71-9007

SAFETY ANALYSIS REPORT

TECH/OPS, INC.

MODEL AI 520

TYPE B(U) PACKAGE

USA/9007/B(U)

RECEIVED
OCT 17 1985
U.S. NUCLEAR REGULATORY COMMISSION
NMSS
Mail Section

Revision 0

16 September 1985

25974

1.0 General Information

1.1 Introduction

Tech/Ops, Inc. Model AI 520 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 AI 520 conforms to the criteria for Type B(U) packaging in accordance with 10 CFR 71 and IAEA Safety Series No. 6, 1973 Revised Edition (as amended).

1.2 Package Description

1.2.1 Packaging

The model AI 520 is 273 millimeters (10.75 inches) long, 133 millimeters (5.25 inches) wide, and 162 millimeters (6.38 inches) high. The packaging incorporates a handle which extends 38 millimeters (1.50 inches) from the top surface and is 209 millimeters (8.25 inches) long. The total mass of the package is 18 kilograms (40 pounds).

The radioactive material is sealed in a source capsule which conforms to the requirements for special form radioactive material. This source capsule is installed onto a source holder assembly. The source holder assemblies used in conjunction with the Model AI 520 are listed in the appendix.

The source holder assembly is housed in an 'S' shaped titanium source tube. The source tube has an outside diameter of 11.8 millimeters (0.465 inch) and an inside diameter of 10.9 millimeters (0.430 inch). One end of the source tube is enclosed by means of a shipping plug that fastens onto a threaded fitting that is welded to the front end plate. The shipping plug is drilled to provide a means for attaching tamper-proof seal wire during transport. The other end of the source tube is enclosed by means of the lock box assembly which is welded to the rear plate of the device. A brass plug is attached to the threaded fitting on the lock box. This brass plug is drilled to provide a means for attaching a tamper-proof seal wire during transport. The locking assembly is used to secure the radioactive source and source holder assembly in the shielded position during transport.

The source tube is surrounded by uranium metal as shielding material. The uranium shielding is cast in place around the source tube. The mass of the uranium shield is 12.3 kilograms (27 pounds).

The uranium shield is encased in a type 304 stainless steel housing. The steel housing is 3.2 millimeters (0.125 inches) thick.

The outer packaging is designed to avoid the collection and retention of water. The package has a smooth, unpainted stainless steel finish to provide for easy decontamination.

The radioactive material is sealed inside a stainless steel source capsule. This capsule acts as the containment vessel for the radioactive material.

1.2.2 Operational Features

The source holder assembly is secured in the proper shielded storage position by means of the locking assembly. With the source holder assembly in the proper shielded storage position, a cap is installed over the source holder assembly and attached to the lock box. This cap is seal wired to prevent inadvertent loosening. Inserting the shipping plug will insure that the source holder assembly is in the proper shielded storage position. The shipping plug is also seal wired to insure against unauthorized tampering or removal.

1.2.3 Contents of the Package

The Model AI 520 is designed for the transport of iridium-192 in quantities up to 120 curies in Tech/Ops source assemblies listed in the appendix. The source capsule used with each of these source assemblies satisfies the criteria for special form radioactive material in accordance with 10 CFR 71 and IAEA Safety Series No. 6, 1973 Revised Edition (as amended).

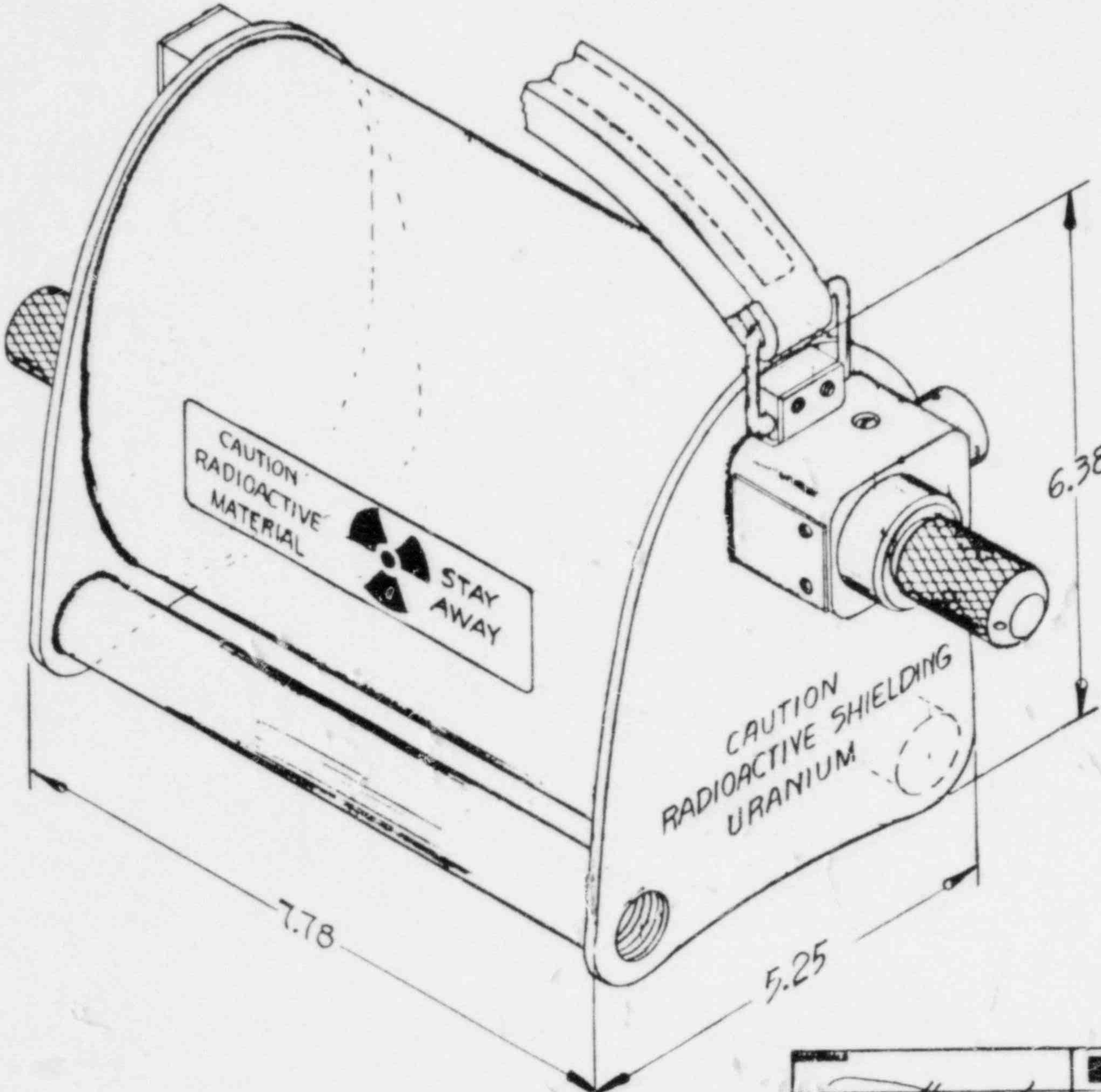
1.3 APPENDIX

Drawing AI52090 Sheets 1 through 4

Drawing AI52091 Sheets 1 through 2

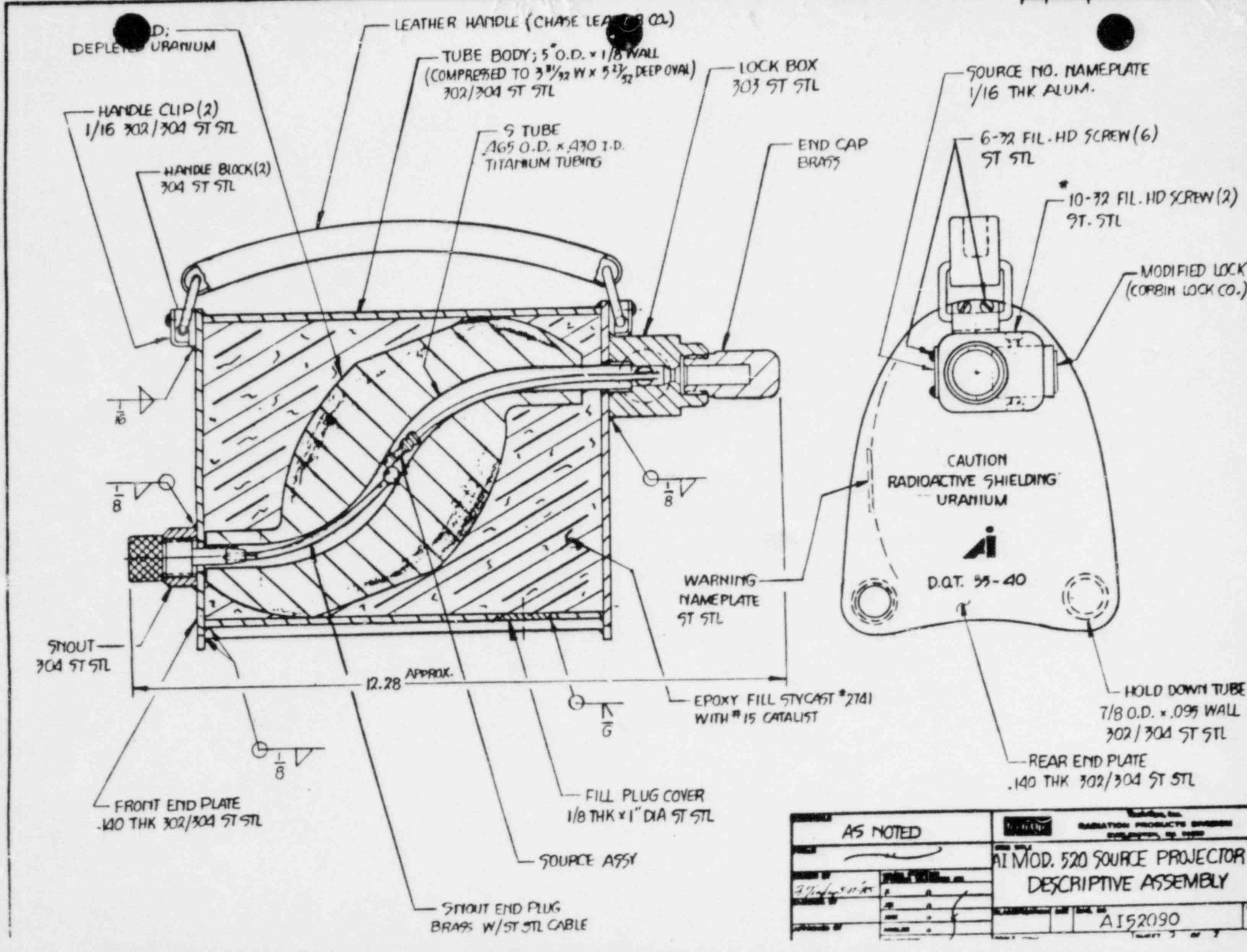
Drawing 42402-1

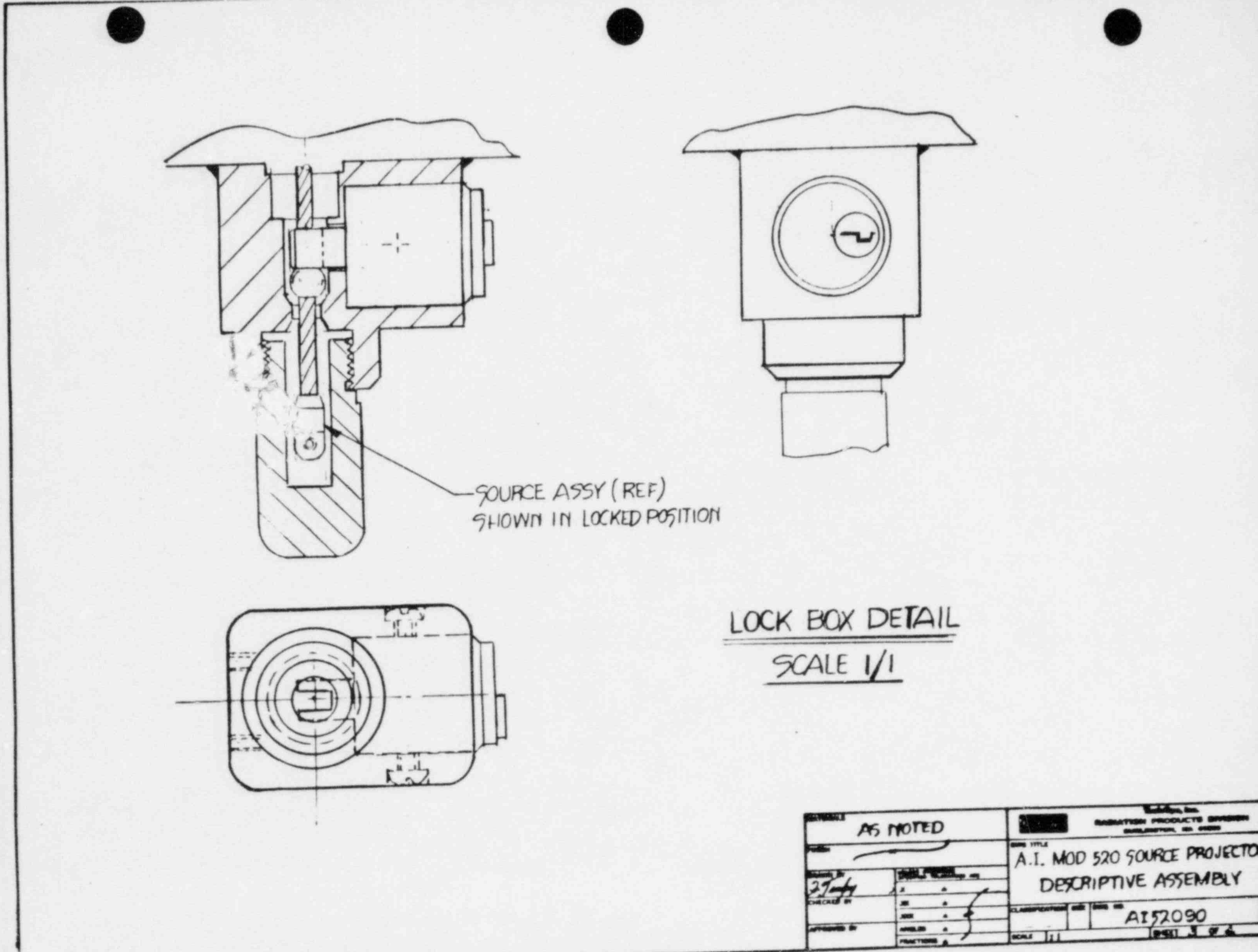
Drawing 42402-4

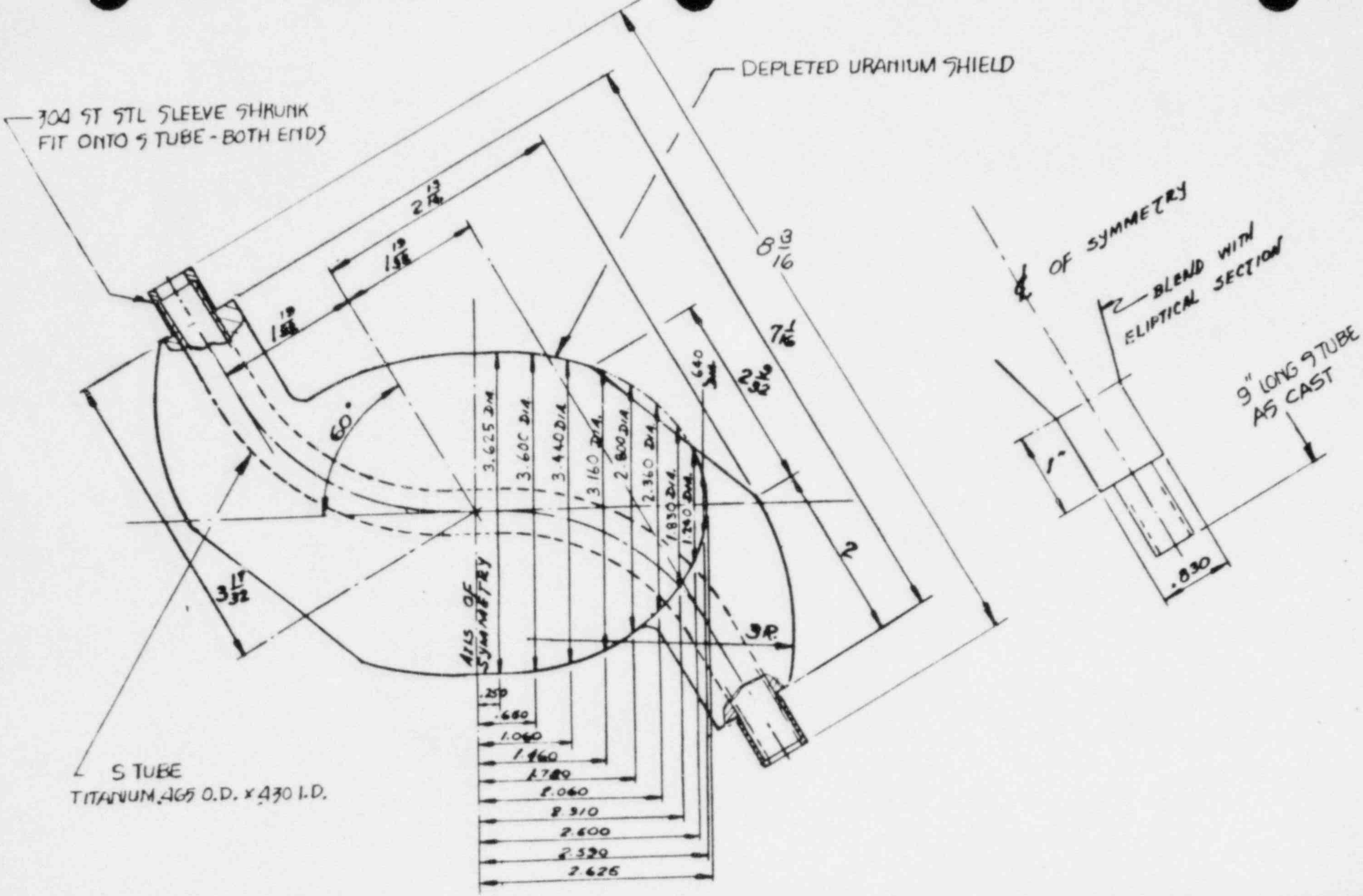


MOD. 520 SOURCE PROJECTOR
DESCRIPTIVE ASSEMBLY

A | A152090


LEATHER HANDLE (CHASE LEA... CO.)
...D; DEPLE... URANIUM
TUBE BODY; 5" O.D. × 1/8 WALL (COMPRESSED TO 3 31/32 W × 5 27/32 DEEP OVAL) 302/304 ST STL
LOCK BOX 303 ST STL
HANDLE CLIP (2) 1/16 302/304 ST STL
HANDLE BLOCK (2) 304 ST STL
S TUBE .465 O.D. × .430 I.D. TITANIUM TUBING
END CAP BRASS
SOURCE NO. NAMEPLATE 1/16 THK ALUM.
6-32 FIL. HD SCREW (6) ST STL
* 10-32 FIL. HD SCREW (2) ST. STL
MODIFIED LOCK (CORBIN LOCK CO.)
CAUTION
RADIOACTIVE SHIELDING
URANIUM
D.O.T. 55-40
WARNING NAMEPLATE ST STL
SNOUT 304 ST STL
12.28 APPROX.
EPOXY FILL STYCAST #2741 WITH #15 CATALIST
HOLD DOWN TUBE
7/8 O.D. × .095 WALL 302/304 ST STL
REAR END PLATE .140 THK 302/304 ST STL
FRONT END PLATE .140 THK 302/304 ST STL
FILL PLUG COVER 1/8 THK × 1" DIA ST STL
SOURCE ASSY
SNOUT END PLUG BRASS W/ST STL CABLE
AS NOTED
RADIATION PRODUCTS DIVISION
AI MOD. 520 SOURCE PROJECTOR
DESCRIPTIVE ASSEMBLY
AI52090


SOURCE ASSY (REF)
SHOWN IN LOCKED POSITION
LOCK BOX DETAIL
SCALE 1/1
AS NOTED
A.I. MOD 520 SOURCE PROJECTOR
DESCRIPTIVE ASSEMBLY
AI52090



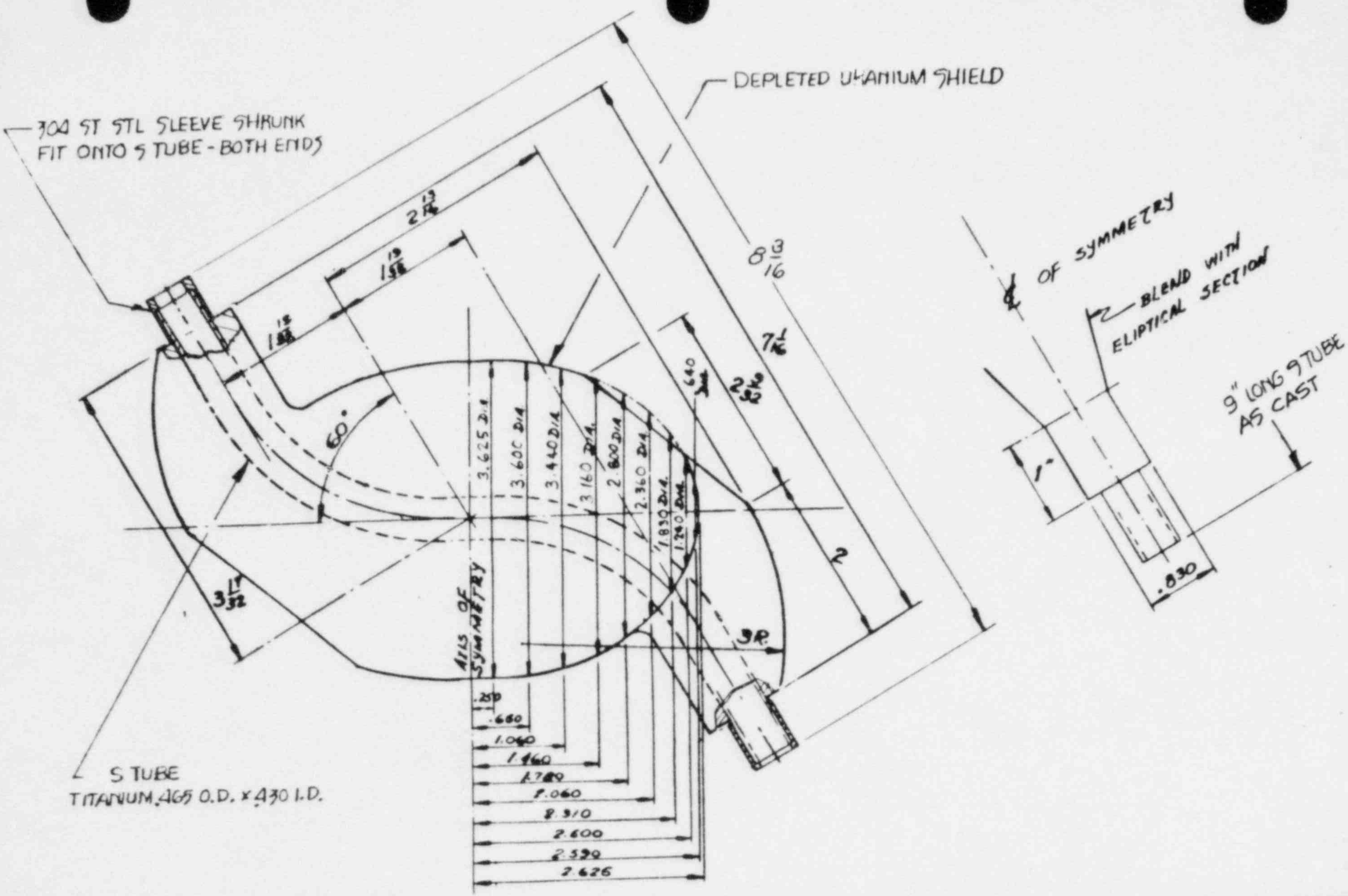
SHIELD DATA

AS NOTED

A.I. MOD 520 SOURCE PROJECTOR

DESCRIPTIVE ASSEMBLY

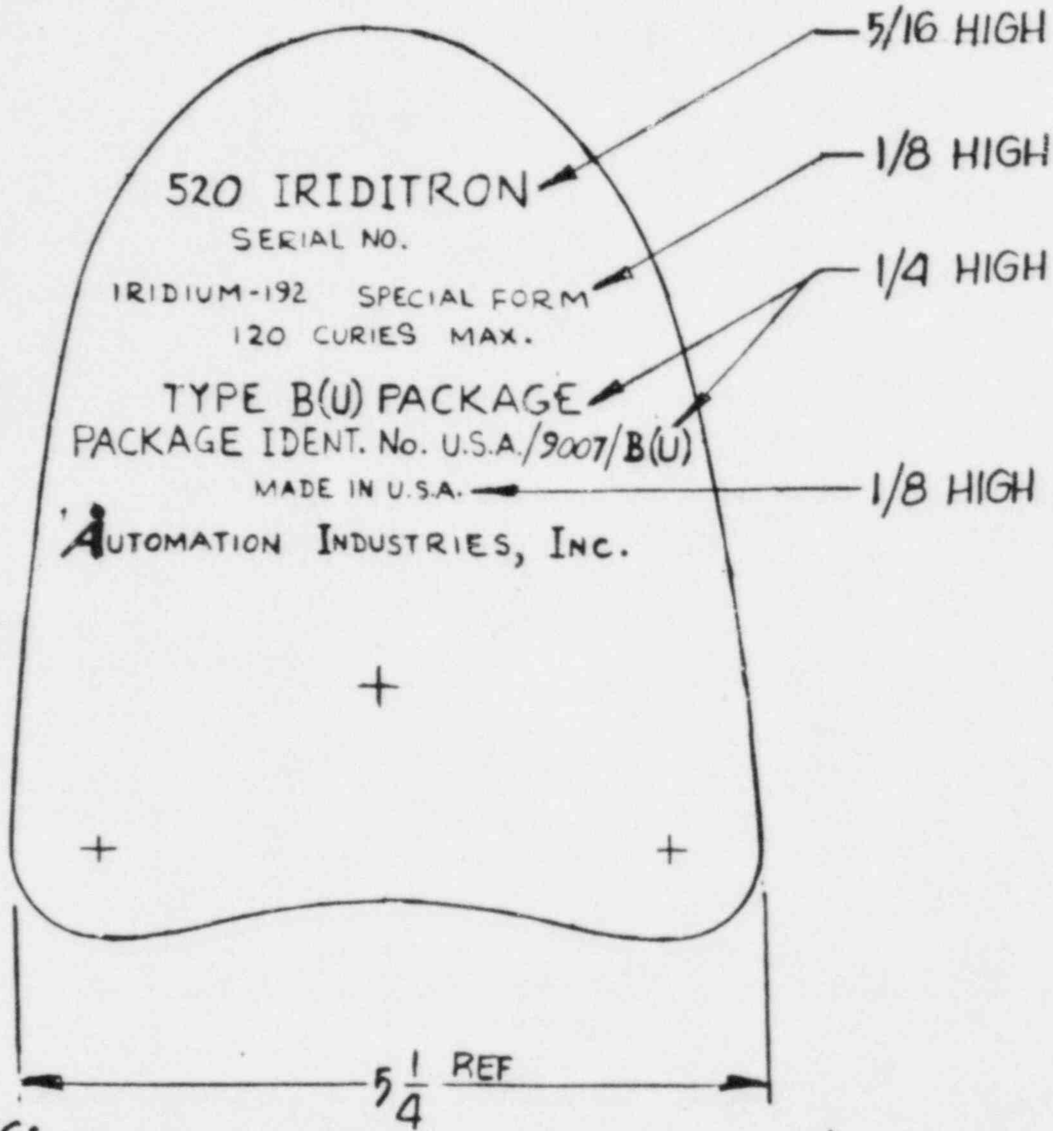
AI52090



SHIELD DATA

AS NOTED	[redacted]
	A.I. MOD 520 SOURCE PROJECTOR DESCRIPTIVE ASSEMBLY
	AI52090

REV.	DATE	DESCRIPTION



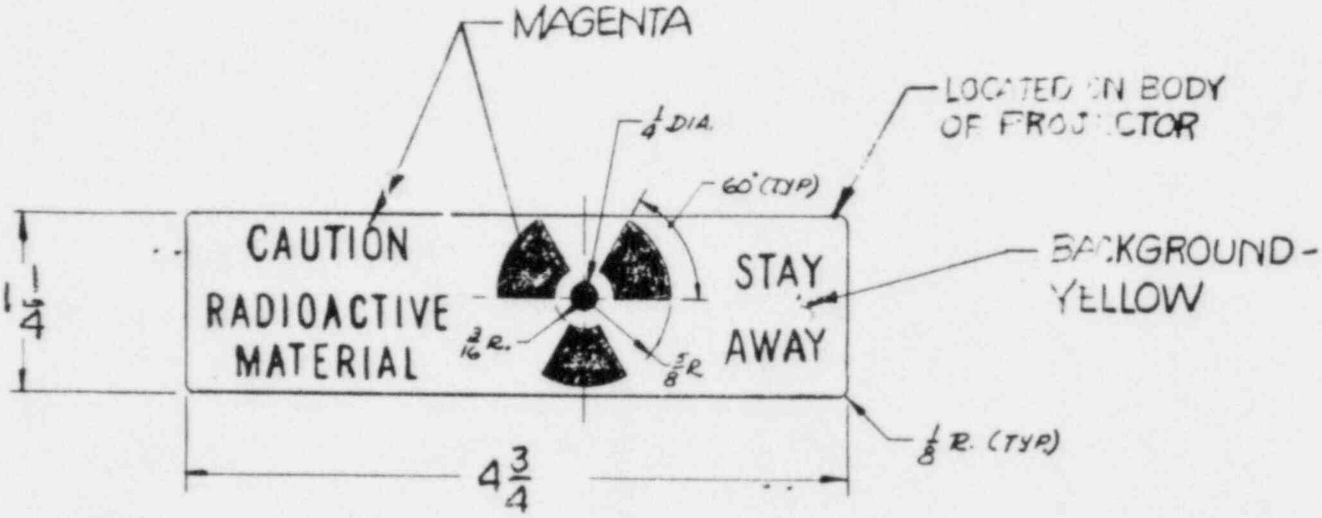
NOTES:

1. ALL CHARACTERS ETCHED INTO NAMEPLATE .010 DEEP

* 2. THE NAMEPLATE IS THE FRONT END PLATE OF THE PROJECTOR BEFORE FINISH MACHINING & WELDING

MATERIALS .140 THK 302/304 ST STL (REF)		Tech Ops — TECH/OPS, INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803
FINISH —		DWG TITLE NAMEPLATE
DRAWN BY A. Tingley 6 SEPT 85	UNLESS OTHERWISE SPECIFIED TOLERANCES ARE .X ±	
CHECKED BY	.XX ±	
	.XXX ±	CLASSIFICATION — SIZE A — DWG. NO. AI52091 — REV.
APPROVED BY	ANGLES ±	
	FRACTIONS ±	SCALE — SHEET 1 OF 2

REV.	DATE	DESCRIPTION

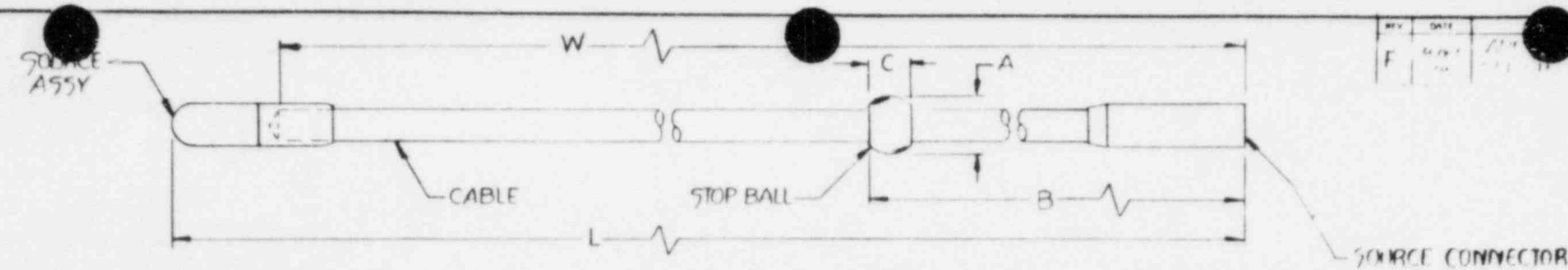


MATL: 20 (.032) GA ALUM. WITH ADHESIVE BACK

MATERIALS: AS NOTED	Tech Ops — TECH/OPS, INC. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803
FINISH: —	DWG TITLE: NAMEPLATE
DRAWN BY: [signature] 8 SEPT 95	UNLESS OTHERWISE SPECIFIED TOLERANCES ARE: .X ± / .XX ± / .XXX ± / ANGLES ± / FRACTIONS ±
CHECKED BY:	CLASSIFICATION / SIZE / DWG. NO. AI52091 / REV.
APPROVED BY:	SCALE: — / SHEET 2 OF 2

63233

SPAULDING CO., INC.



LOCATION COORDINATES	SOURCE ASSY MODEL NO	RADIONUCLIDE	CAPACITY (CURIES)	SOURCE HOLDER DWG NO.	SOURCE CAPSULE ASSEMBLY	CABLE TYPE	SOURCE CONNECTOR DWG NO.	DIM. "L"	DIM. "W"	DIM. "B"	DIM. "C"	DIA "A"	DRIVE CABLE CONNECTOR DWG	EXPOSURE DEVICE USED IN	SOURCE CHANGER	REMARKS
1	A424-1	IR-192	240	A42401-1	60001 60004 OR 875	.187 D TELEFLEX	B55000-900	7.44	6.83	2.373	0.25	0.31	A55000-A	402 404 412 489 490 491 496 498 498A 524 * 525 532 * 533 * 699	414 650 820 855 500-5U(T)	* = USES DRIVE CABLE CONNECTOR B55000-2
2	A424-6	IR-192	120	A42406-1	60001 60004 OR 875	.187 D TELEFLEX	B55000-900	10.69	10.08	N.A.	N.A.	N.A.	A55000-A	511	414 650	
3	A424-9	IR-192	240	A42409-1	60001 60004 OR 875	.187 D TELEFLEX	B55000-900	7.19	6.58	1.225 2.06	0.25	0.31	A55000-A	402 660 713 796	414 650 820 855 500-5U(N)	STOP BALL ADDED (2.06)
4	A424-20	IR-192	240	A42420-1	60001 60004 OR 875	.187 D TELEFLEX	B55000-900	9.38	8.77	1.225	0.25	0.31	A55000-A	684	750 820 855	
5	68309	IR-192	120	B68309	68310	.187 D TELEFLEX	N.A.	AS SPECIFIED TO SUIT DEVICE		N.A.	N.A.	N.A.	N.A.	683	750 820	
6	814	IR-192	120	A81401	60001 60004 OR 875	.187 D TELEFLEX	B55000-900	6.94	6.33	1.625	0.25	0.31	A55000-A	A.I. 520	414 650 820 855 500-5U(N)	
7	848	IR-192	120	A84802	60020 60021 OR 875	.150 D FLEXIBLE SHAFTING	A86101	7.63	6.97	2.56	0.27	0.31	B86101-5	GI CENTURY SPEC 2T GN 20V	414, 500-5U(G) 650	
8	866	IR-192	120	A86602	60020 60021 OR 875	.150 D FLEXIBLE SHAFTING	A86101	6.72	6.06	1.44	0.27	0.31	B86101-5	A.I. 520	414, 500-5U(P) 650	

NOTE:

1. LETTER DESIGNATION WITH MODEL 500-5U SOURCE CHANGER [I.E. 500-5U(N)] INDICATES HOLDOWN CAP TO BE USED. SEE DRAWINGS SK2334-1 & SK2334-2 FOR DETAILS

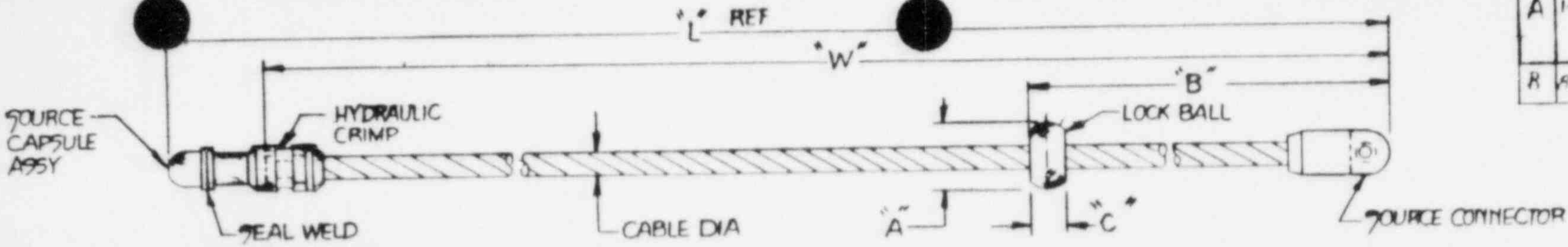
Tech/Ops, Inc.
RADIATION PRODUCTS DIVISION
BURLINGTON, MA 01803

SOURCE TABLE

DWG NO 42402-1

REV F

REV	DATE	DESCRIPTION
A	1-14-86	L1 THRU L8 WAS .132 & L9 ... .17 WAS .113 & ... WAS 1.89
B	9-20-85	2ND BALL ADDED TO B3, C3, H1, J1



LOCATION COORDINATES	A SOURCE ASSEMBLY MODEL NO	B RADIONUCLIDE	C CAPACITY (CURIES)	D SOURCE HOLDER DWG NO	E SOURCE CAPSULE ASSY	F CABLE TYPE	G SOURCE CONNECTOR TYPE	H DIM "L"	J DIM "W"	K DIM "B"	L DIM "C"	M DIA "A"	N DRIVE CABLE CONNECTOR DWG NO	P EXPOSURE DEVICE USED IN	Q SOURCE CHANGER	R REMARKS
1	A.I. 39990; A10	IR-192	120	B5K2332-27	W8 OR W10	3/32 D 7x7	GAMMA UNSLOTTED	7.14	6.62	2.54	.264	.285	A5K2332-12	MODEL 100A SERIES 10A, 20A 30BA, 40BA	500-5U (N) 041026 OR 043859	
2	A.I. 130013; A11	IR-192	120	B5K2332-3	W8 OR W10	3/32 D 7x7	AUTOMATION SCREW	7.08	6.56	2.51	.264	.285	A5K2332-4			
3	A.I. 41706; B2	IR-192	120	B5K2332-14	W8 OR W10	3/32 D 7x7	AUTOMATION SCREW	12.21	11.69	2.26	.264	.285	A5K2332-4	MODEL 50B SERIES 51B, 52B, 53B 110 AB	041024 OR 043861 OR 500-5U(B+N)	
4	A.I 41706; B3	IR-192	120	B5K2332-28	W8 OR W10	3/32 D 7x7	GAMMA UNSLOTTED	12.33	11.81	2.26 7.15	.264	.285	A5K2332-12			2ND BALL ADDED (7.15)
5	A.I.41708; C2	IR-192	120	B5K2332-18	W8 OR W10	3/32 D 7x7	AUTOMATION SCREW	14.83	14.31	2.26	.264	.285	A5K2332-4	MODEL 60C SERIES 61C, 62C, 63C	041027 OR 043862 OR 500-5U(C+N)	
6	A.I.41708; C3	IR-192	120	B5K2332-29	W8 OR W10	3/32 D 7x7	GAMMA UNSLOTTED	14.96	14.44	2.26 9.77	.264	.285	A5K2332-12			2ND BALL ADDED (9.77)
7	A.I.41039; H1	IR-192	120	B5K2332-19	W8 OR W10	3/32 D 7x7	AUTOMATION SCREW	16.14	15.62	2.13 10.95	.264	.285	A5K2332-4	MODEL 151H, 152H, 153H	500-5U (H+N) OR 043864	2ND BALL ADDED (10.95)
8	A.I.41045; J1	IR-192	120	B5K2332-20	W8 OR W10	3/32 D 7x7	AUTOMATION SCREW	13.39	12.87	2.26 8.20	.264	.285	A5K2332-4	MODEL 161J, 162J, 163J	500-5U(J+N) OR 043863	2ND BALL ADDED (8.20)
9	A.I.200-520-009; N2	IR-192	120	B5K2332-37	W8 OR W10	1/8 D 7x7	A.I. TECH/OPS	7.13	6.61	1.78	.226	.290	A5K2332-5	MODEL 520	500-5U (N) OR 043868	
10	A.I. 200-520-010; N3	IR-192	120	B5K2332-23	W8 OR W10	1/8 D 7x7	GAMMA SLOTTED	7.02	6.50	1.74	.226	.290	A5K2332-13			
11	A.I. 200-520-008, N4	IR-192	120	B5K2332-21	W8 OR W10	1/8 D 7x7	AUTOMATION SCREW	6.96	6.44	1.61	.226	.290	A5K2332-4			
12	A.I. 200-520-011; N5	IR-192	120	B5K2332-38	W8 OR W10	1/8 D 7x7	A.I. "SNAP-PIN"	6.98	6.46	1.64	.226	.290	A5K2332-51			
13	A.I. 36910; T1	IR-192	120	B5K2332-36	W8 OR W10	1/8 D 7x7	A.I. TECH/OPS	7.57	7.05	2.32	.226	.312	A5K2332-5	TECH/OPS MOD. 490, 498, 533	500-5U (T) OR 043866	
14	A.I. 36910; T2	IR-192	120	B5K2332-24	W8 OR W10	1/8 D 7x7	GAMMA SLOTTED	7.46	6.94	2.26	.226	.312	A5K2332-13			
15	A.I. 39998; G1	IR-192	120	B5K2332-30	W8 OR W10	1/8 D 7x7	GAMMA UNSLOTTED	7.08	6.56	1.96	.226	.290	A5K2332-12	GAMMA CENTURY "35"	500-5U (N) OR 043867	
16	A.I. 39998; G2	IR-192	120	B5K2332-25	W8 OR W10	1/8 D 7x7	GAMMA SLOTTED	7.08	6.56	1.96	.226	.290	A5K2332-13	GULF NUCLEAR V20		
17	A.I. 39998; G3	IR-192	120	B5K2332-26	W8 OR W10	1/8 D 7x7	GAMMA SLOTTED	7.96	7.44	2.80	.226	.290	A5K2332-13	GAMMA CENTURY-5A	500-5U (G) OR 043867	

NOTES:

1. LETTER DESIGNATION WITH MODEL 500-5U SOURCE CHANGER [i.e. 500-5U (N)] INDICATES HOLDOWN CAP TO BE USED. SEE DRAWINGS SK2334-1 & SK2334-2 FOR DETAILS

TechOps, Inc.
RADIATION PRODUCTS DIVISION
BURLINGTON, MA 01803

DWG TITLE: SOURCE TABLE (AUTOMATION INDUSTRIES)

SIZE: C | DWG NO: 42402-4 | REV: B

2.0 Structural Evaluation

2.1 Structural Design

2.1.1 Discussion

The Model AI 520 is comprised of five structural 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 is fabricated from 3.2 millimeter (0.125 inch) thick Type 304 stainless steel. 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 AI 520 is designed to comply with the requirements for Type B(U) packaging as prescribed by 10 CFR 71 and IAEA Safety Series No. 6, 1973 Revised 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 model AI 520 is 18 kilograms (40 pounds). The shield assembly consists of 12.3 kilograms (27 pounds) of depleted uranium. The center of gravity was located experimentally. It is located 99 millimeters (3.89 inches) from the rear, 94 millimeters (3.69 inches) above the bottom surface, and 51 millimeters (2.00 inches) from the right surface.

2.3 Mechanical Properties of Materials

The outer housing of the Model AI 520 is fabricated from Type 304 stainless steel. This material has a yield strength of 207 MPa (30,000psi).

Drawings of the source capsules used in conjunction with the Model AI 520 are enclosed in Section 2.10. These source capsules are fabricated from either Type 304 or Type 304L stainless steel.

2.4 General Standards for All Packages

2.4.1 Chemical and Galvanic Reactions

The materials used in the construction of the Model AI 520 are uranium metal, stainless steel, brass, titanium, and epoxy. There will be no significant chemical or galvanic action between any of these components.

The possibility of the formation of the eutectic alloy iron uranium at temperatures below the melting temperatures of the individual metals has been considered. The iron uranium eutectic alloy temperature is approximately 725 C (1337 F). 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 AI 520, 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 800 °C (1475 °F) 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 0.18 millimeters (0.007 inch).

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.

Notwithstanding these test results, there are no iron-uranium interfaces in the Model AI 520.

2.4.2 Positive Closure

The source assembly in the model AI 520 cannot be moved to an unshielded position without the unlocking of the key operated lock box and the connection of the drive cable to the source holder assembly. As a safety feature the locking mechanism also has a limiting orifice which prevents accidental withdrawal of the source assembly during hookup. During transport the key is removed and controls disconnected. This allows a cap to be installed over the source assembly holder and a seal wire to hold the cap in place. The shipping plug is also drilled to allow a seal wire to be inserted and hold the cap in place. Positive closure of the package during transport is maintained with these features.

2.4.3 Lifting Devices

The Model AI 520 is designed to be lifted by its handle. The handle is attached to the package by means of handle bails at each end of the handle. A static tensile test of this handle arrangement was made. A report of this test is included in section 2.10. This test demonstrates that the lifting device can support five times the weight of the package without exceeding the yield strength of the material.

2.4.4 Tiedown Devices

The Model AI 520 can be tied down by means of the handle. An analysis of this tiedown arrangement under the load conditions of 10 CFR 71.45(b) is presented in Section 2.10. This analysis demonstrates that the maximum stress generated in the handle would be less than the yield strength of the material. Therefore, we conclude that the Model AI 520 satisfies the tiedown condition of 10 CFR 71.45(b)(1).

Additionally, if the handle were to fail under excessive load, the ability of the package to maintain its structural integrity and shielding efficiency would not be impaired. Therefore, the package tiedown design satisfies the criteria of 10 CFR 71.45(b)(3).

2.5 Standards for Type B Packages

2.5.1 Load Resistance

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

$$\sigma max = \frac{Fl}{8z}$$

where σ max = maximum stress
F = assumed load (890 N or 200 lbs.)
l = length of beam (197 mm or 7.78 in.)
z = section modulus (78,896 mm^3 or 4.81 in^3)

(Ref. Machinery's Handbook, 22nd Edition, p. 294 and 264)

The load is assumed to be 890 newtons (200 lbs.). The container is assumed to be an elliptical cylinder 197 mm (7.78 in.) long, a major axis of 127 mm (5.0 in.), a minor axis of 102 mm (4 in.) and a wall thickness of 3.2 mm (0.125 in.). Consequently, the section modulus of the beam is 78,896 mm^3 (4.81 $in.^3$).

Therefore, the maximum stress generated in the beam under these conditions would be 0.279 mPa (40.43 lb/in^2) which is far below the yield strength of the material.

2.5.2 External Pressure

The Model AI 520 is open to the atmosphere. Thus there will be no differential pressure acting on it. The collapsing pressure of the source capsule is calculated assuming that the capsule is a thin wall tube with a wall thickness equal to the minimum depth of weld penetration which is 0.5 mm (0.020 inch). The collapsing pressure is calculated from:

$$P = 597.6\ t/d - 9.556$$

where P: Collapsing Pressure in MPa
t: Wall Thickness (0.5mm or 0.02 inch)
d: Outside Diameter (6.4 mm or 0.250 inch)

(Ref: Machinery's Handbook, 22nd Edition, p. 330)

From this relationship, the collapsing pressure of the source capsule is calculated to be 37.1 MPa (5548 psi). Therefore, the source capsule could withstand an external pressure of 0.17 MPa (25psi).

2.6.0 Normal Conditions of Transport

2.6.1 Heat

The thermal evaluation of the Model AI 520 is presented in Section 3. From this evaluation, it is concluded that the Model AI 520 will maintain its structural integrity and shielding effectiveness under the normal transport heat condition.

2.6.2 Cold

The metals used in the manufacture of the Model AI 520 can all withstand a temperature of -40°C (-40 °F). The outer package housing and the primary containment are all fabricated from Type 304 stainless steel. As stated in Draft Regulatory Guide, Division 7, Task MS 144-4, austenitic stainless steels are not susceptible to brittle fracture at temperatures encountered in transport.

The epoxy used in the Model AI 520 have an operating temperature range of -43°C to 104°C. From this data, it is concluded that the Model AI 520 will maintain its structural integrity and shielding effectiveness under the normal transport cold condition.

2.6.3 Reduced Pressure

An external pressure test of the Model AI 520 was conducted by Automation Industries, Inc. The device was placed in a pressure chamber and the pressure was reduced to 0.25 kg/cm and maintained its shielding efficiency and structural integrity. A report of this test is presented in a letter to Mr. R. Rawl from Mr. M. Santoro dated 4 December 1981 and included in Section 2.10.

A demonstration of the ability of the source capsules to withstand an external pressure of 0.5 atmosphere is presented in Section 3.5.4.

On the basis of these data, it is concluded that the Model AI 520 will maintain its structural integrity and shielding effectiveness under the normal transport pressure condition.

2.6.4 Vibration

The Model AI 520 has been in use for more than fifteen years. In this period, there has been no evidence of vibration-induced failure.

On the basis of this history, it is concluded that the Model AI 520 will maintain its structural integrity and shielding effectiveness under the normal transport vibration condition.

2.6.5 Water Spray

The water spray test was not acually performed on the Model AI 520. The materials used in the construction of the Model AI 520 are highly water resistant. Therefore, it is concluded that the Model AI 520 will maintain its structural integrity and shielding effectiveness under the normal transport water spray condition.

2.6.6 Free Drop

A prototype Model AI 520 was subjected to the hypothetical accident free fall condition. This is described in Section 2.7.1. On the basis of this test, it is concluded that the Model AI 520 will maintain its structural integrity and shielding effectiveness under the normal transport free drop condition.

2.6.7 Corner Drop

Not applicable

2.6.8 Penetration

A prototype Model AI 520 was subjected to a penetration test by Automation Industries. The package was impacted by the penetration bar in three different attitudes. As a result of these impacts, there was no loss of structural integrity nor reduction of shielding efficiency. A report of this test is presented in a letter to Mr. R. Rawl from Mr. M. Santoro dated December 1981 and included in Section 2.10.

On the basis of this test it is concluded that the Model AI 520 will maintain its structural integrity and shielding effectiveness under the normal transport penetration condition.

2.6.9 Compression

A prototype Model AI 520 was subjected to the compression condition. The total mass of the package is 18 kilograms

(40 pounds). The maximum cross sectional area of the package is 0.03 m^2 (49.6 $in.^2$). Thus, five times the weight of the package (890 newtons or 200 pounds) is greater than 13.8 KPa (two pounds per square inch) times the maximum cross sectional area (441 newtons or 99.2 pounds).

The package was subjected to a compressive load of 1515 newtons (340 pounds). The load was applied for a period of 24 hours. At the conclusion of this test, there was no loss of structural integrity nor reduction of shielding efficiency. A report of this test is presented in a letter to Mr. R. Rawl from Mr. M. Santoro dated 4 December 1981 and on the basis of this test, it is concluded that the Model AI 520 will maintain its structural integrity and shielding effectiveness under the normal transport compression condition.

2.7 Hypothetical Accident Conditions

2.7.1 Free Drop

The Model AI 520 was subjected to the conditions of the free drop by Automation Industries, Inc. The target used in this free drop test consisted of a solid concrete apron with a thickness of 0.2 meters (8 inches). A steel plate with a thickness of 16 mm (0.63 in.) was placed in intimate contact with the concrete apron.

During test, the package fell from a height of 10.3 meters (34 feet) onto the target.

As a result of this test, there was no loss of structural integrity nor loss of shielding efficiency. A report of this test by Mr. M. Santoro dated 24 July 1973 is presented in Section 2.10. On the basis of this test, it is concluded that the Model AI 520 will maintain its structural integrity and shielding effectiveness under the hypothetical free drop accident condition.

2.7.2 Puncture

At the conclusion of the free drop test, the prototype Model AI 520 was twice subjected to the puncture condition by Automation Industries. The target for the puncture test was a steel billet 76 mm (3 inches) in diameter and 203 mm (8 inches) high mounted on the target used in the free drop test.

During this test, the packaged dropped from the height of one meter (40 inches) onto the billet.

As a result of this test, there was no loss of structural integrity nor reduction in shielding efficiency. A report of this test by Mr. M. Santoro dated 24 July 1973 is presented in Section 2.10. On the basis of these tests, it is concluded that the Model AI 520 will maintain its structural integrity and shielding effectiveness under the hypothetical puncture accident condition.

2.7.3 Thermal

At the conclusion of the free drop and puncture tests, the prototype model AI 520 was subjected to the thermal condition by Automation Industries. The package was placed into a kerosene and fuel oil fire. The package remained there for 47 minutes. At the conclusion of the test, the fire was extinguished and the package was allowed to cool only by natural convection and radiation. No artificial cooling methods were used.

As a result of this test, there was no loss of structural integrity nor reduction in shielding efficiency. A report of this test by Mr. M. Santoro dated 24 July 1973 is presented in Section 2.10. On the basis of this test, it is concluded that the Model AI 520 will maintain its structural integrity and shielding effectiveness under the hypothetical thermal accident condition.

2.7.4 Water Immersion

Not Applicable.

2.7.5 Summary of Damage

The tests designed to induce mechanical stress (free drop, puncture) caused minor deformation but no reduction in structural integrity nor impairment of any safety features. The thermal test had no adverse affect on the package.

As a result of these tests, there was no loss of structural integrity nor release of any contents.

Prior to the conduct of these tests and subsequent to the conduct of these tests, measurements of the radiation intensity in the vicinity of the package were made. The results of these measurements demonstrate that there was no reduction in shielding efficiency as a result of these tests.

2.8 Special Form

The Model AI 520 is designed to transport Tech/Ops source capsules. These source capsules have been certified as a special form radioactive material under IAEA Certificate of Competent Authority Number USA/0154/S and USA/0279/S. These certificates are presented in Section 2.10.

2.9 Fuel Rods

Not applicable

2.10 Appendix

IAEA Certificate of Competent Authority USA/0154/S

IAEA Certificate of Competent Authority USA/0279/S

Drawing 60050

Drawings SK2332-7, -8, -9, -10

Test Report: Model AI 520 Holddown Arrangement

Report: Analysis of Model AI 520 Tiedown Arrangement

Letter to Mr. R. Rawl, U. S. Department of Transportation from Mr. M. P. Santoro, Automation Industries, Dated 4 December 1981, describing the results of the Model 520 Penetration Reduced Pressure and Compression Tests.

Automation Industries Test Report by Mr. M. P Santoro, dated 24 July 1973, describing the results of the Model 520 Free Drop, Puncture and Thermal Tests.

US Department
of Transportation

Research and
Special Programs
Administration

IAEA CERTIFICATE OF COMPETENT AUTHORITY

Special Form Radioactive Material Encapsulation

Certificate Number USA/0154/S
(Revision 4)

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 materials as prescribed in IAEA 1/ and USA 2/ regulations for the transport of radioactive materials.

I. Source Description - The source capsules described by this certificate are identified as the Technical Operations, Inc., Models which are described and constructed as follows:

Capsule Model	Approximate Size (in inches, diameter x length)
60001	.25 x .97
60004	.25 x .97
60006 Pellet, Wafer or Large Wafer	.25 x .90
68310 Pellet or Wafer	.25 x .78
60017	.25 x .97
60018	.25 x .97
60020	.25 x .97
60021	.25 x .97

All capsules are constructed of either 304 or 304L stainless steel and conform with the following design drawings:

Capsule Model	Drawing Number
60001	60001 - 1, Rev. M and 60001-5
60004	60004 - 1, Rev. E and 60004 - 2
60006 Pellet	60001 - 5 and 60006 - 3
60006 Wafer	60006 - 1, Rev. H and 60004 - 1, Rev. E
60006 Large Wafer	60006 - 1, Rev. H and 60001 - 5, Rev. F
68310 Pellet	68310 - 9 and 68310 - 10, Rev. A
68310 Wafer	68310 - 1, Rev. F and 68310 - 2, Rev. G
60017	60017 - 1, Rev. A and 60001 - 2
60018	60017 - 1, Rev. A and 60004 - 1, Rev. E
60020	60020 - 3 and 60001 - 5
60021	60020 - 1 and 60004 - 1, Rev. E

II. Radioactive Contents - The authorized radioactive contents consist of metallic Iridium-192 with not more than 240 Curies in models 60001, 60004, 60006 Pellet, Wafer and Large Wafer or 120 Curies in models 60017, 60018, 60020, 60021, 68310 Pellet and Wafer.

Certificate Number USA/0154/S, Revision 4

III. This certificate, unless renewed, expires December 31, 1989.

This certificate is issued in accordance with paragraph 803 of the IAEA Regulations 1/, and in response to the November 1, 1984, petition by Technical Operations, Inc., Burlington, Massachusetts, and in consideration of the associated information therein.

Certified by:

Richard R. Rawl
Chief, Radioactive Materials Branch
Office of Hazardous Materials Regulation
Materials Transportation Bureau

November 9, 1984
(Date)

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, Parts 170-178, USA.

Revision 4 - incorporated new drawing nos; extended expiration date.

US Department
of Transportation

Research and
Special Programs
Administration

400 Seventh Street S.W.
Washington D.C. 20590

IAEA CERTIFICATE OF COMPETENT AUTHORITY

Special Form Radioactive Material Encapsulation

Certificate Number USA/0279/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 - The sources described by this certificate are identified as Automation Industries Models 500-W8 and 500-W10 which are tungsten-inert-gas welded 316 stainless steel encapsulations which measure 0.25 inches (6.4 mm) in diameter by 0.75 inches (19 mm) in length (AI drawing 500-W8 & W10).

II. Radioactive Contents - The authorized radioactive contents of these sources consist of not more than 300 curies of iridium-192 metal wafers.

III. This certificate, unless renewed, expires April 30, 1988.

This certificate is issued in accordance with paragraph 803 of the IAEA Regulations 1/, and in response to the October 19, 1983 petition by Automation Industries, Inc. Phoenixville, PA and in consideration of the associated information therein.

Certified by:

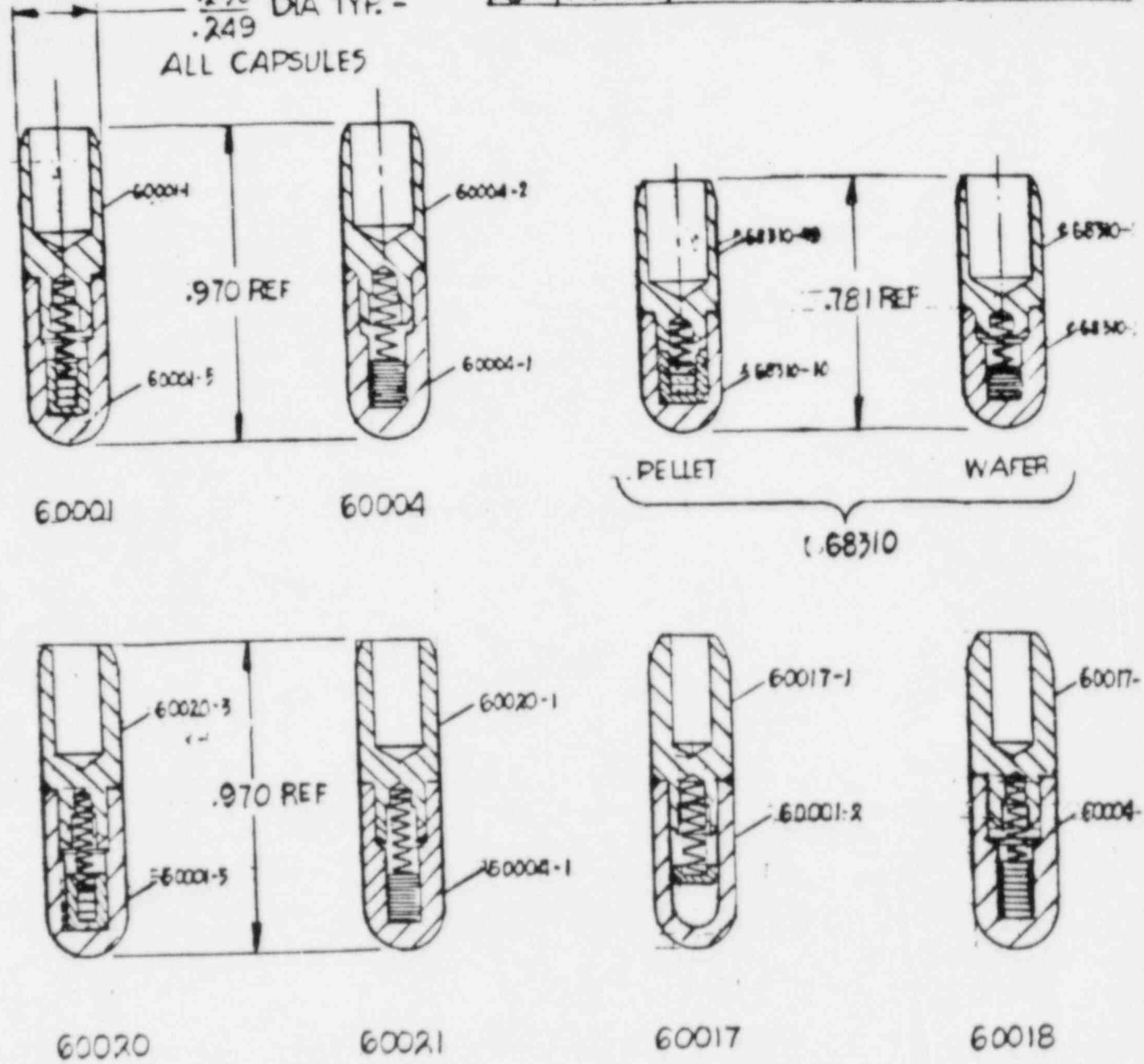
Richard R. Rawl
Chief, Radioactive Branch
Office of Hazardous Materials Regulation
Materials Transportation Bureau

May 10, 1983
(Date)

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.

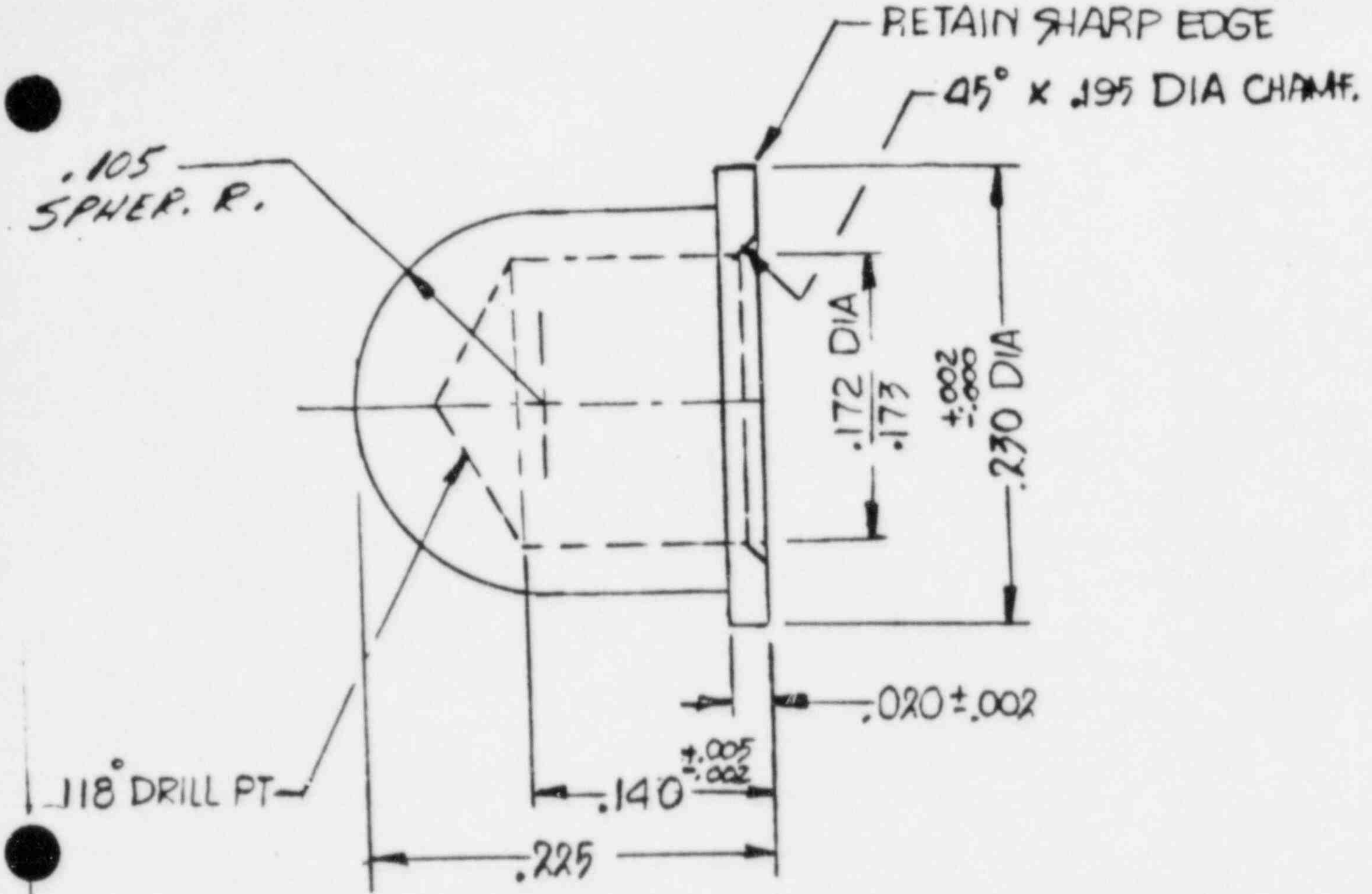
2/ Title 49, Code of Federal Regulations, Part 170-178, USA.

B	9-16-84	60006 REMOVED; ADDED 60020 & 60021
C	1 NOV 84	ADDED 60017 & 60018; ADDED SHT 3



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	CLASSIFICATION / SIZE A / DWG. NO. 60050 / REV C
APPROVED BY	SCALE 2:1 / SHEET 2 OF 3

SPAULDING CO., INC. 21-60169



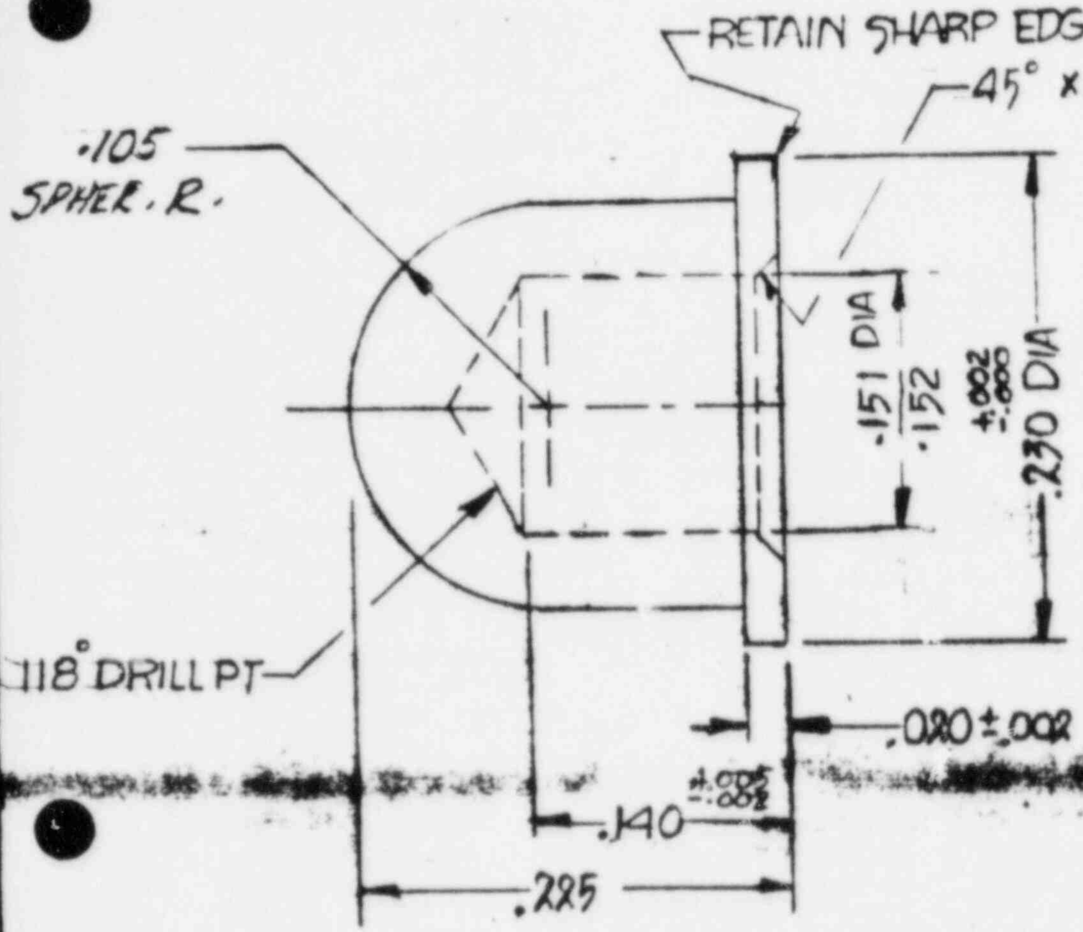
- BREAK CORNER EXCEPT WHERE NOTED

A.I.# C500-W8 & W10

MATERIALS TYPE 316 ST. STL		Tech/Ops, Inc. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803	
FINISH 63/ ALL OVER		DWG TITLE IRIDIUM-192 CAP, HELI-ARC SEA[L] TYPE FOR LOADING 1/8 WAFERS (MOD. 500-W	
DRAWN BY [signature] 3-12-84	UNLESS OTHERWISE SPECIFIED TOLERANCES ARE X ±		
CHECKED BY G.P. 3-16-84	XX ±		
	XXX ± .005	CLASSIFICATION	SIZE A DWG. NO. SK-2332-7
APPROVED BY [signature]	ANGLES ± 0° 30'		
	FRACTIONS ± 1/64	SCALE —	SHEET 1 OF 1

SPAULDING CO., INC. 21-04304

REV.	DATE	DESCRIPTION
A	4-13-84	ADDED 45° x .170 DIA CHAMF.



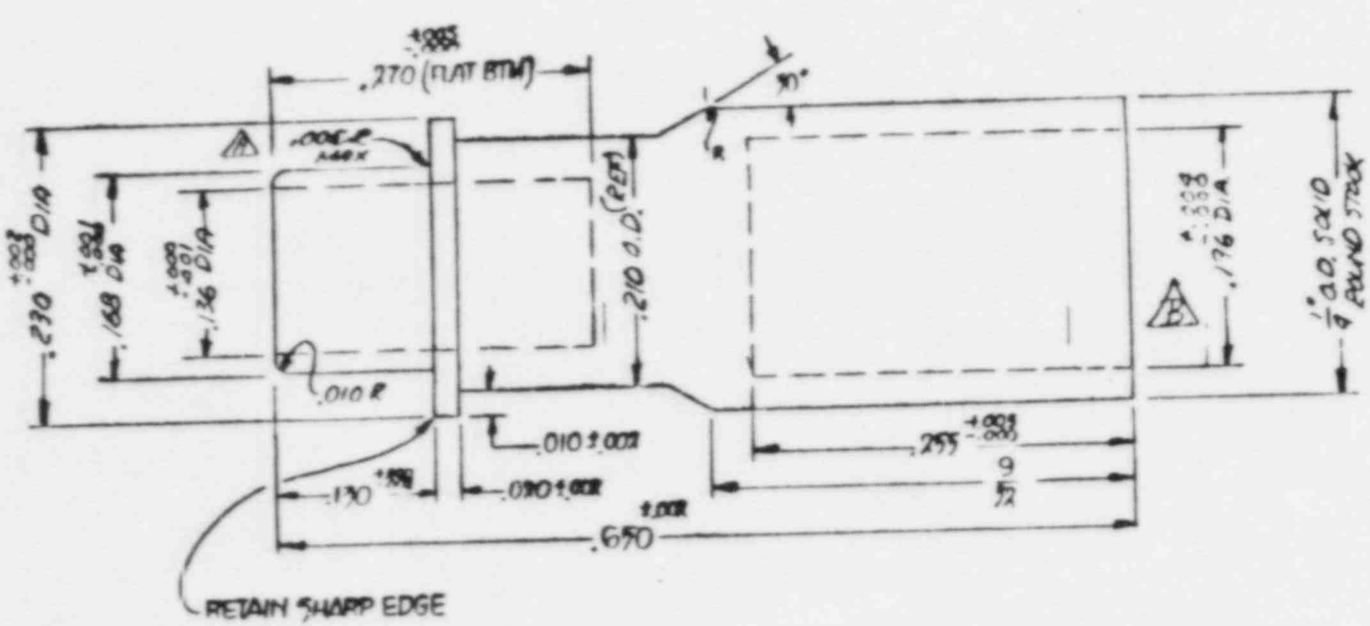
- BREAK CORNER EXCEPT WHERE NOTED

A.I.# C500

MATERIALS: TYPE 316 ST. STL

3-12-84

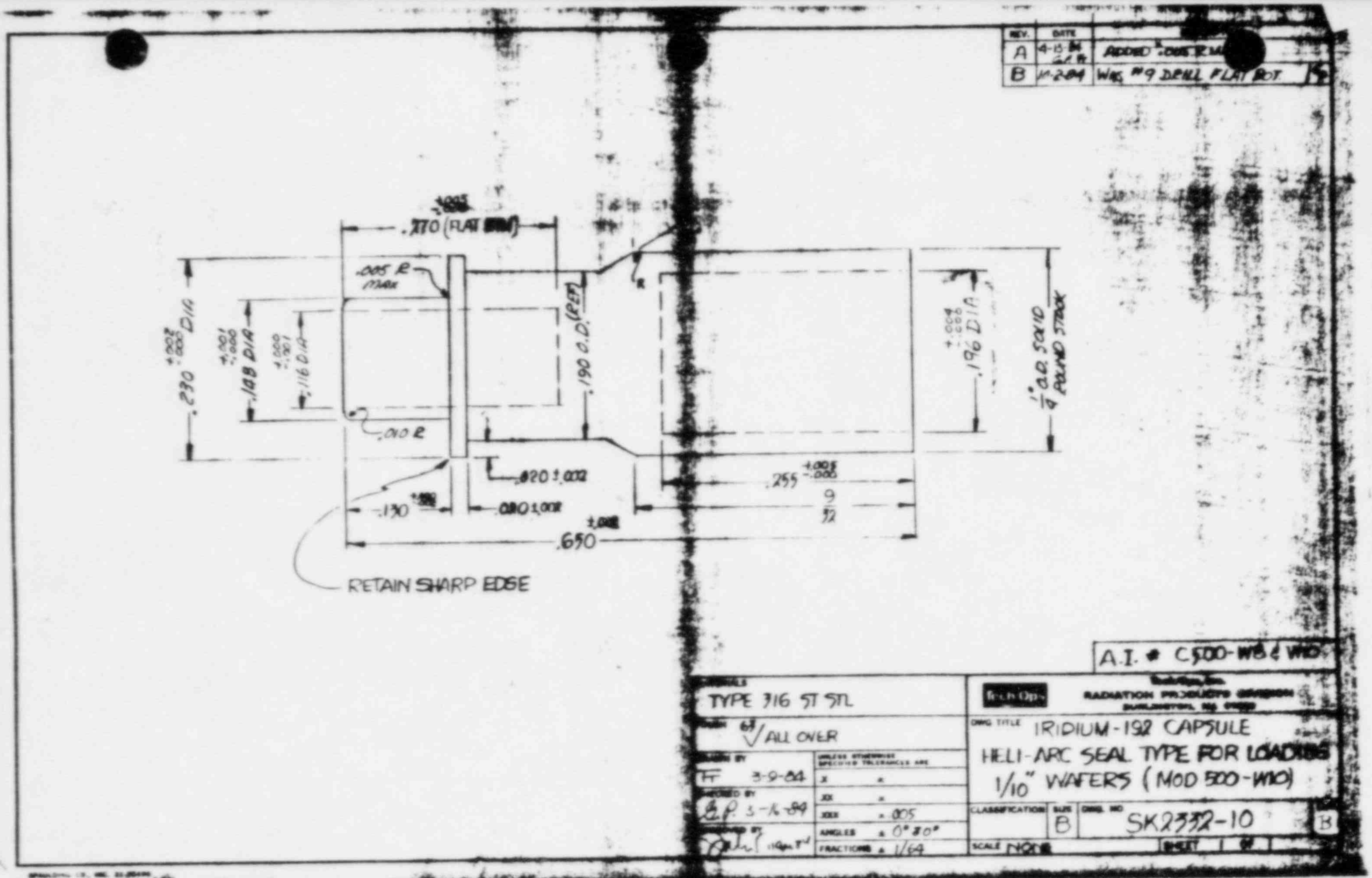
TYPE FOR LOADING



REV.	DATE	DESCRIPTION
A	4-13-84	ADDED .005 R MAX CALLOUT
B	11-2-84	WAS #7 DRILL FLAT BOT

A.I. # C500-WB & W

MATERIALS: TYPE 316 ST STL	Tech Ops — Tech/Ops, Inc. RADIATION PRODUCTS DIVISION BURLINGTON, MA 01803
FINISH: 63 √ ALL OVER	DWG TITLE: IRIDIUM-192 CAPSULE HELI-ARC SEAL TYPE FOR LOAD 1/8" WAFERS (MOD 500-WB)
DRAWN BY: TT 3-10-84	
CHECKED BY: JP 3-12-84	SIZE: B DWG NO: SK2332-9
TOLERANCES: .XXX ± .005; ANGLES ± 0° 30'	



REV. DATE
A 4-13-84 ADDED .005 R MAX
B 11-2-84 WAS #9 DRILL FLAT BOT.
.270 (FLAT BTM)
.005 R MAX
.230 DIA
.148 DIA
.116 DIA
.010 R
.190 O.D. (REF)
R
.196 DIA
1/4" O.D. SOLID ROUND STOCK
.020 ±.002
.130
.080 ±.002
.255 +.005 -.000
9/32
.650 ±.002
RETAIN SHARP EDGE
A.I. # C500-W8 & W10
TYPE 316 ST STL
63 ALL OVER
3-9-84
3-16-84
XXX ±.005
ANGLES ± 0°30'
FRACTIONS ± 1/64
Tech/Ops
RADIATION PRODUCTS DIVISION
IRIDIUM-192 CAPSULE
HELI-ARC SEAL TYPE FOR LOADING
1/10" WAFERS (MOD 500-W10)
SIZE B
SK2332-10
B
SCALE NONE

BY: Cathleen M. Roughan

DATE: 24 September 1985

SUBJECT: Model AI 520 Package Tiedown Test

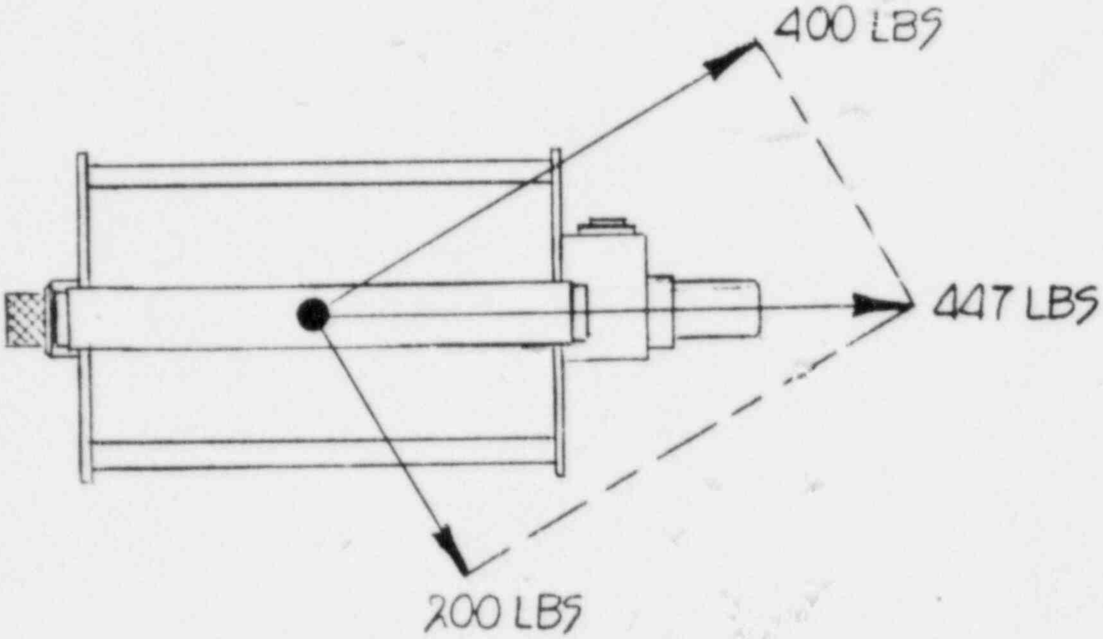
A model AI 520 Type B(U) package, serial number 284 was subjected to the tiedown load standard of 10 CFR 71.45(b). The package was tied down by means of cables attached to each side of each bail connecting the handle to the package.

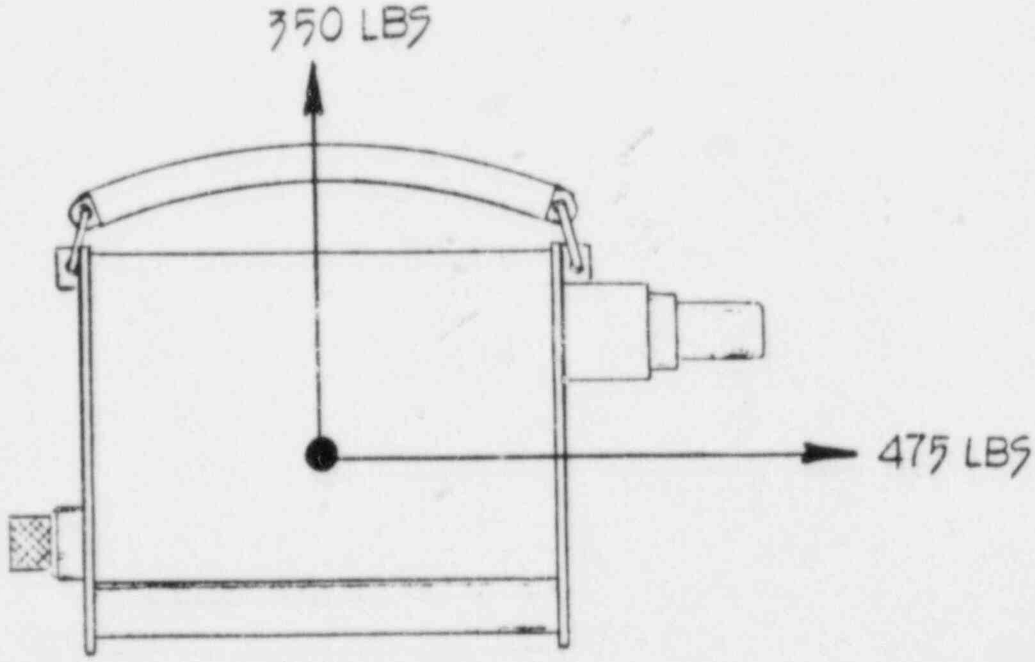
A force of ten times the weight of the package (400 lbs.) in the horizontal direction in which the vehicle travels and a force of five times the weight of the package (200 lbs.) in the transverse horizontal direction produce a resultant horizontal force of 447 lbs. It was concluded that the most severe application of this force was along the direction of the long axis of the package. The actual horizontal force applied in this direction during the test was 475 lbs. The actual vertical force applied to the package during this test was 350 lbs., or greater than five times the weight of the package.

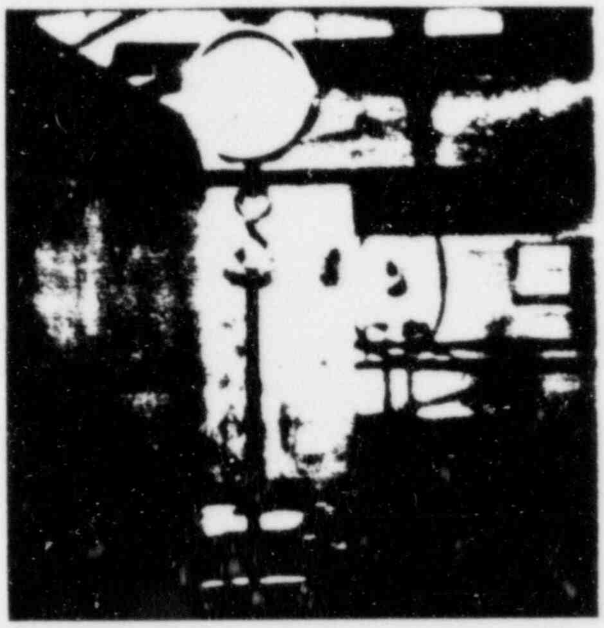
The package was subjected to these forces for one hour.

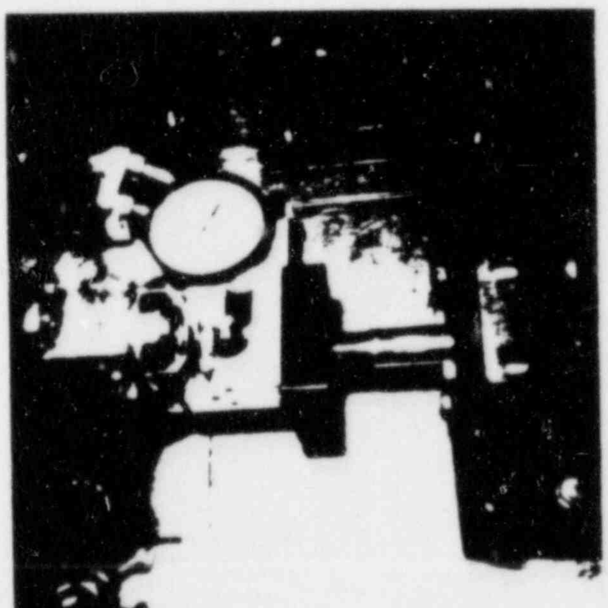
At the conclusion of this test, there was no failure of any component of the package or of the tiedown arrangement.

There was no evidence of any yield of ar omponent. Therefore, it is concluded that the package can withstanu the tiedown load conditions without generating any stress in excess of the yield strength of the material.


400 LBS
447 LBS
200 LBS


350 LBS
475 LBS





BY: Cathleen M. Roughan

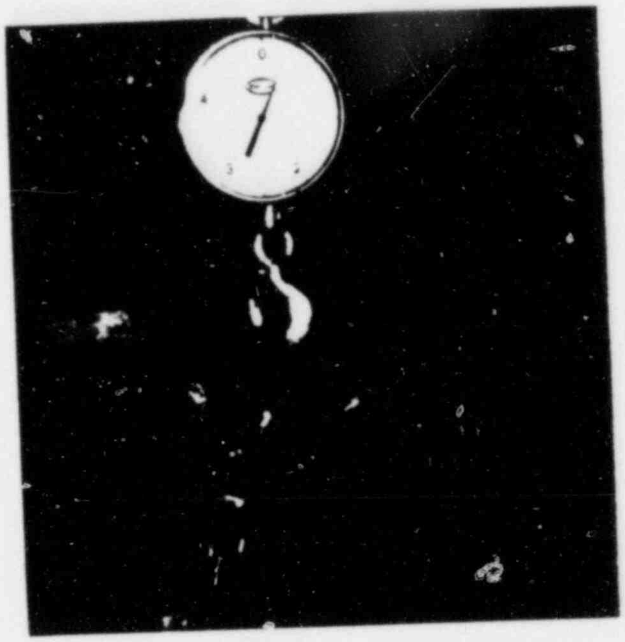
DATE: 24 September 1985

SUBJECT: Model AI 520 Package Lifting Test

A model AI 520 Type B(U) Package, Serial Number 284 , was subjected to the lifting load standard of 10 CFR 71.45(a). The package was secured to a platform, with a mass in excess of ten times the mass of the package, by means of cables attached to each side of each bail that connects the handle to the package.

A force in excess of three times the weight of the package (200 lbs.) was applied to the package handle in the vertical direction. This force was applied for one hour.

At the conclusion of this test, there was no failure of any component of the package or of the handle. There was no evidence of any yield of any component. Therefore, it is concluded that the package can withstand the lifting load conditions without generating any stress in excess of the yield strength of the material.



AUTOMATION INDUSTRIES, INC.
SPERRY PRODUCTS DIVISION
P O Box 245
PHOENIXVILLE, PA 19460
(215) 933-8961

December 4, 1981

Mr. R. R. Rawl
Office of Hazardous Materials Regulation
Materials Transportation Bureau
U.S. Department of Transportation
400 Seventh Street, S.W.
Washington, D.C. 20590

Re: Application For B(U) Certification Of Two (2) Of Automation's Existing Type "B" Packages Having Assigned Identification Numbers As Follows:

USA/9006/B Model 500-SU, IR-192 Source Changer

USA/9007/B Model 520 Iriditron Exposure Device

Dear Mr. Rawl:

The above referenced packages were originally certified as Type "B" packages by your office in 1973. Automation Industries has recently subjected both of these packages to the basic and specific additional test requirements for Type B(U) packages. All additional tests were performed in accordance to, and in sequential order as outlined in the IAEA Safety Series No. 6, 1973 Revised Edition (as amended 1979).

I. SPECIAL NOTES AND CONDITIONS RELATING TO ADDITIONAL TESTS:

A. There have been no design changes to either package such as size, mass, structural configuration, or shielding medium since the original Type "B" approvals were issued in 1973.

B. Each package was subjected to the additional tests separately; and during each test, the test package contained the same encapsulated source of Iridium-192.

C. The contained source of Iridium-192 had a calibrated strength of 17.0 curies on September 1, 1981, and is identified by Automation's serial no. IR-14361.

D. One test specimen of each package design was used throughout all of the additional test requirements.

E. Each test package was surveyed for external surface radiation levels and radiation levels measured at one (1) meter from any external surface; both prior to, and after each test. To further insure structural and containment integrity, an intimate wipe test of the contained IR-192 sealed source and container "S" or "J" tube was performed both prior to and after each test.

After the WATER IMMERSION TEST, Sect. VII, Par. 721, the residual water after each 8 hour hydrostatic test was collected and the volume determined. Two (2) 10ml samples of each batch were assayed by well-counting for a 10 minute period. This procedure was to further assure the integrity of containment.

After completion of all tests covering additional requirements for Type B(U) packaging, the contained source of Iridium-192, serial no. IR-14361 was further leak tested to meet the requirements of Appendix "A" of ANSI Standard N542, Sections:

A2.1.1. Wipe (Smear) Test
A2.1.3. Immersion with Boiling Test.

NOTE: All of Automation's sealed sources of Iridium-192 have an internal void volume of less than 0.10 ml.

F. Considering the materials of construction, compact design configuration, and relatively light mass of both packages, some of the additional test (such as water spray or internal heat generation) were omitted by reasoned consideration or where conservative and reliable engineering judgement clearly obviates the need for testing. These particular tests will be referenced in this report with the notation---"Test Not Required".

Reference to the cumulative effects of the mechanical tests and thermal test performed in 1973 for qualifying as Type "B" Packages will be included in this report with the notation---"Compliance Demonstrated, 1973".

G. A set of photographs will be included as part of this test report to illustrate the various equipment and apparatus used in performing the applicable tests.

H. All of the additional tests for B(U) packaging were performed during th~ period September 1, 1981 through September 11, 1981.

December 4, 1981

II. EQUIPMENT AND INSTRUMENTS EMPLOYED

A. TEST EQUIPMENT

1. Vacuum Pump
   Welch Duo Seal
   Model 1400, S/N 112839

2. Hydrostatic Pump
   Neptune
   Model HP-1, 750 PSIG Max.

3. Pressure Vessel
   Fabricated from 8" std. wt., sch. 40, seamless steel pipe, fitted with 300 lb. RF slip-on blind flange as removable top, and two pressure taps.
   Internal Dimensions: 7.981" I.D. X 14" high

4. Dead weight for compression test.
   Cylindrical, lead shielded, Cobalt-60 transport container. Container S/N SC-204
   Gross weight "Empty": 340 Lbs.

5. Cylindrical Steel Bar for Penetration Test
   Bar diameter: 3.2 cm (1.25")
   Bar weight: 6.0 kg (13.25 Lb.)
   Bar length: 97.2 cm (38.25")
   Striking end: Hemisherical

B. TEST INSTRUMENTS

1. Survey Meter
   Radiac Set, Model 68-27R
   S/N I-130, Calibrated 6-5-81 & 9-7-81

2. Well Counter
   For leak test analysis
   Eberline Mini Scaler
   Model MS-2, S/N 151
   with bicron 2"X2" crystal
   & 1" diam. X 1-1/2" deep cavity
   Bicron Model 2MW2-PQ

3. Rate Meter
   For calibrating source
   Victoreen Model 555
   S/N 279

4. Pressure Gauge
   Marshaltown #G27477
   2-1/2" Dial, 0-400 PSIG
   Calibration: ANSI Grade B, 2%

5. Vacuum Gauge
   Marshaltown #G14489
   2-1/2" Dial, 0-30" Hg. Vac.
   Calibration: ANSI Grade B, 2%

6. Various laboratory supplies such as hot plate, beakers, burettes, syringes, radiac wash, distilled water, rinse bottles, etc...for leak testing and evaluating radioactive concentrations.

C. TEST SPECIMENS

1. Model 500-SU Source Changer
   Type "B" Certificate No. USA/9006/B
   Serial No. 670

2. Model 520 Iriditron, Exposure Device
   Type "B" Certificate No. USA/9007/B
   Serial No. 831

3. Sealed Source of Iridium-192
   Encapsulation: Special Form
   Calibrated Strength: 17.0 Curies (9-1-81)
   Automation's S/N IR-14361

III. RADIATION SURVEYS OF PACKAGES

A 17 curie source of Iridium-192 was inserted into the Model 500-SU source changer and also into the Model 520 Iriditron. Both packages were surveyed for surface radiation levels and for radiation levels measured at one (1) meter from any external surface of the package. These surveys were performed prior to subjecting the packages to the basic and specific additional tests for B(U) packaging. Results of these initial surveys also established a baseline for comparison of radiation levels and integrity of containment prior to and after each sequential test. Results of these initial "baseline" surveys are tabulated below:

A. Model 500-SU source changer, S/N 670
   Results of "baseline" radiation surveys

Area Surveyed	mrem/h at Surface	mrem/h at 1 Meter
L. Side	2.5	0.1
R. Side	11.0	0.15
Front	1.5	0.1
Rear	10.5	0.15
Top	2.3	0.1
Bottom	9.5	0.1

B. Model 520 Iriditron, S/N 831
Results of "baseline Radiation Surveys

Area Surveyed	mrem/h at Surface	mrem/h at 1 Meter
L. Side	26.0	0.1
R. Side	28.0	0.15
Front (lock end)	14.0	0.1
Rear	6.0	0.1
Top	26.0	0.1
Bottom	8.0	0.1

IV.. ADDITIONAL PERFORMANCE TESTS

Each package was tested separately while containing the 17 curie sealed source of Iridium-192. Each package was subjected sequentially to the following prescribed tests required by IAEA Safety Series #6.

A. Reduced Pressure - Sec. II, Par. 221

Specimens placed in pressure vessel and chamber air pressure reduced to 0.25 kg/cm^2 (3.56 #/in^2 Ab.). Specimens were held at this reduced pressure for a period of 3 hours.

1. Evaluation---Visual examination after reduced pressure tests to containers revealed no apparent damage to components.
2. Radiation surveys on all exterior surfaces and at 1 meter distance showed no significant variation from "baseline" surveys.
3. Post contamination wipe (smear) test results on both container surfaces and source capsule were less than 0.0001 micro curies/sq. cm.

B. Water Spray Test---Sec. VII, Pars. 710 & 711

"Test Not Required"

C. Free Drop Test---Sec. VII, Par. 712

"Compliance Demonstrated, 1973"

D. Compression Test---Sec. VII, Par. 713(a)

Since the vertical projected area of the test packages are rather small, a load in excess of five (5) time the actual weight of either package was used in performing this test.

The Model 500-SU source changer weighs 58 pounds.
The Model 520 Iriditron weighs 40 pounds.

We employed a cylindrical, lead shielded transport container weighing 340 pounds for performing the compression test.

Each package was placed in its normal upright position with the base supported by a flat concrete floor. The 340 pound load was positioned on the top surface of each package, and the compressive load applied for an uninterrupted period of 24 hours.

1. Evaluation---Visual examination of each container after the 24 hour load period revealed no apparent damage to containers or components.

2. Radiation surveys on all exterior surfaces and at 1 meter distance showed no significant variation from "baseline" surveys.

3. Post contamination wipe (smear) test results on both container surfaces and source capsule were less than 0.0001 micro curies/sq. cm.

E. Penetration Test---Sec. VII, Par. 714

Each package was subjected to the following penetration test. Each package was placed on flat, horizontal concrete floor. Each package received three (3) impacts from the penetrating bar. The height of free fall of the bar was one meter, measured from the lower hemispherical end of the bar to the upper surface of the test specimen.

The penetrating bar consisted of cylindrical steel rod having a 3.2 cm. (1.25") diameter, and a hemispherical striking end. The overall length of the bar was 38-1/4", and the total weight was 13-3/8 pounds.

The Model 500-SU source changer was subjected to a total of three (3) impacts; one each to the following exterior surfaces:

(a) Center of top surface
(b) Center of right side
(c) Center of rear surface

The Model 520 Iriditron was subjected to a total of three (3) impacts; one each to the following exterior surfaces:

(a) Center of left side
(b) Center of rear end plate
(c) Rear of locking mechanism

1. Evaluation---Visual examination revealed that the penetration test results in little or no damage to either package. A small indentation, barely discernible was noted at each point of impact. There was no deformation of container surfaces, and all welds and locking devices remained intact.

2. The penetrating bar was not deformed as a result of the 6 drops.

3. Radiation surveys on all exterior surfaces of the packages, and at 1 meter distance showed no significant variation from "baseline" surveys.

4. Post contamination wipe (smear) test results on both container surfaces and source capsule were less than 0.0001 micro curies/sq. cm.

F. Free Drops (I & II)---Sec. VII, Par. 719

"Compliance demonstrated, 1973"

G. Thermal Test---Sec. VII, Par. 720

"Compliance demonstrated, 1973"

H. Water Immersion Test---Sec. VII, Par. 721

Both packages were tested separately while containing the 17 curie source of Iridium-192. A pressure vessel was used in conjunction with a hydrostatic pump to exert an external water pressure of 1.5 kg/cm^2 (gauge). The actual test pressure used for these tests was 30 PSIG maintained for a period of 18 hours.

1. Evaluation---Visual examination revealed that the water immersion test resulted in no physical damage to either package.

2. Radiation surveys on all exterior surfaces of the packages, and at 1 meter distance showed no significant variation from "baseline" surveys.

3. Post contamination wipe (smear) test results on both container surfaces and source capsule were less than 0.0001 micro curies/sq. cm.

4. The total volume of pressure vessel equals 700 cu. in. = 11.47 liters.

   Residual water after Model 500-SU source changer was removed from pressure vessel = 7.78 liters.

   Residual water after Model 520 Iriditron was removed from pressure vessel = 7.99 liters.

   For purpose of calculations lets use 8 liters of residual water for both packages.

   A 10 ml sample (1/800 of total residual water) from each test package was assayed by well counting over a 10 minute period. Results of these assayes showed no activity levels above background.

V. <u>INTEGRITY OF CONTAINMENT AND SHIELDING</u>

A. Our well counting instrument is sufficiently sensitive to detect the presence of gamma emission down to 0.005 nci over a 10 minute counting period.

B. After each performance test both packages were evaluated for extent of non-fixed removable surface contamination. This was determined by hand wiping a 300 sq. cm. area of the container surface using a dry cotton wad. Results of well counting demonstrated that in no instance did concentrations of non-fixed contamination exceed 0.0001 micro curies/sq. cm.

C. After each performance test the contained sealed source of Iridium-192 was leak tested by using the wipe (smear) test method described in Appendix "A" of ANSI-N542, Section A2.1.1.

   All exterior surfaces of the capsule were wiped thoroughly with cotton pipe stem cleaners moistened with a 5% solution of radiac wash. The amount of radioactivity removed from the source before and after each performance test was used as an indicator in evaluating the integrity of the package in restricting the loss of radioactive contents. In no case were results of capsule wipe tests in excess of 0.0001 micro curies.

D. To further assure the packages ability to restrict loss of radioactive content, an additional leak test was performed on the contained sealed source of Iridium-192 after the packages had been subjected to the required cumulative tests. This test consisted of "Immersion with Boiling" as specified in Appendix "A" of ANSI-N542, Section A2.1.3.

Immersion with boiling was accomplished by using a standard radiographic exposure device which was equipped with a source guide tube fitted with a perforated "screen-type" end cap which terminated into a 1000 ml beaker containing a 500 ml solution of 5% radiac wash. This arrangement permitted remote handling and positioning of the source during the test. The Iridium-192 source was exposed and immersed into the 500 ml of solvent. The solvent was then boiled for a period of 10 minutes. The sealed source was then removed and allowed to cool. The boiling solvent was retained. The test source was then rinsed in a 150 ml fresh solution of solvent. The rinse solvent was then added to the original boiling solvent---This operation was repeated twice, for a total of three tests, using the original solvent for the boiling. Two 10 ml samples of the original solvent were each assayed by well counting for a 10 minute period. Results of these assays showed no concentrations above 0.002 nci/ml of solvent. Since the total residual solvent after boiling was equal to 600 ml, then the total activity in the solvent is (0.002 nci/ml X 600 ml) equals 1.2 nci total activity.

VI. SUMMARY AND COMMENTS

A. Test results demonstrate that the two (2) packages have successfully met the basic and specific additional test requirements for Type B(U) packaging relating to:

(1) Structural integrity.
(2) Retention of shielding and shielding integrity.
(3) Restricting loss of radioactive contents to less than: $A_2 \times 10^{-6}$ per hour
and
$A_2 \times 10^{-3}$ per week
where A_2 = 20 ci. for Iridium-192.

B. A set of 8 photographs are included as part of this test report which illustrate the various equipment and test apparatus employed.

C. Automation Industries, Inc. requests that both of the above referenced containers be certified as type B(U) packages, and that appropriate Certificates of Competent Authority be established.

Sincerely,

Michael P. Santoro

Michael P. Santoro,
Nuclear Products 12-4-81

MPS:deb
Enc: (8) Photographs

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TEST RESULTS FOR TYPE "B" PACKAGING

IRIDIUM SOURCE CHANGER-SPENT URANIUM TYPE

AND MODEL 520 IRIDITRON EXPOSURE DEVICE

In an effort to reduce transportation costs and also as an effort towards product improvement, Automation Industries, Inc has designed and constructed a new Iridium Source Changer for servicing our Iridium-192 customers.

Our new Source Changer will use Spent Uranium as the shielding medium. By utilizing Spent Uranium, our new changer is approximately one-quarter the volume and one-third the weight of our present lead shielded Changers. The gross shipping weight of the new Source Changer will be sixty (60) pounds. This reduction in size and weight renders a very compact, rugged, and structurally sound design, capable of withstanding severe abuse encountered during shipment and in field use.

The container design consists of a rectangular box, approximately 5" wide x 7" high x 11" long, fitted with a hinged cover to permit access to the internal compartment. The entire unit is fabricated from type 18-8 Stainless Steel sheet, #10 Gage, (0.140" thick), with all corners and seams continuously welded. The Spent Uranium shield is completely encased in an all-welded leak tight compartment. The shield is fixed in the compartment by seal welding the two (2) exit tubes through the partitioning sheet, and then potting with a high temperature solid epoxy. The unit is designed to meet the requirements of D.O.T.-55 Specification.

In essence, this new changer is a miniature version of our present lead shielded changer. All threaded connections, threaded seal caps, transfer tubes, method of packaging, securing and sealing are the same for both units. The procedures to be followed for effecting a source change in the field are also the same for both units. The same operating instructions will apply for both Source Changers.

As designed, the Spent Uranium Changer is a D.O.T.-55 shipping container; however, at this time, Automation Industries, Inc. would also like to qualify it as a Type "B" shipping container. In order to substantiate this qualification, the Spent Uranium Source Changer was subjected to the following test requirements of the International Atomic Energy Agency. Tests were performed sequentially in the order listed below:

A. MECHANICAL TEST

Free Drop #1——The package was dropped from a height of thirty-four (34) feet onto a flat, horizontal, 5/8 inch thick steel plate.

M.P. Santoro (signature) July 24, 19

Michael P. Santoro
Product Manager, Nuclear

MPS 5-8-80 Rev. #1 Dated 5-8-80
See added Appendix "A" Page 8

M.P.S. 1-27-83 Rev. #2 Dated 1-27-83
See added Appendix "B", Pages 9 thru 13.

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Free Drop #2——The package was dropped from a height of forty (40) inches onto the upper end of a steel circular bar which was perpendicular to the concrete pad. The target surface of the circular bar was flat with its outer edges rounded off to a radius of six (6) mm.

Deviations:

(a) For the Free Drop #1, the 5/8" steel plate was not wet floated onto the concrete pad. However, the eight (8) inch thick concrete apron was flat and horizontal, as was the steel plate, and the contact interface was intimate.

(b) For the Free Drop #2, the circular steel bar was three (3) inch diameter in lieu of the fifteen (15) cm. diameter called for.

OBSERVATIONS:

Subsequent to Drops #1 and #2, visual inspection and radiation surveys indicate, that the container and/or containers, as presently designed, would have sustained more severe test conditions, and still maintained integrity. Results of the drop tests showed negligible effects.

B. THERMAL TEST

The container and/or containers were suspended by wire rope from an "A" frame, centered over a 66 inch by 66 inch fuel pan, having five (5) inch sides. The container and/or containers were positioned approximately twelve (12) inches above the surface of the fuel. The fuel consisted of a 50/50 percent mixture of Kerosene and #2 Fuel Oil. Total time of exposure to flame was fourty-seven (47) minutes. This exceeded the required test period by seventeen (17) minutes, since we were unable to extinguish the flame by use of three (3) conventional CO_2 extinguishers. Two (2) local Fire Companies arrived with suitable foam generating equipment to blanket the flame. The container and/or containers were allowed to cool naturally for a period of three (3) hours.

Deviations:

Total time of exposure to flame was fourty-seven (47) minutes, due to difficulty encountered in attempting to extinguish the fire at the thirty (30) minute mark.

M. P. Santoro — July 24, 1973

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For ecological reasons and also potential fire hazards, the same fire was used to expose two (2) different containers simultaneously. (The Spent Uranium Source Changer and Our Model 520 Iriditron Exposure Device.)
An attempt to monitor the flame temperature, using a Weed Model 8000 Temperature Indicator with platinum resistance probe (0 to 1600 °F) failed, due to a malfunction in the instrument or a short in the probe element.

OBSERVATIONS:
After the three (3) hour cooling period, both containers were inspected visually for structural damage, and also monitored for any radiation hazards. There were no apparent high surface radiation levels. Both containers exhibited bulged or "pregnant" attitudes, due to extremely high internal pressures resulting from the decomposition of the trapped epoxy potting resins at the elevated temperatures. The internal gas pressures had to be exceedingly high in order to permanently set a convex bow on all surfaces of the containment shells (#10 Gage, 0.140 inch thick, type 304 Stainless Steel Plate).

The Spent Uranium Source Changer showed no structural failure, nor any loss of shielding integrity, as a result of the fire test.

The Model 520 Iriditron did spring about 50% of the weld seam on the bottom portion of the rear end plate, (Lock Box End).

This occurred at approximately the fourty (40) minute elapsed time mark, while the firemen were preparing to blanket the fire with foam. The weld failure was clearly evidenced by a muffled explosion, followed by a rapid release of expanding gases or epoxy vapors. Close up inspection showed that the lower segment of the rear end plate had pulled away from the shell tube, forming an angle of approximately 15° off the perpendicular. Accordingly, this rotation of the rear end plate caused the lockbox to be cocked upward approximately 15° off the horizontal.

One end of each hold down tube on either side of the Model 520 base, had separated from the end plates. These separations are not relevant to containment of shielding integrity, however, they do attest to the tremendous forces that were built up and released, in order to cause these weld failures.

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It was also noted that the leather handles, and aluminum Radiation Warning Tags and Labels, had completely disintegrated. Stainless Steel Nameplates and chemically etched engravings remained legible. On the Model 520, the aluminum Source Identification Plate was 60% melted away, and the remaining portion not legible.

C. CONTAINMENT AND SHIELDING INTEGRITY

During each test, each container was loaded with a sealed source of Iridium-192 of following strengths:

1. SPENT URANIUM SOURCE CHANGER

Drop Tests 1 and 2, 34 Curies of Iridium-192 (See Chart "A")

30 Minute Fire Test, 30.7 Curies of Iridium-192 (See Chart "C")

2. MODEL 520 IRIDITRON (EXPOSURE DEVICE)

Drop Tests 1 and 2, 24 Curies of Iridium-192 (See Chart "B")

30 Minute Fire Test, 21.5 Curies of Iridium-192 (See Chart "D")

Radiation Surveys were performed on both containers, prior to and after being subjected to each test. Dose rates were measured and recorded for surface levels; at six (6) inches from external surface, and at one (1) meter from the external surface. See Charts "A" to "D" for radiation survey results.

(a) The Spent Uranium Source Changer did not exhibit in any significant change in dose rates after each and cumulative tests.

(b) The Model 520 Iriditron did not exhibit any significant change in dose rates after Drop Tests 1 and 2. However, after the Thermal Test, some of the surface and six (6) inch dose rates increased, while others directly opposite in location decreased, (see Chart "D"). The cumulative average of dose rates did not shift more than 15%. This could be considered negligible. This change in radiation dose levels can be attributed partly to the complete loss of epoxy resin, when the rear end plate seal weld ruptured and relieved the internal pressure. It was calculated

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that the epoxy offered approximately 1% of the shielding value. The major cause of shift in dose levels was caused when the lockbox cocked upwards. This motion of the lockbox pulled the Iridium-192 source capsule out of center position in the shield; approximately 3/16" off center. The source pigtail is positioned and fixed into the shiel' by means of the lock prongs and limiting orifice when the unit is in locked position. Accordingly, when the locking mechanism rotated upward, the source pigtail was displaced an equal amount. This explains why some dose readings increased, while others decreased. Since the Model 520 Shield is overdesigned, with resulting good safety factor; and a 1/2" safe dwell position in the center of the "S" tube, the source capsule can be translated at least 1/4" to eigher side of the theoretical center before appreciable changes in radiation dose levels are noticed. This feature was designed into the unit.

D. PHOTOGRAPHS

The following photographs numbered one (1) through twenty-three (23), illustrate the set-up, progress, and effects of tests on the containers:

#1------------------30 Foot Free Drop
#2------------------Spent Uranium Changer - Prior To Test
#3------------------Model 520 Iriditron - Prior To Test
#4, #5--------------Model 520 Iriditron - After 34 Foot Free Drop
#6------------------Spent Uranium Changer - After 34 Foot Free Drop
#7------------------Model 520 And Source Changer - After All Mechanical Tests
#8, #9--------------Model 520 Iriditron - Before And After Drop Onto Circular Pin
#10, #11------------Source Changer - Before And After Drop Onto Circular Pin
#12, #13------------Close Up Of Fuel Pan - Prior To Thermal Test
#14, #15, #16-------Progress Of Thermal Test
#17, #18------------Source Changer And Model 520 - After Thermal Test Note Source Pigtail Connectors Protruding From Lockboxes. Note Seam Weld Rupture On Model 520 Iriditron.

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#19-----------------Side View Of Model 520 -
After Thermal Test
Note Cocked Position Of Lockbox
#20, #21------------Radiation Surveys
#22, #23------------Radiation Surveys

E. INTEGRITY OF SOURCE CAPSULE (ENCAPSULATION)

After completion of all tests, both source capsules were leak tested to determine whether there was any leakage of radioactive contents. Both leak test results were negative with respect to leakage.

Source Serial Number IR-6964, contained in Model 520 Iriditron.
Leak Tested on June 6, 1973 After Fire Test
Removable Contamination. Less than 0.001 micro curies

Source Serial Number IR-7056, contained in Spent Uranium Source Changer.
Leak Tested on June 6, 1973 After Fire Test
Removable Contamination: Less than 0.001 micro curies

Visual inspection of the two (2) Source Pigtails when inspected under magnification while viewing through our Hot-Cell viewing window, indicated that there was no mechanical damage imparted to either capsule assembly as result of tests.

F. RECOMMENDATIONS

Due to the severity of the Thermal Test, (Oil Fire), we would suggest that anyone performing this test, do so in a very isolated area, removed from any flammable equipment or buildings. It is also recommended that trained professional fire-fighting personnel and equipment, be on hand to terminate the test, and for obvious safety reasons. The heat intensity of this test is so overwhelming, that it is impossible to approach the flame with conventional hand-held fire extinguishers, when attempting to extinguish the flame after the thirty (30) minute exposure.

G. CONCLUSION

It is our opinion that both of these containers satisfactorily met the Type "B" test requirements of The International Atomic Energy Agency, and that they be certified as such by assignment of individual Certification Marks as issued by the U.S. Department Of Transportation, (D.O.T.). We desire that this certification

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or permit be acceptable for both domestic and export shipments.

Since the Model 520 Iriditron is an Exposure Device, used in Industrial Radiography, and the Spent Uranium Source Changer is a shipping Container for transporting new replacement sources to our customers, and the returning of decayed sources to our Phoenixville facility for ultimate disposal, it is hoped that this type "B" certification will not require that our domestic customers register with the D.O.T. to enable authorized receipt, use, or transshipment of these containers. (They are D.O.T. 55 Spec. containers, and we do not feel that our domestic customers should be burdened with additional registration, simply because we tested and proved that the containers will withstand the more rigorous tests of Type "B" packaging.)

H. SPECIAL FORM MATERIAL

(a) The Spent Uranium Source Changer and the Model 520 Iriditron, will be used only as shielded containers for the isotope Iridium-192 in solid metallic form. The wafers of Iridium-192 are encapsulated into stainless steel capsules using a 1770°F silver braze, (Eutectic Welding Alloys Company, #1807), for the sealing process. The sealed sources are decontaminated and leak tested prior to insertion into the shielding units.

(b) To date we have distributed over 7400 Iridium-192 Sealed Source Capsules of this design to licensed recipients.

(c) The isotope Iridium-192 in solid metallic form, is an noble metal and meets all the requirements of melting point, sublimation, percussion friability, low solubility or dissolution, and chemical stability tests, as outlined in the International Atomic Energy Agency regulations. Since we encapsulate no wafers of metallic Iridium-192 which have any dimension less than 0.5 mm, the radioactive material in itself is Special Form.

I. REQUEST FOR APPROVALS

(a) We request that the Spent Uranium Source Changer be certified as a Type "B" package for shipping Special Form, Sealed Sources of Iridium-192, up to, but not exceeding, 300 Curies.
Specific Activity Range: 300 To 400 Curies/gram

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(b) We request that the Model 520 Iriditron be certified as a Type "B" package for shipping Special Form, Sealed Sources of Iridium-192, up to, but not exceeding, 120 Curies.
Specific Activity Range: 300 To 400 Curies/gram.

(c) We request that our Iridium-192 Isotope be certified as Special Form Shipment and/or Special Form Material.

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REVISION #1. APPENDIX "A" (ADDED 5-8-80)

ADDITIONAL DROP TEST PERFORMED TO MODEL 520 SHIELD TO INSURE THAT FORCE OF IMPACT OCCURRED TO MOST VULNERABLE PART OF THE DEVICE.

(a) Date of Test: April 2, 1975

(b) Description of Test: 30 ft. free drop onto unyielding target consisting of 6 inch thick flat steel plate.

(c) Orientation of Device: A guy wire was employed to maintain proper orientation to assure that maximum damage occurred to the locking mechanism and protruding seal plug connector.

(d) Test Specimen: The 520 shield was the same unit which had previously been subjected to sequential drop, puncture, and fire exposure when qualifying the unit for Type "B" Packaging.

RESULTS & OBSERVATIONS

(a) After Impact: The locking mechanism remained locked---The protruding seal plug connector was slightly deformed---And the guy wire still maintained the 520 shield in a vertical attitude.

(b) After removing guy wire, deformed seal plug connector was removed---
There was no evidence of any damage to the source pigtail connector---And the source pigtail assembly was still retained in the proper locked, stored position.

(c) Conclusion: Results of this test clearly demonstrates the inherent stability of the Model 520 shield and that the device would withstand tests of this severity.

Michael P. Santoro May 8, 1980.
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General Manager, Nuclear Products.

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REVISION #2. APPENDIX "B" (ADDED 1-27-83)

I. SCOPE: TO DOCUMENT RESULTS OF MECHANICAL TESTS PERFORMED ON THE COMBINATION PACKAGE CONSISTING OF AUTOMATION INDUSTRIES MODEL 500-SU IRIDIUM-192 SOURCE CHANGER (CONTAINMENT VESSEL) WHEN ENCASED WITHIN A STEEL DRUM OVERPACK.

A. PACKAGE DESCRIPTION: The complete package assembly consists of Automation Industries Model 500-SU Iridium-192 Source Changer (Containment Vessel) completely encased within a #18 gage steel drum which measures 15-1/8" outside diameter and a total height of 13-3/4". The drum is fitted with a top opening lid which is secured with a clamp ring and seal bolt. Two (2) close fitting molded hair-packs are fitted within the drum to receive and maintain the containment vessel in a fixed position during transport. (See Automation's Dwg. No. D-500SU-OP for complete specifications.)

B. GROSS WEIGHT OF COMPLETE PACKAGE (CONTAINMENT VESSEL PLUS DRUM OVERPACK): 80 Pounds.

C. MODEL NUMBER OF COMPLETE PACKAGE: Model 500SU-OP.

D. TYPE AND FORM OF RADIOACTIVE CONTENT: Metallic wafers of Iridium-192 as sealed sources which meet the requirements of special-form encapsulation; and depleted uranium shield casting of the 500-SU.

E. MAXIMUM QUANTITY OF RADIOACTIVE CONTENT PER PACKAGE: 300 Curies of Iridium-192, plus 39 pounds of depleted uranium (shield casting of the 500-SU containment vessel).

II. PERFORMANCE TESTING - GENERAL FOR ALL PACKAGING - SUBPART C

A. 71.31(c)(1) LIFTING DEVICES: The complete package assembly was supported by the two (2) lifting handles and a static load of 260 pounds was distributed over the top surface of the package. Loading was maintained for a period of 5 minutes. At completion of test, visual inspection revealed no evidence of system failure or deformation to any of the supporting components that would indicate stresses in excess of the yield strength. (See attached photograph #1).

B. 71.31(c)(4) LIFTING DEVICES, EXCESSIVE LOAD: (Test performed by the testing laboratories of W.B. Coleman Company, Philadelphia, PA). The package was fixtured onto a tensile testing machine and an upward vertical force was applied to one of the lifting handles and gradually increased until failure. The handle grip loop failed at 2040 pounds. Failure consisted of the grip loop separating and pulling out of the handle mounting bracket. Visual inspection revealed that the excessive load to the handle did not generate excessive stress to the drum housing nor impair the containment or shielding properties of the package. (See attached photograph #2).

M.P. Santoro Jan. 27, 19[illegible]
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C. 71.31(d)(1) TIE-DOWN DEVICES: A static force applied through the center of gravity of the package having a vertical component equal to two (2) times the weight of the package (160 pounds), a horizontal component equal to ten (10) times the weight of the package (800 pounds), and a horizontal component in the transverse direction equal to five (5) times the weight of the package (400 pounds). Since we cannot control the orientation of the package in relation to the direction of vehicle travel, we have selected the centerline passing through the two (2) handles as the direction of the 800 pound horizontal vector. The resultant of these components is equal to a static force of 910 pounds rotated through 27 degrees off the centerline passing through the handles, and having an angle of declination equal to 10 degrees. (This test was performed by the testing laboratories of W.B. Coleman Company, Philadelphia, PA).

The package was fixtured onto a tensile testing machine with steel banding straps securely tightened to the hold-down loops to maintain proper orientation of the package and also support the package during the test. A one (1) inch diameter ram was attached to the crosshead to transfer and direct the 910 pound force in line with the center of gravity of the package. This load was maintained for five (5) minutes.

At full loading (910 pounds) there was no failure in the tie-down system---The tie-down straps remained intact as did the handle loops. Further inspection revealed that the test load did not generate excessive stress to the drum body nor to the tie-down system. (See attached photograph #3).

D. 71.31(d)(3) TIE-DOWN DEVICES, EXCESSIVE LOAD: (Test performed by the testing laboratories of W.B. Coleman Company, Philadelphia, PA). The package was fixtured onto the tensile testing machine so that loading would be applied to the tie-down loop at approximately 45 degrees from the horizontal when the package would be in its normal upright shipping attitude. Loading was gradually increased until failure. The tie-down handle loop failed at 1385 pounds. Failure consisted of the handle loop separating and pulling out of the handle mounting bracket. Visual inspection revealed that excessive loading to the tie-down device to point of failure did not generate excessive stress to the drum housing nor impair the containment or shielding properties of the package. (See attached photograph #4).

E. 71.32(a) LOAD RESISTANCE: (Test performed by the testing laboratories of W.B. Coleman Company, Philadelphia, PA). The package was tested as a simple beam supported at its ends along both its vertical axis and horizontal axis. A static load of 400 pounds was applied normal to and uniformly distributed along the length of its upper surface. For both tests the load was maintained for a duration of five (5) minutes.

Visual examination at completion of tests showed no evidence that any surface of the package was stressed to its yield point. (See attached photograph #5).

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III. PERFORMANCE TESTING - FOR NORMAL CONDITIONS OF TRANSPORT "APPENDIX "A"

A. APPENDIX "A-6", FREE DROP: The package was subjected to three (3) free drops through a distance of four (4) feet onto a flat horizontal surface (blacktop roadway). The points of impact were to the top clamping ring, the bottom rim and to the side wall of the drum.

These tests imparted very little damage to the drum other than removal of paint and slight surface scratches to the metal at points of impact. (See attached photograph #6).

B. APPENDIX "A-7", CORNER DROP: The package was subjected to one (1) foot corner drops onto each quarter of the top clamping ring, and onto each quarter of bottom rim (total of eight drops). The surface of impact was a flat horizontal blacktop roadway.

Again, damage was very minimal consisting of paint removal and slight surface scratches to the metal at points of impact. (See attached photograph #7).

C. APPENDIX "A-8", PENETRATION: The package was supported by a flat horizontal blacktop roadway. The package was subjected to two (2) impacts from the penetrating bar. One (1) drop onto the center of the top lid, and the second drop onto the center of the drum's bottom with the drum resting in the inverted position.

The penetrating bar consisted of a cylindrical steel rod having a 1-1/4" diameter, and a hemispherical striking end. The overall length of the bar was 38-1/4", and the total weight was 13-3/8 pounds. The height of free fall of the bar was 40 inches measured from the lower hemispherical end of the bar to the upper surface of the test package.

Visual examination revealed that the penetration drops resulted in very little damage to the two (2) surfaces of impact. Damage to both surfaces at point of impact consisted of a hemispherical depression approximately 3/4" in diameter and 1/4" deep. There was no piercing or tearing of either test surface. (See attached photograph #8).

D. APPENDIX "A-9", COMPRESSION: A static load of 460 pounds was equally distributed over the top surface of the drum while the drum was in its normal upright transport position and supported by a flat horizontal concrete floor slab. The compressive load was maintained continuously for a period of 24 hours.

Visual examinations after testing revealed no evidence of any damage to the package resulting from this loading, nor any indications of deformation to any of supporting components which would indicate stresses in excess of the yield strength. (See attached photograph #9).

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IV. PERFORMANCE TESTING - HYPOTHETICAL ACCIDENT CONDITIONS - "APPENDIX-B"

A. APPENDIX "B-1", FREE DROP THROUGH 30 FEET: A sealed source of IR-192, serial number 15202, having a calibrated strength of 8.5 curies on January 12, 1983 was loaded into and secured within a Model 500-SU Source Changer, serial number SU-644. This will be designated as the containment vessel.

The containment vessel was then inserted into the drum overpack and properly positioned and secured within the cavity of the molded hair-packs. The drum was then closed with the top removable lid and secured and locked by the clamp ring and seal bolt assembly. This complete assembly will be designated as the Model 500SU-OP overpack assembly, and will have a gross shipping weight of 80 pounds.

Prior to drop, the package was surveyed for external surface radiation levels and radiation levels measured at three (3) feet from all external surfaces of the package. Results of these surveys indicated the highest levels recorded on any exterior surface of the drum was 1.8 MR/HR and 0.1 MR/HR when measured at a distance of three (3) feet from any exterior surface.

The package was hoisted to the rooftop of a 34 foot high building, and allowed to drop onto a flat horizontal essentially unyielding blacktop roadway.

Impact occurred at the lower side surface of the drum between the area of the lower chime bead and the bottom rim. Essentially it approximated a bottom corner drop.

The damage to the package was minimal considering the amount of energy absorbed. The structural soundness of the package was unchanged and the integrity of closures and containment remained intact. The only physical damage consisted of flattening of the bottom rim of the drum at surface of impact and a slight perforation of the side wall also within the area of impact. The perforation resembled a right angle slit having a width of 3/32" and unequal legs of 1-1/2" X 1". The perforation was actually the imprint of the rear lower corner of the containment vessel which compressed the hair pack at the instant of impact with sufficient force to locally shear the side wall of the drum by the combined actions of shear, elongation, and forging.

Radiation surveys on all exterior surfaces of the package, and at a distance of 3 feet from all exterior surfaces demonstrated that there was no increase in surface radiation levels or transport index resulting from the free drop test. The highest surface radiation level remained at 1.8 MR/HR as did the transport index at 0.1 MR/HR.

Upon removal of the seal bolt, clamping ring, top lid, and upper hair-pack mold from the package, we noted that containment vessel was still properly positioned by the orientation bracket and properly nested within the lower hair-pack cavity. This demonstrated that the hair-packs have an excellent capacity for energy absorbtion, combined with good elasticity and resiliency. Examination of the containment vessel revealed no damage to any of exterior surfaces, seal wires or closures. (See attached photograph #10).

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B. APPENDIX "B-2", PUNCTURE: The package was subjected to four (4) drops through a distance of 40 inches measured from the lowest surface of the package to the top of a cylindrical mild steel bar which was mounted vertically on a flat horizontal unyielding surface. The bar was 6 inches in diameter, 8 inches in length, with a flat horizontal top surface whose edge was rounded to a 1/4" radius.

The four (4) drops were so directed so that impacts would occur to the following surfaces of the package: Center of top lid, center of bottom, mid-point of side with dr m falling horizontally, and onto the seal bolt and locking lugs of the clamp ring assembly.

Visual examinations after testing indicated that damage to the package resulting from these drops were very minimal; consisting of very slight crescent shaped indentations to the flat surfaces of drum lid and bottom. (See attached photograph #11).

V. SUMMARY AND COMMENTS:

A. Test results demonstrate that the combination containment vessel and drum overpack assembly, Automation Industries, Inc. Model 500SU-OP has successfully met the test requirements for both normal and accident conditions of transport relating to:

(1) Structural integrity

(2) Retent of shielding and shielding integrity

(3) Restricting loss of any radioactive content

B. The above radioactive material packages will continue to be designed and fabricated in accordance to Automation Industries' Quality Assurance Program, NRC Docket No. 71-0264, approved October 9, 1979.

C. All tests covered by Revision #2, Appendix "B" of this report were conducted during the period of January 4 through January 21, 1983.

D. Automation Industries, Inc. reque s that the combination containment vessel and drum overpack assembly, Model 500SU-OP be certified as a Type "B(U)" packa e for transporting sealed sources of special-form, Iridium-192 u to a maximum of 300 curies per package, and that the appropri e certificates of competent authorities be established.

Michael P. Santoro Jan. 27, 1[illegible]
Michael P. Santoro, Mgr. Engr.,
Nuclear Products

3.0 Thermal Evaluation

3.1 Discussion

The Model AI 520 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 120 curies of iridium-192. The corresponding decay heat generation rate is 1.03 watts.

3.2 Summary of Thermal Properties of Materials

The melting temperatures of the metals used in the construction of the Model AI 520 are:

Brass	930 °C	(1706 °F)
Uranium	1133 °C	(2070 °F)
Steel	1345 °C	(2453 °F)
Tungsten	3370 °C	(6098 °F)
Titanium	1820 °C	(3308 °F)

The epoxy used in this device has an operating temperature range of -43 °C to 104 °C (-45 °F to 220 °F).

3.3 Technical Specifications of Components

Not applicable

3.4 Normal Conditions of Transport

3.4.1 Thermal Model

The heat source in the Model AI 520 is a maximum of 120 curies of Iridium-192. Iridium-192 decays with a total energy liberation of 1.45 MeV per disintegration or 8.58 milliwatts per curie. Assuming all the decay energy is transformed into heat, the heat generation rate for the 120 curies of iridium-192 would be 1.03 watts.

To demonstrate compliance with the requirements of 10 CFR 71.43 (g) and paragraph 230 of IAEA Safety Series No. 6, a separate analysis is presented in Section 3.6. The thermal model employed is described in that analysis.

To demonstrate compliance with the requirements of paragraph 240 of IAEA Safety Series No. 6 for Type B(U) packaging, a separate analysis is presented in Section 3.6. The thermal model employed is described in that analysis.

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 efficiency of the package. As presented in Section 3.6, the maximum temperature in the shade would not exceed 43 °C (119 °F) and the maximum temperature when insolated would not exceed 62 °C (144 °F).

3.4.3 Minimum Temperatures

The minimum normal operating temperature of the Model AI 520 is -40 °C (-40 °F). 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 thermal accident condition, which is shown to result in no reduction in structural integrity or shielding efficiency.

3.4.5 Maximum Thermal Stresses

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 under Normal [illegible]ditions of Transport

The normal transport thermal condition will hav[illegible]dverse effect on the structural integrity or shieldin[illegible]iency of the package. The applicable conditions of I[illegible]fety Series No. 6 for Type B(U) packages are shown to be satisfied by the Model AI 520.

3.5.0 Hypothetical Thermal Accident Evaluation

3.5.1 Thermal Model

A prototype Model AI 520 package was subjected to the hypothetical thermal accident condition by Automation Industries Inc.

3.5.2 Package Conditions and Environment

The prototype Model AI 520 package which was subjected to the hypothetical thermal accident condition had previously been subjected to free drop test and puncture test. The package had suffered minor structural deformation during these mechanical tests, but suffered no reduction in structural integrity or shielding efficiency.

3.5.3 Package Temperatures

During the hypothetical thermal accident test, the package was placed into a kerosene and fuel oil fire. The package remained there for 47 minutes.

The possibility of the formation of an iron-uranium eutectic allow was addressed in Section 2.4.1 where it was concluded that the formation of the alloy was not a likely possibility. There was no indication of any melting or alloy formation as a result of this thermal test.

3.5.4 Maximum Internal Pressures

The maximum internal pressure generated during the thermal test is described in the Automation Industries Test Report by Mr. M. Santoro, dated 24 July 1973 and presented in Section 2.10.

In Section 3.6.3, an analysis of the source capsule, which serves as the primary containment, under the thermal test condition is presented. This analysis demonstrates that the maximum internal gas pressure at 800 °C would be 373 kPa (54 psi).

The critical location for failure is the source capsule weld. The analysis shows that an internal pressure of 373 kPa (54 psi) would generate a maximum stress of 1.96 MPa (284 psi). At 870 °C (1600 °F), the yield strength of Type 304 stainless steel is 69 MPa (10,000 psi).

Therefore, if the source capsule were to reach a temperature of 800 °C, the maximum stress in the capsule would be only 3% of the yield strength of the material.

3.5.5 Maximum Thermal Stresses

There were no significant thermal stresses generated during the thermal test. A description is presented in the Automation Industries Test Report by Mr. M. Santoro dated July 1973 and presented in Section 2.10.

3.5.6 Evaluation of Package Performance

As a result of the hypothetical thermal accident test, the bottom portion of the rear end plate sprung approximately 50% of its weld seam. This occurred after the thirty minute mark as documented in the test results presented in Section 2.10. There was no reduction in shielding efficiency as a result of this damage. There was no impairment of any design or safety features. There was no damage to the locking assembly or package closure. There was no release of the package contents.

A shielding efficiency test was performed at the conclusion of the thermal test. This shielding efficiency test demonstrated that there was no reduction in shielding efficiency as a result of the thermal test condition.

A report of the thermal test by Automation Industries' Mr. M. Santoro dates 24 July 1973 is presented in Section 2.10.

3.6.0 Appendix

3.6.1 Model AI 520 Type B(U) Thermal Analysis: 10 CFR 71.43(g) and paragraph 230 of IAEA Safety Series No. 6

3.6.2 Model AI 520 Type B(U) Thermal Analysis: Paragraph 240 of IAEA Safety Series No. 6

3.6.3 Iridium-192 Source Capsule Thermal Analysis

3.6.1 Model AI 52Ø Type B(U) Thermal Analysis
10 CFR71.43(g) and paragraph 231 of
IAEA Safety Series No. 6

This analysis demonstrates that the maximum surface temperature of the Model AI 52Ø will not exceed 5Ø °C with the package in the shade and an ambient temperature of 38°C.

To assure conservatism, the following assumptions are used:

(a) The entire decay heat (1.Ø3 watts) is deposited in the exterior surfaces of the package.

(b) The interior of the package is perfectly insulated and heat transfer occurs only from the exterior surface to the environment.

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

(d) The only heat transfer mechanism is free convection.

Using these assumptions, the maximum wall temperature is found from

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

where q = Heat deposited per unit time in the face of interest (Ø.26 watts)

h = Free convection heat transfer coefficient for air

$= 1.32 \left(\frac{\Delta T}{d}\right)^{1/4}$ watt/m² °C

A = Area of the face of interest (Ø.Ø181 m²)

Tw = Maximum temperature of the surface of the package

Ta = Ambient Temperature (38 °C)

From this relationship, the maximum temperature of the surface is 42.3°C. This satisfies the requirement of 1Ø CFR 71.43(g) and paragraph 23Ø of IAEA Safety Series No. 6.

3.6.2 Model AI 520 Type B(U) Thermal Analysis paragraph 240 of IAEA Safety Series No. 6

This analysis demonstrates that the maximum surface temperature of the Model AI 520 will not exceed 82 °C when the package is in an ambient temperature of 38°C and is insolated in accordance with 10 CFR 71.71(c)(1) and Table III of IAEA Safety Series No. 6.

The calculational model consists of taking a steady state heat balance over the surface of the package. In order to assure conservatism, the following assumptions are used.

(a) The package is insolated at the rate of 775 W/m (800 cal/cm ^{2}-12 hr) on the top surface, 194 W/m (200 cal/cm ^{2}-12 hr) on the side surfaces and no insolation on the bottom surface.

(b) The decay heat load is added to the solar heat load

(c) The package has an unpainted stainless steel surface. The solar absorptivity is assumed to be 0.9. The solar emissivity is assumed to 0.8.

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

(e) The package is approximated as a rectangular parallel piped 198 mm (7.8 in) long, 133 mm (5.25 in) wide, and 162 mm (6.38 in) high transported on the bottom. The surface area of the top and bottom are 0.0263 m^2. The total surface area of the sides is 0.1073 m^2.

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

$$q_{in} = q_{out}$$

The heat load applied to the package is

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

where : solar absorptivity (0.9)

q_s: solar heat load (41 .2 watts)

q_d: decay heat load (1.03 watts)

The heat dissipation is expressed as

$$q_{out} = q_c + q_r$$

where q_c: convective heat transfer

q_r: radiative heat transfer

The convective heat transfer is

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

where h: convective heat transfer coefficient

A: area of the surface of interest

T_w: Temperature of the surface

T_a: Ambient Temperature (38°C)

The radiative heat transfer is

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

where σ: StefanBoltzmann Constant (5.669×10^{-8} W/m²°K)

E: Emissivity (0.8)

Iteration of this relationship yields a maximum wall temperature of 61.5°C which satisfies the requirements of paragraph 240 of IAEA Safety Series No. 6.

3.6.3 Model AI 520 Type B(U) Source Capsule Thermal Analysis Paragraph 238 of IAEA Safety Series No. 6 1973

This analysis demonstrates that the pressure inside the source capsule used in conjunction with the Model AI 520, when subjected to the hypothetical thermal accident 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 6.35 mm (0.250 inch). The source capsule is seal welded. The minimum weld penetration is 0.5 mm (0.02 inch). 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 (20 °C and 100 kPa). 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 238 of IAEA Safety Series No. 6, it is assumed that the capsule could reach a temperature of 800 °C (1475 °F). Using the ideal gas law and requiring the air to occupy a constant volume, the internal gas pressure could reach 373 kPa (54 psi).

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:

$$\sigma_l A_l = P A_P$$

where σ_l : Longitudinal Stress
A_l : Stress Area
P : Pressure
A_P : Pressure Area

From this relationship, the maximum longitudinal stress is calculated to be 900 kPa (129 psi).

The hoop stress is calculated from

$$2\sigma_h L t = P d_l$$

where σ_h : Hoop Stress
L : Length of the Cylinder
t : Thickness of the Cylinder (0.5mm or 0.02inch)

From this relationship, the hoop stress is calculated to be 1.96 MPa (284 psi).

At a temperature of 870 °C (1600 °F), the yield strength of Type 304 stainless steel is 69 MPa (10,000 psi). Therefore, under the conditions of paragraph 238 of IAEA Safety Series No. 6, the stress generated is less than 3% of the yield strength of the material.

4.0 Containment

4.1.0 Containment Boundary

4.1.1 Containment Vessel

The containment system for the Model AI 520 is the radioactive source capsule as described in Section 1.2.3 of this application. This source capsule is certified as special form radioactive material in IAEA Certificate of Competent Authority Number USA/0279/S or USA/0154/S.

4.1.2 Containment Penetrations

There are no penetrations of the containment.

4.1.3 Seals and Welds

The containment is seal welded by a tungsten inert gas welding process which is described in Tech/Ops Standard Source Encapsulation Procedure presented in Section 7.4. The minumum weld penetration is 0.5 mm (0.02 inch).

4.1.4 Closure

Not applicable.

4.2.0 Requirements for Normal Conditions of Transport

4.2.1 Release of Radioactive Material

The source capsules used in conjunction with the Model AI 520 have satisfied the requirements for special form radioactive material as prescribed in 10 CFR 71.77 and IAEA Safety Series No. 6. There will be no release of radioactive material under the normal conditions of transport.

4.2.2 Pressurization of the Containment Vessel

Pressurization of the source capsules under the conditions of the hypothetical thermal accident was demonstrated to generate stresses well below the yield strength of the capsule material as described in Section 3.6.3. Therefore, the containment will withstand the pressure variations of normal transport.

4.2.3 Coolant Contamination

Not applicable.

4.2.4 Coolant Loss

Not applicable.

4.3 Containment Requirements for the Hypothetical Accident Condition

4.3.1 Fission Gas Products

Not applicable.

4.3.2 Release of Contents

The hypothetical accident conditions of 10 CFR 71.73 will result in no loss of package containment. This conclusion is based on information presented in Sections 2.7.1, 2.7.2, 2.7.3, 2.7.4, and 3.5.

5.0 Shielding Evaluation

5.1 Discussion and Results

The principle shielding of the Model AI 520 is the uranium shield assembly. The mass of the uranium shield is 12.3 kilograms (27 pounds).

A shielding efficiency test of a Model AI 520 was made by Automation Industries. The package contained 17 curies of Iridium-192. A report of this test is presented in a letter to Mr. R. Rawl from Mr. M. Santoro dated 4 December 1981 and included in section 2.10. Extrapolation of these data to a capacity of 120 curies of Iridium-192 is presented in Table 5.1. Since the model AI 520 contains no neutron source, the gamma dose rates are the total dose rates which are presented. As shown in Table 5.1, the maximum dose rates are below the regulatory requirements.

Table 5.1
Summary of Maximum Dose Rates
mR/hr

At Surface			At One Meter from Surface		
Top	Side	Bottom	Top	Side	Bottom
183.5	197.6	56.5	0.7	1.1	0.7

5.2 Source Specification

5.2.1 Gamma Source

The gamma source is Iridium-192 in a sealed capsule as special form radioactive material in quantities up to 120 curies.

5.2.2 Neutron Source

Not applicable.

5.3 Model Specification

Not applicable.

5.4 Shielding Evaluation

A shielding efficiency test of a Model AI 520 containing 17 curies of Iridium-192 was performed. The results of this test, which are presented in Section 2.10, demonstrate that the does rates surrounding this package are within the regulatory limits.

6.0 Criticality Evaluation

Not applicable.

7.0 Operating Procedures

7.1 Procedure for Loading the Package

The procedure for fabricating the special form source capsule is presented in Section 7.4.1. The procedure for loading the source assemblies into the package is also included in Section 7.4.1.

7.2 Procedure for Using the Exposure Device

The procedure for performing industrial radiography with the model AI 520 exposure device is included in section 7.4.2.

7.3 Procedure for Unloading the Package

The procedure for unloading the package is presented in section 7.4.2.

7.4 Preparation of a Package for Transport

The procedure for preparation of a package for transport is included in the Model AI 520 Instruction Manual presented in Section 7.4.2.

7.4 Appendix

7.4.1 Procedure for Encapsulation of Sealed Sources

7.4.2 Model AI 520 Exposure Device Operation Manual

ENCAPSULATION OF SEALED SOURCES

A. Personnel Requirements

Only an individual qualified as a Radiological Technician shall perform the operations associated with the encapsulation of sealed sources. A second Radiological Technician must be available in the building when these operations are being performed.

B. General Requirements

1. In the Burlington, MA facility, a loading cell shall be used for the encapsulation of sealed sources and repackaging of sealed sources. The maximum amount and form of radioactive material which may be handled in the loading cell is specified below:

Radioisotope	Form	Maximum Activity
Iridium-192	Solid Metallic	2000 curies
Cobalt-60	Solid Metallic or sealed sources	1 curie
Cesium-137	Sealed Sources only	100 curies
Ytterbium-169	Sealed Sources only	100 curies
Tantalum-182	Sealed Metallic or Solid Carbide	100 curies

Limits for any other radioisotopes or forms shall be specified by the Radiation Safety Committee.

2. In the Phoenixville, PA facility, the general purpose hot cell shall be used for the encapsulation of sealed sources and repackaging of sealed sources. The maximum amount and form of radioactive material which may be handled in the cell is specified below:

Radioisotope	Form	Maximum Activity
Iridium-192	Solid Metallic	20,000 curies
Cobalt-60	Solid Metallic	1 curie
Cobalt-60	Sealed Sources	300 curies
Cesium-137	Sealed Sources	200 curies
Ytterbium-169	Sealed Sources	100 curies
Tantalum-182	Solid Metallic or Solid Carbide	100 curies

Limits for other radioisotopes or forms shall be specified by the Radiation Safety Committee.

3. The loading and general purpose hot cells are designed to be operated at less than atmospheric pressure. The exhaust blower should not be turned off during the operation or at any time that radioactive material is in the cell.

4. Unencapsulated radioactive material shall not be stored in these cells when the cell is unattended. Material may only be stored inside these cells in welded capsules or screw top capsules. When radioactive material is stored in these cells, a radioactive material tag identifying the types, quantities, locations and storage dates of all such material shall be attached to the manipulator or to the cell body adjacent to the window.

5. When any "through the wall" tool is removed, the opening shall be closed with the plug provided. All tools shall be decontaminated whenever they are removed from the cell.

6. Each individual performing this operation must wear a film badge and pocket dosimeter at waist level and a second film badge and pocket dosimeter in the vicinity of the head. All operations must be monitored with a calibrated and operational radiation survey meter.

C. Preparatory Procedure

1. Record the names and initial pocket dosimeter readings for the personnel performing the loading operation on the Loading Log Sheet.

2. Check the cell lights for proper operation. Check the cell manipulators both visually and operationally. Assure that all cell ports are plugged.

3. Assure that the exhaust system is operational. Record the manometer reading on the Loading Log Sheet. If the manometer reading is less than 0.5 inch or greater than 2.0 inches of water, the filter must be changed.

4. Assure that the air sampling system is operational and that sample filters are in place.

5. Perform the preoperational contamination survey as indicated on the Loading Log Sheet. Record the results on the Loading Log Sheet.

6. Perform the encapsulation procedure omitting the insertion of any activity. Examine this dummy capsule weld. If this weld is acceptable, preparation of active capsules may proceed. If the weld is not acceptable, the condition responsible for this unacceptable weld must be corrected prior to proceeding. This step must also must performed each time the welding electrode is changed.

D. Encapsulation Procedure for Burlington, MA Facility

1. Prior to use, assemble and visually inspect the two capsule components to assure the weld zone does not exhibit 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 30 minutes. Dry the capsule components at 100° C for a minimum of 20 minutes.

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

4. Place capsule bottom in weld positioning device. Withdraw the posting bar.

5. Move the drawer bar of the source transfer container into the loading cell. Open the screw top capsule.

6. Withdraw the proper amount of activity from the screw top capsule and place it in the capsule bottom. A brass rivet must be used with wafers to prevent contamination of weld zone.

7. Assure that all unused radioactive material is removed from the loading cell by installing it in the screw top capsule and withdrawing the drawer bar of the source transfer container from the cell.

8. Remove the rivet (if applicable).

9. Assemble the capsule components.

10. Weld adhering to the written welding procedure for the capsule being welded.

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

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

14. Count the patch with the scaler counting system. The patch must show no more than .005 microcurie of contamination. If the patch shows more than .005 microcurie, the capsule must be cleaned and rewiped. If the rewipe patch still shows more than 0.005 of contamination, steps 10 through 14 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; repeat steps 10 through 15.

16. Transfer the welded source capsule to the sealed source section of the loading cell.

17. For wire mounted source capsules, 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.

    For source holder mounted source capsules, transfer the capsule to the appropriate source holder loading fixture. Insert the source capsule into the source holder. Screw the source holder together and install the roll pin. Check to assure that the pin does not protrude on either side.

18. Apply the tensile test to assembly between the capsule and connector by applying proof load of 100 lbs. Extension under the load shall not exceed 0.05 inch. If the extension exceeds 0.05 inch, the source must be disposed of as radioactive waste.

19. Assure that the cell tunnel door is closed. Position the source in the exit port of the loading cell. Use the remote control to insert the source into 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.

20. Again using remote control, eject the source from cell into source changer through the tube gauze wipe test fixture. Monitor the radiation level as the source changer shielded door is opened. Remove the tube gauze and count with scaler counting system. This assay must show no more than 0.005 microcurie. If contamination is in excess of this level, the source is leaking and shall be rejected.

21. At the end of the day's operations, perform the post-operational contamination survey as indicated on the Loading Log Sheet. Record the results on the Loading Log Sheet.

22. Record the final pocket dosimeter readings for the personnel performing the loading operation on the Loading Log Sheet.

23. Record the daily Air Sample results on the Loading Log Sheet.

F. Encapsulation Procedure for Phoenixville, PA Facility

1. Prior to use, assemble and visually inspect the two capsule components to assure the weld zone does not exhibit 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 30 minutes. Dry the capsule components at 100° C for a minimum of 20 minutes.

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

4. Place capsule bottom in weld positioning device. Withdraw the posting bar.

5. Remove a storage rod from the storage pit in the cell floor. Remove the threaded end cap from the storage rod and remove the screw top capsule. Open the screw top capsule.

6. Withdraw the proper amount of activity from the screw top capsule and place it in the welded capsule bottom. A brass rivet must be used with wafers to prevent contamination of the weld zone.

7. Assure that all unused radioactive material is removed from the hot cell by installing it into the screw top capsule. Close the screw top capsule and place it into the threaded end cap of the storage rod. Reinstall the end cap onto the storage rod. Replace the storage rod into the storage pit in the cell floor.

8. Remove the rivet (if applicable).

9. Assemble the capsule components.

10. Weld adhering to the written welding procedure for the capsule being welded.

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

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

14. Count the patch with the scaler counting system. The patch must show no more than .005 microcurie of contamination. If the patch shows more than .005 microcurie, the capsule must be cleaned and rewiped. If the rewipe patch still shows more than 0.005 of contamination, steps 10 through 14 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; repeat steps 10 through 15.

16. Transfer the welded source capsule to the sealed source section of the hot cell.

17. For wire mounted source capsules, 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.

    For source holder mounted source capsules, transfer the capsule to the appropriate source holder loading fixture. Insert the source capsule into the source holder. Screw the source holder together and install the roll pin. Check to assure that the pin does not protrude on either side.

18. Apply the tensile test to assembly between the capsule and connector by applying proof load of 100 lbs. Extension under the load shall not exceed 0.05 inch. If the extension exceeds 0.05 inch, the source must be disposed of as radioactive waste.

19. Assure that the cell tunnel door is closed. Position the source in the exit port of the loading cell. Use the remote control to insert the source into 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.

20. Again using remote control, eject the source from cell into source changer through the tube gauze wipe test fixture. Monitor the radiation level as the source changer shielded door is opened. Remove the tube gauze and count with scaler counting system. This assay must show no more than 0.005 microcurie. If contamination is in excess of this level, the source is leaking and shall be rejected.

21. At the end of the day's operations, perform the post-operational contamination survey as indicated on the Loading Log Sheet. Record the results on the Loading Log Sheet.

22. Record the final pocket dosimeter readings for the personnel performing the loading operation on the Loading Log Sheet.

23. Record the daily Air Sample results on the Loading Log Sheet.

MODEL AI 520
EXPOSURE DEVICE
OPERATION MANUAL

NOTICE

This device is used as a radiographic exposure device and Type B(U) transport package for Tech/Ops, Inc. radioactive sources listed in this manual. The user should become thoroughly familiar with the instruction manual before attempting operation of the equipment.

In order to use this equipment to perform industrial radiography within the United States, the user must be specifically licensed to do so. Application for a license should be filed on Form NRC-313R with the appropriate U.S. Nuclear Regulatory Commission Regional Office listed in Appendix D of 10 CFR 20 or with the appropriate agreement state office.

Prior to initial use of Radiographic exposure device as a transport package, the user in the United States must register his name, license number and package identification number with:

Director
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555

The user must have in his possession a copy of USNRC Certificate of Compliance Number 9007 issued for this package.

Prior to the first export hsipment of this exposure device from the United States, the user must also register his identity with:

Office of Hazardous Materials Regulation
Materials Transportation Bureau
U.S. Department of Transportation
Washington, DC 20590

The user must have in his possession a copy of International Atomic Energy Agency Certificate of Competent Authority Number USA/9007/B(U)T issued for this radiographic exposure device.

Users of this equipment outside the United States must comply with the regulatory, licensing and transportation rules and regulations as they apply in their respective countries.

GENERAL

The AI model 520 exposure device is used as a portable radiographic device primarily for the radiography of steel in the thickness range of (0.25 - 3 inches).

The basic radiography system consists of the model AI 520 radiographic exposure device, the source drive assembly and the source guide tube. The exposure device serves as the storage and transport package for the radioactive source.

The exposure device is 7.78 inches long (198 mm), 5.25 inches wide (133 mm) and 6.38 inches high (162 mm). The total weight of the exposure device is 40 pounds (18 kg).

The exposure device is approved as a Type B(U) transport package under USNRC Certificate of Compliance Number 9007 and IAEA Certificate of Competent Authority Number USA/9007/B(U). The capacity of the system is 120 curies of Iridium-192 as one of the source assemblies listed in Table 1.

Radiation Safety Considerations

Pursuant to USNRC and agreement state regulations, all personnel present during radiographic and source changing operations are required to wear a direct reading pocket dosimeter and either a film badge or a thermoluminescent dosimeter (TLD). The pocket dosimeter must be recharged at the start of each shift. The operator should frequently check the pocket dosimeter reading througout the shift. Dosimeter readings must be recorded at the end of each shift. Records of the initial and final readings of the pocket dosimeter must be kept for inspection by the USNRC.

In the event that a person's pocket dosimeter is found to be off scale, that person must stop all work with radiation immediately. His film badge (or TLD) must be sent in immediately for processing, and he must not reenter a restricted area until it has been determined that he received less than the maximum allowed occupational exposure as defined in 10CFRPart 20.101.

Personnel performing source changing and radiographic operations must also have a calibrated and operable radiation survey meter capable of measuring from 2mR/hr to at least 1000 mR/hr to determine radiation levels when performing these operations.

Areas in which source changing or radiography is performed must be identified. If a permanent radiographic installation is used, it must have the appropriate personnel access control devices as defined in 10 CFR 20.203. Otherwise, certain areas must be established as follows:

TABLE 1

SOURCE ASSEMBLIES USED IN CONJUNCTION WITH
AUTOMATION INDUSTRIES MODEL 520 EXPOSURE DEVICE

AUTOMATION INDUSTRIES SOURCE ASSEMBLY DESIGNS

200-520-008, N1

200-520-009, N2

200-520-010, N3

200-520-008, N4

200-520-011, N5

TECH/OPS SOURCE ASSEMBLY DESIGNS

814

844

866

Access to the Restricted Area must be controlled. A Restricted Area is defined in 10 CFR 20.105 as the area where an individual could receive an exposure in excess of two milliroentgens in any one hour, or 100 milliroentgens in seven consecutive days or 500 milliroentgens in one year. The Restricted Area should also be posted with signs reading "Caution (or Danger) - Radiation Area." Signs reading "Caution (or Danger) - High Radiation Area" should be posted around the perimeter where an individual could receive an exposure in excess of 100 milliroentgens in any one hour.

The radiographer or radiographer's assistant must guard against unauthorized entrance into these areas at all times. No personnel should be allowed into the restricted area without a direct reading pocket dosimeter and either a film badge or TLD.

Receipt of Radioactive Material

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 Part 20.205 requires that this be done expeditiously upon notification of its arrival.

Upon receipt, survey the exposure device with a survey meter as soon as possible, preferably at the time of pickup and no more than three hours later if it was received after normal working hours. Radiation levels should not exceed 200 milliroentgens per hour at the surface of the exposure device, nor 10 milliroentgens per hour at a distance of three feet from the surface. Actual radiation levels should be recorded on the receiving report. If the radiation levels exceed these limits, the container should be secured in a Restricted ARea, and the appropriate personnel notified.

All components should be inspected for physical damage.

The radioisotope, activity, model number, and serial number of the source and the package model number and serial number should be recorded.

Operation

1. Survey the entire circumference of the exposure device to assure the source is properly stored and to obtain a reference reading of the radiographic exposure device. Assure that the device is locked.

2. Position the exposure device at the required radiographic location and the control housing as far away as possible and preferably behind any available radiation shielding.

3. Remove the outlet plug assembly and attach the source guide tube. Position the end of the source tube at the desired radiographic exposure location, assuring that the bend radius of the source tube is greater than 24 inches.

4. Remove the brass cap from the lock box assembly keeping the device locked. The source assembly connector will protrude about 1/2" from the lock box. This is normal.

5. Connect the drive cable to the source assembly connector. Assure the connection is secure before continuing. Turn the swivel fitting of the drive cable tube until the fitting is secure in the lock box of the exposure device.

6. Assure that there are no unauthorized personnel in the restricted area. Unlock the exposure device.

7. At the controls rapidly crank the source to the exposing position. Observe the survey meter during this procedure. The radiation intensity should greatly increase as the source first exits the exposure device and then drop steadily until the source reaches the exposing position.

8. Operator should wait in a low background area during the exposure. A survey is required to be made of the restricted area boundary while the source is exposed to assure that the boundary is properly set up.

9. At the conclusion of the exposure rapidly crank the source back into the exposure device. Observe the survey meter during this procedure. The radiation intensities should increase steadily as the source approaches the exposure device and then drop to background as the source enters the exposure device.

10. Approach the exposure device observing the survey meter. Survey the entire circumference of the exposure device the length of the source guide tube and the collimator if one is present. Readings of the device should be similar to the reference reading obtained earlier, but should not exceed 200 millirem/hour at the surface or 10 millirem per hour at three feet from the surface of the device. If unusual radiation levels exist, restrict the area and alert the Radiation Safety Officer.

11. When the source is determined to be properly stored, lock the source assembly in the stored position by depressing the plunger lock and removing the key.

12. If the exposure is the last exposure required, remove the source guide tube and screw the outlet plug in place.

13. To remove the guide tube and controls, first assure the plunger lock is depressed and the outlet plug is securely fastened. Remove the guide tube by unscrewing the swivel fitting at the lock box.

14. When the swivel fitting is disengaged, disconnect the drive cable from the source assembly connection. The source assembly connector will remain exposed approximately 1/2". Do not attempt to push it in.

15. Screw the lock box plug over the exposed connector onto the threaded fitting of the lock box.

Source Changes

Source changes may be done using Tech/Ops Models 414, 650, 820, or AI500SU source changers, which also serve as shipping containers. The specific instructions for the appropriate source changer should be followed to perform a source exchange. The source exchange must be done in a Restricted Area as previously described. The same personnel monitoring requirements and safety precautions previously described for performing radiography must also be followed in performing source exchanges.

1. Survey the source changer to ensure the source is in the proper storage position.

2. Position the source changer and exposure device close together so that one length of source guide tube will connect them with no sharp turns or bends. The bend radius of the guide tube should never be less than twenty inches. Shorter bend radii can restrict source movement in the source guide tube.

3. Remove the storage plug from the exposure device, and attach the source guide tube. Remove the source changer cover and attach the other end of the tube to the empty chamber of the source changer. Attach the control unit to the exposure device.

4. Crank the source rapidly from the exposure device to the source changer. During this procedure the radiation intensity should increase as the source is first exposed, drop slightly as the source is cranked out, and then drop to background as the source enters the source changer.

5. Approach the device and source changer with the survey meter. Survey the entire circumference of the source changer, the exposure device, and source guide tube to assure the source is properly stored.

6. Disconnect the drive cable from the source assembly.

7. Disconnect the source guide tube from the source changer. If a replacement source is to be installed in the exposure device, connect the source guide tube to the fitting above the chamber contianing the new source. Connect the drive cable to the new source.

8. At the controls crank the new source into the exposure device. Observe the survey meter during this procedure. The radiation intensity should increase as the source leaves the source changer and approaches the exposure device. The intensity should drop to background as the source enters the exposure device.

9. Approach the exposure device observing the survey meter. Survey the entire circumference of the device and the source guide tube to assure the source is properly shielded. Radiation levels should not exceed 200 mR/hr at the surface or 10 mR/hr at three feet from the surface.

10. When the source is determined to be properly transferred and shielded, depress the plunger lock and remove the key. Disconnect the source guide tube from the source changer.

11. Secure the source in the source changer in accordance with the appropriate source changer instruction manual.

12. Disconnect the control unit and source guide tube from the exposure device.

13. Attach the identification plate of the old source to the chamber of the source changer containing the old source. Affix the identification plate of the replacement source to the exposure device.

14. Return the source changer to Tech/Ops, Inc. promptly, follwing the shipping instructions.

Shipment of Radioactive Source

1. Assure that the source assembly is secured in the proper storage position and the exposure device is locked. Assure that the brass plugs are seal wired with tamperproof seals.

2. If the exposure device 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 71.71. The exposure device should be put in the outer package with sufficient blocking to prevent shifting during transportation.

3. 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 Part 172.403. The radiation exposure limits for each shipping label are given in figure 1. If radiation levels above 200 mR/hr at the surface or 10 mR/hr at one meter from the surface are measured, the package must not be shipped.

4. Properly complete two shipping lables indicating the radioisotope, 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 one meter from the surface of the package. Put these two labels on opposite sides of the package 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.) and the identification number (UN 2974). If the source changer is packaged inside an outer container, mark the outside package "INSIDE PACKAGE COMPLIES WITH PRESCRIBED SPECIFICATIONS - TYPE B(U) USA/9007/B(U)."

5. Complete the appropriate shipping papers - Examples are shown in Figure 2 and 3. These shipping papers must include·

   a. Proper Shipping Name (Radioactive Material, Special Form, n.o.s.) and Identification Number (UN2974)

   b. Name of Radionuclide (Iridium-192)

   c. Activity of the Source (in Curies)

   d. Category of Label Applied (i.e. Radioactive Yellow II)

	Maximum Radiation Level	
	at Surface	at One Meter
Radioactive White I 	0.5 mR/hr	None
Radioactive Yellow II 	50 mR/hr	1.0 mR/hr
Radioactive Yellow III 	200 mR/hr	10 mR/hr

FIGURE - 1

e. Transport Index

f. Package Identification Number (i.e. USA/9007/B(U) Type B)

g. 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 Tranportation."

Notes: 1. For air shipments, the following shipper's certificastion 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 are are in proper condition for carriage by air according to applicable national governmental regulations."

2. For air shipments to, from or through the United States, a "CARGO AIRCRAFT ONLY" label and the shipping papers must state:

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

6. Due to the depleted uranium used as shielding in the exposure device, a notice must also be enclosed in or on the package included with the packing list, or otherwise forwarded with the package. This notice must include the name of the consignor or consignee and the following statement:

"This package conforms to the conditions and limitations specified in 49 CFR 173.424 for excepted radioactive material, articles manufactured from depleted uranium, UN 2909.

7. For shipment of an empty exposure device, assure that there is no source in the container. If the radiation level is below 0.5 mR/hr at the surface, and there is no measurable radiation level at one meter from the container, no label is required. Mark the outside of the package with the proper shipping name (Radioactive material, articles manufactured from depleted uranium UN 2909). Mark the outside of the package:

"Exempt from specification packaging, shipping paper and certification, marking and labeling and exempt from the requirements of Part 175 per 49 CFR 173.421-1 and 49 CFR 173.424."

Additionally, a notice must be enclosed in or on the package included with the packing list or otherwise forwarded with the package. This notice must include the name of the consignor or consignee and the statement:

"This package conforms to the conditions and limitations specified in 49 CFR 173.424 for excepted radioactive materials, articles manufactured from depleted uranium, UN 2909."

8. Return the container to Tech/Ops, Inc. according to proper procedures for transporting radioactive material as established in Title 49 Code of Federal Regulations part 172-178.

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.

STRAIGHT BILL OF LADING - SHORT FORM
ORIGINAL – NOT NEGOTIABLE

Shipper's No.

Carrier's No.

CARRIER ______________ RECEIVED, subject to the classifications and tariffs in effect on the date of the issue of this Bill of Lading,

RADIATION PROD. DIV. OF
Tech/Ops, Inc.

Burlington, Mass ______________ 19 ______ From

Shipper hereby certifies that he is familiar with all the terms and conditions of the said bill of lading, including those on the back thereof, set forth in the classification or tariff which governs the transportation of this shipment, and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

(Mail or street address of consignee — For purposes of notification only)

Consigned to: Tech/Ops, Inc.
Radiation Products Division

Destination: 40 North Avenue
Burlington, Massachusetts 01803
USA

Route ______________ Car Initials and Number ______________

No. Packages	Kind of Package, Description of Articles, Special Marks and Exceptions	*Weight (Sub. to Cor.)	Or Rate Class	Ck Col.
1	Metal Container (AI Model 520)			
	Radioactive Material, Special Form N.O.S. UN2974 Iridium-192 27 Curies			
	Radioactive Yellow II Labels Transport Index: 0.4			
	USA/ 9007 /B(U) Type B			
	RELEASED VALUE NOT TO EXCEED 40¢ PER POUND			

Subject to Section 7 of conditions of applicable bill of lading, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement:

The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

TECH/OPS

(Signature of consignor)

If charges are to be prepaid, write or stamp here, "To be Prepaid."

Received $ ______________

to apply in prepayment of the charges on the property described hereon.

Agent or Cashier

Per ______________

(The signature here acknowledges only the amount prepaid.)

Charges advanced $ ______________

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

*If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's or shipper's weight." NOTE — Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property. The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding ______ per ______

Tech/Ops, Inc. Shipper, Per ______________ Agent ______________ Per ______________

Permanent post-office address of shipper
40 North Avenue
Burlington, Massachusetts 01803 U.S.A.

FIGURE -2

SHIPPER'S DECLARATION FOR DANGEROUS GOODS

Shipper	Air Waybill No Page 1 of 1 Pages Shipper's Reference Number (optional)
Consignee Tech/Ops, Inc. Radiation Products Division 40 North Avenue Burlington, Massachusetts 01803 USA	

Two completed and signed copies of this Declaration must be handed to the operator

TRANSPORT DETAILS

This shipment is within the limitations prescribed for (delete non-applicable) [redacted] | CARGO AIRCRAFT ONLY	Airport of Departure
Airport of Destination: BOSTON	

WARNING

Failure to comply in all respects with the applicable Dangerous Goods Regulations may be in breach of the applicable law, subject to legal penalties. This Declaration must not, in any circumstances, be completed and/or signed by a consolidator, a forwarder or an IATA cargo agent.

Shipment type: (delete non-applicable) [redacted] | RADIOACTIVE

NATURE AND QUANTITY OF DANGEROUS GOODS

Dangerous Goods Identification						
Proper Shipping Name	Class or Division	UN or ID No	Subsidiary Risk	Quantity and type of packing	Packing Inst.	Authorization
Radioactive Material Special Form N.O.S.	7	UN2974		Iridium 192 Metal Solid 27 curies 1 Type B(U) Package	II Yellow T.I. 0.4 Dimensions 5 in x 7 in x 11 in	Special Form Certificate USA/0154/S Type B(U) Package Certificate USA/9007 B(U)

Additional Handling Information

I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked and labelled, and are in all respects in the proper condition for transport by air according to the applicable International and National Government Regulations.	Name/Title of Signatory Radiological Technician Place and Date Burlington, MA Signature (see warning above)

FIGURE - 3

Maintenance

It is recommended that inspection and maintenance of the Model AI 520 exposure device and the control unit be performed at intervals not to exceed three months.

Control Unit and Source Guide Tubes

1. Disconnect the control unit from the exposure device.

2. Inspect the entire length of each control hose to assure that each section is free from cuts and damage.

3. Inspect the end fittings to assure that they are tightly connected. Check the threads on the fittings for damage.

4. To remove the drive cable, turn the hand crank of the control unit in the expose direction. The emergent cable should be cranked into a bucket or other container to keep it clean.

5. If the crank will no longer turn a stop spring has been put on the drive cable. This must be removed before the drive cable can be completely withdrawn from the crank.

6. Clean the drive cable with chlorothene and flush the control housing and the source guide tubes.

7. Thoroughly dry the drive cable, control housing, and the source guide tube. Any remaining solvent can cause permanent damage.

8. Check the source guide tubes for binding by holding them vertical and dropping a dummy source through them.

9. Wipe the source guide tubes and control housings with a cloth soaked in chlorothene and flex them to check for internal damage.

10. If the control housings or guide tubes are cut or flattened they should be repaired or replaced.

11. The guide tubes or control housings may be covered with tape where only the outer plastic is cut through.

12. Check for excessive wear on the connector.

13. Lightly grease the drive cable with Texaco Unitemp grease.