Tech/Ops

Radiation Products Division
40 North Avenue
Burlington Massachusetts 01803
Telephone (617) 272-2000

29 October 1981

Mr. Charles E. MacDonald, Chief
Transportation Certification Branch
Division of Fuel Cycle and Material Safety
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. MacDonald:

We request issuance of a USNRC Certificate of Compliance of Radioactive Materials Package for Tech/Ops, Inc. Model 858 Type B Package. We are enclosing eight copies of the Safety Analysis Report for the Model 858 for your review. In accordance with 10CFR170.31, Item 11E, we are also enclosing a check for $200 for the application fee.

We are applying to the U.S. Department of Transportation for an International Atomic Energy Agency Certificate of Competent Authority for Type B(U) packaging under the 1973 Revised Edition of IAEA Safety Series No. 6. We ask that this package be reviewed for conformance to these requirements also.

We trust that this application satisfies your requirements for issuance of this certificate. If we can provide any additional information, please contact us.

Sincerely,

John J. Munro III
Technical Director

JJM/fb
Enclosures

19858

Tech/Ops

Radiation Products Division
40 North Avenue
Burlington, Massachusetts 01803
Telephone (617) 272-2000

29 October 1981

Mr. Richard R. Rawl, Chief
Radioactive Materials Branch
Office of Hazardous Materials Regulation
Materials Transportation Bureau
Research and Special Programs Administration
U.S. Department of Transportation
400 7th Street NW
Washington, DC 20590

Dear Mr. Rawl:

We request issuance of an International Atomic Energy Agency Certificate of Competent Authority for Type B(U) packaging under the 1973 Revised Edition of IAEA Safety Series No. 6 for Tech/Ops Model 858 Type B package.

We are enclosing a copy of the Safety Analysis Report for this package. We have filed a similar application with the U.S. Nuclear Regulatory Commission requesting issuance of a USNRC Certificate of Compliance for this package.

We trust this application provides the information necessary for your review. If we can provide any additional information, please contact us.

Sincerely,

John J. Munro III
Technical Director

JJM/fb
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Tech/Ops

Radiation Products Division
40 North Avenue
Burlington, Massachusetts 01803
Telephone (617) 272-2000

SAFETY ANALYSIS REPORT

TECH/OPS

MODEL 858

TYPE B(U) PACKAGE

1.0 General Information

1.1 Introduction

The Tech/Ops Model 858 is designed for use as a gamma ray projector and shipping container for Type B quantities of radioactive material in special form. The Model 858 is similar to Tech/Ops Model 680 (USA/9035/B(U)) and Tech/Ops Model 676 (USA/9029/B(U)).

The Model 858 conforms to the criteria for Type B packaging in accordance with 10CFR71 and satisfies the criteria for Type B(U) packaging in accordance with IAEA Safety Series No. 6, 1973. The source to be used in conjunction with the Model 858 is Tech/Ops sealed source assembly Model No. A424-14. The Model 858 will contain a maximum of 110 curies of cobalt-60 as special form.

1.2 Package Description

1.2.1 Packaging

The Model 858 is 14.62in (371mm) high, 21 inches (533mm) long and 12 inches (305mm) wide. The gross weight of the package is 502 pounds (228kg). The radioactive source assembly is stored in a zircalloy or titanium "S" tube in the geometric center of the package. The "S" tube is cast inside a depleted uranium shield assembly. The weight of the uranium shield is 327 pounds 149kg.

The shield is enclosed in a shell fabricated of ¼ inch (6.35mm) thick hot rolled steel. The shield is fixed in position within the shell by the retaining bar assembly and the collimator positioning tube. The void space between the shield and the shell is filled with a castable rigid polyurethane foam. Steel-uranium interfaces are separated with 0.010 inch (0.254mm) thick copper separators.

Attached to the sides of the container are 0.50 inch 12.7mm thick hot rolled steel side frames which are welded to the shell using a ¼ inch fillet weld.

Mounted at each end of the "S" tube are positioning devices. The source assembly is locked in position by means of the control cable connector and additionally secured by means of a shipping plug. A protective shipping plate (¼ inch thick steel) is mounted over the control cable connector assembly.

Tamperproof seals are provided during shipment of these sources. Assembly joints which are not leak-tight and two one inch diameter pour holes provide passageways for the escape of any gas generated from decomposition of the potting foam in the event the projector is involved in a fire accident. The outer packaging is designed to avoid the collection and retention of water. The package is painted and finished to provide for easy decontamination. The radioactive material is sealed inside a source capsule, which is the containment vessel of the package.

The Model 858 is similar to the Model 676 which has been approved for use as a Type B package under USNRC Certificate of Compliance No. 9029 and is also similar to the Model 680 which has been previously approved for use as a Type B package under USNRC Certificate of Compliance No. 9035.

1.2.2 Operational Features

The source assembly is secured in the proper position by the control cable connector and lock assembly. This assembly requires a key for operation, and thus provides positive closure. A ¼ inch (6.35mm) thick steel shipping plate is used to protect the assembly during shipment. Additionally, the source assembly is secured by means of a shipping plug inserted in the opposite end of the "S" tube.

1.2.3 Contents of Packaging

The Model 858 is designed for a capacity of up to 110 curies of cobalt-60 as Tech/Ops Source Assembly A424-14. The source assembly is in special form as prescribed in 10CFR71 and IAEA Safety Series No. 6, 1973.

1.3 APPENDIX

- Descriptive Assembly Drawings, Model 858

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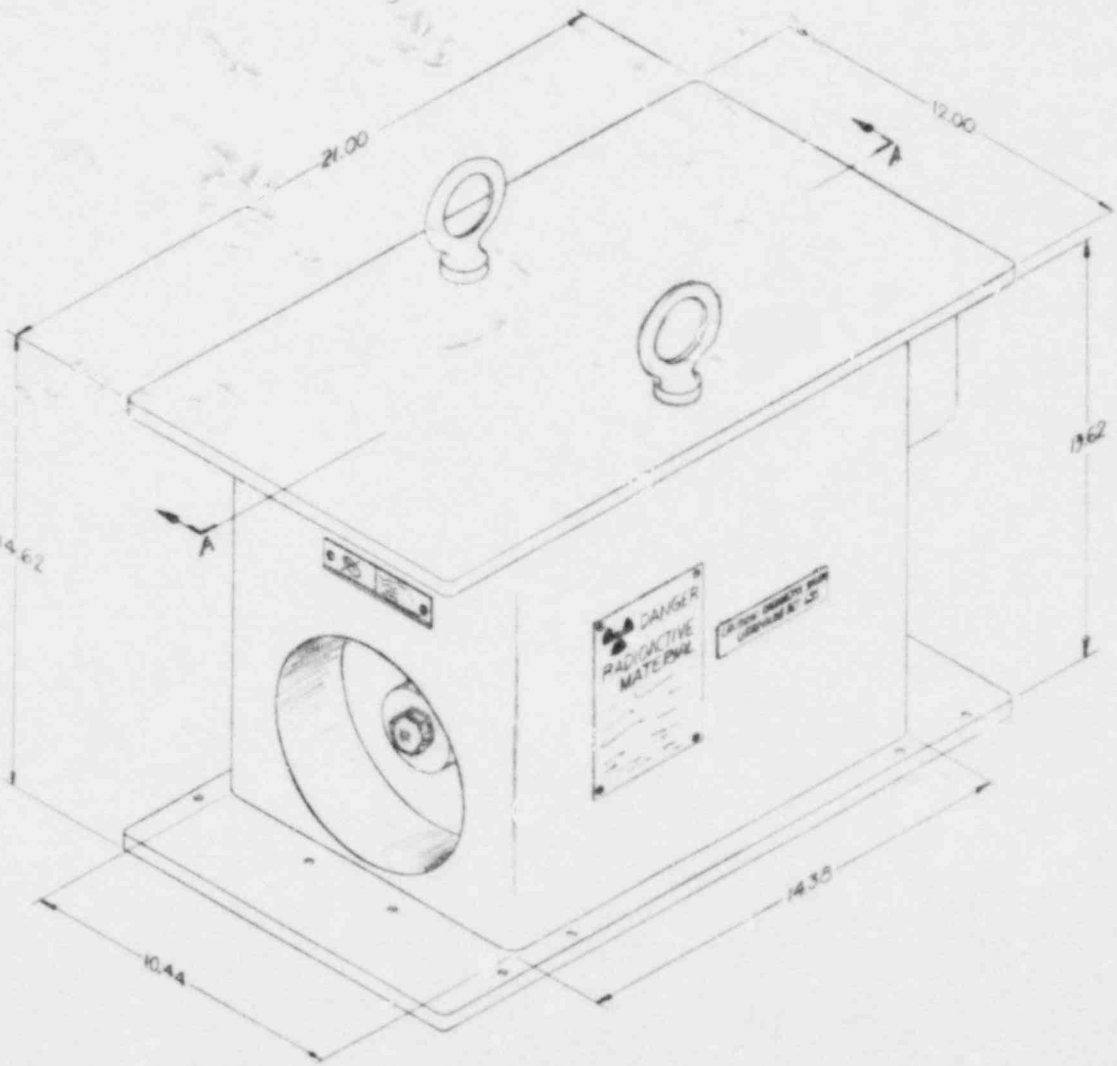
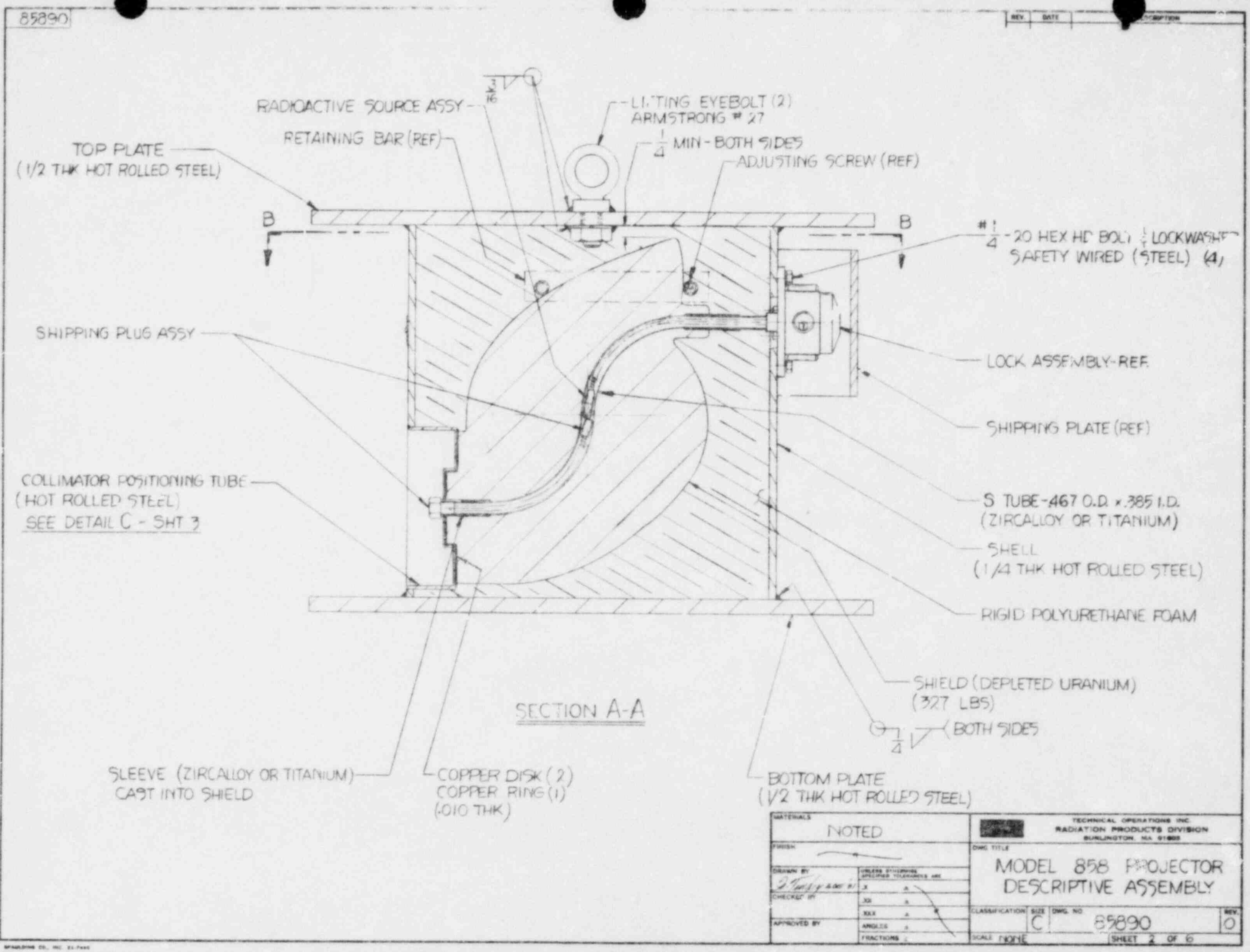
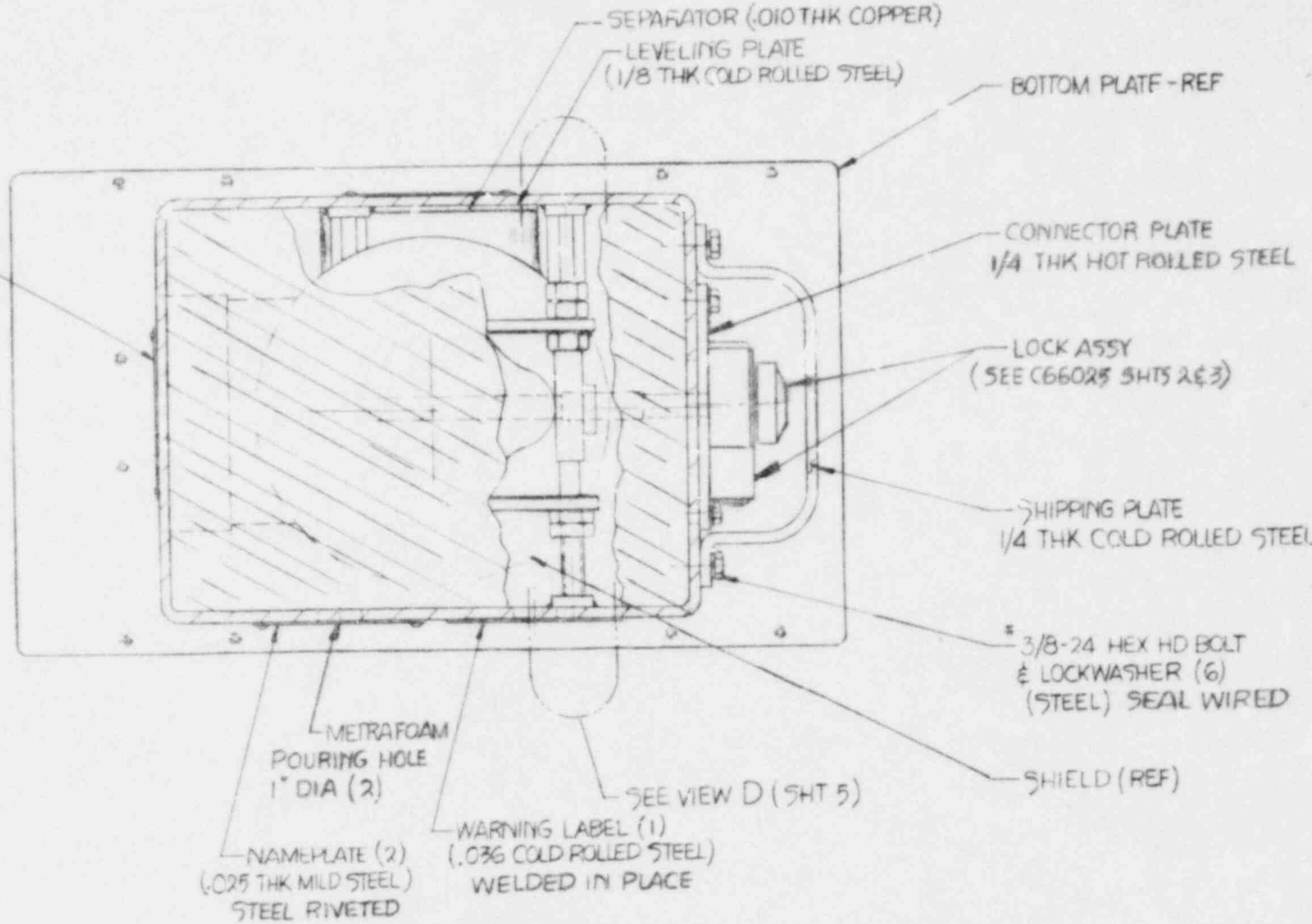
29 Oct 1981



SEE SHEETS 2-5	MODEL 858 PROJECTOR DESCRIPTIVE ASSEMBLY
	85890

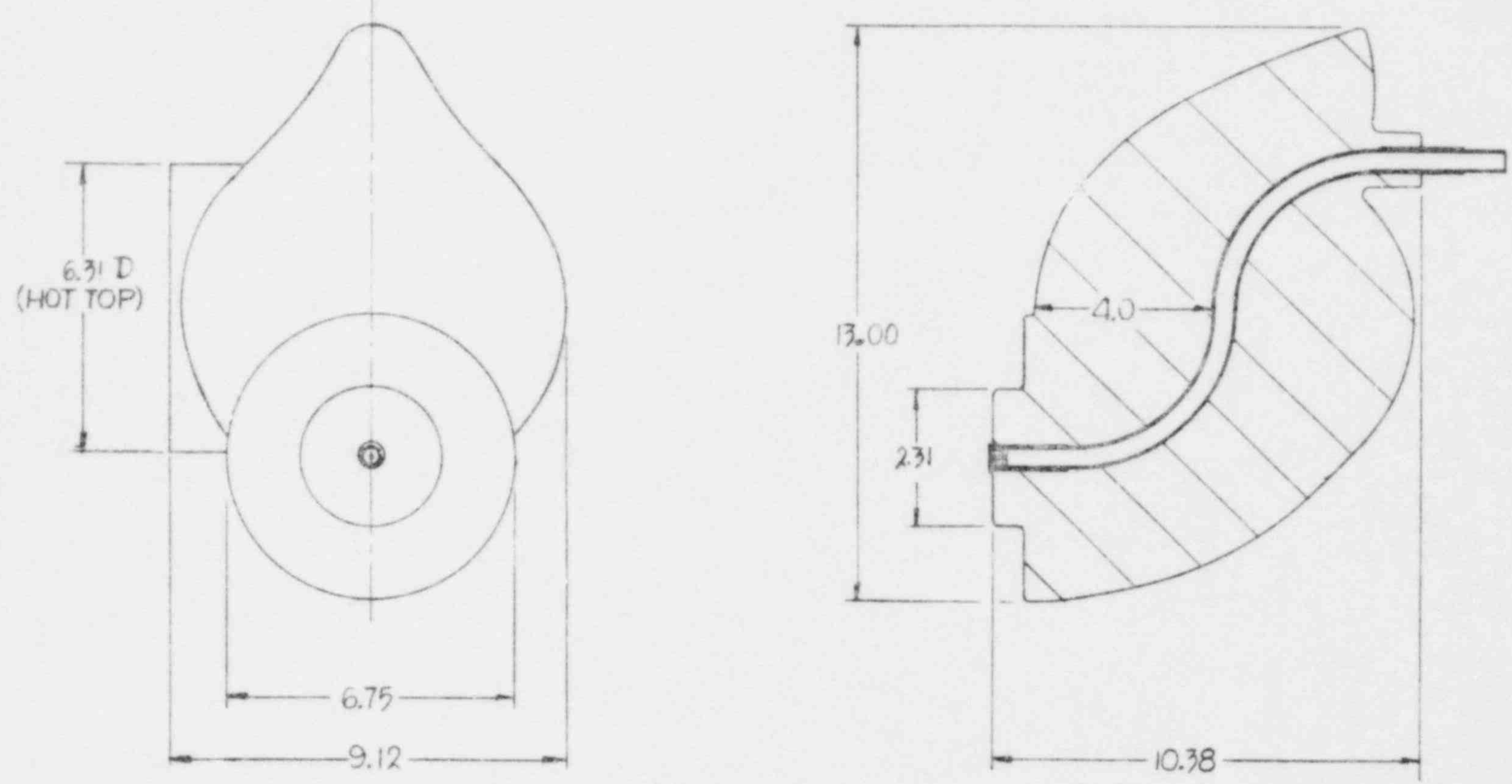

85890
REV
DATE
DESCRIPTION
RADIOACTIVE SOURCE ASSY
3/16
LIFTING EYEBOLT (2)
ARMSTRONG # 27
RETAINING BAR (REF)
1/4 MIN - BOTH SIDES
ADJUSTING SCREW (REF)
TOP PLATE
(1/2 THK HOT ROLLED STEEL)
B
B
#1/4 -20 HEX HD BOLT 1/4 LOCKWASHER
SAFETY WIRED (STEEL) (4)
SHIPPING PLUG ASSY
LOCK ASSEMBLY-REF
SHIPPING PLATE (REF)
COLLIMATOR POSITIONING TUBE
(HOT ROLLED STEEL)
SEE DETAIL C - SHT 3
S TUBE -467 O.D. x .385 I.D.
(ZIRCALLOY OR TITANIUM)
SHELL
(1/4 THK HOT ROLLED STEEL)
RIGID POLYURETHANE FOAM
SHIELD (DEPLETED URANIUM)
(327 LBS)
SECTION A-A
1/4 BOTH SIDES
SLEEVE (ZIRCALLOY OR TITANIUM)
CAST INTO SHIELD
COPPER DISK (2)
COPPER RING (1)
(.010 THK)
BOTTOM PLATE
(1/2 THK HOT ROLLED STEEL)
MATERIALS
NOTED
FINISH
DRAWN BY
CHECKED BY
APPROVED BY
UNLESS OTHERWISE SPECIFIED TOLERANCES ARE
.X
.XX
.XXX
ANGLES
FRACTIONS
TECHNICAL OPERATIONS INC.
RADIATION PRODUCTS DIVISION
BURLINGTON, MA 01803
DWG TITLE
MODEL 858 PROJECTOR
DESCRIPTIVE ASSEMBLY
CLASSIFICATION
SIZE
C
DWG. NO.
85890
REV.
0
SCALE NONE
SHEET 2 OF 6



SECTION B-B

MATERIALS: NOTED	TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803
FINISH	DWG TITLE: MODEL 858 PROJECTOR DESCRIPTIVE ASSEMBLY
DRAWN BY	CLASSIFICATION / SIZE: C / DWG. NO: 85890 / REV: 0
CHECKED BY	SCALE / SHEET 3 OF 6
APPROVED BY	

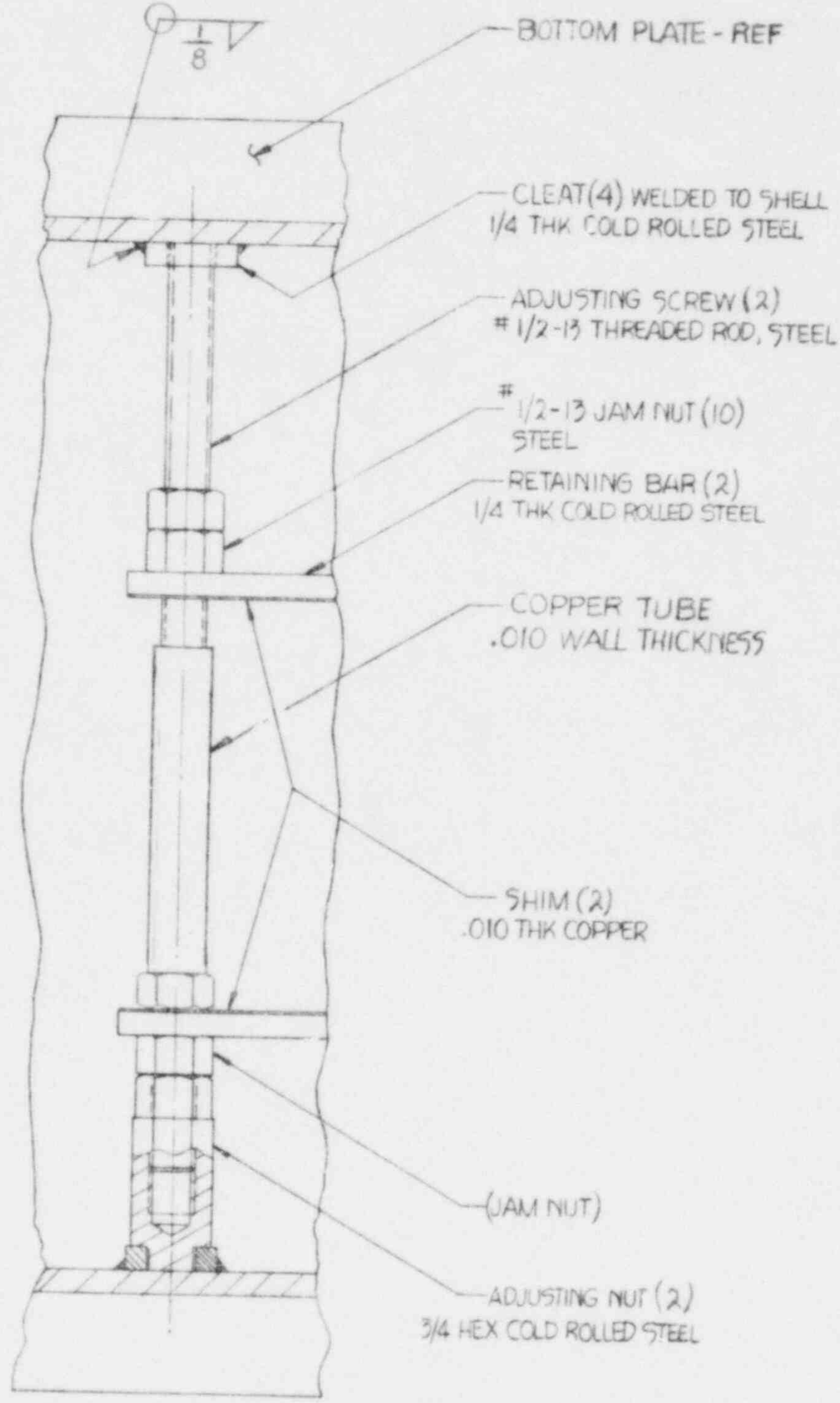
1-6



SHIELD DATA

327 LBS

MATERIALS: SEE SHT 2	TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803
DWG TITLE	MODEL 858 PROJECTOR DESCRIPTIVE ASSEMBLY
SIZE	C
DWG. NO	85890
REV	0



VIEW D

ROTATED 180°

SCALE: 1/1

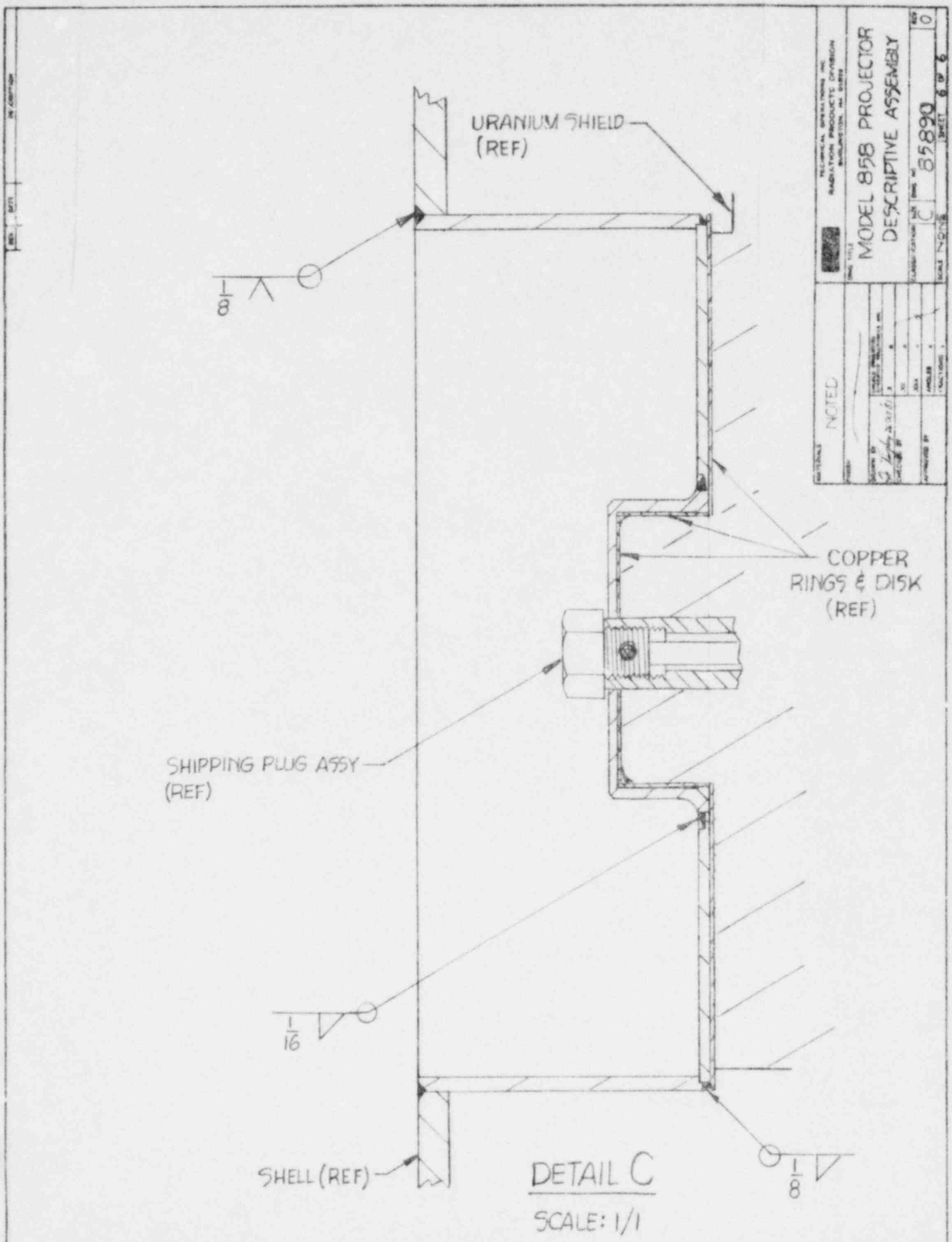
TECHNICAL OPERATIONS INC.
RADIATION PRODUCTS DIVISION
BURLINGTON, MA 01803

MATERIALS: NOTED

DWG TITLE: MODEL 858 PROJECTOR DESCRIPTIVE ASSEMBLY

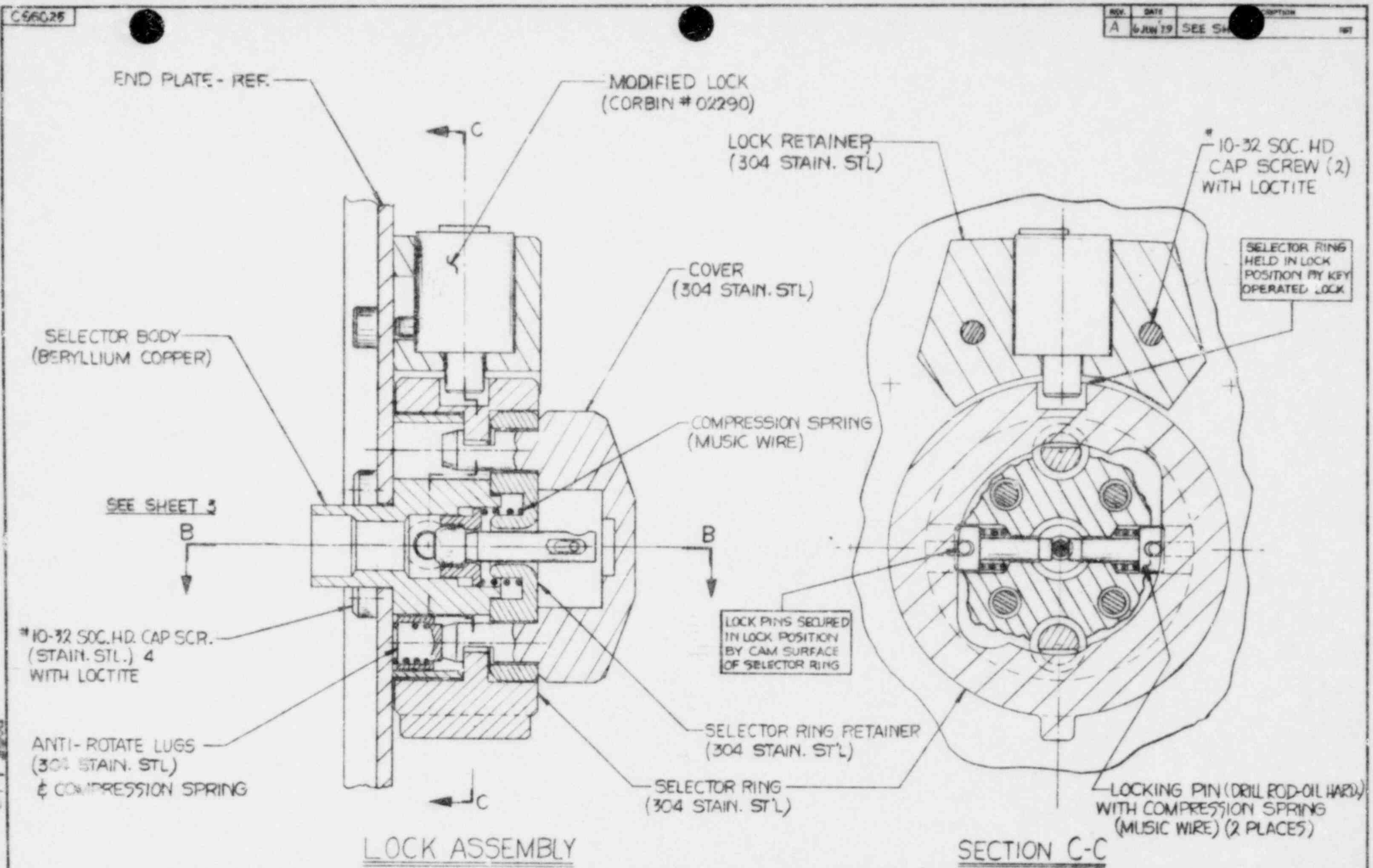
SIZE: C DWG NO: 85890 REV: 0

SCALE: 1:1 SHEET 5 OF 6



DETAIL C

SCALE: 1/1



MATERIALS: NOTED

FINISH: —

DRAWN BY: 6-27-78

CHECKED BY:

APPROVED BY:

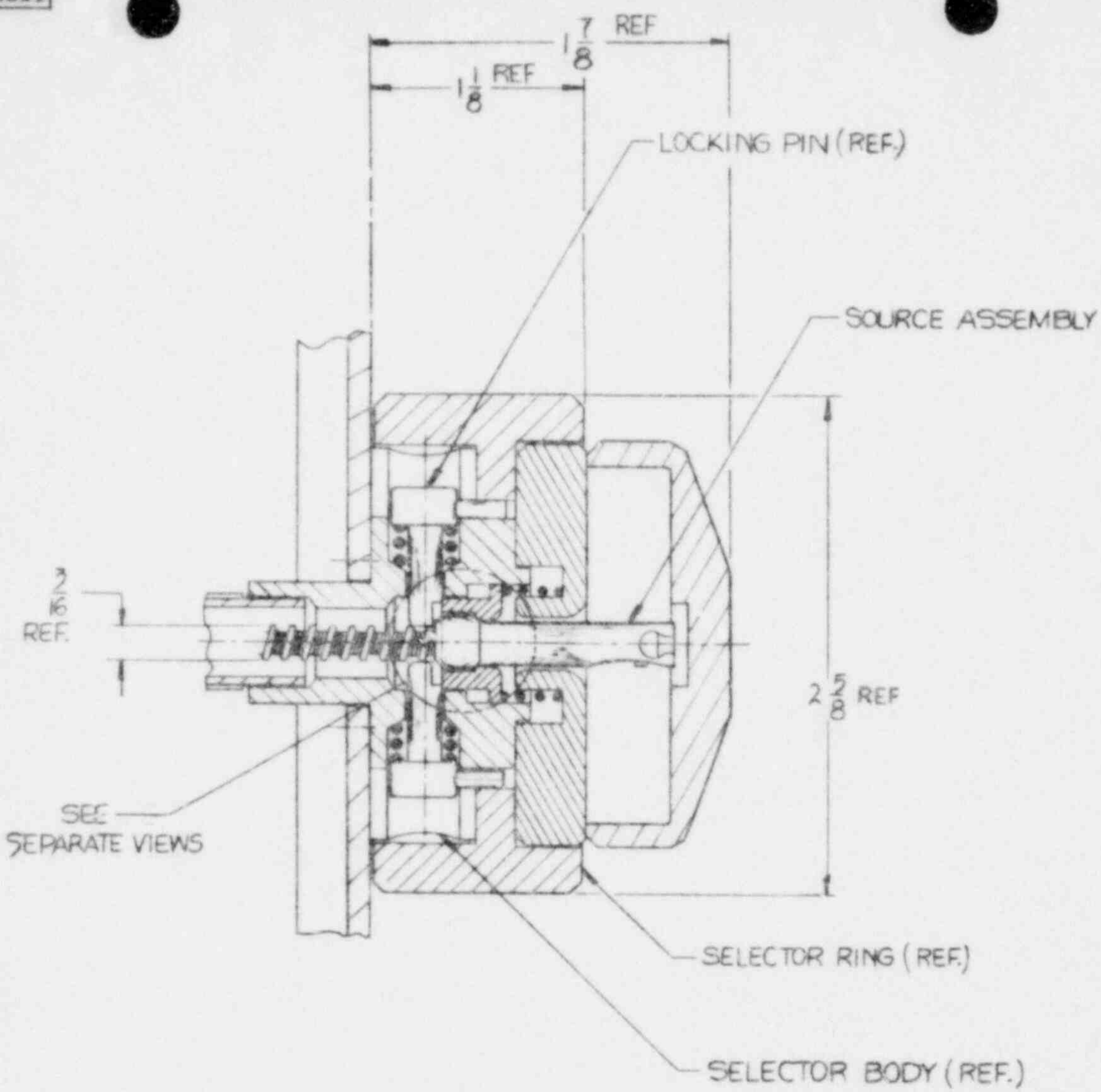
TECHNICAL OPERATIONS INC.
RADIATION PRODUCTS DIVISION
BURLINGTON, MA 01803

DWG TITLE: MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY

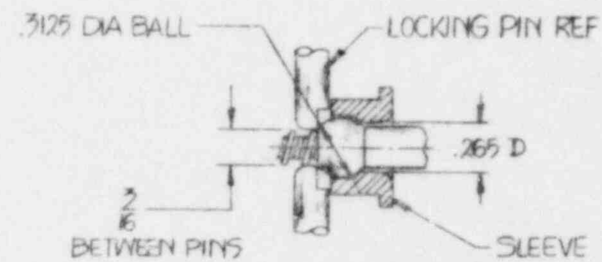
SIZE: C — DWG. NO. 66025 — REV. A

C66025

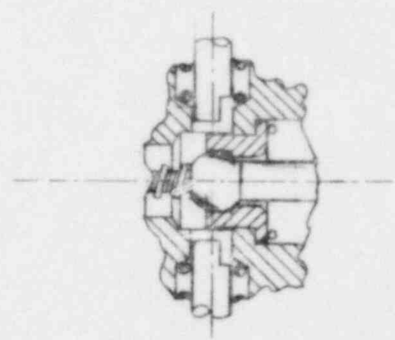
REV.	DATE	DESCRIPTION
A	6-18N 79	SEE S[illegible]



SECTION B-B



LOCKED POSITION



UNLOCKED POSITION

PAGE 1-11

MATERIALS NOTED	TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803
FINISH	DWG TITLE MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY
DRAWN BY [signature] 6-27-78 / CHECKED BY / APPROVED BY	CLASSIFICATION / SIZE C / DWG. NO. 66025 / REV. A

2. Structural Evaluation

2.1 Structural Design

2.1.1 Discussion

Structurally the Model 858 consists of five components: a source capsule, shield assembly, outer shell, side frames and lock assembly. The source capsule is the primary containment vessel. It meets the requirements for special form radioactive material as outlined in 10CFR71 (see Section 2.8). The shield is 327 pounds (149kg) of depleted uranium. The shield assembly fulfills two functions. it provides shielding for the radioactive material and, together with the positioning mechanisms insures proper positioning of the source. The shield assembly is supported on one end with retaining bars which are forced together by means of hex nuts threaded on adjusting screws. The adjusting screws and retaining bars are secured with jam nuts. The shield is supported on the opposite end by the collimator positioning tube. The entire shield assembly is potted in a castable rigid polyurethane foam and encased in a ¼ inch (6.35mm) thick hot rolled steel shell. Steel-uranium interfaces are separated with copper. Attached to the shell are side frames made of 0.50 inch (12.7mm) thick steel which are welded to the shell. The key operated lock assembly and control cable connector secure the source in the shielded position. A ¼ inch (6.35mm) thick steel shipping cover plate is installed to protect the lock from damage. Positive proof of source position is evidenced by the use of seal wire on this shipping cover plate.

2.1.2 Design Criteria

The Model 858 is designed to comply with the requirements of 10CFR71 and IAEA Safety Series No. 6, 1973. The device is simple in design, such that there are no design criteria which cannot be evaluated by straight-forward application of the appropriate section of 10CFR71 or IAEA Safety Series No. 6, 1973.

2.2 Weights and Centers of Gravity

The Model 858 projector weighs 502 pounds (228kg). The shield assembly contains 327 pounds (149kg) of depleted uranium. The center of gravity is located approximately at the geometric center of the package.

2.3 Mechanical Properties of Materials

The Model 858 gamma ray projector shell is made of hot rolled steel. This material has a yield strength of 40,000 pounds per square inch (276MN/m^2). (Reference: Machinery's Handbook, 20th Edition, 1976, p. 452).

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2.4 General Standards for All Packages

2.4.1 Chemical and Galvanic Reactions

The materials used in the construction of the Model 858 gamma ray projector are uranium metal, steel, beryllium copper, bronze, copper, and zircalloy or titanium. There will be no significant chemical or galvanic action between any of these components.

The possibility of the formation of the eutectic alloy of iron uranium at temperatures below the melting temperatures of the individual metals was considered. The iron uranium eutectic alloy temperature is approximately 1337°F (725°). However, vacuum conditions and extreme cleanliness of the surfaces are necessary to produce the alloy at this low temperature. Due to the conditions under which the shields are mounted, sufficient contact for this effect does not exist.

In support of this conclusion, the following test results are presented. A thermal test of a sample of bare depleted uranium metal was performed by Nuclear Metals, Inc. The test indicated that the uranium sample oxidized such that the radial dimension was reduced by 1/32 inch. A subsequent test was performed in which a sample of bare, depleted uranium metal was placed on a steel plate and subjected to the thermal test conditions. The test showed no alloying or melting characteristics in the sample, and the degree of oxidation was the same as evidenced in the first test. A copy of the test report appears in Section 2.10.

Although the likelihood of the formation of an iron-uranium eutectic alloy is remote, copper separators are used at steel-uranium interfaces.

2.4.2 Positive Closure

The Model 858 source cannot be exposed without opening a key-operated lock. Access to the lock requires the removal of the shipping cover plate. Additionally, this shipping cover plate is seal wired and provided with a tamperproof seal.

2.4.3 Lifting Devices

The Model 858 is designed to be lifted by two eyebolts, Armstrong No. 27. These eyebolts are fastened through the container end plate by 5/8 - 11 nuts. Both the nut and the eyebolt shoulder are welded to the container endplate by a 3/16 inch fillet weld all around.

The root diameter of a 5/8 - 11 thread is 0.5135 in. Therefore, the root area is 0.207 in^2. Assuming that the material has a yield point of 40,000psi, each eyebolt can support 8,280 pounds without exceeding the yield strength of the material. This is more than 16 times the weight of the package. Therefore, the lifting is capable of supporting more than three times the weight of the package as prescribed in 10CFR71.31(c).

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2.4.4 Tiedown Devices

The tiedown devices on the Model 858 are the eyebolts. As shown in the above analysis, these eyebolts can withstand the load combination of 10CFR71.31 without exceeding the yield strength of the material.

2.5 Standards for Type B and Large Quantity Packages

2.5.1 Load Resistance

Considering the package as a simple beam supported on both ends with a uniform load of 5 times the package weight evenly distributed along its length, the maximum stress can be computed from:

$$S = \frac{Fl}{8Z}$$

where: F: total load (2510 pounds)

l: length of beam (21 inches)

Z: section modulus of beam (85.6 in^3)

(Reference: Machinery's Handbook, 21st ed., 1979, p. 404)

Thus, the maximum stress generated in the beam is 77.0 pounds per square inch (532kN/m^2), which is far below the yield strength of the material, 40,000psi (276MN/m^2).

2.5.2 External Pressure

The Model 858 is open to the atmosphere; thus, there will be no differential pressure acting on it. The collapsing pressure of the source capsules can be found:

$$P = 86,670 \frac{t}{D} - 1386$$

where: P: collapsing pressure in pounds per square inch

t: wall thickness in inches (0.020 inch)

D: outside diameter in inches (0.25 inch)

(Reference: Machinery's Handbook, 21st ed., 1979, p. 440)

The collapsing pressure of the capsules is calculated to be 5550 pounds per square inch (38.3MN/m^2). Therefore, the capsule can withstand an external pressure of 25psig.

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2.6 Normal Conditions of Transport

2.6.1 Heat

The thermal evaluation is performed in Chapter 3 of this application. From this evaluation, it can be concluded that the Model 858 can withstand the normal heat transport conditions.

2.6.2 Cold

The metals used in the manufacture of the Model 858 can all withstand temperatures of -40^0F (-40^0C). The lower operating limit of the polyurethane foam is -100^0F (-73^0C). Thus, it is concluded that the Model 858 will withstand the normal transport cold conditions.

2.6.3 Pressure

The Model 858 is open to the atmosphere; thus, there will be no differential pressure acting on it. In Section 3.5.4, the source capsules are demonstrated to be able to withstand an external pressure reduction of 0.5 atmospheres (50.7kN/m^2).

2.6.4 Vibration

The Model 858 is similar to Tech/Ops Model 680 which has been in use for eleven years. During that time there has never been a vibrational failure reported. Thus, we contend the Model 858 will not undergo a vibrational failure in transport.

2.6.5 Water Spray Test

The water spray test was not actually performed on the Model 858. We contend that the materials used in construction of the Model 858 are all highly water resistant and that exposure to water will not reduce the shielding or affect the structural integrity of the package.

2.6.6 Free Drop

The drop analysis performed in hypothetical accident conditions (see Section 2.7.1) is sufficient to satisfy the requirements outlined for the normal transport free drop condition in 10CFR71 and IAEA Safety Series No. 6, 1973. On this basis, we conclude that the Model 858 can withstand the free drop without impairment of the shielding or package integrity.

2.6.7 Corner Drop

Not Applicable

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2.6.8 Penetration

A penetration test of the Model 858 was not actually performed. However, the similar Model 684 was subjected to the penetration test with no resultant loss of shielding or package integrity (a copy of the test report is enclosed in Section 2.10). The following analysis demonstrates that the maximum damage exhibited by the Model 858 due to the penetration test is less than that of the Model 684.

The maximum stress observed in a flat rectangular plate supported on all edges due to concentrated central loading is:

$$\sigma = \frac{0.62F}{t^2}\left[\ln\left(\frac{L}{2r_o}\right) + 0.577\right]$$

where: F : total load

t : thickness of plate (inches)

L : length of longest side (inches)

r_o: 0.325t (inches)

(Reference: Machinery's Handbook, 21st ed., 1979, p. 436)

The appropriate dimensions for the Model 858 and Model 684 are:

	Model 858	Model 684
t	0.25 inch (6.35mm)	0.1875 in. (4.76mm)
L	21 inch (533mm)	17 in. (432mm)
r_o	0.0813 in. (2.06mm)	0.0609 in. (1.55mm)

The calculated stress for the Model 858 is 54.0F; for the Model 684, it is 97.3F. In both cases the load F (40 inch drop of a 13 pound hemispherical billet) and the material of construction (hot rolled steel) are the same. The maximum stress, and thus the maximum damage, to the flat plate occurs in the Model 684. The shipping plate which protects the lock mechanism is the same in the two models. As the Model 684 successfully withstood the penetration condition, we conclude that the Model 858 will undergo the penetration test with no loss of structural integrity or shielding. (A copy of the test report for the Model 684 is enclosed in Section 2.10).

2.6.9 Compression

The gross weight of the Model 858 is 502 pounds (228kg). The maximum cross-sectional area of the package is 307 square inches ($0.20m^2$). Thus two pounds per square inch times the cross-sectional area (614 pounds, (279kg) is less than five times the package weight, 2510 pounds (1141kg). For this analysis, the load will be taken to be 2510 pounds.

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The maximum stress generated in a flat rectangular steel plate with all edges fixed and a load distributed uniformly over the surface of the plate can be computed from:

$$S = \frac{0.5\ F}{t^2 \left[\frac{l}{w} + 0.623 \left(\frac{l}{w} \right)^5 \right]}$$

where:
- S: maximum stress
- F: total load (2510 pounds)
- t: thickness of plate (0.25 inches)
- w: width of plate (14.6 inches)
- l: length of plate (21 inches)

(Reference: Machinery's Handbook, 21st ed., 1979, p. 436)

From this relationship, the maximum stress generated in the plate is 3807 pounds per square inch ($26.3 MN/m^2$). This figure is greatly below the yield strength of the material, 40,000 pounds per square inch ($276 MN/m^2$). Thus, it can be concluded that compression will not adversely affect the package.

2.7 Hypothetical Accident Conditions

2.7.1 Free Drop

The Model 858 was not actually submitted to the 30 foot drop test. However, the Model 672 was submitted to the drop test (the test report appears in Section 2.10). The Model 858 has approximately the same weight and is constructed from the same materials as the Model 672.

	Model 672	Model 858
Length	24 inches (610mm)	21 inches (533mm)
Width	14 inches (356mm)	14.6 inches (371mm)
Height	12.5 inches (318mm)	12 inches (305mm)
Weight of Shield	401 lbs. (182kg)	327 lbs. (149kg)
Gross Weight of Container	580 lbs. (264kg)	502 lbs. (228kg)
Side Frame Material	1 in (25mm) thick hot rolled steel	0.5 inch thick (13mm) hot rolled steel
Shell Material	¼ inch thick (6.35mm) steel	¼ inch thick (6.35mm) hot rolled steel

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29 Oct 1981

Based on the satisfactory performance of the Model 672, we conclude that the Model 858 will undergo no loss of shielding or structural integrity as a result of the 30 foot free drop test.

2.7.2 Puncture

The Model 858 was not submitted to the puncture test of 10CFR71. However, the similar Model 676 was submitted to the puncture test.

There was no resultant damage to the container, nor reduction in shielding. (A copy of the test report appears in Section 2.10). The shipping plate used in the Model 858 is the same as that used in the Model 676. The Model 676 puncture test report (included in Section 2.10) shows that the shipping plate withstood the puncture test. On this basis, we conclude that the Model 858 can successfully withstand the puncture condition of 10CFR71.

2.7.3 Thermal

The thermal analysis is presented in Section 3.5. There it is shown that the melting point of the materials, except the potting compound, used in the construction of Model 858 are all greater than 1475^{0}F (800^{0}C).

Thus, it is concluded that the Model 858 satisfactorily meets the requirements for the hypothetical accident-thermal evaluation as set forth in 10CFR71.

2.7.4 Water Immersion

Not Applicable

2.7.5 Summary of Damage

The tests designed to induce mechanical stress (drop, puncture) would cause minor deformation, but no reduction in the safety features of the package. The thermal test will result in no reduction of the safety of the package. It can be concluded that the hypothetical accident conditions have no adverse effect on the shielding effectiveness and structural integrity of the package.

2.8 Special Form

The Model 858 gamma ray projector is designed for use with Tech/Ops source assembly A424-14. This source assembly has been previously certified as special form radioactive material. (IAEA Certificate of Competent Authority No. USA/0165/S, see Section 2.10). We contend that this certificate is sufficient evidence that the requirements for special form radioactive materials, as established in IAEA Safety Series No. 6, 1973 are satisfied.

2.9 Fuel Rods

Not Applicable

2.10 APPENDIX

- Nuclear Metals, Inc., Test Report: Iron Uranium Alloying
- Test Report: Penetration Test, Model 684
- Test Report: Drop and Puncture Tests, Model 672
- Test Report: Puncture Test, Model 676
- Descriptive Assembly Drawings, Source Assembly
- IAEA Certificate of Competent Authority No. USA/0165/S

NUCLEAR METALS, INC.

2229 MAIN STREET
CONCORD, MASSACHUSETTS 01742

28 January 1974

Technical Operations, Inc.
Radiation Products Division
South Avenue
Burlington, Massachusetts 01803

Attention: Mr. J. Lima

Gentlemen:

In response to a request by Joe Lima of Tech Ops, a simulated fire test was performed on samples of bare depleted uranium in contact with mild steel, the object being to determine what, if any, alloying or melting would occur under these conditions.

TEST DATA:

A 3/4-inch diameter x 5/8-inch long bare depleted uranium specimen was set on a 1-inch diameter x 1/8-inch thick mild steel plate, placed in a thin wall ceramic crucible. A mild steel cover plate was used on top of the crucible to act as a partial air seal. The crucible was loaded in a preheated 1450°F resistance heated furnace, held for 35 minutes, then removed and allowed to air cool under a ventilated hood.

RESULTS:

No reaction was evidenced between the two metals. Both separated readily and showed no alloying or melting characteristics.

Oxidation of the uranium was about the same degree as that reported to Joe Lima on an earlier experiment.

The test was performed by NMI on 25 January 1974.

Very truly yours,

John G. Powers

John G. Powers
Project Engineer

REVISION O
29 Oct 1981

TEST REPORT RADIATION PRODUCTS DIVISION

BY: John J. Munro III

DATE: 5 September 1979

SUBJECT: Model 684 Penetration Test

On 5 September 1979, a penetration test was performed on a Technical Operations Model 684 Shipping Container in accordance with 10CFR71 Appendix A.8 and IAEA Safety Series No. 6, 1973, paragraphs 714a and 714b.

The hemispherical end of a vertical steel cylinder 1.25 inch in diameter weighing 14 pounds was dropped from the height of 40 inches onto the geometric center of the bottom surface of the Model 684. There was no deformation and no damage which would affect the shielding or structural integrity of the package.

A second test was conducted using the same cylinder. It was dropped from the height of 40 inches onto the shipping plate. There was no deformation and no damage which would affect the shielding or structural integrity of the package.

Documentry photographs are enclosed.

Performed by

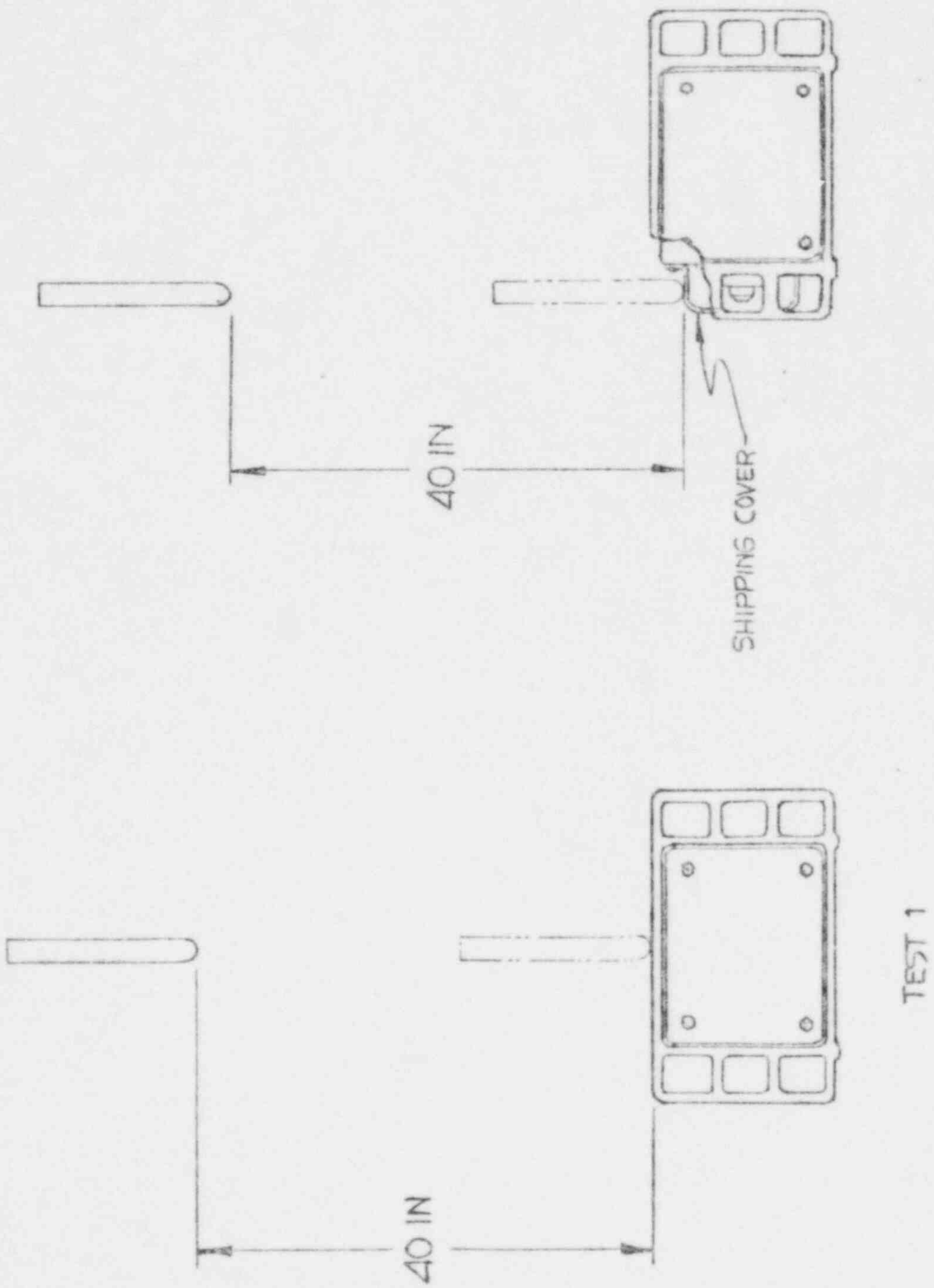
John J. Munro III

Witnessed by

Angelo Kiklis

REVISION O

29 Oct 1981

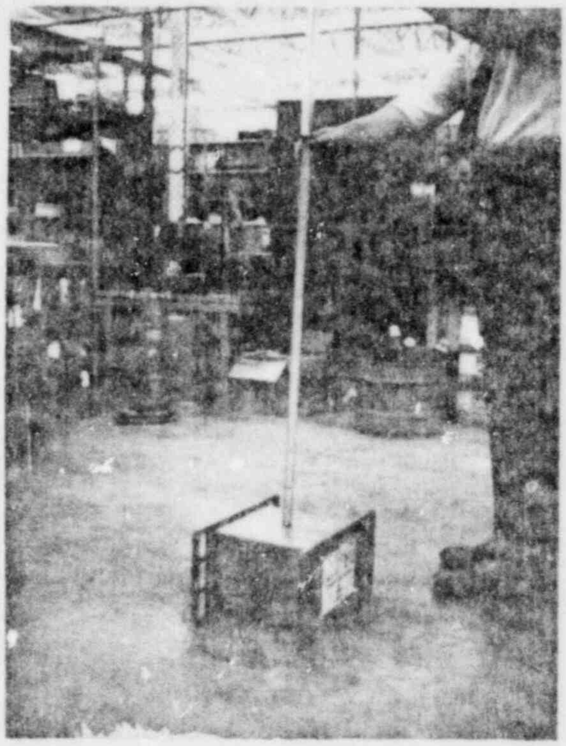


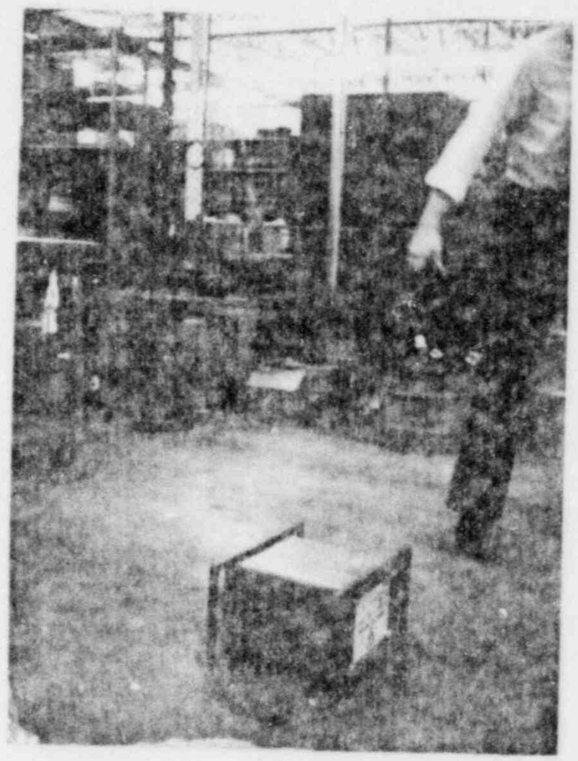
PENETRATION TEST

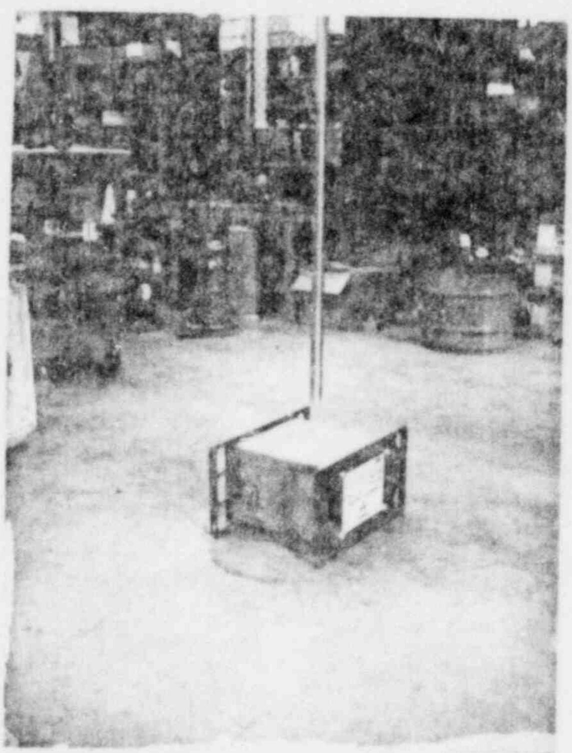
MODEL 684

REVISION O

29 Oct 1981







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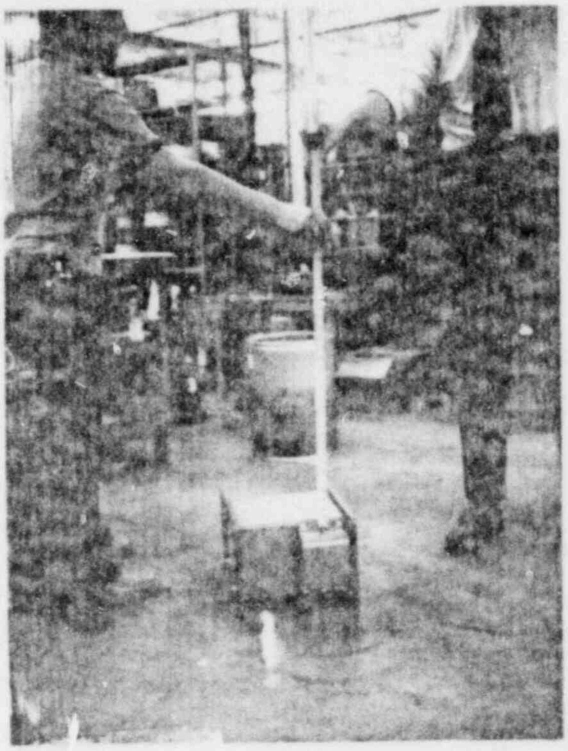

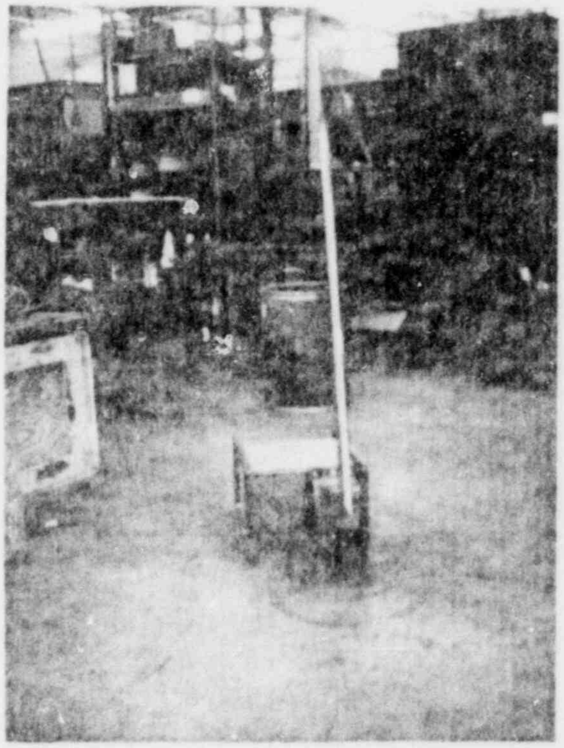

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TEST REPORT

DESCRIPTION: Model 672 - 30' Drop DATE March 18, 1970

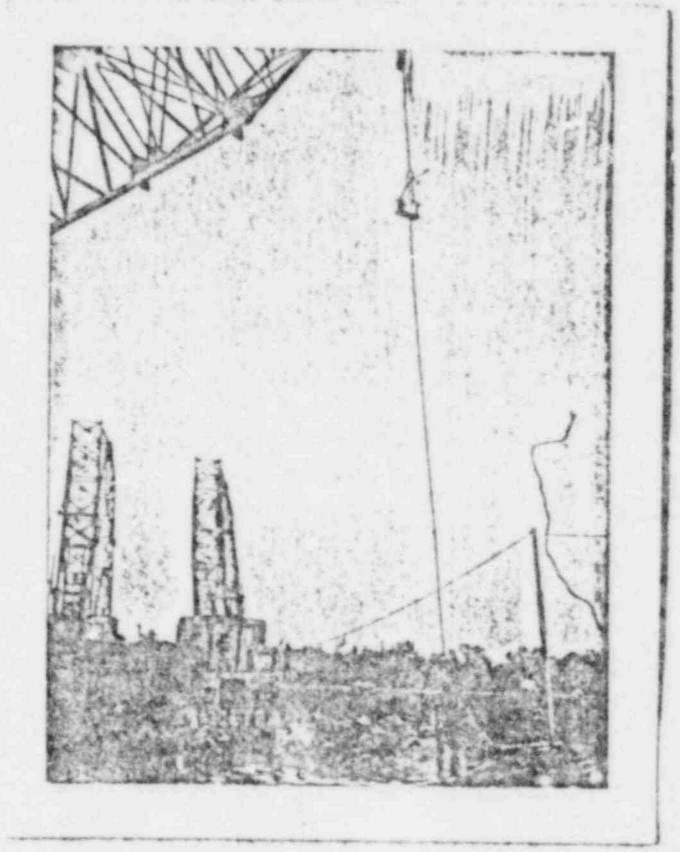
The first drop test landed on the right rear corner of the side plate and was bent in 1-1/2" and forward 1/2". No other damage was sustained.

The second drop test landed on the left side of the side plate breaking 2/3 of the weld and was bent in 1". The Source Tube remained straight and the front nut turned freely.

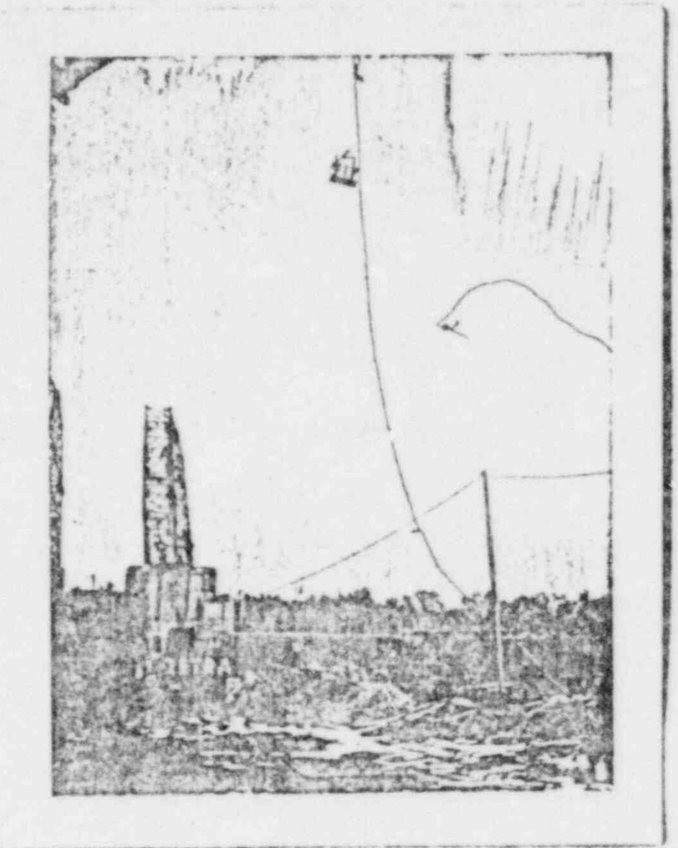
The puncture test (41" drop on to a 6" dia. steel billet) left a slight mark on the skin.

CONCLUSION:

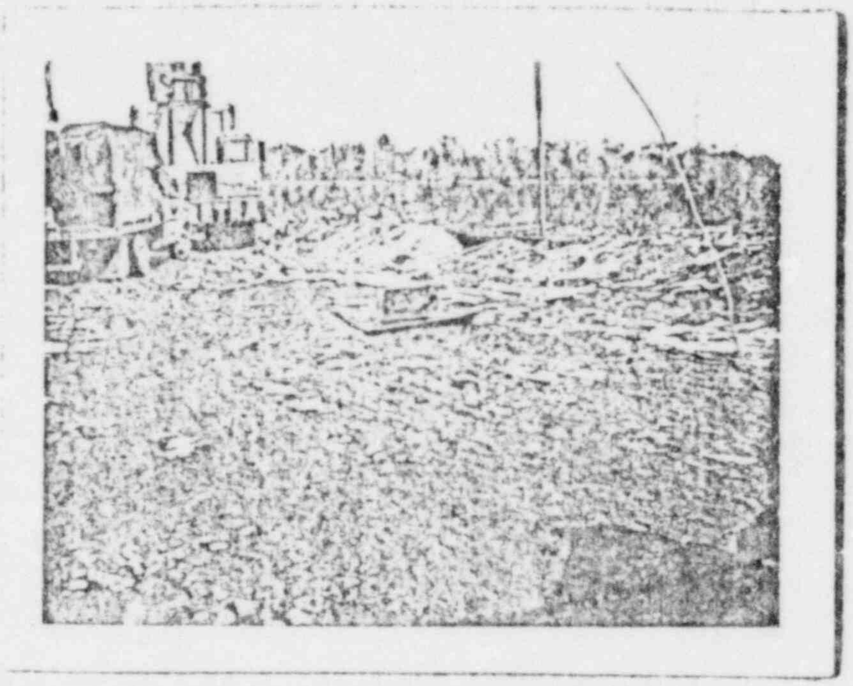
BY Richard Evans WITNESSED BY Fred Hauser



MODEL 672 BEING RAISED TO 30 FEET FOR DROP TEST



MODEL 672 DROPPING FROM 30 FEET ONTO STEEL PLATE



MODEL 672 UPON IMPACT ON STEEL PLATE AFTER BEING DROPPED THROUGH 30 FEET

TEST REPORT

DESCRIPTION: DATE 9 December 1974

Puncture Test of Model 676 Container Connector

A Model 676 Gamma Ray Projector with Shipping Plate installed was dropped from a height of 40 inches onto a six inch diameter, eight inch high steel Billet as shown in Figure 1 a. The Container impacted on the Shipping Plate as shown in Figure 1 b.

CONCLUSION:

No damage to the container, shipping plate or control cable connector resulted. There was no reduction of shielding effectiveness nor loss of Radioactive Material.

BY Don Brasseur WITNESSED BY John J. Munro 111

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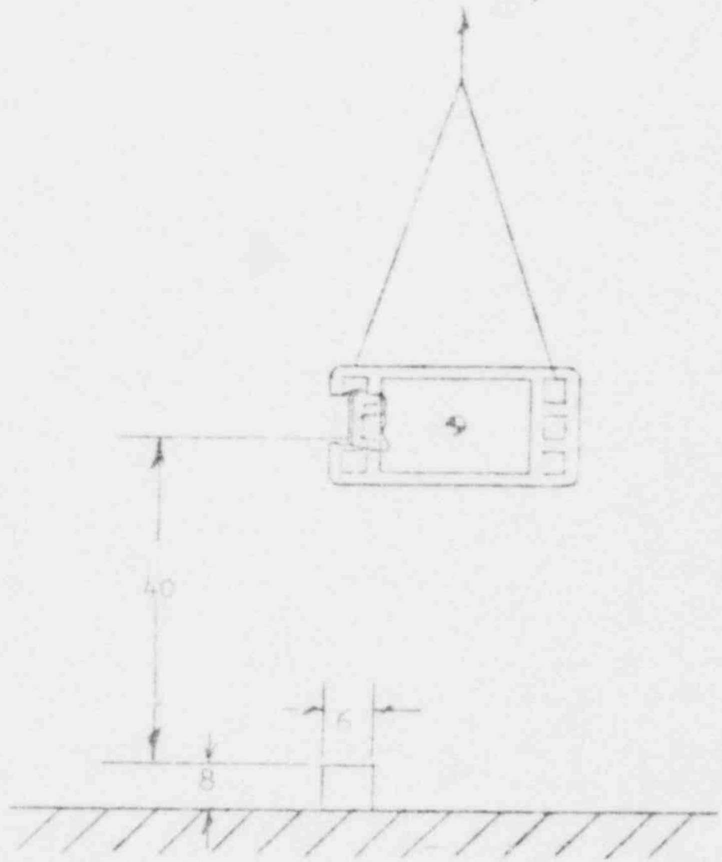
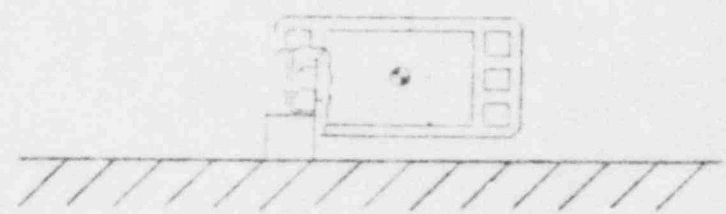
PUNCTURE TEST

CONTROL CABLE CONNECTOR ASSEMBLY

Model 676 Gamma Ray Projector
(weight 545 pounds) dropped from
a height of 40 inches onto a steel
cylinder (6in dia x 8 in high)



1a



1b

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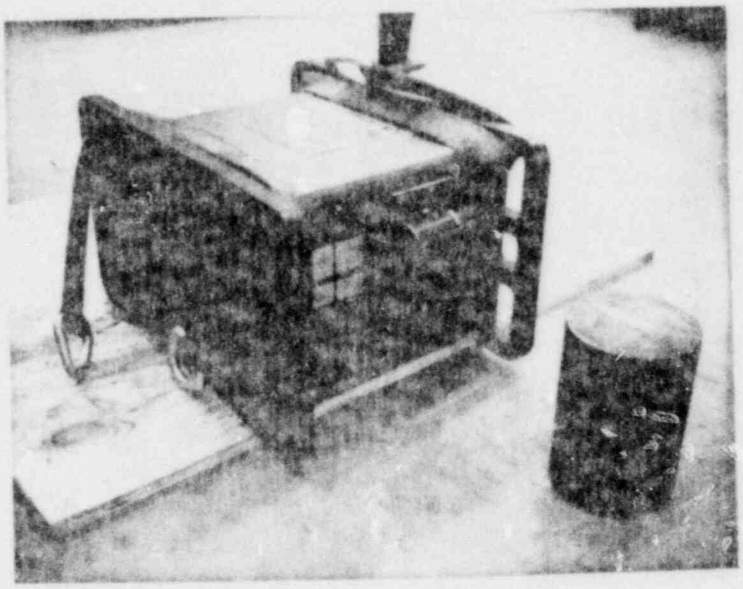

Model 676 at Conclusion of Puncture Test

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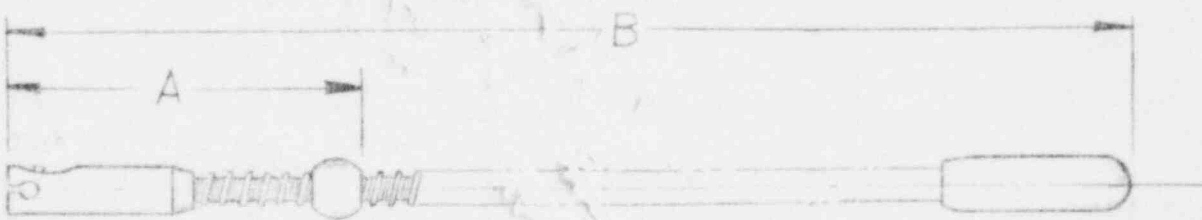
A60060

REV.	DATE	DESCRIPTION

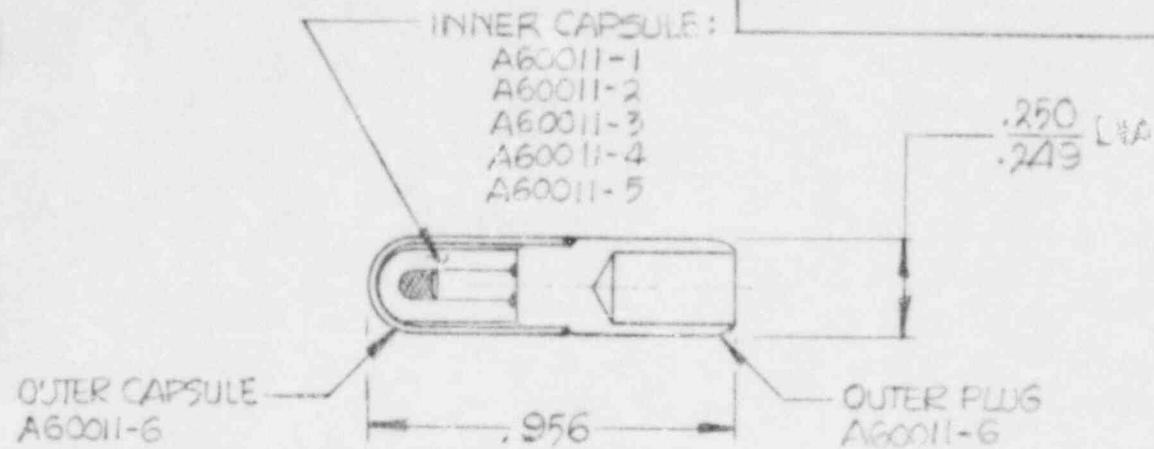
MODEL	CAPACITY (CURIES)	CAPSULE STYLE	DIM A (INCHES)	DIM B (INCHES)
A424-2	22	60011, 60001	N.A.	9 11/16
A424-3	22	60011, 60001	N.A.	11 13/16
A424-4	55	60011, 60000	N.A	20
A424-5	6	60011, 60001	N.A.	7 7/16
A424-7	165	60012, 60002	N.A.	17 1/4
A424-8	110	60011, 60000	N.A.	11 15/16
A424-10	6	60011, 60004	1.225	7 3/4
A424-11	55	60011, 60004	1.225	9 9/16
A424-12	110	60011, 60004	1.225	10 7/8
A424-13	330	60012, 60002	1.225	10 15/16
A424-14	110	60011, 60004	1.225	10 5/8
A424-15	11	60011, 60004	1.225	8 15/16
A424-16	55	60011, 60000	2.373	13 1/2
A424-17	55	60011, 60000	2.373	13 1/2
A424-18	33	60011, 60000	1.225	10 1/4
A424-19	0.11	60001, 60004	1.225	7 3/16
A453-1	110	60011, 60000	N.A.	11 15/16
A453-2	165	60012, 60002	N.A.	17 1/4
A453-[illegible]	550	60012, 60002	N.A.	17 1/4
A453[illegible]	1100	60013, 60003	N.A.	17 1/4
A453-7	110	60011, 60000	N.A	11 15/16
A453-8	55	60011, 60000	N.A.	11 15/16
A453-9	55	60011, 60000	2.373	13 1/2
A453-10	55	60011, 60000	2.373	13 1/2



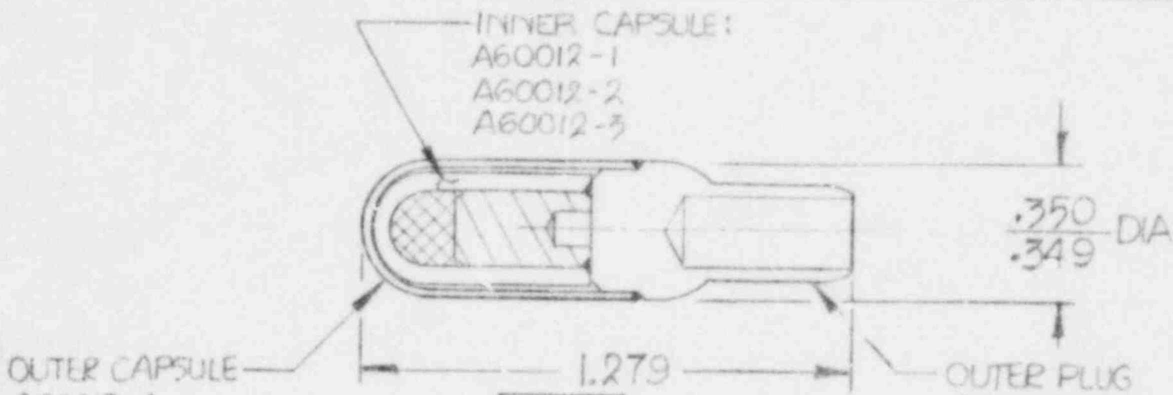
MATERIALS	TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803
FINISH	DWG TITLE: ^{60}COBALT SOURCE REFERENCE
DRAWN BY [illegible] 79	UNLESS OTHERWISE SPECIFIED TOLERANCES ARE .X ± .XX ± .XXX ± ANGLES ± FRACTIONS ±
CHECKED BY	CLASSIFICATION / SIZE A / DWG. NO. 60060 / REV.
APPROVED BY	SCALE — SHEET 1 OF 3

A60060

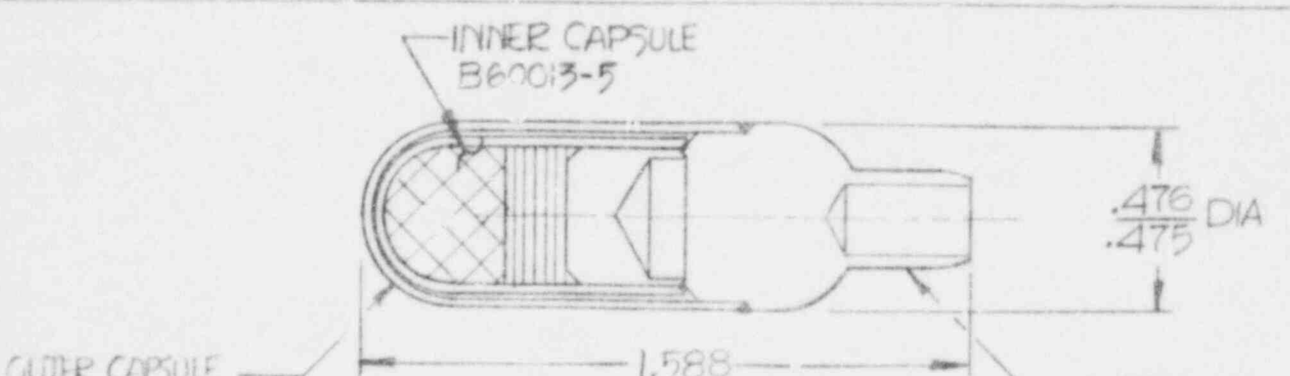
REV.	DATE	DESCRIPTION



60011



60012



60013

MATERIALS	TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803
FINISH	DWG TITLE COBALT ^{60} SOURCE REFERENCE (DOUBLE ENCAPSULATION)
DRAWN BY	UNLESS OTHERWISE SPECIFIED TOLERANCES ARE .X ±
CHECKED BY	.XX ±
	.XXX ±
APPROVED BY	ANGLES ±
	FRACTIONS ±

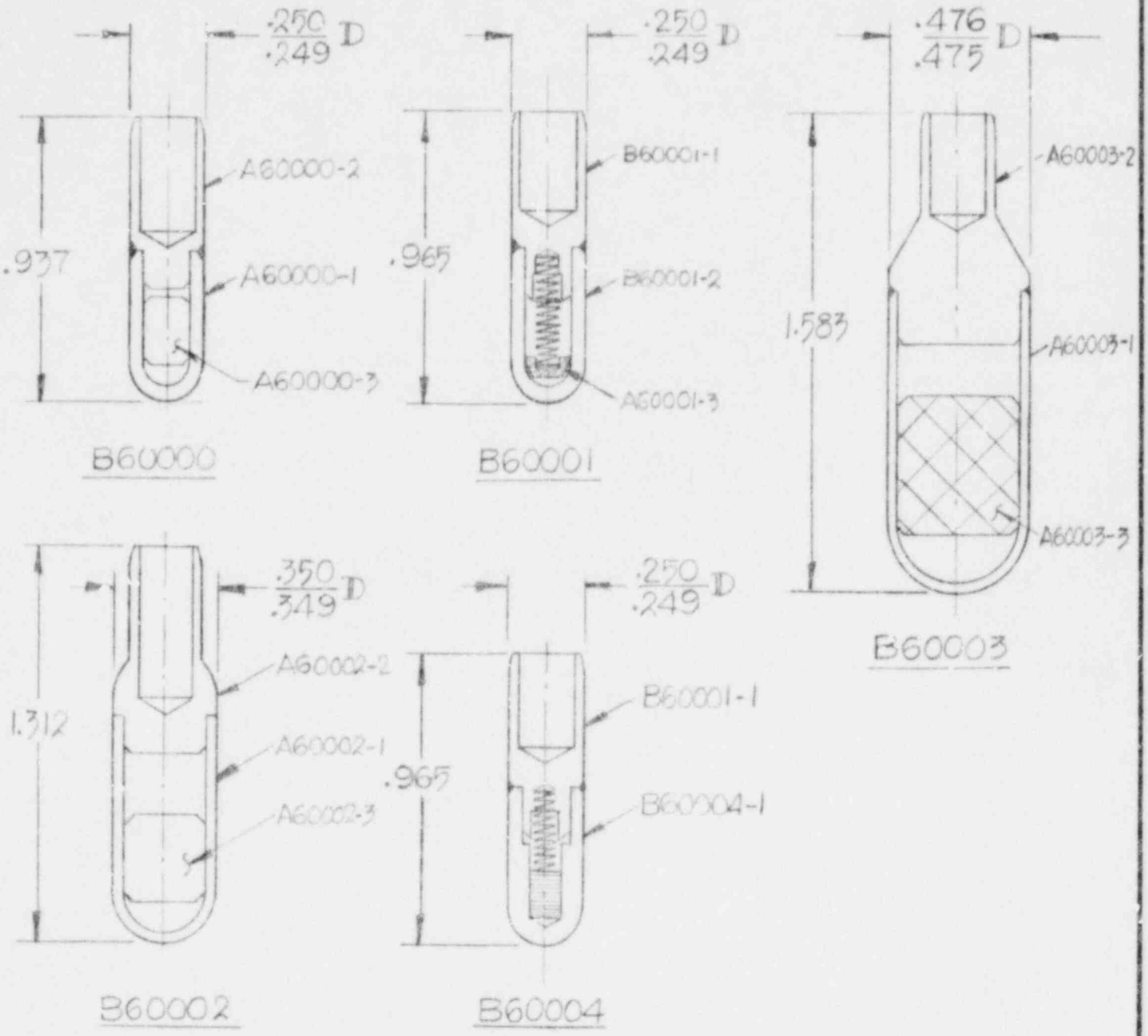
CLASSIFICATION	SIZE	DWG. NO.	REV.
	A	60060	

SCALE	2:1	SHEET 2 OF 3

SPAULDING CO., INC. 21-60169

A60060

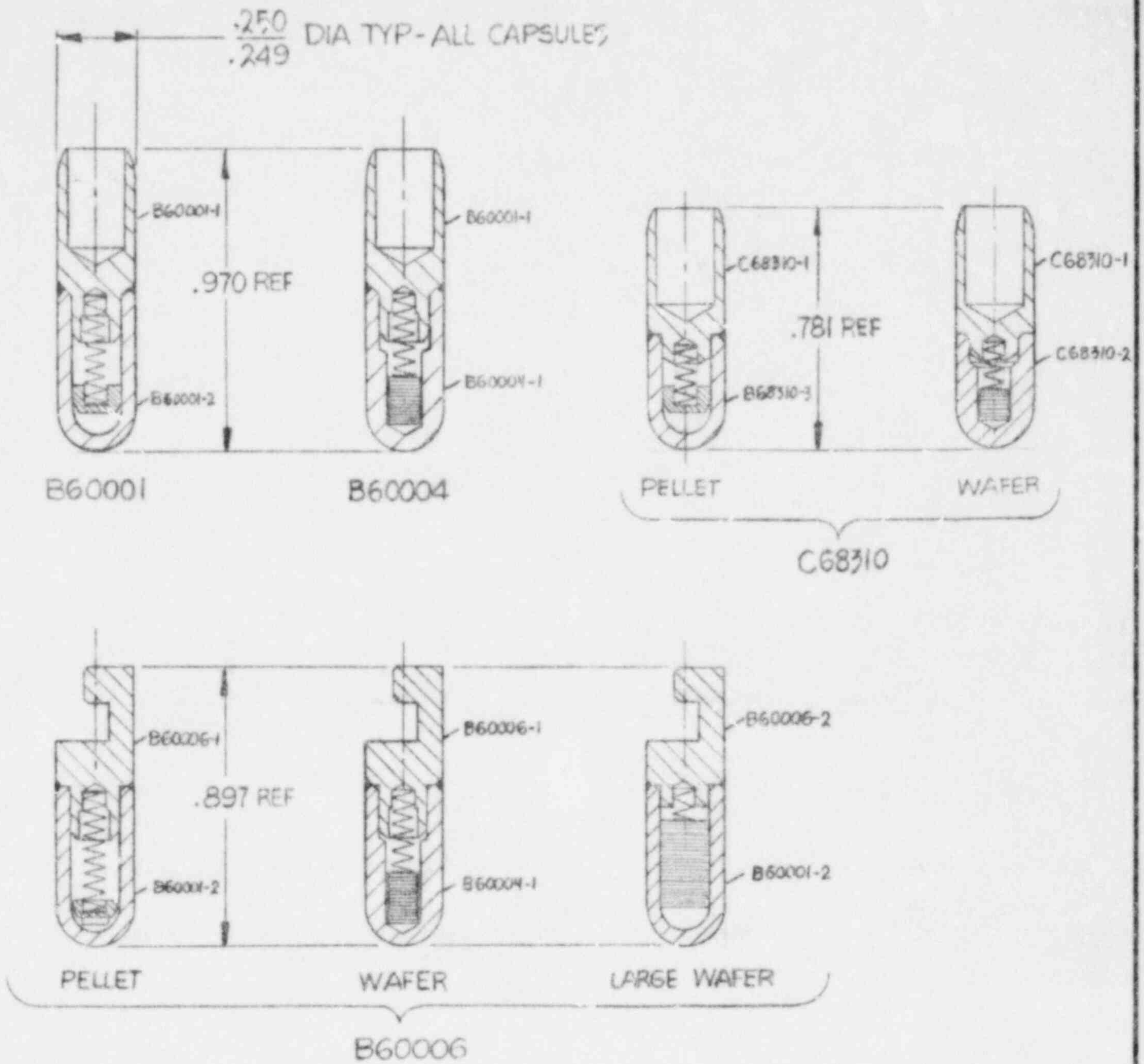
REV.	DATE	DESCRIPTION



MATERIALS		TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803			
FINISH		DWG TITLE COBALT 60 SOURCE REFERENCE (SINGLE ENCAPSULATION)			
DRAWN BY	UNLESS OTHERWISE SPECIFIED TOLERANCES ARE				
	.X ±				
CHECKED BY	.XX ±				
	.XXX ±	CLASSIFICATION	SIZE A	DWG. NO. 60060	REV.
APPROVED BY	ANGLES ±				
	FRACTIONS ±	SCALE 2:1		SHEET 3 OF 3	

A60050

REV.	DATE	DESCRIPTION
A	12-18-78	CALLOUT B68310-3 WAS C68310-3 & B60001-2 WAS B66001-? (ERRORS)



MATERIALS	TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803
FINISH	DWG TITLE 192 IRIDIUM SOURCE REFERENCE
DRAWN BY 6-05-78	UNLESS OTHERWISE SPECIFIED TOLERANCES ARE .X ± .XX ± .XXX ± ANGLES ± FRACTIONS ±
CHECKED BY	
APPROVED BY	

CLASSIFICATION	SIZE	DWG. NO.	REV.
	A	60050	A
SCALE 2:1		SHEET 2 OF 2	

IAEA CERTIFICATE OF COMPETENT AUTHORITY

REFER TO:

Special Form Radioactive Material Encapsulation

Certificate Number USA/0165/S
(Revision 0)

This certifies that the encapsulated sources, as described, when loaded with the authorized radioactive contents, have been demonstrated to meet the regulatory requirements for special form radioactive material as prescribed in IAEA[1] and USA[2] Regulations for the transport of radioactive materials.

I. Source Description and Radioactive Contents - The sources described by this certificate consist of the following Technical Operations, Inc., models which are welded capsules constructed of either 304 or 304L stainless steel to the listed capsule designs (see Appendix A) and which contain not more than the listed quantities of Cobalt 60 in metallic form:

Model	Capsule Style	Activity (Curies)
A424-2	60011, 60001	22
A424-3	60011, 60001	22
A424-4	60011, 60000	55
A424-5	60011, 60001	6
A424-7	60012, 60002	165
A424-8	60011, 60000	110
A424-10	60011, 60004	6
A424-11	60011, 60004	55
A424-12	60011, 60004	110
A424-13	60012, 60002	330
A424-14	60011, 60004	110
A424-15	60011, 60004	11
A424-16	60011, 60000	55
A424-17	60011, 60000	55
A424-18	60011, 60000	33
A424-19	60001, 60004	0.11
A453-1	60011, 60000	110
A453-2	60012, 60002	165
A453-5	60012, 60002	550
A453-6	60013, 60003	1100
A453-7	60011, 60000	110
A453-8	60011, 60000	55
A453-9	60011, 60000	55
A453-10	60011, 60000	55

II. This certificate, unless renewed, expires on September 30, 1982.

This certificate is issued in accordance with paragraph 803 of the IAEA Regulations and in response to the July 26, 1979, petition by Technical Operations, Inc., Burlington, Massachusetts, and in consideration of the associated information therein.

Certified by:

R. R. Rawl

September 17, 1979
(Date)

R. R. Rawl
Designated U.S. Competent Authority for the
International Transportation of Radioactive Materials
Office of Hazardous Materials Regulation
Materials Transportation Bureau
U.S. Department of Transportation

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[1] "Safety Series No. 6, Regulations for the Safe Transport of Radioactive Materials, 1973 Revised Edition" published by the International Atomic Energy Agency (IAEA), Vienna, Austria.

[2] Title 49, Code of Federal Regulations, Part 170-178, USA.

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3.0 Thermal Evaluation

3.1 Discussion

The Model 858 is a completely passive thermal device and has no mechanical cooling system nor relief valves. All cooling of the package is through free convection and radiation. The heat source is 110 curies of cobalt-60. The corresponding decay heat is 1.84 watts.

32. Summary of Thermal Properties of Materials

The melting points of the materials used in the construction of the Model 858 are:

Steel	2453°F	(1345°C)
Uranium	2070°F	(1133°C)
Copper	1940°F	(1060°C)
Titanium	3300°F	(1820°C)
Bronze	1840°F	(1005°C)
Beryllium Copper	1600°F	(870°C)
Zircalloy	3350°F	(1845°C)

The polyurethane foam has a minimum operating range of -100°F (-73°C) to 200°F (93°C). It will decompose at the fire test temperature (800°C). Decomposition will result in gaseous byproducts which will burn in air.

3.3 Technical Specification of Components

No Applicable

3.4 Normal Conditions of Transport

3.4.1 Thermal Model

The heat source in the Model 858 is a maximum of 110 curies of cobalt-60. Cobalt-60 decays with a total energy liberation of 2.82 MeV per disintegration or 16.7 milliwatts per curie. Assuming that all of the decay energy is transformed into heat, the heat generation rate for the 110 curies of cobalt-60 would be 1.84 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.

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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 41^0C and the maximum temperature when inselated would be less than 63^0C.

3.4.3 Minimum Temperatures

The minimum normal operating temperature of the Model 858 is -40^0C (-40^0F). This temperature will have no adverse affect on the package.

3.4.4 Maximum Internal Pressures

Normal operating conditions generate negligible internal pressures. Any pressure generated is significantly below that generated during the hypothetical thermal accident, which is shown to result in no loss of shielding nor containment.

3.4.5 Maximum Thermal Stresses

The maximum temperatures that occur during normal transport are low enough to insure that thermal gradients will cause no significant thermal stresses.

3.4.6 Evaluation of Package Performance for Normal Conditions of Transport

The thermal conditions of normal transport are insignificant from a functional viewpoint for the Model 858. The applicable conditions of IAEA Safety Series No. 6, 1973 Edition for Type B(U) packages have been shown to be satisfied by the Model 858.

3.5 Hypothetical Accident Thermal Evaluation

3.5.1 Thermal Model

The Model 858, including the source assembly, is assumed to reach the thermal test temperature of 800^0C. At this temperature the polyurethane foam will have decomposed and the resulting gases will have escaped the package through vent holes and non-leak tight assembly joints.

3.5.2 Package Conditions and Environment

The Model 858 underwent no significant damage during the free drop and puncture tests. The package used in this analysis is considered undamaged.

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3.5.3 Package Temperatures

As indicated in Section 3.5.1, the entire package is assumed to reach a temperature of 800°C. Examination of the melting temperatures of the materials used in the construction of the Model 858 indicates that there will be no damage to the package as a result of this temperature. The possibility of the formation of an iron-uranium eutectic alloy was addressed in Section 2.4.1 where it was concluded that the formation of the alloy was not a likely eventuality.

3.5.4 Maximum Internal Pressures

The Model 858 packaging is open to the atmosphere. Therefore, there will be no pressure buildup within the package. In Section 3.6, an analysis of the source capsules under the thermal test condition demonstrates that the maximum internal gas pressure at 800°C is 54psi ($377kN/m^2$).

In Section 3.6.3, an analysis is presented which demonstrates that the maximum stress generated in the source capsule (containment) under the thermal test conditions could only be 3% of the yield strength of the material at the test temperature.

3.5.5 Maximum Thermal Stresses

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

3.5.6 Evaluation of Package Performance

The Model 858 will undergo no loss of structural integrity or shielding when subjected to the thermal accident condition. The pressures and temperatures have been demonstrated to be within acceptable limits.

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3.6 APPENDIX

3.6.1 Model 858 Type B(U) Thermal Analysis: Paragraphs 231 and 232 of IAEA Safety Series No. 6, 1973 Edition

3.6.2 Model 858 Type B(U) Thermal Analysis: Paragraph 240 of IAEA Safety Series No. 6, 1973 Edition

3.6.3 Model 858 Type B(U) Source Capsule Thermal Analysis: Paragraph 238 of IAEA Safety Series No. 6, 1973 Edition

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3.6.1 Model 858 Type B(U) Thermal Analysis

Paragraphs 231 and 232 of IAEA Safety Series No. 6, 1973 Edition

This analysis demonstrates that the maximum surface temperature of the Model 858 will not exceed 50°C (122°F) with the package in the shade and at an ambient temperature of 380°C (100°F).

To assure conservatism, the following assumptions are used:

a. The entire decay heat (2.0 watts) is deposited in the exterior faces of the Model 858.

b. The interior of the Model 858 is perfectly insulated and heat transfer occurs only from the exterior wall to the atmosphere.

c. Because each face of the package eclipses a different solid angel, it is assumed that twenty-five percent of the total heat is deposited in the smallest face (front).

d. The only heat transfer mechanism is free convection.

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

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

$$\text{and } h = 1.42\left[\frac{T_w - T_a}{L}\right]^{\frac{1}{4}}$$

where q : Heat deposited per unit time in the face of interest (0.50 watts)

h : Free convective heat transfer coefficient for air in watts/m^2 °c

A : Area of the face of interest ($0.113m^2$)

T_w: Maximum temperature of the wall of the package .

T_a: Ambient temperature (38°C)

L : Height of the face of interest (0.371m)

From this relationship, the maximum temperature of the wall is 40.0°C (104.1°F). This satisfies the requirement of paragraphs 231 and 232 of IAEA Safety Series No. 6, 1973 Edition.

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3.6.2 Model 858 Type B(U) Thermal Analysis

Paragraph 240 of IAEA Safety Series No. 6, 1973 Edition

This analysis demonstrates that the maximum surface temperatures of the Model 858 will not exceed 82°C (180°F) when the package is in an ambient temperature of 38°C (100°F) 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 are used.

a. The package is insolated at the rate of 775 w/m^2 (800 cal/cm^2 - 12h) on the top surface, 194 w/m^2 (200 cal/cm^2 - 12h) on the sides and no insolation on the bottom.

b. The decay heat load is added to the insolation heat load.

c. The solar absorptivity is assumed to be 0.9. The solar emissivity is assumed to be 0.8.

d. The package is assumed to undergo free convection from the top and sides and undergo radiation from the top, sides and bottom. The inside faces are considered insulated so there is no conduction into the package. The faces are considered to be sufficiently thin that no temperature gradients exist.

e. The package is approximated as a rectangular solid of 0.37m length, 0.37m high and 0.30m wide.

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

$$\alpha q_i + q_d = q_c + q_r$$

where α : Absorptivity (0.9)

q_i: Solar Heat Load (182.2 watts)

q_d: Decay Heat Load (2.0 watts)

q_c: Convective Heat Transfer

q_r: Radiative Heat Transfer

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The convective heat transfer is:

$$q_c = \left[(hA)_{top} + (hA)_{sides}\right] (T_w - T_a)$$

where h : Convective Heat Transfer Coefficient

A : Area of the surface of interest

T_w: Temperature of the 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: Stephan Boltzman Constant (5.67×10^{-8} w/m^2 - ^{0}K^4
ε: Emissivity (0.8)

Iteration of this relationship demonstrates that the wall temperature is 62.2^{0}C which satisfies the requirement of paragraph 240 of IAEA Safety Series No. 6, 1973 Edition.

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3.6.3 Model 85E Source Capsules - Thermal Analysis

Paragraph 238 of IAEA Safety Series No. 6, 1973 Edition

This analysis is intended to demonstrate that Tech/Ops source capsules which are of 0.25 inch (6.35mm) diameter, seal welded to a minimum penetration of 0.020 inch (0.51mm), made of Type 304 or 304L stainless steel, and licensed as special form containers under IAEA Safety Series No. 6, 1973, also meet the requirements of paragraph 238, IAEA Safety Series No. 6, 1973, i.e., containment under specified thermal test conditions.

The actual containment vessel for the radioactive material is the welded source capsule. These capsules are all 0.25 inches (6.35mm) in diameter and less than 1 inch (25.4mm) in length.

The internal volume of the source capsules contains only cobalt-60 metal (as a solid) and air. It is assumed at the time of loading that the entrapped air in the capsule is at standard temperature and pressure (20°C, 0.101 Meganewtons per square meter). We contend that this is a conservative assumption because, during the welding process the internal air is heated, causing some of the air mass to escape before the capsule is sealed. When the welded capsule returns to ambient temperature, the internal pressure is somewhat reduced.

As described in Tech/Ops standard source encapsulation procedure, the minimum weld penetration is 0.020 inch (0.51mm). Under conditions of internal pressure, the critical location for failure is this weld. Since the capsule has an outside diameter of 0.25 inch (6.35mm), this weld has a cross-sectional area of 0.014 square inches ($9.30mm^2$).

Under conditions of paragraph 238 of IAEA Safety Series, No. 6, it is assumed that the capsule could reach a temperature of 1475°F (800°C). Using the ideal gas law and requiring the air to occupy a constant volume:

$$P_2 = \frac{P_1 T_2}{T_1}$$

P_1 = Initial pressure ($0.101 MN/m^2$)

T_1 = Initial temperature (293°k)

T_2 = Final temperature (1093°k)

The internal gas pressure could reach $0.377 MN/m^2$. It is assumed that the capsule can be treated as a thin-walled, cylindrical pressure vessel.

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The maximum longitudinal tensile stress can be calculated by writing a longitudinal force balance through the weld:

$$\text{stress x area}_s - \text{pressure x area}_p = 0$$

$$S_l \pi \frac{(d_0{}^2 - d_i{}^2)}{4} - P\pi \frac{d_i{}^2}{4} = 0$$

where S_l = longitudinal stress

d_0 = outer diameter (6.35cm)

d_i = inner diameter (5.35cm)

P = pressure ($0.377 MN/m^2$)

Thus, the longitudinal stress is $0.922 MN/m^2$

The hoop stress can be found in a similar fashion. Taking a longitudinal cross-section and summing forces:

$$\text{hoop stress x area}_s - \text{pressure x area}_p = 0$$

$$2S_h lt - Pd_i l = 0$$

where S_h = hoop stress

l = length of cylinder

t = thickness of weld (0.51mm)

Thus, the hoop stress is $1.98 MN/m^2$

At a temperature of 1600°F (870°C) the yield strength of type 304 stainless steel is 10,000 psi ($69.0 MN/m^2$). Thus, the pressure induced stresses are less than 3% of the yield strength at 800°C.

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4. Containment

4.1 Containment Boundary

4.1.1 Containment Vessel

The containment system for the Model 858 gamma ray projector is the Tech/Ops Model A424-14 source assembly. The source assembly is currently certified as special form containment for radioactive materials (IAEA Certificate of Competent Authority Number USA/1065/S).

The actual containment vessel is the welded source capsule, either style 60004 or 60011. The capsules are made of Type 304 or 304L stainless steel. They are seal welded with a minimum weld penetration of 0.020 in. (0.51mm). The capsules are rounded cylinders 0.25 inches (6.4mm) in diameter and 0.96 inches (24mm) in length. Capsule style 60011 is a double encapsulation, the inner capsule located inside the capsule of the above dimensions. Appropriate design drawings are enclosed in section 1.10.

4.1.2 Containment Penetrations

There are no penetrations of containment. The source capsule is seal welded to provide conformity to special form requirements.

4.1.3 Seals and Welds

The containment vessel is tungsten inert gas welded by General Electric Co., Vallecitos, California. This is done in accordance with Tech/Ops standard source encapsulation procedure (see section 7.4). The minimum weld penetration is 0.020 inches (0.51mm). This has proved acceptable for approval of this vessel as special form.

4.1.4 Closure

Not Applicable

4.2 Requirements for Normal Conditions of Transport

4.2.1 Release of Radioactive Material

The source assemblies used meet the requirements of special form radioactive material as delineated in IAEA Safety Series No. 6, 1973 and 10CFR71. Thus, there will be no release of radioactive materials under conditions of normal transport.

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4.2.3 Coolant Contamination

Not applicable

4.2.4 Coolant Loss

4.3 Containment Requirements for the Hypothetical Accident Condition

4.3.1 Fission Gas Products

4.3.2 Release of Contents

The hypothetical accident conditions as outlined in 10CFR71, Appendix B. 1., 2., and 3. have been shown (Sections 2.7.1, 2.7.2 and 3.5 respectively) to result in no loss of package containment.

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5. Shielding Evaluation

5.1 Discussion and Results

The Model 858 is shielded with 327 pounds (149kg) of depleted uranium. The uranium metal is cast around the zircalloy or titanium "S" tube which holds the source. The storage position for the source is at the inflection in the "S" tube.

A radiation profile of Model 858 SN 1 containing 99Ci of Cobalt-60 (see section 5.5) was made. An extrapolation to a capacity of 110Ci yielded the results which are presented in Table 5.1. From this data, it is concluded that the Model 858 complies with the regulatory standards in 10CFR71 and IAEA Safety Series No. 6, 1973.

TABLE 5.1

SUMMARY OF MAXIMUM DOSE RATES
(mR/hr)

	Contact			At 1 Meter		
	Side	Top	Bottom	Side	Top	Bottom
Gamma	156	122	133	1.8	1.1	1.1
Neutron	Not applicable			Not Applicable		
Total	156	122	133	1.8	1.1	1.1

Hypothetical accident conditions will result in essentially no change in the above radiation intensities.

5.1 Source Specification

5.2.1 Gamma Source

The gamma source used is encapsulated cobalt-60 in quantities of up to 110 curies.

5.2.2 Neutron Source

Not Applicable

5.3 Model Specifications

Not Applicable

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5.2.2 Neutron Source

Not Applicable

5.3 Model Specifications

Not Applicable

5.4 Shielding Eva'uation

The Model 858 shielding evaluation was performed on Model 858 Serial Number 1, containing 99Ci of cobalt-60. The radiation profile is included in Section 5.5. Extrapolation of this data to the capacity of 110 curies (Section 5.1) clearly indicates that the Model 858 conforms to regulatory radiation limits. As the hypothetical accident evaluation (Section 2.7) revealed no change in the shielding arrangement, it is concluded that shielding after the hypothetical accident is essentially unchanged. Therefore, the radiation profile indicates the package will be within acceptable limits.

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5.5 APPENDIX

- Model 858: Radiation Profile

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RADIATION PROFILE

Model 858 Serial Number 1

Source Model Number A424-14

Serial Number 1939; 99 Curies ^{60}Cobalt

Location	At Surface	At 1 Meter From Surface
Top	110	1.0
Right Side	130	1.2
Bottom	120	1.0
Left Side	100	1.0
Front	140	1.3
Back	130	1.6

NOTES:
1. All intensities are expressed in units of milliroentgens per hour.
2. Intensities expressed are the maximum intensities on the particular surface.
3. Measurements were made with an AN/PDR - 27(J) Survey Meter.

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6. Criticality Evaluation

Not Applicable

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7. Operating Procedures

7.1 Procedures for Loading the Package

Section 7.4 describes the procedure for fabricating the special form source encapsulation. Section 7.4 also contains the procedure for loading this source assembly into the package and preparing the package for transport.

7.2 Procedures for Unloading the Package

Section 7.4 contains the procedure for unloading the source assembly from the package.

7.3 Preparation of an Empty Package for Transport

Section 7.4 describes the procedure for preparing an empty package for transport.

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7.4 APPENDIX

- Encapsulation of Sealed Sources
- Technical Operations Model 858: Procedures of Loading - Unloading the Package

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RADIATION SAFETY MANUAL
Part II In Plant Operations
Section 2

ENCAPSULATION OF SEALED SOURCES

A. Personnel Requirements

Only an individual qualified as a Senior Radiological Technician shall perform the operations associated with the encapsulation of ^{192}Iridium. There must be a second qualified radiological technician available in the building when these operations are being performed.

B. General Requirements

The ^{192}Iridium loading cell shall be used for the encapsulation of solid metallic ^{192}Iridium and the packaging of sealed sources such as ^{170}Thulium, ^{137}Cesium and ^{169}Ytterbium. Solid metallic ^{60}Cobalt not exceeding one curie may be handled in this cell also.

The maximum amount of ^{192}Iridium to be handled in this cell at any one time shall not exceed 1000 curies. The maximum amount of ^{137}Cs to be handled in this cell at any one time shall not exceed 100 curies.

This cell is designed to be operated at less than atmospheric pressure. The exhaust blower provided shall not be turned off except when the cell is in a decontaminated condition.

Sources shall not be stored in this cell overnight or when cell is unattended. Unencapsulated material shall be returned to the transfer containers and encapsulated sources transferred to approved source containers.

When any of the "through-the-wall" tools such as the welding fixture or transfer pigs are removed, the openings are to be closed with the plugs provided. These tools shall be decontaminated whenever they are removed from the hot cell.

C. Preparatory Procedure

1. Check welding fixture, capsule drawer and manipulator fingers from cell and survey for contamination. If contamination in excess of 0.001μCi of removable contamination is found, these items must be decontaminated.

2. If the welding fixture or the electrodes have been changed, perform the encapsulation procedure omitting the insertion of any activity. Examine this dummy capsule by sectioning thru weld. Weld penetration must be not less than 0.020 inch.

   If weld is sound and penetration is at least 0.020 inch, the preparation of active capsules may proceed. If not, the condition responsible for an unacceptable weld must be corrected and the preparatory procedure repeated.

3. Check pressure differential across first absolute filter, as measured by the manometer on the left side of the hot cell. This is about ½ inch of water for a new filter. When this pressure differential rises to about 2 inches of water, the filter must be changed.

D. Encapsulation Procedure

1. Prior to use, assemble and visually inspect the two capsule components to determine if weld zone exhibits any misalignment and/or separation. Defective capsules shall be rejected.

2. Degrease capsule components in the Ultrasonic Bath, using isopropyl alcohol as degreasing agent, for a period of 10 minutes. Dry the capsule components at 100°C for a minimum of twenty minutes.

3. Insert capsule components into hot cell with the posting bar.

4. Place capsule in weld positioning device.

5. Move drawer of source transfer container into hot cell.

6. Place proper amount of activity in capsule. Disposable funnel must be used with pellets and a brass rivet with wafers to prevent contamination of weld zone.

7. Remove unused radioactive material from the hot cell by withdrawing the drawer of the source transfer container from the cell.

8. Remove funnel or rivet.

9. Assemble capsule components.

10. Weld adhering to the following conditions:

a. Electrode spacing .021" to .024" centered on joint ±.002"; use jig for this purpose.

b. Preflow argon, flush 10 seconds.

c. Start 15 amps.

d. Weld 15 amps.

e. Slope 15 amps.

f. Post flow 15 seconds

11. Visually inspect the weld. An acceptable weld must be continuous without cratering, cracks or evidence of blow out. If the weld is defective, the capsule must be cleaned and rewelded to acceptable conditions or disposed of as radioactive waste.

12. Check the capsule in height gauge to be sure that the weld is at the center of the capsule.

13. Wipe exterior of capsule with flannel patch wetted with EDTA solution or equivalent.

14. Count the patch with the scaler counting system. Patch must show no more than .005μCi of contamination. If the patch shows more than .005μCi, the capsule must be cleaned and rewiped. If the rewipe patch still shows more than 0.005μCi of contamination, steps 8 through 11 must be repeated.

15. Vacuum bubble test the capsule. Place the welded capsule in a glass vial containing isopropyl alcohol. Apply a vacuum of 15 in Hg (gauge). Any visual detection of bubbles will indicate a leaking source. If the source is determined to be leaking, place the source in a dry vacuum vial and boil off the residual alcohol. Reweld the capsule.

16. Transfer the capsule to the swaging fixture. Insert the wire and connector assembly and swage. Hydraulic pressure should not be less than 1250 nor more than 1500 pounds.

17. Apply the tensile test to assembly between the capsule and connector by applying proof load of 75 lbs. Extension under the load shall not exceed 0.1 inch. If the extension exceeds 0.1 inch, the source must be disposed of as radioactive waste.

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18. Position the source in the exit port of hot cell. Withdraw all personnel to the control area. Use remote control to insert source in the ion chamber and position the source for maximum response. Record the meter reading. Compute the activity in curies and fill out a temporary source tag.

19. Using remote control, eject the source from cell into source changer through the tube gauze wipe test fixture. Monitor before reentering the hot cell area to be sure that the source is in the source changer. Remove the tube gauze and count with scaler counting system. This assay must show no more than 0.005μCi. If contamination is in excess of this level, the source is leaking and shall be rejected.

20. Complete a source loading log (Figure II.2.1) for the operation.

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Technical Operations

Model 858

Procedures for Loading - Unloading the Package

Wear personnel monitoring devices during all source changing procedures. Monitor all operations with a calibrated, operable survey meter.

Note: All the precautions used when making radiographic exposures must be followed.

1. Survey the projector to ensure that the source is in the proper position.

2. Locate the projector and source changer in a restricted area. Locate the devices so as to avoid sharp bends in the guide tube or control housing.

   The control cable housing bend radius should not be less than 36 inches (0.914m), and the guide tube bend radius should not be less than 20 inches (0.508m).

3. Set the source changer for operation.

4. Attach one end of a guide tube fitting to the fitting above the empty chamber in the source changer and the other end to the source changing fixture attached to the projector.

5. Attach the control cable to the projector.

   a. Unlock the projector with the key provided and turn the connector selector ring from the LOCK position to the CONNECT position. when the ring is in the CONNECT position, the storage cover will disengage from the projector.

   b. Slide the control cable collar back and open the jaws of the swivel connector, exposing the male portion of the connector. Engage the male and female portions of the swivel connector by depressing the spring loaded locking pin toward the projector with the thumbnail. Release the locking pin and test that the connection has been made.

   c. Close the jaws of the control cable connector over the swivel type connector.

   d. Slide the control cable collar over the connnector jaws. Hold the control cable collar flush against the projector connector and rotate the selector ring from the CONNECT position to the OPERATE position.

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6. Crank the source into source changer.

    a. Survey this operation with a survey meter to be sure the source has been transferred from projector to changer.

    b. With a survey meter verify radiation level does not exceed 200 mR/hr at the surface of the changer.

7. Disconnect the control cable from the source assembly. Disconnect the guide tube from the source changer. Secure the source in the source changer.

8. IF THE PROJECTOR IS TO REMAIN EMPTY:

    a. Fully retract the control cable. Disengage the control cable from the projector and lock the projector.

    b. Attach the identification plate of the source to the source changer.

    c. Affix a green "empty" tag to projector.

    d. Perform a wipe test of the projector to assure that the contamination level observed is less than 0.001 microcuries per 100 square centimeters.

    e. Survey the projector to determine the proper RADIOACTIVE shipping labels to be applied.

    f. Mark the projector: Radioactive - "LSA". Affix the proper shipping labels to the package.

    g. Complete the proper shipping papers.

9. IF THE PROJECTOR IS TO BE RELOADED:

    Connect the source changer end of the guide tube to the fitting above the new source in the source changer. Connect the drive cable to the new source assembly.

10. Crank source to full retraction within the projector.

    a. Survey this operation with a survey meter to be sure the source has been transferred into the projector.

    b. With a survey meter verify radiation level does not exceed 200mR/hr at the surface of the projector.

11. Disconnect the control cable and lock the projector.

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12. Disconnect the source guide tube from the projector and source changer.

13. Affix the identification plate of the new source to the projector and attach the identification plate of the old source to the source changer.

14. Prepare for shipment.

    a. Again survey projector to insure that the radiation level does not exceed 200mR/hr at the surface of the projector.

    b. Survey the radiation level at a distance of three feet from the surface of the projector. This radiation level should not exceed 10mR/hr. The highest radiation level measured at three feet from the container is used to determine the Transport Index in accordance with 49CFR173.389(h).

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Tech/Ops Model 858

Procedure for Shipping Radioactive Material

The Model 858 meets the requirements for a Type B shipping container under the regulations of the U.S. Nuclear Regulatory Commission, the U.S. Department of Transportation and the International Atomic Energy Agency. The container has been assigned USNRC Certificate of Compliance No. ________ for domestic shipments and IAEA Certificate No. USA/ /B(U)T for international shipments.

The following shipping procedures comply with NRC Regulations 10CFR Part 71 and DOT Regulations 49CFR Parts 171 through 179 regarding the transportation of radioactive materials.

1) Ensure that the source is locked into place in its storage position. To check this, the lock should be in the down position, and the selector ring should be immobile. Secure the cover plate to the container, and seal wire the hex head bolts to provide a tamper proof seal.

2) Perform a radioactive contamination wipe test of the outer shipping package. This consists of rubbing filter paper or other absorbent material, using heavy finger pressure, over an area of $100cm^2$ ($16in^2$) of the package surface. The activity on the filter paper should not exceed $0.001\mu Ci$ of removable contamination.

3) Survey the package with a survey meter at the surface and at a distance of three feet from the surface to determine the proper radioactive shipping labels to be applied to the package as required by 49CFR Part 172.403. The radiation exposure limits for each shipping label are given in Figure 1. If radiation levels above 200mR/hr at the surface or 10mR/hr at three feet from the surface are measured, the container must not be shipped.

4) Properly complete two shipping labels indicating the radioactive isotope, activity and the transport index. The transport index is used only on Yellow II and Yellow III labels and is defined as the maximum radiation level in milliroentgens per hour measured at a distance of three feet from the surface of the package. Put these two labels on opposite sides of the container after making sure any previous labels have been removed. The package should be marked with the proper shipping name (Radioactive Material, Special Form, n.o.s.). If the exposure device is packaged inside an outer container, mark the outside package "INSIDE PACKAGE COMPLIES WITH PRESCRIBED SPECIFICATIONS - TYPE B USA/ /B(U)."

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5. Complete the shipping papers indicating:

   a. Proper shipping name (Radioactive Material, Special Form, n.o.s.) and identification number (NA9182).

   b. Name of radionuclide (^{60}Cobalt)

   c. Physical or chemical form (special form)

   d. Activity of Source (expressed in curies or millicuries)

   e. Category of label applied (i.e., Radioactive Yellow III)

   f. Transport Index

   g. USNRC Identification Number of DOT Specification Number (USNRC: USA/ /B)

   h. For export shipments, IAEA Identification Number (IAEA: USA/ /B)

   i. Shipper's Certification:

      "This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transport according to the applicable regulations of the Department of Transportation."

Notes:

1. For air shipments, the following shipper's certification may be used:

   "I hereby certify that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked and labeled and are in proper condition for carriage by air according to applicable national governmental regulations."

2. For air shipments, the package must be labeled with a "CARGO AIRCRAFT ONLY" label and the shipping papers must state:

   "THIS SHIPMENT IS WITHIN THE LIMITATIONS PRESCRIBED FOR CARGO-ONLY AIRCRAFT."

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Shipment of Empty Container

(1) Ensure that the source is removed, and the connector assembly is in the LOCK position with the lock plunger in the down position and the key removed. Secure the cover to the outer container with the hex head bolts, and secure the bolts with seal wire.

(2) Mark the outside of the outer shipping package: "RADIOACTIVE - MATERIAL - LSA, n.o.s."

(3) Perform a radioactive contamination wipe test of the shipping package and ensure that the wipe test does not exceed 0.001 microcuries per 100 square centimeters.

(4) Survey the package at the surface and at three feet from the surface to determine the proper radioactive shipping labels to be applied to the package.

a. If the surface radiation level is less than 0.5 milliroentgens per hour and there is no measurable radiation level at three feet from the surface, no label is required. Mark the outside of the package with the statement: "Exempt from specification packaging, marking and labeling, and exempt from the provisions of 49CFR173.393 per 49CFR173.391(c). Exempt from the requirements of 49CFR Part 175 per 49CFR175.10(a)(6)."

Properly complete the shipping papers:

(1) Proper shipping name (Radioactive Device n.o.s.) and identification number (UN 2919)

(2) Name of radionuclide (Depleted Uranium)

(3) Physical or Chemical Form (Solid Metal)

(4) Activity (in curies or millicuries)

(5) The statement "Exempt from specification packaging, marking and labeling, and exempt from the provisions of 49CFR173.393 per 49CFR173.391(c). Exempt from the requirements of 49CFR Part 175 per 49CFR175.10(a)(6)."

(6) Shipper's Certification:

"This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transport according to the applicable regulations of the Department of Transportation."

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Notes:

(1) For Air Shipments, the following shipper's certification may be used:

> "I hereby certify that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked and labeled and are in proper condition for carriage by air according to applicable national governmental regulations."

(2) For Air Shipments, the following statement must appear:

> "This shipment is within the limitations prescribed for passenger aircraft in accordance with 49CFR175.10(a)(6)."

b. If the surface radiation level exceeds 0.5 millireontgens per hour, or if there is a measurable radiation level at three feet from the surface, use the criteria of Table 7.4.2 to determine the proper radioactive shipping labels to be applied to the package.

Complete the shipping papers indicating:

(1) Proper Shipping Name (Radioactive Material, LSA, n.o.s.) and identification number (UN2912).

(2) Name of radionuclide (Depleted Uranium)

(3) Physical or Chemical Form (Solid Metal)

(4) Activity (In curies or millicuries)

(5) Category of label applied (i.e., Radioactive Yellow II).

(6) Transport Index

(7) USNRC Identification Number
(USNRC USA/ /B)

(8) For Export Shipments, IAEA Identification Number
(IAEA USA/ /B)

(9) Shipper's Certification:

> "This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transport according to the applicable regulations of the Department of Transportation."

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Notes:

(1) For Air Shipments, the following shipper's certification may be used:

"I hereby certify that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked and labeled and are in proper condition for carriage by air according to applicable national governmental regulations."

(2) For Air Shipments, the package must be labeled with a "CARGO AIRCRAFT ONLY: label and the shipping papers must state:

"THIS SHIPMENT IS WITHIN THE LIMITATIONS PRESCRIBED FOR CARGO-ONLY AIRCRAFT."

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8. Acceptance Tests and Maintenance Program

8.1 Acceptance Tests

8.1.1 Visual Inspection

The package is visually examined to assure that the appropriate fasteners are wired properly and that the package is properly marked.

The seal weld of the radioactive source capsule is visually inspected for proper closure.

8.1.2 Structural and Pressure Tests

The swage coupling between the source capsule and cable is subjected to a static tensile test with a load of seventy-five pounds. Failure of this test will prevent the source assembly from being used.

8.1.3 Leak Tests

The radioactive source capsule (the primary containment) is wipe tested for leakage of radioactive contamination. The source capsule is subjected to a vacuum bubble leak test. The capsule is then subjected to a second wipe test for leakage of radioactive contamination. These tests are described in Section 7.4. Failure of any of these tests will prevent use of this source assembly.

8.1.4 Component Tests

The lock assembly of the package is tested to assure that security of the source will be maintained. Failure of this test will prevent use of the package 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 at three feet from the surface are measured using a small detector survey instrument (e.g., AN/PDR-27). These radiation levels, when extrapolated to the rated capacity of the package, must not exceed 200 milliroentgens per hour at the surface, nor ten milliroentgens per hour at three feet from the surface of the package. Failure of this test will prevent use of the package.

8.1.6 Thermal Acceptance Tests

Not Applicable

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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 assembly is leak tested at manufacture. Additionally, the source assembly is wipe tested for leakage of radioactive contamination every six months.

8.2.3 Subsystem Maintenance

The lock assembly is tested as described in Section 8.1.4, prior to each use of the package. Additionally, the package is inspected for tightness of fasteners, proper seal wires and general condition prior to each use.

8.2.4 Valves, Rupture Discs, and Gaskets

Not Applicable

8.2.5 Shielding

Prior to each use, a radiation survey of the package is made to assure that the radiation levels do not exceed 200 milliroentgens per hour at the surface, nor ten milliroentgens per hour at three feet from the surface.

8.2.6 Thermal

Not Applicable

8.2.7 Miscellaneous

Inspections and tests designed for secondary users of this package under the general license privisions of 10CFR71.12(b) are included in Section 7.4.

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