
Left	19.5	109.3	128.4	1.1	7.3	8.4
Bottom	19.5	109.3	128.4	1.1	7.3	8.4

TOLERANCES IN INCHES UNLESS NOTED OTHERWISE

.X± | .XX± | .XXX± | X°±

SHEET: 2 OF: 2

SCALE: None

DATE: 25 August 82

USAGE: Dual Source Container

DRAWN BY: D.E.

REVISED

CHKD. DATE

TITLE: Keg Design Dual Port Container Radiation Profile

CHKD. DATE

PROJECT NO.: 297/82 FVS

DRAWING NO.: A 297.04

APPVD. DATE

APPVD. DATE

DRAWING SIZE

Amersham Corporation
2636 S. Clearbrook Drive
Arlington Heights, Illinois 60005
(312) 593-6300

Amersham

6. Criticality

Not applicable.

Revision 0
25 August 1982

7. Operating Procedures

7.1 Procedures For Loading The Package

The sources are fabricated in appropriately shielded enclosures, keeping exposures to operators as low as reasonably achievable as is required by 10 CFR Part 20. All operations including welding, special form testing, and leak testing are performed in shielded enclosures. When a source has been found to meet all specifications, it is loaded into the custom designed nose plug or source holder and is transferred by the appropriate remote handling tool into the shipping/storage container. The source assembly is then securely placed into a stainless steel insert. Upon completion, the stainless steel encased WEP shielding plug is installed (as needed) and the screw cap is threaded hand tight plus ¼ turn onto the stainless steel support tube or insert. The latch bar is then placed into position and secured by the use of a key-operated padlock.

When loading is complete, a surface and 1 meter gamma and neutron radiation measurement is conducted to insure conformance with the radiation limits imposed in 49 CFR Part 172.

7.2 Procedure For Unloading The Package

The following procedure is employed in unloading a package.

1. Acquire the padlock key, unlock and remove padlock.
2. Rotate the latch bar to the open position.
3. Loosen and unscrew the threaded screw cap.
4. Using the appropriate remoting handling tool remove the stainless steel encased WEP shielding plug (as applicable).
5. Affix the appropriate remote handling tool to the source assembly.
6. Dislodge the source assembly from the insert and immediately upon removal, place the source assembly into an adequately shielded facility.
7. After source removal, check the container for contamination. The surface of the container must have no significant radioactive contamination as provided in 49 CFR 173.397(a).

8. Replace the stainless steel encased WEP shielding plug (as applicable), attach the threaded screw cap, and rotate the latch bar to the closed position.

9. Install and lock the padlock.

7.3 Preparation of an Empty Package For Transport

The following procedure is employed in preparatio. ^f an empty package for transport.

1. If the container is to be shipped empty, measure the dose rate at the surface of the container with appropriate gamma and neutron meters.

2. If the dose rate is less than 0.5 mrem/hr, deface the radioactive transport stickers and apply "empty" stickers.

3. If container has been found to be free of contamination (as defined in 49 CFR 173.397(a)), ship as non-radioactive material.

7.4 Appendix

Not applicable.

8. Acceptance Tests and Maintenance Program

8.1 Acceptance Tests

All containers of these designs will be manufactured and used accordance with Amersham Corporation's Quality Assurance Program which was submitted to the Nuclear Regulatory Commission on July 30, 1982.

8.1.1 Visual Inspection

The package is visually examined to insure proper assembly and that the package is correctly marked.

8.1.2 Structural and Pressure Tests

Prototypes of each special form design are tested to a minimum of 290 psi external pressure.

8.1.3 Leak Tests

Each radioactive source capsule will be subjected to the leak tests prescribed for special form sources in IAEA Safety Series No. 6, 1973 Edition and/or the USA Regulations in 49 CFR Part 173. Failure of any of these tests will prevent the use of the source capsule.

8.1.4 Component Tests

The lock assembly, consisting of a padlock(s), latch bar(s), and screw cap(s) is tested for fit and function to insure that the security of the container will be maintained. Failure of this test will prevent the use of the container until the lock assembly is corrected and retested.

8.1.5 Tests For Shielding Integrity

The radiation levels at the surface of the package and 1 meter from the surface are measured with a gamma and neutron meter. The resulting combined radiation readings must not exceed 200 millirems per hour at the surface and 10.0 millirems per hour at 1 meter. Failure of this test will prevent the use of the package.

8.1.6 Thermal Acceptance Test

Not applicable.

8.2 Maintenance Program

8.2.1 Structural and Pressure Tests

Not applicable.

8.2.2 Leak Tests

As described in Section 8.1.3, the radioactive source capsule is leak tested at manufacture.

8.2.3 Subsystem Maintenance

The lock assembly is tested as described in Section 8.1.4 prior to each use of the package.

8.2.4 Valves, Rupture Disks and Gaskets

Not applicable.

8.2.5 Shielding

Before shipment of a source, a radiation survey of the package is done to ensure that the radiation levels do not exceed 200 millirems per hour at the surface of the container and ten millirems per hour at one meter from the surface.

8.2.6 Thermal

Not applicable.

8.2.7 Miscellaneous

Not applicable.