Amersham Corporation
40 North Avenue
Burlington, MA 01803
tel (617) 272-2000
tel (800) 225-1383

Amersham
QSA

Mr. Cass R. Chappell, Section Leader
Cask Certification Section
Storage and Transport Systems Branch
Division of Industrial and Medical Nuclear Safety
NMSS
U. S. Nuclear Regulatory Commission
Washington, DC 20555

31 March 1994

Dear Mr. Chappell:

In reference to docket number 71-9033, we are providing the additional information requested in your letter dated 15 December 1993.

The revisions are as described below and have been included as revised pages. All changes are indicated by a vertical line in the margin.

Drawings

1) Drawing 66030 sheets 1-4 were inadvertently left out of our consolidated application. We have enclosed these drawings.

2) The changes made to these drawings were inadvertent and they have been revised to reflect the proper information and revision level.

3) The drawings have been revised to show the additional lead shielding on the shield and the text changed on page 2-1.

General

1) The text has been clarified to reference the different versions ie narrow and wide body and the appropriate shield weights for the different versions. The text was changed on pages 1-1, 1-2 and 2-1.

NTOI Letter: LA
1/1

Thermal

1) The reference to activity has been removed, as it is not needed in this calculation on page 3-2.

Operating Procedures

1) Step 7 in section 7.1 has been revised.

Acceptance Tests and Maintenance Program

1) The third paragraph in section 8.1.1 has been revised to reference the appropriate drawings for inspection.

2) The title has been changed to specify the maintenance is for non automatic locking devices.

3) The reference to Appendix 8.3 has been deleted, this information is given in step 27.

In addition to the above changes, we have corrected a minor typographical error on page 3-7 and have updated the index.

Please contact me you need any additional information. Thank you for your assistance.

Sincerely,

Cathleen Roughan

Cathleen Roughan
Regulatory Affairs Manager

Amersham Corporation
40 North Avenue
Burlington, MA 01803
tel (617) 272-2000
tel (800) 225-1383

Amersham
CSA

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Cathleen Roughan

Cathleen Roughan
Regulatory Affairs Manager

TABLE OF CONTENTS PAGE

1. General Information

1.1 Introduction

Amersham Corporation, Model 660 series is designed for use as a radiographic exposure device and a transport package for Type B quantities of radioactive material in special form. The Model 660 conforms to the criteria for Type B(U) packaging in accordance with 10 CFR 71 and IAEA Safety Series No. 6, 1985 Edition (as amended).

The 660 series includes all of the following models; 660, 660E, 660A, 660AE, 660B and the 660BE. These models are all structurally identical, all materials of construction and methods of fabrication are essentially the same. The models with the designation A, AE, B, and BE all utilize an automatic securing mechanism to secure the source assembly. The models with an "E" designation have an electrical circuit to allow compatibility with an automatic exposure unit. Throughout this evaluation, all the models are considered interchangeable, except where specifically designated.

1.2 Package Description

1.2.1 Packaging

The Model 660 series is 12 7/8 inches (327 mm) long, 5 1/4 inches (133mm) wide and 9 5/8 inches (244mm) high. The packaging incorporates an aluminum handle for movement of the exposure device. The total mass of the package is 53 ± 3 lbs. (24 ± 1.36 Kg). Earlier versions were only 4 5/8 inches wide (referred to as narrow body) and had a total weight of 48 lbs. (21.8 Kg) with a shield assembly weight of 35 lbs. (15.9 Kg).

The following descriptive break-down is provided to identify the distinguishing feature(s) of each model. Also included is a diagram which lists the maximum activity authorized for use with each different device model number. see page 1-25

Model #	Drawing #	Revision	Description
660	66030	-	Narrow body Pre-automatic lock
660	66025	B	Wide body Pre-automatic lock
660E			Any version of the 660 with the addition of an electrical hookup as previously approved
660A	66030	A	Narrow body retrofitted with automatic locking mechanism
660A	66030	D	Wide body retrofitted with automatic locking mechanism

660AE			Any version of the 660A with the addition of an electrical hookup as previously approved
660B	66025	F	Wide body manufactured with automatic locking mechanism
660BE			Any version of the 660B with the addition of an electrical hookup as previously approved

The radioactive material is sealed in a source capsule which conforms to the requirements for special form radioactive material. This source capsule is installed in a source holder assembly.

The source holder assembly is housed in an "S" shaped titanium or zircalloy source tube. The source tube has an inside diameter of 0.385 in. (9.78mm) and a minimum wall thickness of .041 inches (1mm). The source tube is surrounded by depleted uranium metal as shielding material. The depleted uranium shielding is cast in place around the source tube. The mass of the wide body depleted uranium shield is 37 ± 3 lbs. (16.8 ± 1.36 Kg).

The depleted uranium shield on some packages may have supplemental lead (as shown in drawings 66025 Rev. F and 66030 Rev. D) or tungsten shielding. The addition of this shielding does not impair the package's ability to meet the Type B requirements as demonstrated in the report in Appendix 2.10.

The depleted uranium shield is encased in a steel housing. The housing is made up of a shell and two end plates. The shell is fabricated from .060 in. (1.5mm) thick stainless or carbon steel. The end plates are fabricated from .120 inch (3mm) thick steel and are bolted together by means of 4 tapped rods that extend through the shell and by flat head screws. The void space in the housing is filled with a rigid polyurethane foam. The outer packaging is designed to avoid the collection and retention of water. The package has a smooth finish to provide for easy decontamination.

Attached to the rear plate is the control connector and lock assembly. This assembly incorporates either:

1. an automatic locking feature that locks the source assembly in the exposure device when the source is returned to the stored position for models 660A, 660B, 660AE and 660BE, or

2. a selector ring assembly that by manual operation secures the source assembly in the shielded position for the model 660 and 660E.

1.3 APPENDIX

Drawings:

66025 sheets 1-3 Rev. F Model 660B
Descriptive Drawing. Pages 1-5, 6 & 7

60025 sheets 1-4 Rev. B Model 660
Descriptive Drawing. Pages 1-8, 9, 10 & 11

66030 sheets 1-3 Rev. D Model 660A
Descriptive Drawing. Pages 1-12, 13 & 14

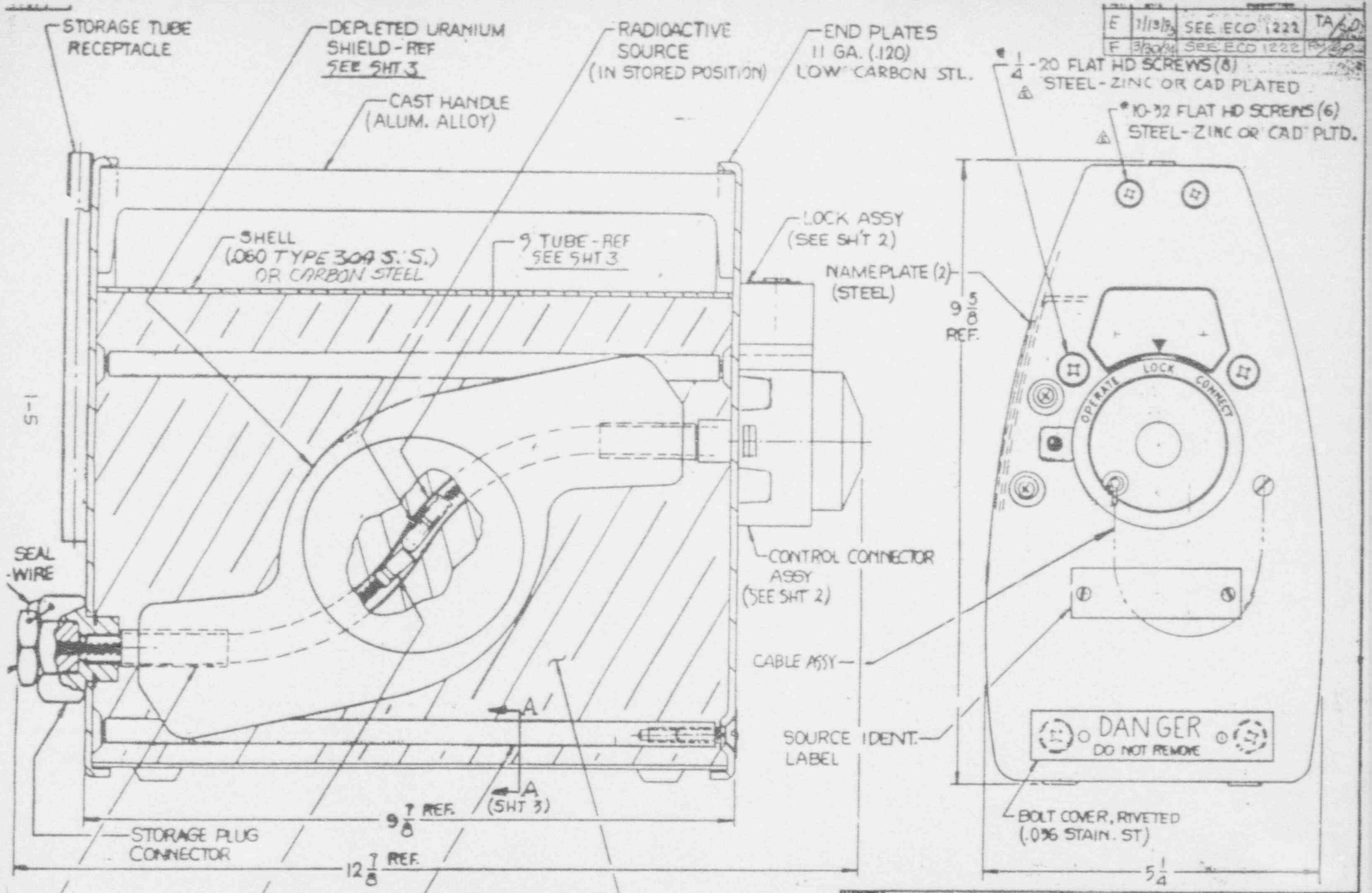
66030 sheets 1-3 Rev. A Model 660A
Descriptive Drawing. Pages 1-15, 16 & 17

66030 sheets 1-4 Rev. Model 660
Descriptive Drawing. Pages 1-18, 19, 20 & 21

Diagram showing maximum activity for each
Model 660 variation. Page 1-25

USNRC Certificate of Compliance No. 9033 Rev. 8.
Pages 1-23 & 24

Drawing 42409 Rev. C Source Assembly. Page 1-22



MOD NO.	MAX CAPACITY
660B	140 CI

TOTAL WEIGHT - 53 LBS ± 3lbs.

E	1/13/84	SEE ECO 1222	TA
F	3/30/84	SEE ECO 1222	

NOTED

TECHNICAL OPERATIONS INC.
RADIATION PRODUCTS DIVISION
BURLINGTON, MA 01803

MODEL 660 GAMMA RAY PROJECTOR
SHIPPING CONTAINER
DESCRIPTIVE ASSEMBLY

CLASSIFICATION: C
DWG. NO. 66025
REV. F

REV	DATE	DESCRIPTION
E	1-13-93	SEE ECO 1222
F	3/30/94	SEE ECO 1222
A	6 JAN 89	SEE SHT 1
B	14 MAY 89	WAS SHT 2 OF 3
C	11-21-89	SEE SHT 1 & THIS SHT WAS SHT 2 OF 3
D	4-3-90	SEE SHT 3

END PLATE - REF.

MODIFIED LOCK (CORBIN # 02250)

10-32 SOC. HD CAP SCREW (2) WITH LOCTITE

COVER (304 ST. STL.)

SLEEVE (DRILL ROD)

COMPRESSION SPRING (LEE # LC-045-H-2)

SELECTOR BODY (303 ST STL)

*10-32 SOC HD CAP SCR. (STAIN. STL.) 4 WITH LOCTITE

ANTI-ROTATE LUGS (303 STAIN. STL) & COMPRESSION SPRING

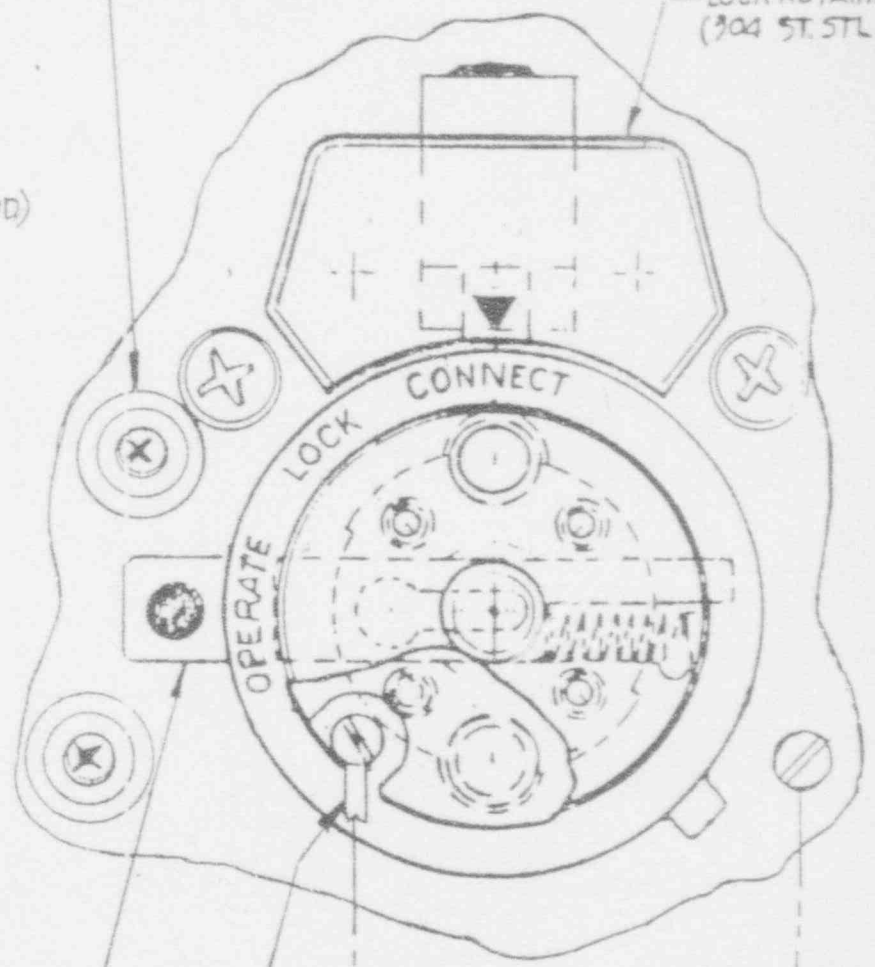
SELECTOR RING (304 ST. STL.)

SELECTOR RING RETAINER (303 ST. STL)

LOCKING SLIDE (1/4 x 1/2 FLAT GND STOCK OIL HARDENING)

PROTECTIVE BUMPER (2) (RUBBER)

LOCK RETAINER (304 ST. STL)



CABLE ASSY (ST STL & NYLON COVERED)

LOCK ASSEMBLY

MATERIAL: NOTED

FINISH:

DRAWN BY

CHECKED BY

APPROVED BY

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE: .X ±, .XX ±, .XXX ±, ANGLES ±, FRACTIONS ±

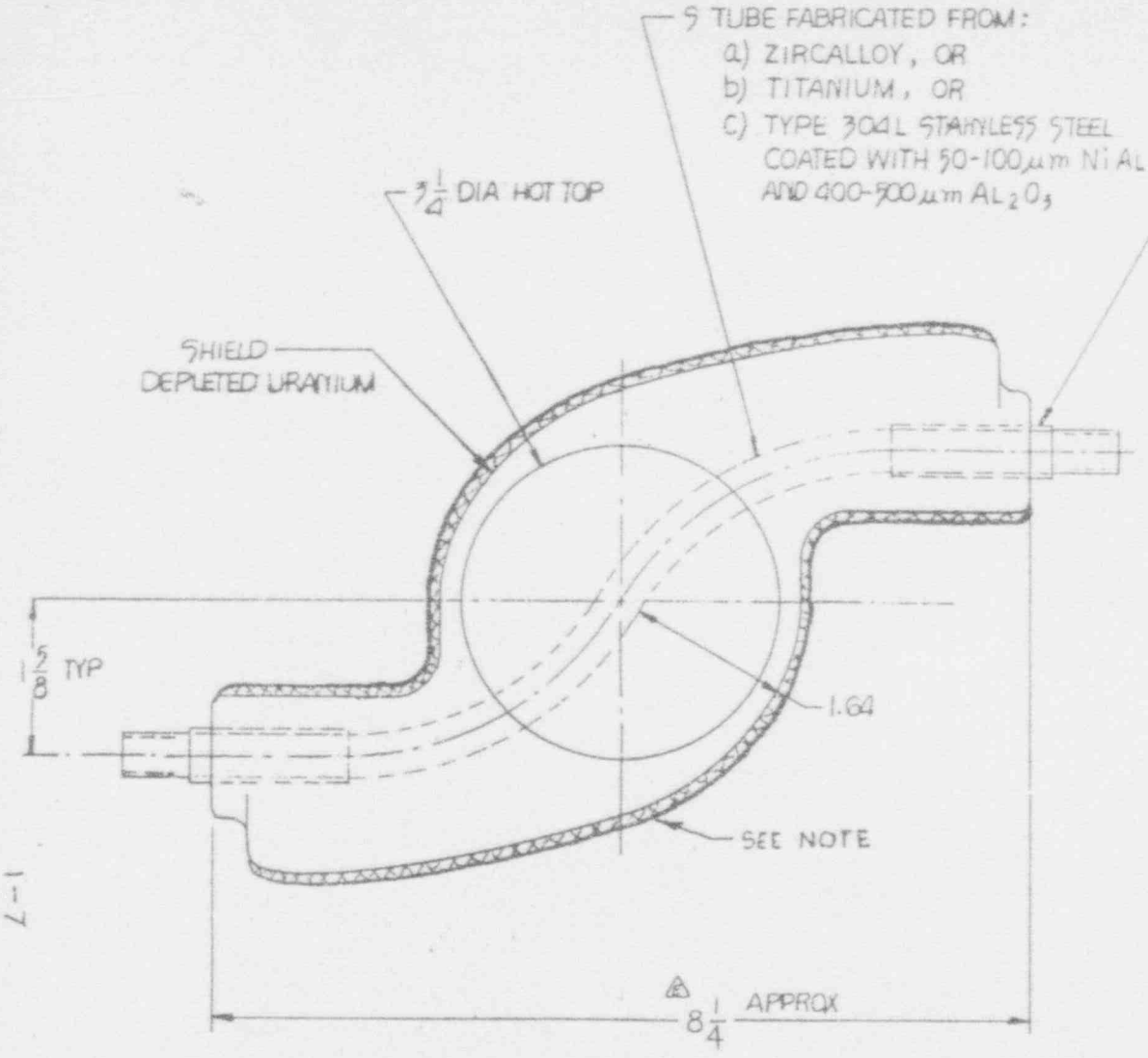
TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803

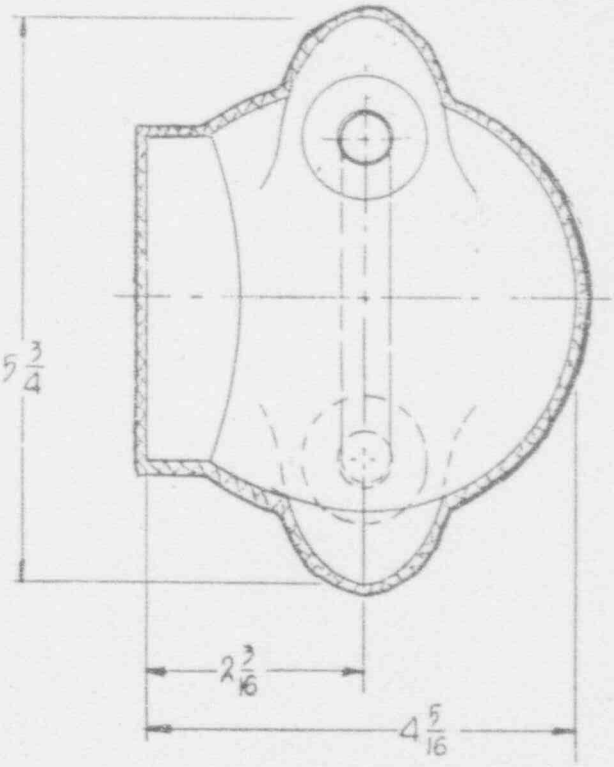
DWG TITLE: MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY

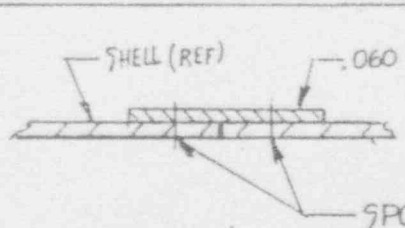
CLASSIFICATION | SIZE: C | DWG NO: 66025 | REV: F

SCALE 2:1 | SHEET 2 OF 3

C	11-22-89	WAS SHT 4 OF 4 & REV OF THIS SHT WAS – F/G & ADDED SECT. A-A F/G
D	9-4-90	ADDED "WELDED & INSPECTED IN ACCORDANCE WITH – – –" WAS "(MIL-W-6858)" E.C.O. # 718 F/G
E	1-13-93	SEE ECO 1222 TM 2/2
F	3/30/93	ADDED LEAD TO NOTE PER ECO 1222 RM 4/6







WELDED & INSPECTED IN ACCORDANCE WITH MIL SPEC W-6858

D

SECTION A-A

SCALE: 1/1

SHIELD DATA

37 LBS ± 3 lbs.

NOTE: ADDITIONAL LEAD SHIELDING NOT TO EXCEED 3 lbs. MAX. THICKNESS 1/4", TUNGSTEN NOT SHOWN.

MATERIALS	AS NOTED
FINISH	
DRAWN BY	
CHECKED BY	
APPROVED BY	
UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:	X ± ; XX ± ; XXX ± ; ANGLES ± ; FRACTIONS ±

Tech/Ops, Inc.
RADIATION PRODUCTS DIVISION
BURLINGTON, MA 01803

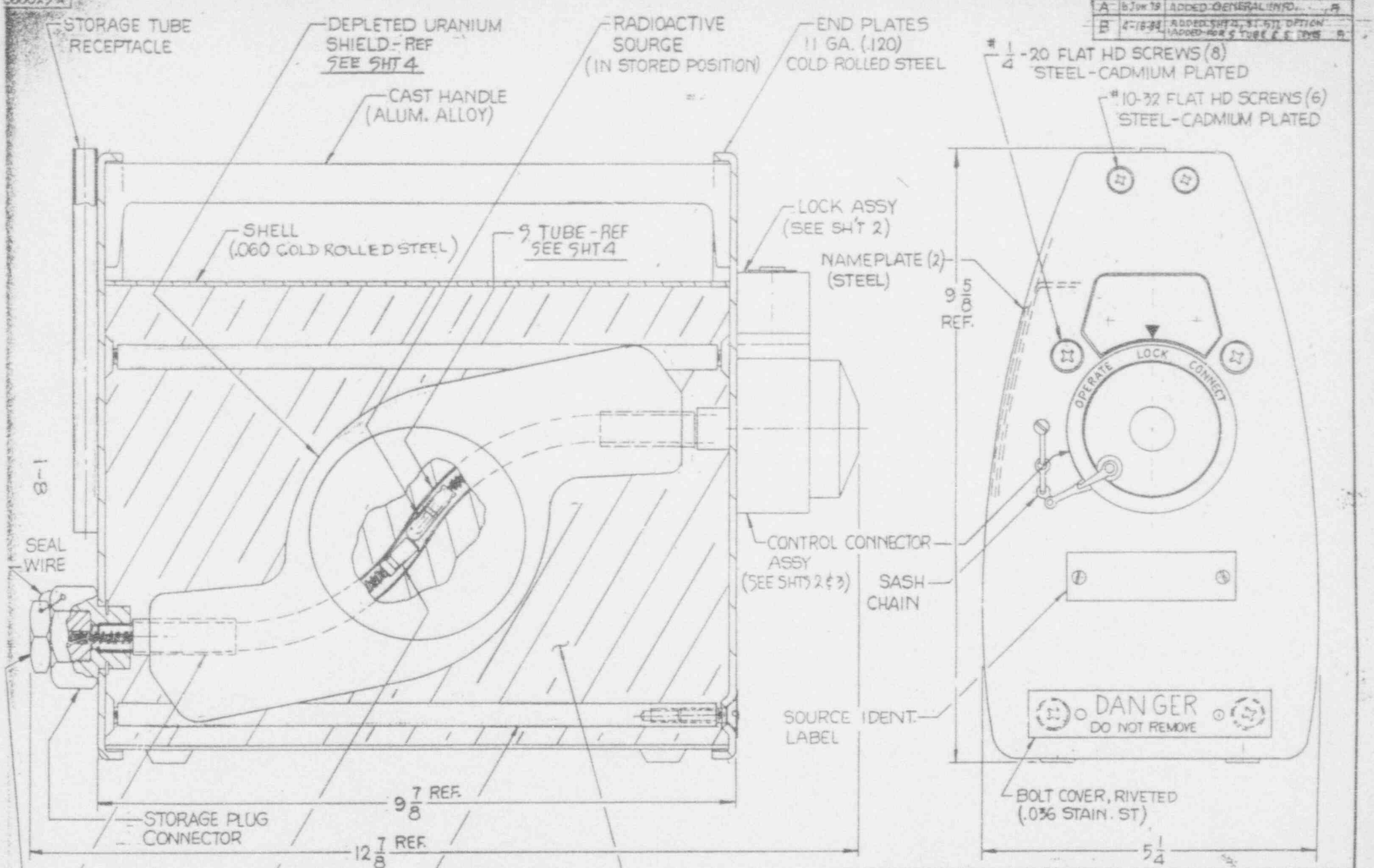
DRAWING TITLE
MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY

CLASSIFICATION	SIZE	DRWG NO	REV
	C	66025	F

SCALE 1:1 SHEET 3 OF 3

C66025 R

REV.	DATE	DESCRIPTION
A	6 JUN 79	ADDED GENERAL INFO.
B	4-16-84	ADDED SHT 2, S.S. SEAL OPTION ADDED FOR 5 TUBE S.S. DWG



MOD. NO.	MAX CAPACITY
660	120 Ci

TOTAL WEIGHT - 48 LBS

MATERIALS	NOTED
FINISH	
DRAWN BY	
CHECKED BY	
APPROVED BY	
UNLESS OTHERWISE SPECIFIED TOLERANCES ARE	X ±, XX ±, XXX ±, ANGLES ±, FRACTIONS ±

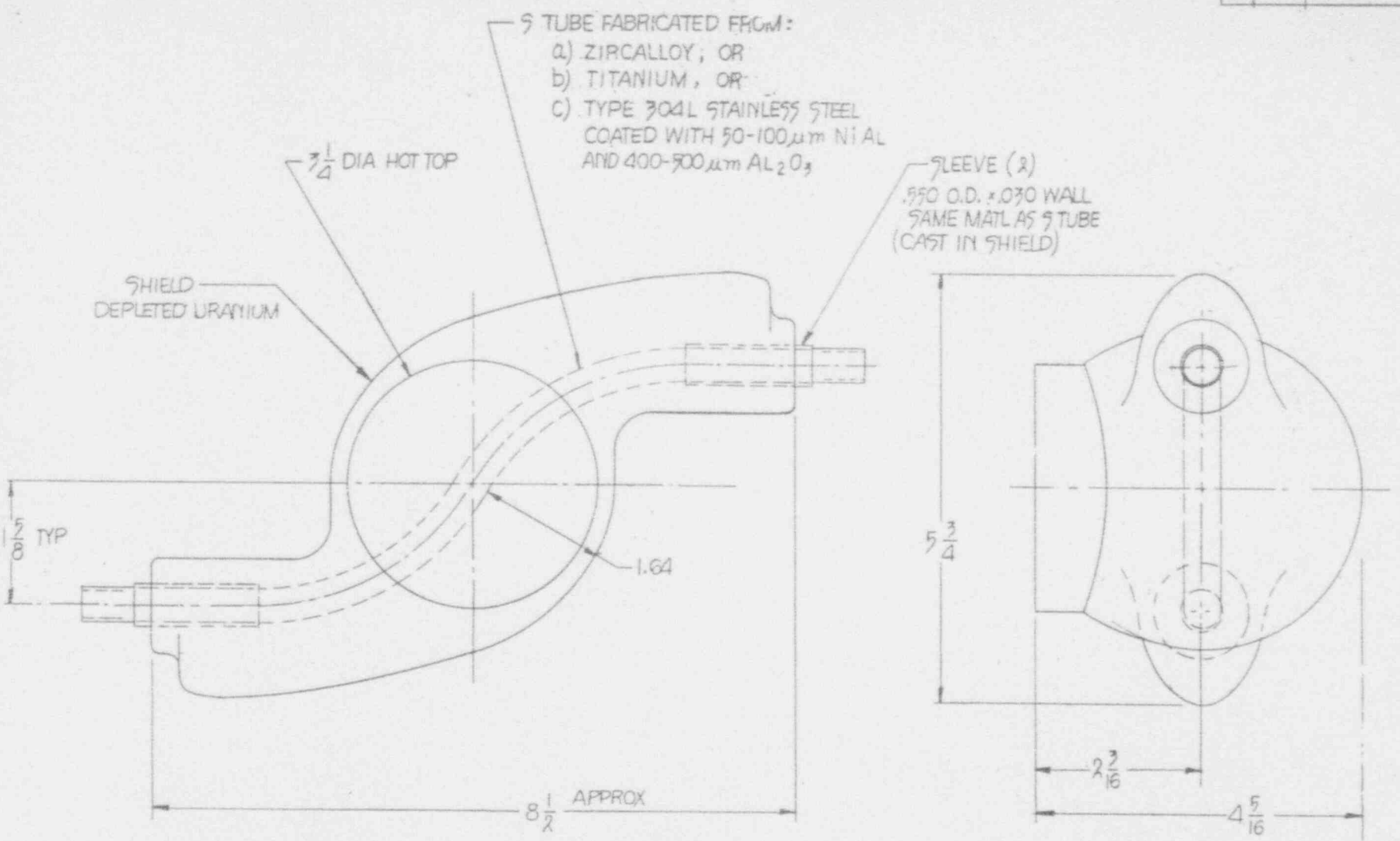
TECHNICAL OPERATIONS INC.
RADIATION PRODUCTS DIVISION
BURLINGTON, MA 01803

DWG TITLE
MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY

CLASSIFICATION	SIZE	DWG. NO.	REV.
	C	66025	B

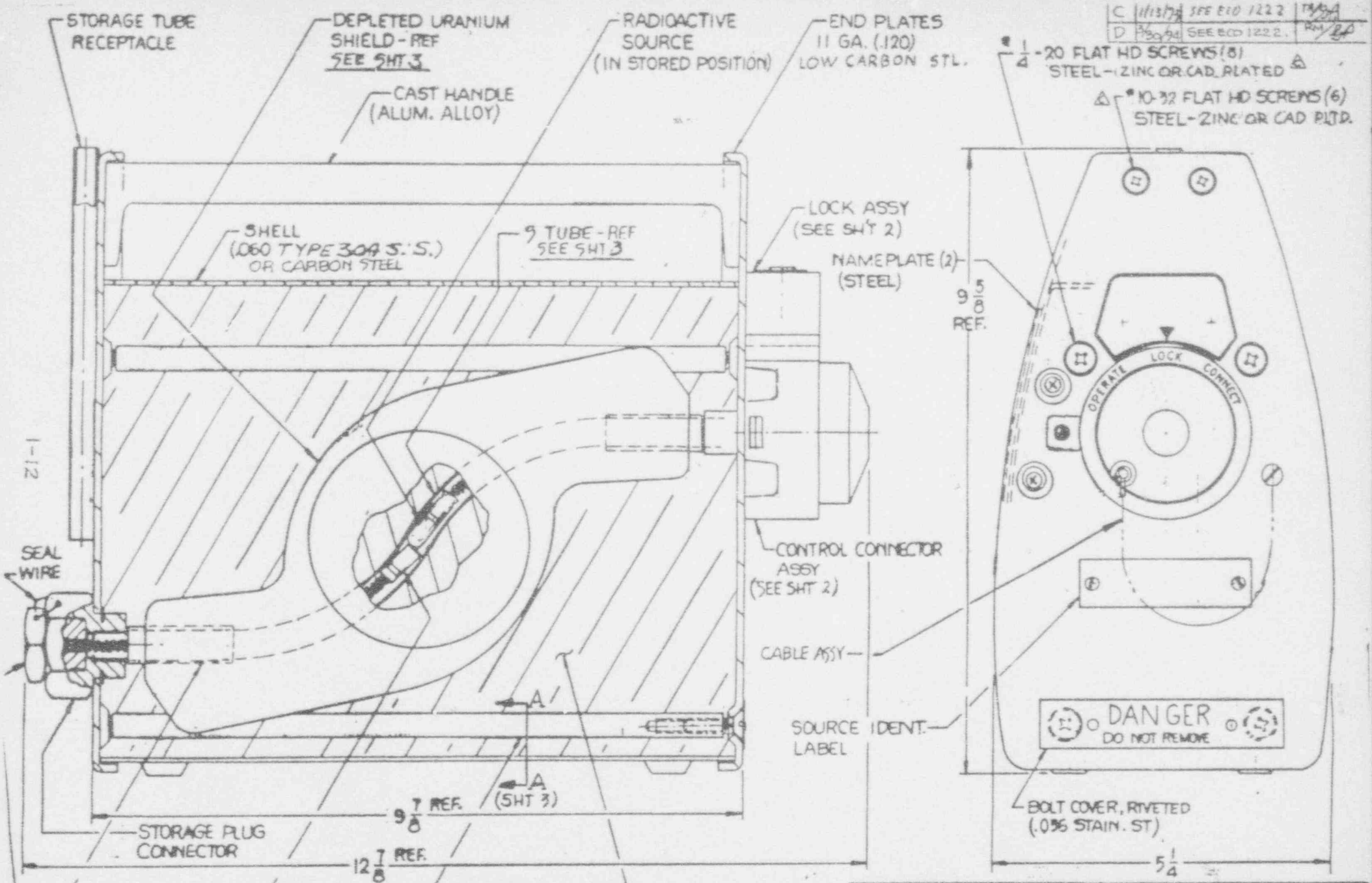
SCALE : | SHEET 1 OF 4

REV.	DATE	DESCRIPTION
B	4-8-86	SEE SHT 1



SHIELD DATA
35 LBS

MATERIALS: AS NOTED	Tech Ops	Tech/Ops, Inc. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803	
FINISH	DWG TITLE: MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY		
DRAWN BY: J. Tinsley 4-12-86	UNLESS OTHERWISE SPECIFIED TOLERANCES ARE: X ±		
CHECKED BY: [illegible]	XX ±		
APPROVED BY: [illegible]	XXX ±		
	ANGLES ±		
	FRACTIONS ±	CLASSIFICATION	SIZE: C DWG. NO. 66025 B
		SCALE 1:1	SHEET 4 OF 4



MOD NO	MAX CAPACITY
660A	120 Ci

TOTAL WEIGHT - 53 LBS ± 3 lbs.

C	11/13/73	SEE ECO 1222	TM/BM
D	1/30/74	SEE ECO 1222.	TM/BM

MATERIAL: MOPED

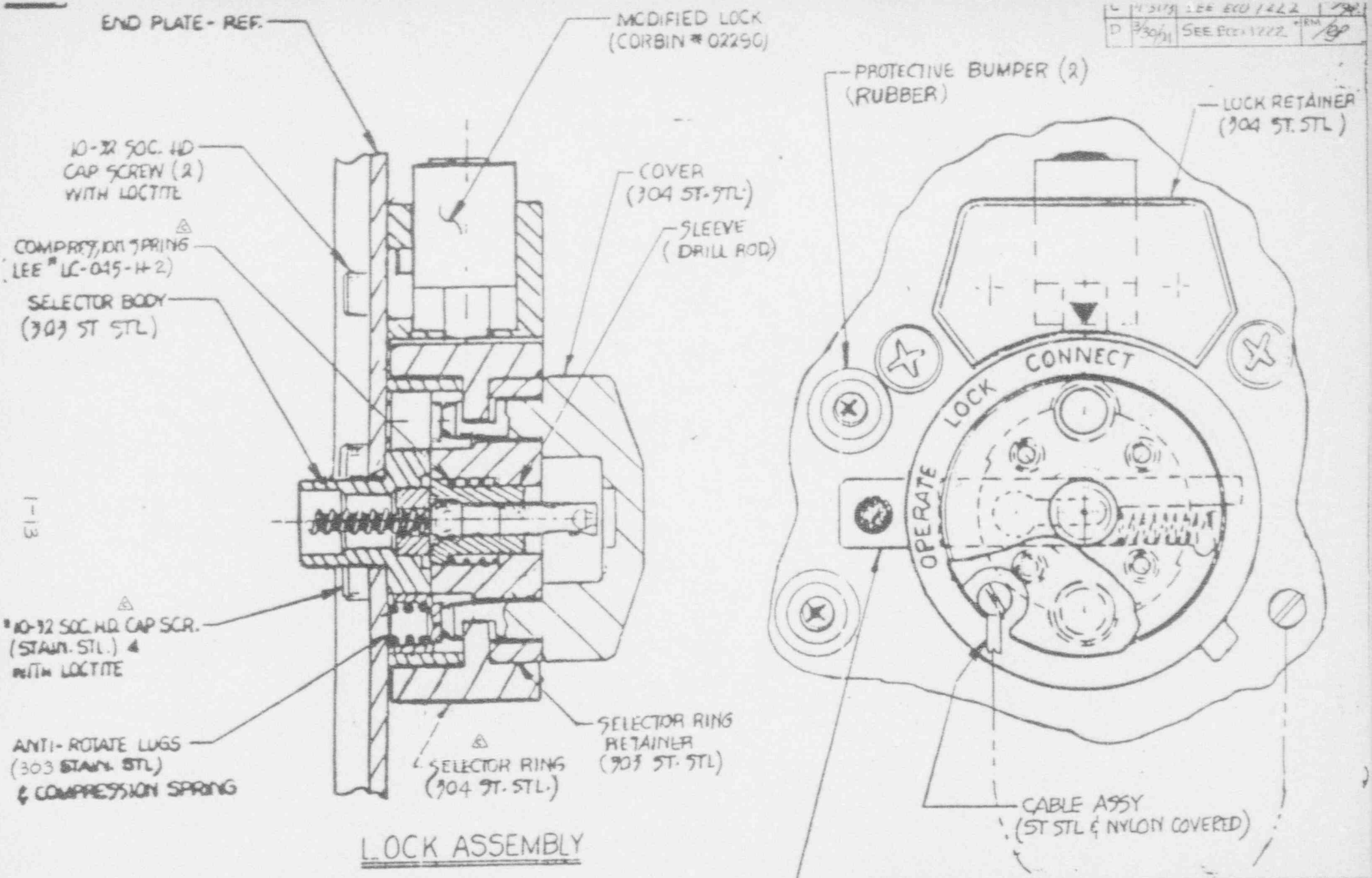
MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY

CLASSIFICATION: C | SIZE: D | DWG. NO. 66030 | REV. D

SCALE: 1:1 | SHEET 1 OF 3

1-12

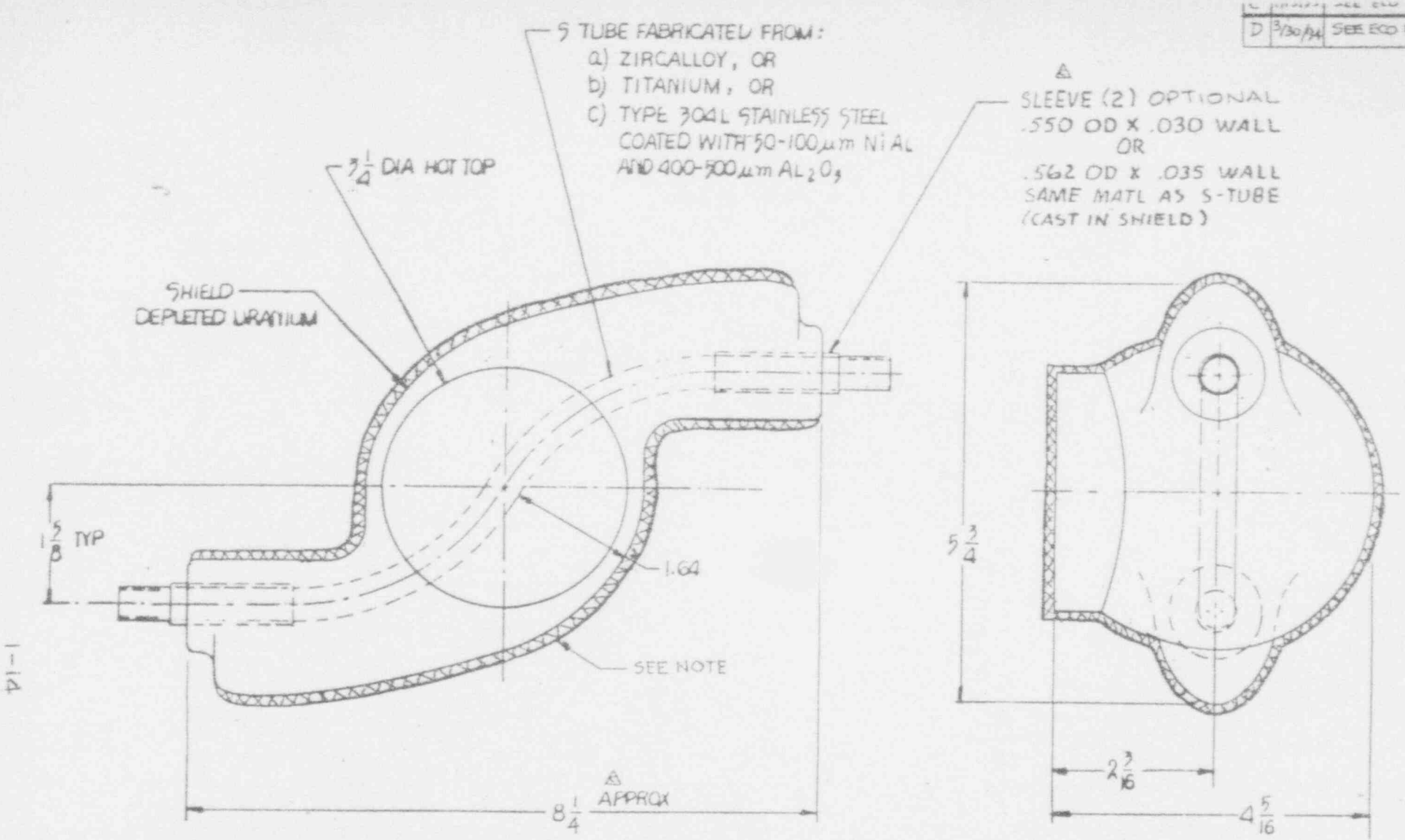
C	4/31/91	SEE ECO 1422	
D	3/30/21	SEE ECO 1222	RM

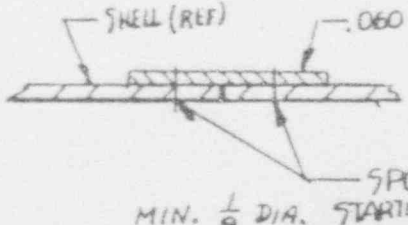


LOCK ASSEMBLY

MATERIAL: NOTED		RADIATION PRODUCTS DIVISION	
FINISH		MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY	
DRAWN BY: J. Tingley 4-27-87		CLASSIFICATION: C	DWG. NO. 66030 REV. D
CHECKED BY:		SCALE: 2:1	SHEET 2 OF 3
APPROVED BY:			

D	3/30/94	SEE ECO 12272	RM





SECTION A-A

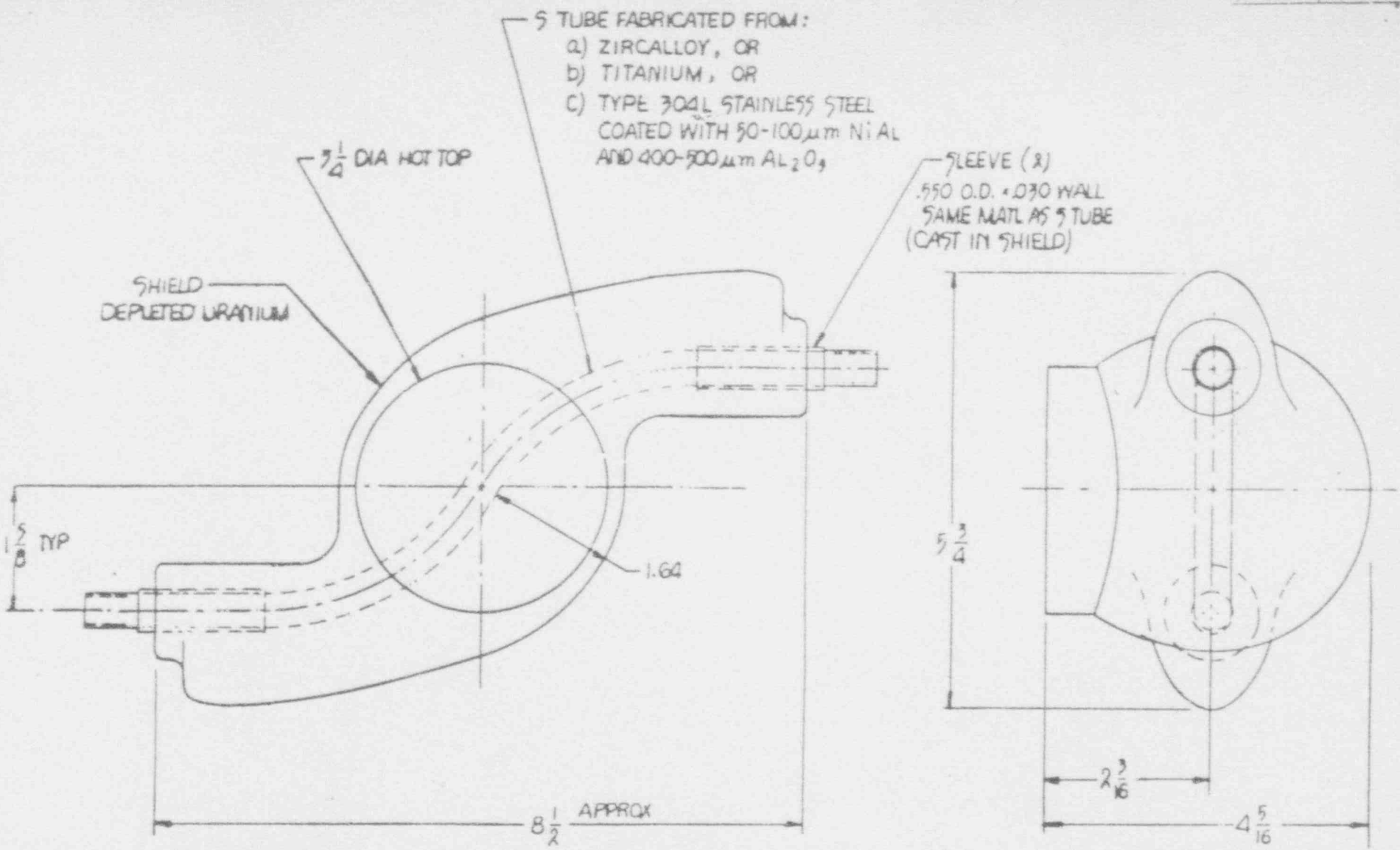
SCALE: 1/1

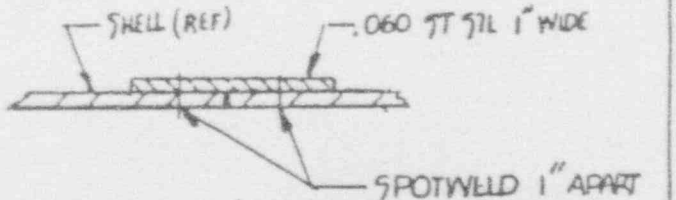
SHIELD DATA

37 LBS ± 3 lbs.

NOTE: ADDITIONAL LEAD SHIELDING NOT TO EXCEED 3 lbs. MAX. THICKNESS 1/4". TUNGSTEN NOT SHOWN.

MATERIAL: AS NOTED	RADIATION PRODUCTS DIVISION, BURLINGTON, MA 01803	
FINISH:	DRAWING TITLE: MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY	
DRAWN BY:	CLASSIFICATION: C	DWG. NO. 66030
CHECKED BY:	SCALE: 1:1	SHEET 3 OF 3
APPROVED BY:		





SECTION A-A

SCALE: 1/1

SHIELD DATA

39 LBS

SHT. 3 OF 3

AS NOTED	RADIATION PRODUCTS DIVISION
	TITLE: MODEL 660 GAMMA RAY PROBE SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY
	SIZE C — 66030 — REV A

MATERIAL	NOTED
FINISH	
DRAWN BY	
APPROVED BY	
TOLERANCES	X ± .1, .XX ± .02, .XXX ± .010, ANGLES ± 1°, FRACTIONS ± 1/64

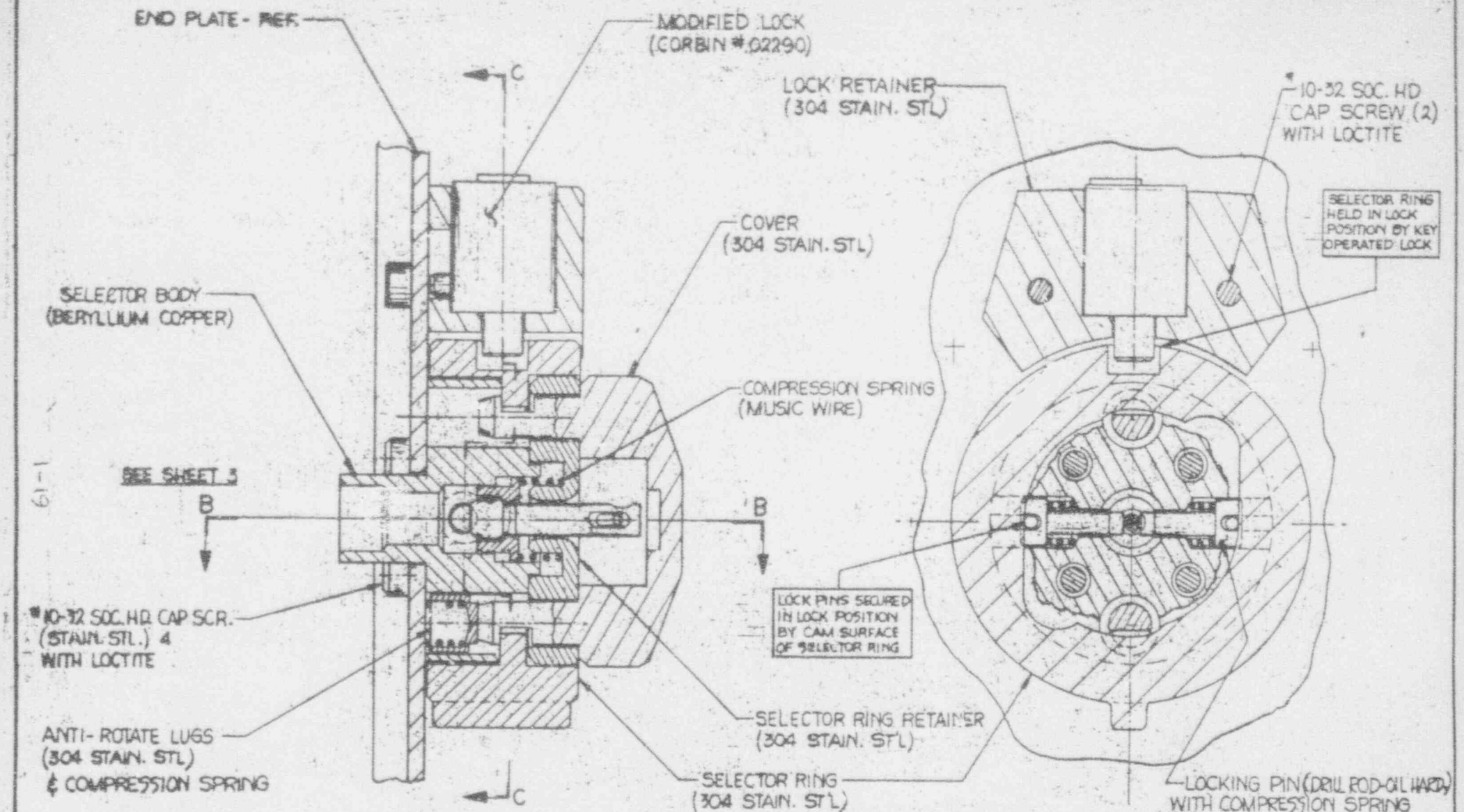
TECHNICAL OPERATIONS INC.
RADIATION PRODUCTS DIVISION
BURLINGTON, MA 01803

DRAWING TITLE
MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER
DESCRIPTIVE ASSEMBLY

CLASSIFICATION	SIZE	DRAWING NO.	REV.
	C	66030	

SCALE 1:1 SHEET 1 OF 4

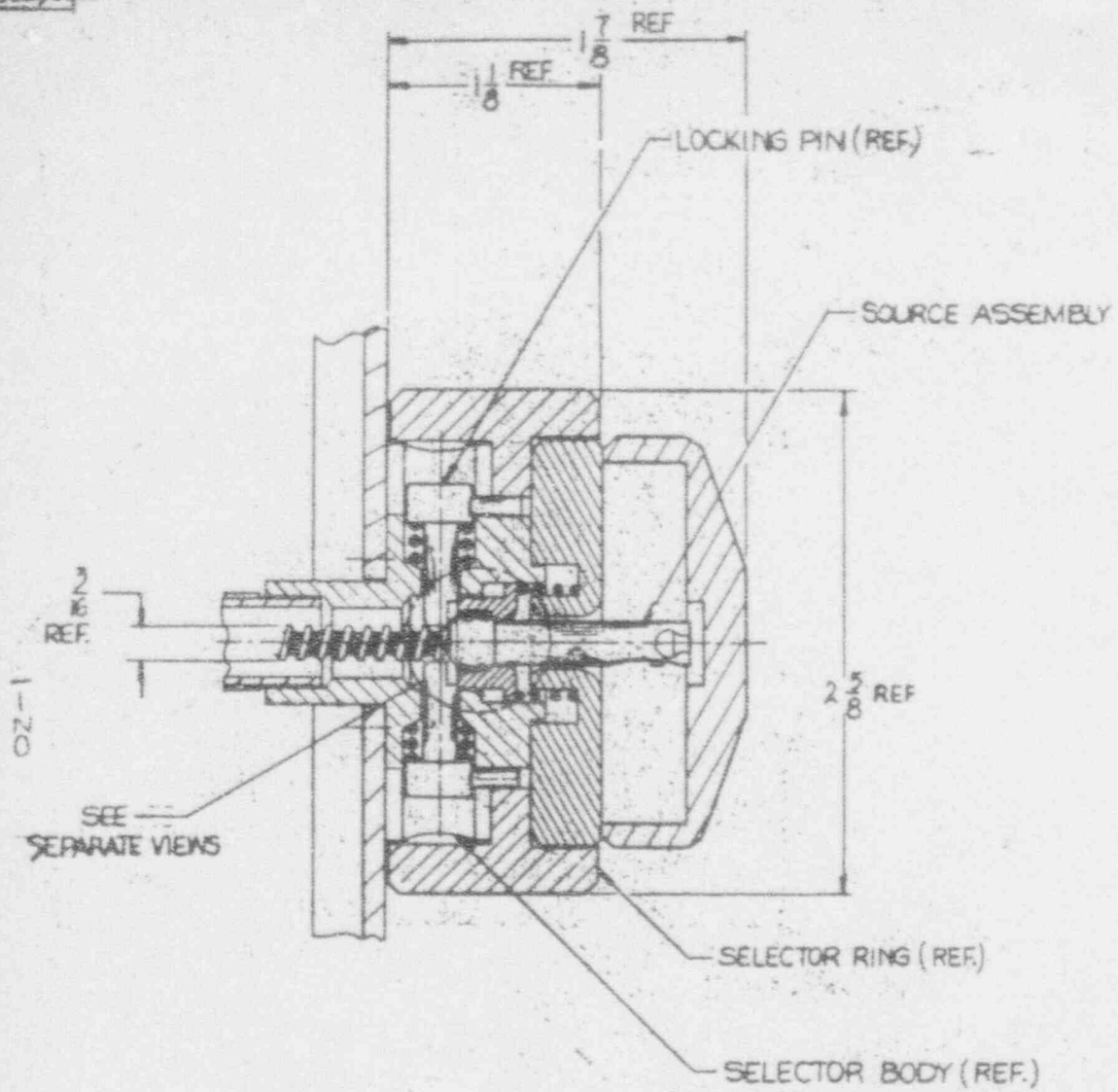
C66030



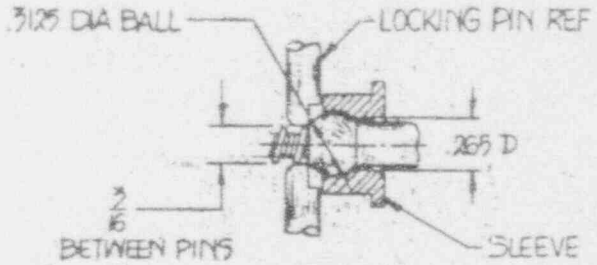
LOCK ASSEMBLY

SECTION C-C

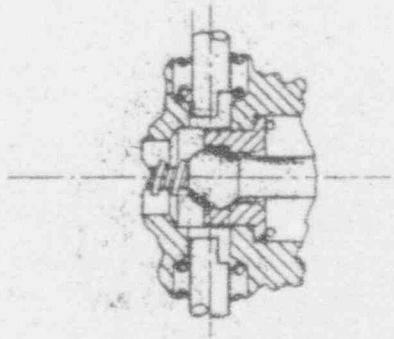
NOTED	TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803	
	MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY	
	CLASSIFICATION: C	SIZE: C DWG. NO. 66030 REV. —
	SCALE 2:1	SHEET 2 OF 4



SECTION B-B



LOCKED POSITION

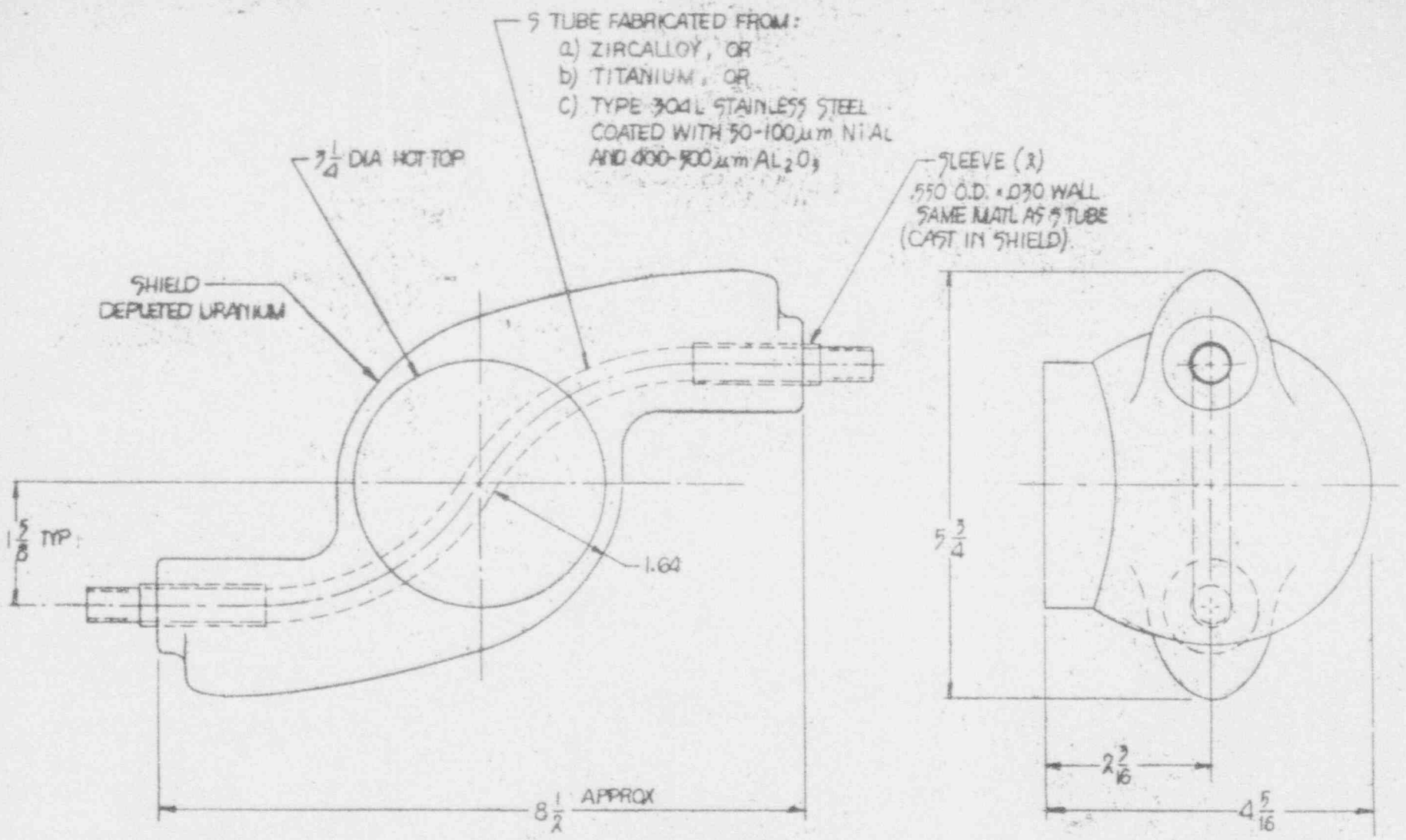


UNLOCKED POSITION

NOTED	TECHNICAL OPERATIONS INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803
	DRAW TITLE: MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY
	CLASSIFICATION: C DWG. NO. 66030
	SCALE 2:1 SHT. 3 OF 4

C66030

REV.	DATE	DESCRIPTION

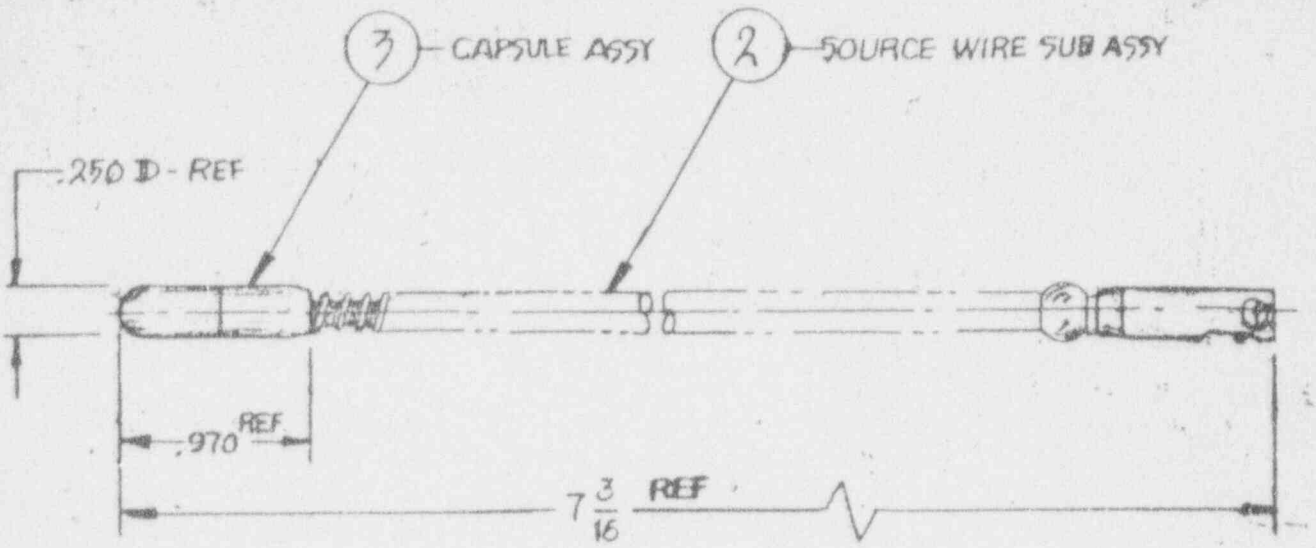


I-21

SHIELD DATA
35 LBS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	AS NOTED	Tech Ops. Tech Ops, Inc. RADIATION PRODUCTS DIVISION BURLINGTON, MA. 01803
		DRAWING TITLE: MODEL 660 GAMMA RAY PROJECTOR SHIPPING CONTAINER DESCRIPTIVE ASSEMBLY
		CLASSIFICATION: C SIZE: C DWG. NO. 66030 REV. 1
		SCALE 1:1 SHEET 2 OF 4

B	3-7-84	DWG # WAS REVISED & REDRAWN DUE TO CHANGES (REV A ON FILE)
C	8/11/92	SAFETY CLASS ADDED ECA 1024 TA



NOTES:

1. INSERT SOURCE WIRE SUB ASSY INTO CAPSULE ASSY. ASSURE THAT SOURCE WIRE IS FULLY INSERTED. (USE PAINTED END AS GAGE)
2. SWAGE CAPSULE ASSY TO SOURCE WIRE SUB ASSY USING FIXTURE NO. D859 HYDRAULIC PRESSURE MUST BE WITHIN THE RANGE OF 1250 (MIN.) & 1500 (MAX) LBS
3. APPLY THE TENSILE TEST BETWEEN THE CAPSULE & SOURCE WIRE SUB ASSY. APPLY A PROOF LOAD OF 100 LBS EXTENSION UNDER THE LOAD SHALL NOT EXCEED 0.05 INCH
4. FOR DETAILED PROCEEDURES, SEE RADIATION SAFETY MANUAL, PART B, SECTION 2

NOTE: THIS SOURCE ASSY IS USED IN CONJUNCTION WITH THE FOLLOWING RADIOGRAPHIC EXPOSURE DEVICES: MODEL # 660, 713

MATERIALS: SEE BM 42409

FINISH:

DRAWN BY: Dunphy 7 Mar 84

CHECKED BY:

APPROVED BY:

UNLESS OTHERWISE SPECIFIED TOLERANCES ARE
.X ±
.XX ±
.XXX ±
ANGLES ±
FRACTIONS ±

TechOps, Inc.
RADIATION PRODUCTS DIVISION
BURLINGTON, MA 01803

DWG TITLE: MODEL 424-9 SOURCE ASSY

CLASSIFICATION	SIZE	DWG. NO.	REV
A	A	42409	C

SCALE 1:1 | 1-22 | SHEET 1 OF 1

SPAULDING CO., INC. 21-25486

NRC FORM 616
(9-85)
10 CFR 71

NUCLEAR REGULATORY COMMISSION

CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES

1.a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. PACKAGE IDENTIFICATION NUMBER	d. PAGE NUMBER	e. TOTAL NUMBER PAGES
9033	8	USA/9033/B(U)	1	2

2. PREAMBLE

a. This certificate is issued to certify that the packaging and contents described in Item 5 below, meets the applicable safety standards set forth in Title 10, Code of Federal Regulations, Part 71, "Packaging and Transportation of Radioactive Material."

b. This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. THIS CERTIFICATE IS ISSUED ON THE BASIS OF A SAFETY ANALYSIS REPORT OF THE PACKAGE DESIGN OR APPLICATION

a. ISSUED TO (Name and Address)

Amersham Corporation
40 North Avenue
Burlington, MA 01803

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

Amersham Corporation application dated December 1, 1989, as supplemented.

c. DOCKET NUMBER 71-9033

4. CONDITIONS

This certificate is conditional upon fulfilling the requirements of 10 CFR Part 71, as applicable, and the conditions specified below.

5.

(a) Packaging

(1) Model No.: 660, 660E, 660A, 660AE, 660B or 660BE

(2) Description

A steel encased uranium shielded Gamma Ray Projector. Primary components consist of an outer steel shell, polyurethane potting material, uranium shield, "S" tube, and end plugs. The contents are securely positioned in the "S" tube by a source cable locking device and shipping plug. Tamper-proof seals are provided on the packaging. The maximum total weight of the package is approximately 53 pounds.

(3) Drawings

The packaging is constructed in accordance with the following Technical Operations, Inc. Drawings:

(i) Model No. 660B - Drawing No. 66025, Sheets 1, 2 and 3, Rev. D;

(ii) Model No. 660 - Drawing No. 66025, Sheets 1, 2 and 3, Rev. B, and Sheet 4, Rev. -; or Drawing No. 66030, Sheets 1, 2, 3 and 4, Rev. -;

(iii) Model No. 660A - Drawing No. 66030, Sheets 1, 2 and 3, Rev. A; or Drawing No. 66030, Sheets 1, 2 and 3, Rev. B.

Model Nos. with an E suffix have an electrical circuit.

(b) Contents

(1) Type and form of material

Iridium-192 sources which meet the requirements of special form radioactive material.

(2) Maximum quantity of material per package

(i) 140 Curies for the Model No. 660B or 660BE package.

(ii) 120 Curies for the Model No. 660, 660E, 660A or 660AE package.

6. The source shall be secured in the shielded position of the packaging by the source assembly. The source assembly must be fabricated of materials capable of resisting a 1475 °F fire environment for one-half hour and maintaining their positioning function. The source assembly must engage the locking device. The source assembly must be of sufficient length and diameter to provide positive positioning of the source within the depleted uranium shield assembly.

7. The source assembly for use with this packaging is limited to Technical Operations, Inc. Model No. 424-9 as shown in Technical Operations, Inc. Drawing No. 42409, Rev. B.

8. The name plate must be fabricated of materials capable of resisting the fire test of 10 CFR Part 71 and maintaining its legibility.

9. In addition to the requirements of Subpart G of 10 CFR Part 71:

(a) The package must meet the Acceptance Test and Maintenance Program of Chapter 8.0 of the application, as supplemented; and

(b) The package shall be prepared for shipment in accordance with the Operating Procedures in Chapter 7.0 of the application, as supplemented.

10. The package authorized by this certificate is hereby approved for use under general license provisions of 10 CFR §71.12.

11. Expiration date: October 31, 1995

REFERENCES

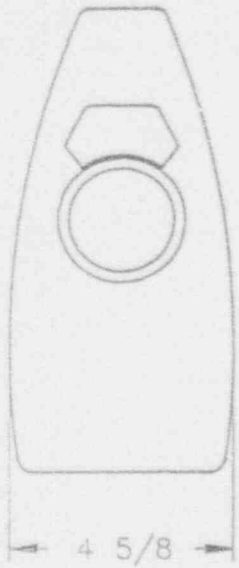
Amersham Corporation Application dated December 1, 1989.

Supplements dated: April 24, August 23, September 6, September 17, October 26 and November 27, 1990.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

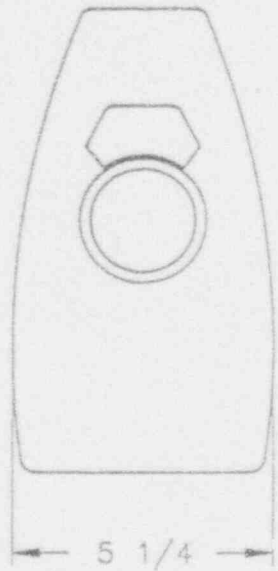
Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards
and Transportation, NMSS

Date: DEC 0 5 1990



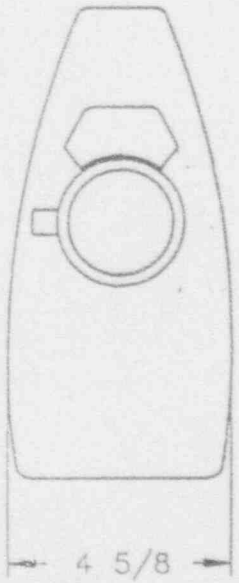
NARROW BODY
660
120 Ci

660E



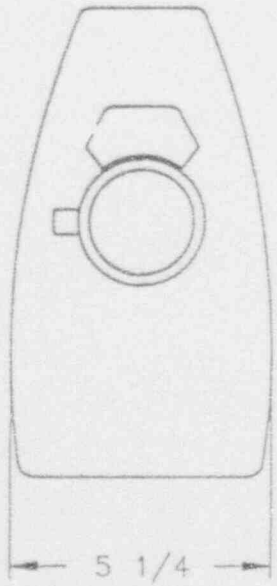
WIDE BODY
660
120 Ci

660E



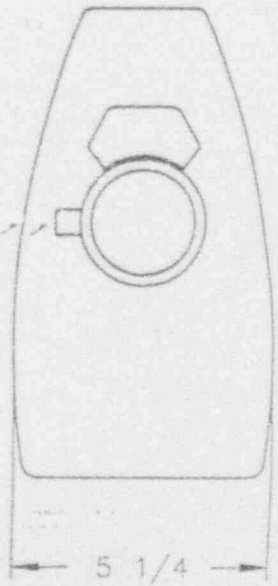
NARROW BODY
660A
120 Ci

660AE



WIDE BODY
660A
120 Ci

660AE



WIDE BODY
660B
140 Ci

660BE

2. Structural Evaluation

2.1 Structural Design

2.1.1 Discussion

The Model 660 series is comprised of five primary components: a source capsule, source holder assembly, shield assembly, outer housing assembly and locking assembly. The source capsule is the primary containment vessel. It satisfies the criteria for special form radioactive material. The shield assembly provides shielding for the radioactive material and, together with the source holder assembly and locking assembly, assures proper positioning of the radioactive source.

The outer housing consists of a shell and two end plates that are secured together by means of four tapped rods. The housing provides the structural integrity of the package.

The lockbox assembly secures the source holder assembly in the shielded position at the center of the source tube and assures positive closure.

2.1.2 Design Criteria

The Model 660 series is designed to comply with the requirements for Type B(U) packaging as prescribed by 10 CFR 71 and IAEA Safety Series No. 6 1985 Edition (as amended). All design criteria are evaluated by a straightforward application of the appropriate section of 10 CFR 71 or IAEA Safety Series No. 6.

2.2 Weights and Centers of Gravity

The total mass of the wide body Model 660 series is 53 ± 3 lbs. (24 ± 1.36Kg). The shield assembly consists of 37 ± 3 lbs. (16.8 ± 1.36 Kg) of depleted uranium. The center of gravity is located approximately in the center of the device. When required, up to 3 lbs. (6.6 Kg) of supplemental lead may be added.

2.3 Mechanical properties of Materials

The outer housing of the Model 660 series is fabricated from 304 stainless steel and low carbon steel. These materials have a yield strength of 30,000 PSI (207 MN/m^2).

The source capsules used in conjunction with the Model 660 are fabricated from titanium or stainless steel.

2.4 General Standards for All Packages

2.4.1 Minimum Package Size

Package exceeds minimum package size requirements specified by 10 CFR Part 71.43(a).

2.4.2 Tamperproof Feature

See Section 1.2.2 and 2.4.3.

2.4.3 Positive Closure

The control connector and lock assembly consists of a hardened steel locking slide (Models 660A, 660B, 660AE and 660BE only), a selector ring with three operating positions (connect, lock, and operate), and a casting which houses a key type lock.

The control connector and lock assembly provide for system safety in the following ways:

1. The source cannot be moved from the exposure device until a secure connection has been made between the source assembly and the control cable.

2. For the models 660 and 660E the locking assembly cannot unlock the source until the following conditions are met;

   a) key lock is unlocked,
   b) the drive cable has been connected to the source assembly,
   c) the control unit has been connected to the exposure device and,
   d) the selector ring has been rotated to the operate position,

3. For the models 660A, 660AE, 660B and 660BE, the locking assembly cannot unlock the source until the following conditions are met;

   a) key lock is unlocked,
   b) the drive cable has been connected to the source assembly,
   c) the control unit has been connected to the exposure device,
   d) the selector ring has been rotated to the operate position and,
   e) the locking slide is manually moved to the unlocked position.

   Note: When the locking slide is in the locked position a green colored indicator is visible. When in the unlocked position a red colored indicator can be seen.

4. The locking slide automatically locks the source assembly when the stop ball on the source assembly releases a spring loaded sleeve, that keeps the locking slide open during exposure of the source The source assembly cannot be exposed again, until the locking slide is manually reset to the open position.

During transport a protective cap is inserted into the control connector, the selector ring is rotated to the lock position and the key lock is depressed into a recess in the selector ring. A storage plug is also threaded into the front of the exposure device and positioned against the source capsule on the source assembly preventing movement until the storage plug is removed. During transport the storage plug is seal wired to provide a tamper indicator.

Positive closure of the package during transport is maintained with these features.

2.4.4 Chemical and Galvanic Reactions

The materials used in the construction of the Model 660 series are depleted uranium metal, stainless steel, steel, titanium, rigid polyurethane foam and when required, supplemental lead or tungsten. There will be no significant chemical or galvanic action between any of these components.

The possibility of the formation of a eutectic alloy of iron and depleted uranium at temperatures below the melting temperatures of the individual metals has been considered. The iron-uranium eutectic alloy temperature is approximately 1337°F (725°C). However, vacuum conditions and extreme cleanliness of the surfaces are necessary to produce this alloy at this low temperature. Due to the conditions in which the shield is mounted in the Model 660, sufficient contact for this effect would not exist.

In support of this conclusion, the following test results are presented. On 28 November 1973, a thermal test of a sample of bare depleted uranium metal was performed by Nuclear metals, Inc., Concord, MA. The sample was placed in a ceramic crucible and inserted in a furnace preheated to 1475°F (802°C) and remained there for thirty minutes. The sample was then removed and allowed to cool. The test indicated that the uranium sample oxidized such that the radial dimension was reduced by 0.007 in. (0.18mm).

On 25 January 1974, a subsequent test was performed by Nuclear Metals, Inc. In this test, a sample of bare depleted uranium metal was placed on a steel plate and subjected to the thermal test conditions. The test revealed no melting or alloying characteristics in the sample and the degree of oxidation was the same as experienced in the earlier test.

In July 1992, two Model 660's manufactured in 1974 with supplemental lead shielding, were disassembled and visually examined. There was no evidence of any problematic degree of eutectic alloying. The products were then reassembled and drop tested, to show that the additional weight, did not have any adverse effect on the structural integrity of the product. The test report and photo's are included in appendix 2-10.

2.5 Lifting and Tiedown Standards for all Packages

2.5.1 Lifting Devices

The Model 660 series is designed to be lifted by its handle. Failure of this lifting system could be accomplished by shearing two #10-32 flat head screws securing one side of the handle. The yield strength of the screw material is assumed to be 40,000 pounds per square inch. The cross sectional area of each screw is 0.02 in.^{2} (12.9 mm^2). Therefore, a load of 1600 lbs. (7117N) must be applied to generate stress equal to the yield strength of the material.

This is equal to thirty times the weight of the package.

3.4.3 Minimum Temperatures

The minimum normal operating temperature of the Model 660 Series is -40°F (-40°C). This temperature will have no adverse effect on the structural integrity or shielding efficiency of the package.

3.4.4 Maximum Internal Pressures

Normal operating conditions will generate negligible internal pressures. Any pressure generated is significantly below that which would be generated during the hypothetical accident thermal condition, which is shown to result in no reduction in structural integrity or shielding efficiency.

3.4.5 Maximum Thermal Stress

The maximum temperatures which will occur during normal transport are sufficiently low to assure that thermal gradients will cause no significant thermal stresses.

3.4.6 Evaluation of Package Performance for Normal Conditions of Transport.

The normal transport thermal condition will have no adverse effect on the structural integrity or shielding efficiency of the package. The applicable conditions of IAEA Safety Series No. 6 for Type B(U) packages are shown to be satisfied by the Model 660 Series.

3.5 Hypothetical Accident Thermal Evaluation

3.5.1 Thermal Model

The Model 660 Series, including the source assembly, is assumed to reach the fire test temperature of 1475°F (802°C). At this temperature the polyurethane potting compound will have decomposed and the resulting gases will have escaped the package through the assembly joints which are not leak-tight.

During a hypothetical fire test, the supplemental lead shielding would melt and affect the shielding integrity. The maximum thickness of lead that may be installed in a device is limited to 0.25 inch. Using the calculational model below the increase in surface radiation levels and at one meter could increase to 667 mR/hr at the surface and 30 mR/hr at one meter. This is below the allowable 1 R/hr at one meter after an accident condition as described in 10 CFR Part 71.51(2).

maximum allowable at surface for final accepted package = 200 mR/hr = I_s

maximum allowable at one meter for final accepted package = 10 mR/hr = I_s

transmission factor for 0.25 lead from Amersham Radiation Safety Handbook = 0.3 = T_f

I_s = Intensity shielded

q_r = Radiative heat transfer

$= \sigma \epsilon A (Tw^4 - Ta^4)$

Where σ = Stefan Boltzmann Constant ($5.669 \times 10\text{-}8$ $W/m^2 \cdot K^4$)

ϵ = Emissivity (0.8)

Iteration of this relationship yields a maximum wall temperature of 154°F (68°C) which satisfies the requirements of paragraph 543 of the IAEA Safety Series No. 6, 1985 Edition (as amended).

The maximum wall temperature will not adversely affect the package, as it will not cause cracking or melting of the shielding material and will not alter the semetric form or physical state of the radioactive material.

3.6.3 Amersham Model 660 Series Type B(U) Source Capsule Thermal Analysis Paragraph 553 of IAEA Safety Series No. 6 1985 Edition (as amended).

This analysis demonstrates that the pressure inside the source capsule used in conjunction with the Model 660 Series, when subjected to the hypothetical accident thermal condition, does not exceed the pressure which corresponds to the minimum yield strength at the thermal test temperature.

The source capsule is fabricated from stainless steel, either Type 304 or 304L. The outside diameter of the capsule is 0.250 in. (6.35 mm). The source capsule is seal welded. The minimum weld penetration is 0.016 in (0.41 mm). Under conditions of internal pressure, the critical location for failure is this weld.

The internal volume of the source capsule contains only Iridium metal (as a solid) and air. It is assumed at the time of loading, the entrapped air is at standard temperature and pressure 68°F and 14.7 psi (20°C and 101 kN/m^2). 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 would be somewhat reduced.

Under the conditions of paragraph 553 of IAEA Safety Series No. 6, 1985 Edition (as amended) it is assumed that the capsule could reach a temperature of 1475°F (802°C). Using the ideal gas law and requiring the air to occupy a constant volume, the internal gas pressure could reach 54 psi (372 KN/m^2).

The capsule is assumed to be a thin walled cylindrical pressure vessel with the wall thickness equal to the depth of weld penetration.

The maximum longitudinal stress is calculated from:

$\sigma A = PA_p$

where σ = Longitudinal Stress
A = Stress Area

7. Operating Procedure

7.1 Procedure for Loading the Package

1. Ensure that the source is locked into place in its storage position. To check this, the dust cover should be in place, the lock should be in the down position, the key removed, the dust cover should be in place, and the selector ring should be immobile.

2. The storage plug should be properly inserted. (attach a tamper proof security seal with an identification mark to the storage plug).

3. Assure all the conditions of the Certificate of Compliance are met and the package has all the required markings.

4. If the shipping container is to be packaged in a crate or other outer packaging, the outer packaging must be strong enough to withstand the normal conditions of transport. These requirements are outlined in 10 CFR 71. The shipping container should be put in the outer package with sufficient blocking to prevent shifting during transportation.

5. 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 16 in.^{2} (100 cm^2) of the package surface. The activity on the filter paper should not exceed 0.001 uCi of removable contamination.

6. Survey the package with a survey meter at the surface and at a distance of one meter from the surface to determine the proper radioactive shipping labels to be applied to the package as required by 49 CFR 172.403. If radiation levels above 200 mR/hr at the surface or 10 mR/hr at 40 inches (1m) from the surface are measured, the container must not be shipped.

7. Complete shipment of the package according to proper procedures for transporting radioactive material as established in 49 CFR 171-178.

   NOTE: The U.S. Department of Transportation, in 49 CFR 173.22 (c) requires each shipper of Type B quantities of radioactive material to provide prior notification to the consignee of the dates of shipment and expected arrival.

7.2 Procedure for Unloading the Package

The consignee of a package of radioactive material must make arrangements to receive the package when it is delivered. If the package is to be picked up at the carrier's terminal, 10 CFR 20.205 requires that this be done expeditiously upon notification of its arrival.

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 properly seal wired. The package is inspected to assure that the required marking and labeling is securely attached to the package.

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

The package is inspected to assure it was manufactured in accordance with drawing 66025 or 66030, see Appendix 1.3.

8.1.2 Structural and Pressure Tests

The swage coupling between the source capsule and cable of the source assembly is subjected to a static tensile test with a load of 100 lbs. (445N).

8.1.3 Leak Tests

The radioactive source capsule, which serves as the primary containment, is wipe tested for leakage of radioactive contamination and must be less than 0.005 microcuries of removable contamination. The source capsule is subjected to a vacuum bubble leak test. Failure of either 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 the security of the source will be maintained. A simulated (dummy) source assembly is installed in the radiographic exposure device and the lockbox locked. An attempt is made to pull the simulated source out through the lockbox. The shipping plugs are installed and checked to be sure they are attached securely to the device. Failure of either of these two tests will prevent use of the package until the cause of the failure is corrected and retested.

8.1.5 Tests for Shielding Integrity

With the package containing a source assembly, the radiation levels at the surface of the package and at 40 inches (1m) from the surface of the package are measured using a small detector survey instrument. These radiation levels, when extrapolated to the rated capacity of the package, must not exceed 200 milliroentgens per hour at the surface of the package nor 10mR/hr at 40 inches (1m) from the surface.

8.1.6 Thermal Acceptance Tests

Not applicable.

8.2 Maintenance Program

8.2.1 Structural and Pressure Tests

8.2 Maintenance

Inspection and maintenance of the Model 660 exposure device should be performed as described below. A quarterly check should be performed and at least annually, the lock mechanism should be stripped for maintenance.

Quarterly Check

a) Clean and inspect the projector for wear or obvious damage. Report any defect which might affect safe operation and withdraw it from service until repairs can be effected.

b) See that the radioisotope warning labels are secure and legible. Do not cover with any other labels.

c) Check that the source outlet shipping plug is in place and that the screw and nut turn freely, but are not loose.

d) Check that the selector ring and lock mechanism operate freely. If operation is faulty, contact Amersham to arrange for servicing.

e) If any operational problems are discovered, the lock mechanism should be stripped for maintenance.

Exposure Device without Automatic Locking Mechanism - Models 660 and 660E

To service the exposure device, remove the source following the source changing procedures. After the source has been removed, service the exposure device by performing the following steps:

1. Remove the Danger Tag (secured with rivets) from the bottom of the rear plate.

2. Remove the rear plate by unscrewing the six phillips head screws securing it to the exposure device body.

3. Unlock the connector lock, and then remove the lock assembly and control unit connector assembly by unscrewing the six socket head screws securing them to the rear plate.

4. Disassemble the control unit connector assembly, referring to Figure 1 for component identification and for order of removal. There are several spring loaded parts in the connector assembly, so care should be taken that these parts are not lost.

5. To disassemble the lock assembly, refer to Figure 1 for component identification and for order of removal. Remove the lock (2) from the lock retainer (3) by unscrewing the screw (4) and turning the key about 90°.

6. Remove the front end plate from the exposure device, and remove the guide tube connector and retaining ring with Tru Arc pliers, referring to Figure 1. The handle may be left on the front plate.

7. Clean all parts in mineral spirits (or equivalent).

damage and proper alignment. Relubricate the parts and reassemble.

22. Secure the rear end plate to the exposure device and handle using the six attaching phillips head screws and replace the protective plate over the bottom two rear plate screws using pop rivets (0.125 in diameter x 0.295 in long).

23. Check the system for proper reassembly. Check all connections and fittings for tightness. Check for proper operation of the control unit and control unit connector assembly.

24. Reload the source in the exposure device by following the appropriate operations manual for the device.

25. Survey the exposure device on all sides to ensure that radiation levels do not exceed 200 mR/hr at the surface nor 10 mR/hr at one meter from the surface.

26. Check the exposure device for the proper labels.

27. Check the general condition of the outside surfaces for excessive wear. See below for most likely excessive wear characteristic.

Outer Container

Sliding the product on abrasive surfaces, can, over a period of time, cause wear-through of the extended feet on the bottom of the unit.

This wear characteristic, has no adverse affect on the structural integrity, functionality or safety standards of the product.

If and when, wear through of the feet occurs, repair procedures should be considered in order to prevent any damage occurring to the end plates. The product can be returned to Amersham Corporation for repair. This repair can occur in two ways.

a) Additional foot pads (66001-51) can be welded over the existing foot pad locations, or

b) The outer shell is removed and a new outer shell is installed.

Devices with Automatic Locking Mechanisms/Model 660B, 660BE, 660A, and 660AE

(a) Cover Plate Removal

1. Remove the Danger Tag (secured with rivets) from the bottom of the rear plate.

2. Remove the rear plate by unscrewing the six phillips head screws securing it to the exposure device body.

(b) Refer to Figure 2 and dismantle the selector assembly taking care not to lose the spring loaded parts.

Remove the lock (2) from the lock retainer (3) by undoing screw (4) and turning the key through 90 degrees.

(c) Remove 4 screws securing the front end plate.

Remove the guide tube connector nut (17) and retaining ring (18).

(d) Clean all parts with mineral spirits or equivalent and inspect for wear. Replace as necessary.

(e) Lightly grease the inside surfaces of the selector ring (10) and the lock retainer (3) using type MIL-G-23827 B grease.

Reassemble the lock by placing the return springs and spring guides into the lock, depressing the internal plunger (5), inserting the lock into the retainer (3) and securing the lock with the cap screw (4).

Attach the lock assembly to the mounting plate with two socket screws (1).

(f) Begin the Selector Assembly reassembly by lightly coating the components with type MIL-G-23827 B grease. See Figure 2.

Hold rear end plate horizontally, face up and the lock in the 12 o'clock position.

Insert the 5/8 diameter of the selector boy (6) into the mating hole in the center of the rear plate. The narrow end of the slot of selector body.

Locate the locking slide (7) and return spring (8) into mating slot of selector body.

Placing the selector ring (10, with the work "CONNECT" at the 12 o'clock position, over the selector body. Push the locking slide in slightly so the selector ring will clear and rest the selector ring on the top surface of the selector body.

Insert springs (14) into holes at the top and bottom of the selector body. Place the anti-rotation lugs (13) over the springs.

Place the sleeve (12), with the large diameter facing down, on the center of the locking slide. Place the spring (11) over the sleeve.

Install the selector ring retainer (9) into the selector ring. Ensure that the three non-threaded holes line up under the word "CONNECT". See Figure 2. Depress the selector ring retainer into the selector ring until its top is flush with the top of the selector ring.

(g) While holding the assembly firmly against the end plate, turn it over to expose the back side. Install the four socket head screws (15) and the lock washers (16) and torque to 30 lbs.ft. ±5 lbs.ft. to secure the connector assembly to the rear plate.

Insert the "U-Tool" into the top and bottom holes of the selector assembly. Rotate the selector ring toward the "OPERATE" position. Remove the "U-Tool". Continue rotating to "OPERATE" position.

Push the locking slide until the sleeve snaps into place.

(h) While still in the "OPERATE" position, wind out a short length of the drive cable and pass it through the front of the selector assembly. Couple the cable to the test jumper connector and withdraw it into the selector assembly.