Los Alamos NATIONAL LABORATORY EST. 1943

memorandum

Off-Site Source Recovery Project
N3-International Threat Reduction

To/MS: OSR File
From/MS: J. Andrew Tompkins, N-3 MS J552
Phone/Fax: 770-517-4320
Symbol: N3-09-067
Date: June 15, 2009

OSR-SF-010: Special Form Character of Mound Lab MC2893 Heat Sources

History/Background

In 1973, the need arose to document the special form character of the Mound Laboratory[1] manufactured Milliwatt Generators. The Milliwatt electric generator system was used to power the electronics on small devices that could not be conveniently powered with chemical batteries. The heat source capsule for these nuclear batteries was designated as Model MC2893. The MC2893 is a triply encapsulated sealed source. The cladding materials are T-111 alloy (TA 90% , W 8%, Hf 2%) and Hastelloy C (Ni 54%, Mo 17%, Cr 16%, Fe 5%, W 4%, Co 2.5%) specially chosen for their high temperature strength and ductility, see the attachments (figure A-1) and drawings for further details.

The manufacturer of the heat source for these nuclear batteries, Mound Laboratory, was tasked by Sandia National Laboratory the overall project manager to provide testing that met the requirements of the USDOT as detailed in 49CFR173.469.

Special Form Character of Model MC2893A Heat Sources

Special form testing of 2 inert test capsules (for the MC2893 heat source) was documented in *Milliwatt Generator Progress Report July 16, 1973 – August 15, 1973*. In the Appendix of this report (p. 11) the testing of the capsules per DOT 173.469 was documented.

Specific tests requirements are as follows:

- Free drop 30 ft. (9 m)
- Percussion 3 lb steel billet dropped 40” (1 m)
- Heating in air for 10 minutes at 1475°F
- Immersion in water for 24 hr.

At the end of the special form test series, the condition of both test items was documented by visual inspection, radiography, and helium leak testing.

1. No detectable damage to the liner or strength member body walls or weld.
2. Distortion of the fuel slug
3. Some distortion of the outer clad body wall and cap
4. No detectable damage to the outer clad weld.

[1] Mound Laboratory in Miamisburg, OH was a AEC GOCO operated by Monsanto Research Corporation in 1973.

5. Helium leak check rate was at 5.3 E-9 (Std. cc/s) or less

It should be noted that Helium leak test rates less than 1 E-7 (Std. cc/s) meet the leakage requirements for AEC sealed source production in 1973.

CONCLUSIONS
After submission of the Progress Report with test data (Appendix) Sandia National Laboratory[2] Milliwatt Generator Program engineers wrote a letter to file on September 19, 1973. The memo to file concluded that the MC2893 Heat source had passed all US DOT Special Form testing requirements and therefore the heat sources can be classified as Special Form radioactive material for the purposes of the USDOT.

After reviewing MC2893 drawings, specification sheets, assembly schematics, and special form testing summary, I conclude that the MC2893 heat sources have been tested and documented as special form radioactive material. Sources with more than 30 years of service life should be leak tested (alpha contamination) and visually examined for bulging on an annual basis. Any deformation of capsule excludes it from SF status.

JAT/ml

Attachments:

- drawings of source capsule C-AY291675 & C-AY314643
- Schematics of Source capsule Assembly Fig. A-1
- MilliWatt Generator Specification sheets (2)
- MilliWatt Generator Progress Report (Appendix), July 16, 1973 – August 15, 1973
- SNL Memo, DOT Tests of MC2893 Heat Source, dated September 19, 1973

OSR File, MS J552
N-3 File, MS D541

[2] Sandia National Laboratory, Albuquerque, NM was an AEC GOCO facility operated by ATT in 1973.

KC12|0060|0060

SI METRIC

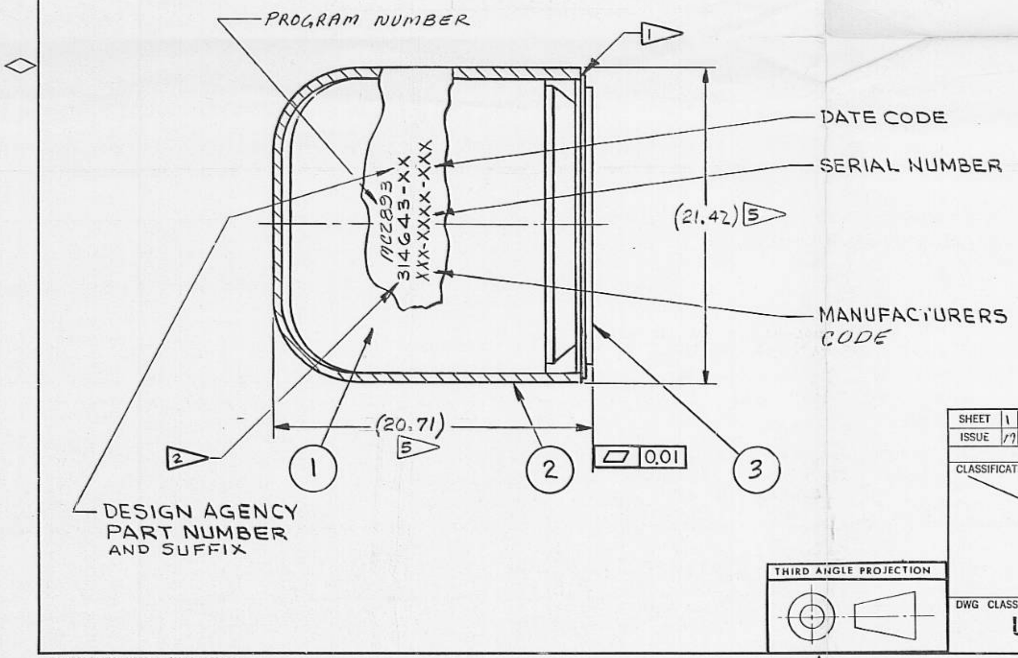
NOTES:

1. ASSEMBLE ITEMS 1, 2 & 3 AND GTA WELD PER MOUND MANUAL MD-70169 OPN 20.
2. MARKING PER AY291675.
3. THIS ASSEMBLY TO COMPLY WITH PS314643.
4. TOOL MADE SAMPLE PER EP401011.
5. GAGE FINAL ASSEMBLY DIAMETER USING GAGE GA7434 AND HEIGHT USING GAGE GA7435 PER MOUND MANUAL MD-70166 OPN 14.

DESIGN AGENCY ~~PART OR~~ CONTROL NO.
AY314643-000

REVISIONS

ISSUE	DESCRIPTION / PREPARED BY	DATE	CHKR	ENGR
	DTER 7612695C			
G	REVISED AND REDRAWN C. SHORT, MD/L.C. WATKINS 2531 W. AMOS, MD	12-15-76	JCA	gsll
H	REVISED O.D, LENGTH, FLATNESS TOLERANCE AND ADDED NOTE 5 F. MORRIS, MD/R. JANKOWSKI 2531 W. AMOS, MD	7-18-77		
J	(21.42) WAS (21.46 L.L. ETTER, MD/R. JANKOWSKI 2531 W. AMOS, MD	7-27-77		
	CER 771887SC	8-4-77		
K	W.DANIEL MD/R.JANKOWSKI 2531 E.A.MERSHAD/AC0780360MD-C	11-03-78	E.S.	CWS
L	W.DANIEL MD/R.JANKOWSKI 2531 E.HOWELL MD/AC0790202 MD-C	07-17-79	E.S.	CWS
M	D. MILLER MD/R.T. JANKOWSKI 2531 E.I. HOWELL/AC0790339MD-C	01-16-80	E.S.	CWS



TIE SC/MD

SHEET	1
ISSUE	M

SHEET INDEX

CLASSIFICATION CATEGORY

DESIGN AGENCY APPROVALS: ORG | DATE | INITIALS

MFG AGENCY APPROVALS

TITLE: MC2893 UAS-

MFG AGENCY NUMBER

DWG CLASSIFICATION LEVEL: **UNCLASSIFIED**

PART CLASSIFICATION: **UNCLASSIFIED**

SIZE: C | DWG NUMBER: AY314643

SCALE 5/1 | SHEET 1 OF 1

CODE IDENT NO. 14213

DECK - 50, 95, 01, 60, 49, 98, CM 52, 53 | DWG NO. AY314643

SI METRIC

NOTES:

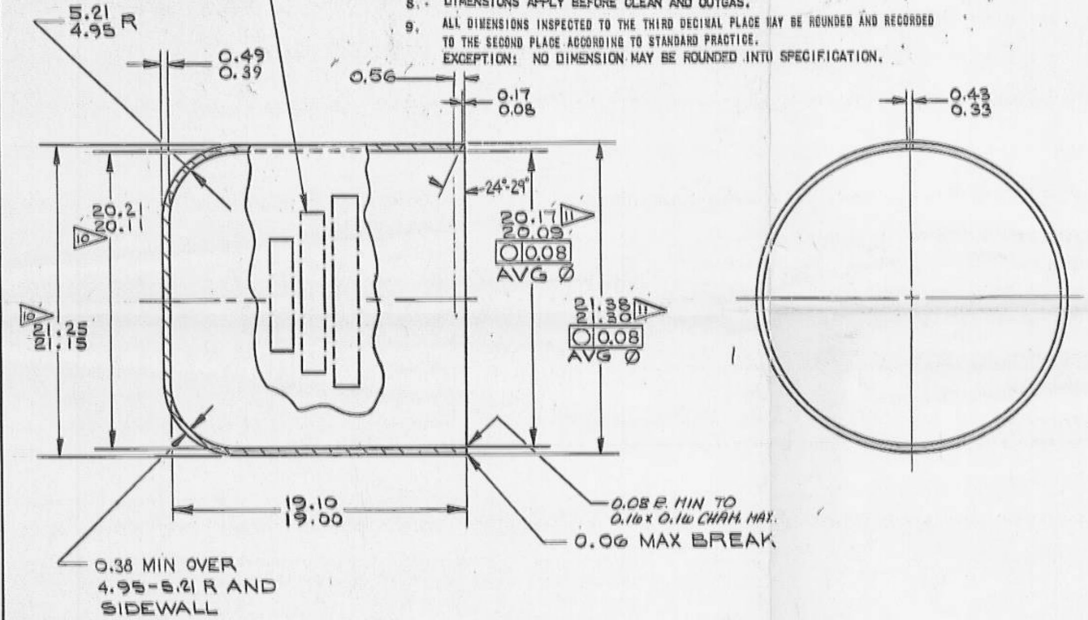
1. MATERIAL: .51 HASTELLOY "C" PER MOUND SPEC SPA750029.
2. BLANK Ø (44.62).
3. FABRICATE PER MOUND MANUAL MD-70166 OPN 7.
4. DYE PENETRANT PER MOUND MANUAL MD-70166 OPN 12.
5. CLEAN PER MOUND MANUAL MD-70166 OPN 10.
6. OUTGAS PER MOUND MANUAL MD-70166, OPN 7, SUBOPN 29
7. MARK PER MOUND SPEC SPA750035 PARAGRAPH 3.1.4. LASER MARKING (1.5 mm HIGH CHARACTERS) LOCATE APPROXIMATELY IN AREA SHOWN. MARKING TO BE APPLIED UPON RECEIPT OF SERIAL NUMBER LISTING FROM LANL.
8. DIMENSIONS APPLY BEFORE CLEAN AND OUTGAS.
9. ALL DIMENSIONS INSPECTED TO THE THIRD DECIMAL PLACE MAY BE ROUNDED AND RECORDED TO THE SECOND PLACE ACCORDING TO STANDARD PRACTICE. EXCEPTION: NO DIMENSION MAY BE ROUNDED INTO SPECIFICATION.
10. DIMENSIONS APPLY 5.60/5.70 UP FROM INSIDE BOTTOM.
11. ROUNDNESS DIMENSION APPLIES 0.56/3.73 FROM OPEN END.
13. DATE CODE REFLECTS MIDDLE MONTH OF EACH QUARTER - B (FEB.) E (MAY) H (AUG.) K (NOV.) - AND YEAR.
14. FOR FINAL ACCEPTANCE GAGE COMPONENT USING GA7931 FOR DEPTH, GA7932 FOR INSIDE DIAMETER TOP, AND GA7933 FOR OUTSIDE DIAMETER.

DESIGN AGENCY CONTROL NO.
AY291675-000

REVISIONS

ISSUE	DESCRIPTION (PREPARED BY)	DATE	CHKR	ENGR	
	DTER 761269SC				
U	N.J. TRENT MD/R. JANKOWSKI 2527 P. TEANEY/AC0810805MD-C	10-15-81	E.S.	CWS	
V	N.J. TRENT MD/R. HARNER 1412 S. RAGLAND/AC0810944MD-C	12-4-81	E.S.	CWS	
W	N.J. TRENT MD/R. JANKOWSKI 2527 P. TEANEY/AC0811020MD-C	1-15-82	DEB	CWS	
Y	D. RYAN MD/R. JANKOWSKI 2527 P. TEANEY/AC0830326MD-C	2-25-83	E.S.	CWS	F
Z	D. RYAN MD/A. MCKEVER 2561 P. TEANEY/AC0831117MD-C	7-6-83	E.S.	CWS	F
AA	J. RODGERS MD/A MCKEVER 2561 P. TEANEY/AC0840749MD-C	4-24-84	E.S.	CWS	
AB	M. WILLENBRINK MD/C A MCKEVER 2561 P. TEANEY/AC0842132MD-C	12-1-84	E.S.	CWS	
AC	B. KELLY MD / C McKEVER 2561 P. TEANEY / AC0842157MD-C	12-14-84	E.S.	CWS	
AD	B. KELLY MD / C McKEVER 2561 P. TEANEY / AC0850067MD-C	1-9-85	E.S.	CWS	

MARKING AS DETERMINED BY PROGRAM, SEE VIEW "A"



FOR MC2893		FOR MC2893A	FOR MC3599
MC2893	PROGRAM NUMBER	MC2893A	MC3599
314643-XX	DESIGN AGENCY PART NUMBER AND SUFFIX	318020-XX	318160-XX
XXX-XXXX-XXX		UAS-XXXX-XXX	UAS-XXXX-XXX

DATE CODE — SERIAL NUMBER — MANUFACTURERS CODE

VIEW "A"
ROTATED 90° 7

TIE SC/MD (MC2893) (MC2893A) (MC3599)

SHEET	1
ISSUE	AD

SHEET INDEX

CLASSIFICATION CATEGORY

DESIGN AGENCY APPROVALS — ORG — DATE — INITIALS

MFG AGENCY APPROVALS

THIRD ANGLE PROJECTION

DWG CLASSIFICATION LEVEL: **UNCLASSIFIED**

PART CLASSIFICATION

TITLE: BODY, CLAD

UAS-

MFG AGENCY NUMBER

SIZE	DWG NUMBER
C	AY291675

SCALE 5/1 — SHEET 1 OF 1

DWG NO. AY291675

CODE IDENT NO. 14213

Sandia Laboratories

Albuquerque, New Mexico
Livermore, California

date: September 19, 1973

to: Distribution

Copies: Forest
Holliday
Levine
Neale
Biver

Paul O'Brien

from: P. D. O'Brien - 2334

subject: DOT Tests of the MC2893 Heat Source

As reported in Mound Laboratory's July 16-August 15, 1973, Milliwatt Generator Heat Source Progress Report, the MC2893 Heat Source has survived the sequence of tests prescribed by the Department of Transportation as necessary to qualify the contained ^{238}Pu as "special form radioactive material". Two heat sources were tested: one contained ThO_2 shards as a stand-in for PuO_2 shards; the other contained a UO_2 pellet as a stand-in for a PuO_2 pellet. Both samples survived the tests with only minor damage to the clad and with no breach in any of the three layers of containment.

Results of the tests were reviewed with E. L. Barraclough, of the ALO Operational Safety Division. Mr. Barraclough concurs in the conclusion that the MC2893 meets the DOT requirements for special form material. There is no formal certification procedure; when appropriate, one simply states that the heat source has passed the DOT tests (which include free drop from 30 feet, percussion, heating to 1475° F for 10 minutes, and 24-hour wafer immersion).

In Mr. Barraclough's opinion, minor design changes---with Sandia deciding what is "minor"---may be made without invalidating the applicability of the test results. Thus, small changes in dimensions and configuration (for example, to increase the void volume to permit a longer service life) can be made as long as the weld joints, material thicknesses, length-to-diameter ratio, etc., remain essentially as in the test capsules.

By the Code of Federal Regulations definition, special form radioactive materials are "those which, if released from a package, might present some direct radiation hazard but would present little hazard due to radiotoxicity and little possibility of contamination". Contrary to my earlier understanding, the "package" to which this definition refers is a DOT-approved shipping container such as the Follansbee drum used by Mound to ship bare heat sources or the modified 6M container used at Sandia to transport assembled MC2730 RTG's. Therefore, the DOT tests do nothing to facilitate future shipments---they merely verify that what we've been doing all along is legal.

PDO:2334:klp

Copy to:
Art Kuntz - GEND
W. R. Amos - Mound
E. L. Barraclough - ALO
J. P. Shoup - 2330
M. K. Parsons - 2334
P. D. O'Brien - 2334
C. C. Burks - 1511
R. W. Pinkham - 1514
A. W. Forter - 7221
File - 2334 (4.6.10)

I HAD SUSPECTED THERE WAS SOME CONFUSION ON THIS,
ASK

MILLIWATT GENERATOR HEAT SOURCE PROGRESS REPORT

July 16, 1973 - August 15, 1973

Wayne R. Amos

Wayne R. Amos, Program Manager
Milliwatt Generator Program

Monsanto

MOUND LABORATORY
Miamisburg, Ohio
operated by
MONSANTO RESEARCH CORPORATION
a subsidiary of Monsanto Company
for the
U. S. ATOMIC ENERGY COMMISSION
U. S. Government Contract No. AT-33-1-GEN-53

APPENDIX

Department of Transportation Testing of Milliwatt Generator Heat Source Capsules

by

C. G. Anderson
R. L. Wise
W. B. Cartmill
D. L. Coffey

Introduction

Milliwatt Generator Heat Source test capsules MTC-10 and MT-38 were subjected to the Department of Transporation (DOT) tests. After test completion, they were evaluated by subjecting them to various visual, dimensional, metallographic, chemical, dye penetrant, and radiographic tests. The following describes the capsules, the tests performed, the post-test evaluations, the results obtained, and the conclusions drawn from these results.

II. Capsule Descriptions

Test capsule MTC-10 was of the "six-watt" design and contained a UO_2 pellet as fuel simulant. The liner also contained the Ta foam and Y foil associated with the pellet type fuel. This capsule was assembled and welded in the normal manner. A sketch of this capsule is shown in Figure A-1.

Test capsule MT-38 was of the same basic "six-watt" design and was assembled and welded in the same manner. This unit contained ThO_2 shards (105-250μ) as fuel simulant. A sketch of this capsule is shown in Figure A-2.

III. Tests Performed - From 49 CFR 173.469

The following tests were performed on each of the two capsules:

If encapsulated, the capsule must retain its contents when subjected to all of the performance tests prescribed in this section, and must not melt, sublime, or ignite at temperatures below 1475°F.

(1) Free drop. A free drop through a distance of 30 feet on to a flat, essentially unyielding horizontal surface, striking the surface in such a position as to suffer maximum damage.

(2) Percussion. Impact of the flat circular end of a one-inch diameter steel rod weighing three pounds, dropped through a distance of 40 inches. The capsule or material shall be placed on a sheet of lead, of hardness number 3.5 to 4.5 on the Vickers scale, and not more than one-inch thick, supported by a smooth, essentially unyielding surface.

(3) Heating. Heating in air to a temperature of 1475°F and remaining at that temperature for a period of 10 minutes.

(4) Immersion. Immersion for 24 hours in water at room temperature. The water shall be at pH 6 - pH 8, with a maximum conductivity of 10 micromhos/cm.

PELLET FUEL FORM CAPSULE

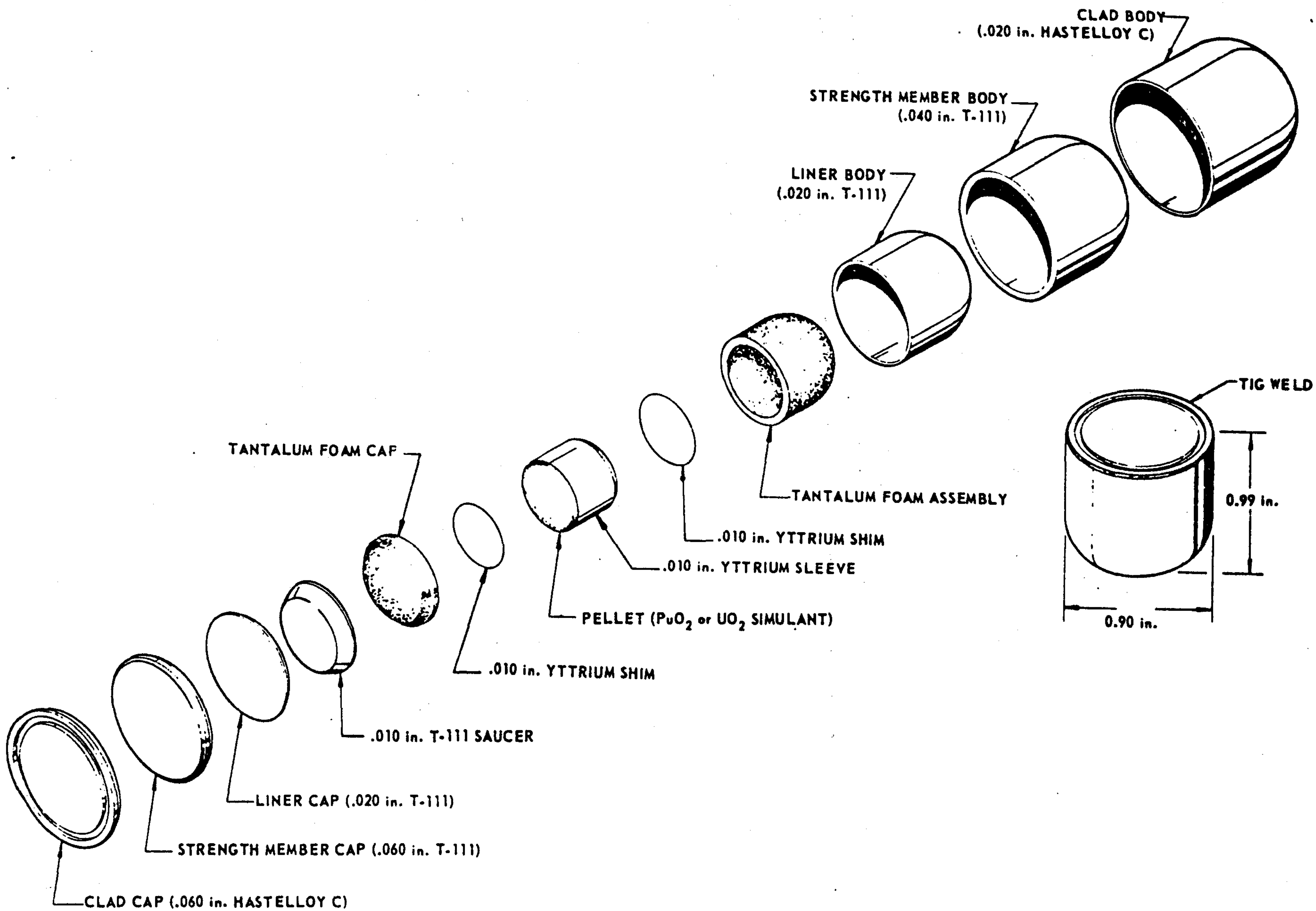


FIGURE A-1

MILLIWATT GENERATOR HEAT SOURCE
(Shards Fuel Form)

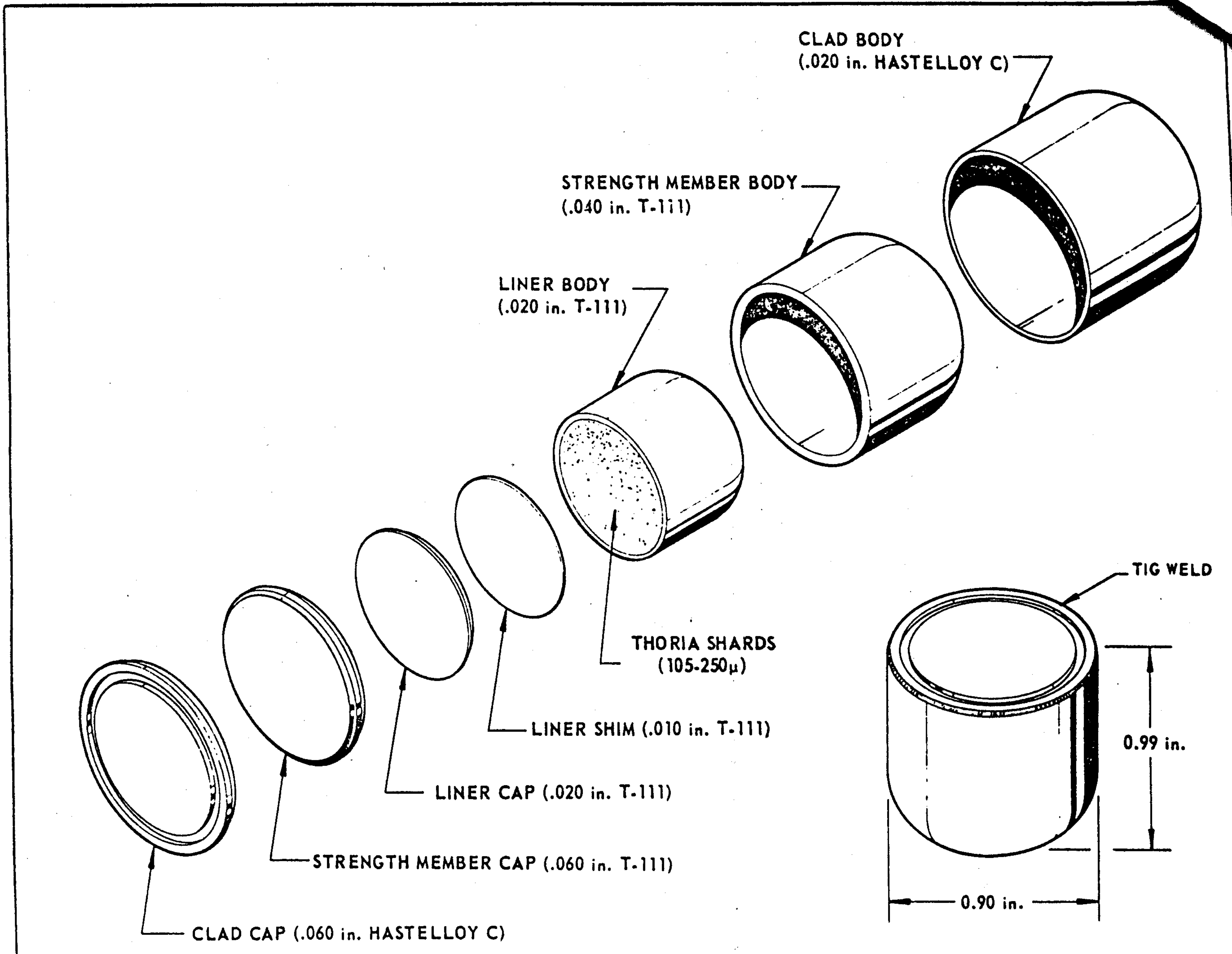


FIGURE A-2

Preliminary Observations During Testing

The free fall test did little more than abraid the flat cap edges. The capsules were dropped to impact at 45°. The percussion test made a slight indentation in each capsule, while the heating test darkened (apparently oxidized) each capsule. No effect whatever was evident from the water immersion test.

V. Detailed Analyses

Both capsules were initially subjected to helium leak and radiographic inspections. The results of these inspections are given in Table A-I. It can be seen that radiography did not detect any significant defects due to the testing and the helium leak rates were quite low.

Each member (clad, strength member, and liner) were given detailed examinations prior to cutting them and removing them from the subsequent member. The results follow.

MTC-10 - The clad had an overall black discoloration which x-ray diffraction analysis identified as chromium oxide and nickel oxide. There were two deformation areas. One was 0.700" long from the weld to the dome and was 0.200" wide at the held and 0.400" wide at the dome end. The other deformation was on the weld and was 0.300" long.

There was no discoloration of the strength member. There was one deformed area on the weld 0.150" long. There were no dye penetrant indications. The underbead had a drop through puddle at the start of the weld and was 0.090" long. There was undercut in the overlap 0.300" long.

There was no discoloration of the liner except that which is normally seen from the strength member weld. There was no deformation of the liner. There were no dye penetrant indications.

The foam spacer assembly displayed no discoloration or deformation. The top of the UO_2 pellet was broken into several pieces.

Photographs of each assembly were taken at the impact face. The top and underbead of each weld, the foam spacer assembly, and the fuel were photographed. Cross section metallography through the impact area and 180° of impact was performed. The photographs are shown in Figures A-3 through A-9.

Table A-I

RADIOGRAPHIC AND HELIUM LEAK CHECK DATA ON MWG CAPSULES AFTER DOT TESTS

Four radiographic views were made at 45° intervals of the clad and strength member for general condition after tests.

Inspection results are as follows:

<u>MTC-10</u>

(1) No detectable damage to the liner or the strength member body walls or weld.

(2) Indication of additional cracking of the fuel slug.

(3) Some distortion of the clad body wall.

(4) Some distortion of the clad end cap near weld.

(5) No detectable damage to the clad weld.

(6) Helium leak check - 5.2×10^{-9} cc/sec.

<u>MT-38</u>

(1) No detectable damage to the liner or the strength member body walls or welds.

(2) Shim distorted.

(3) Some distortion of clad body wall below weld.

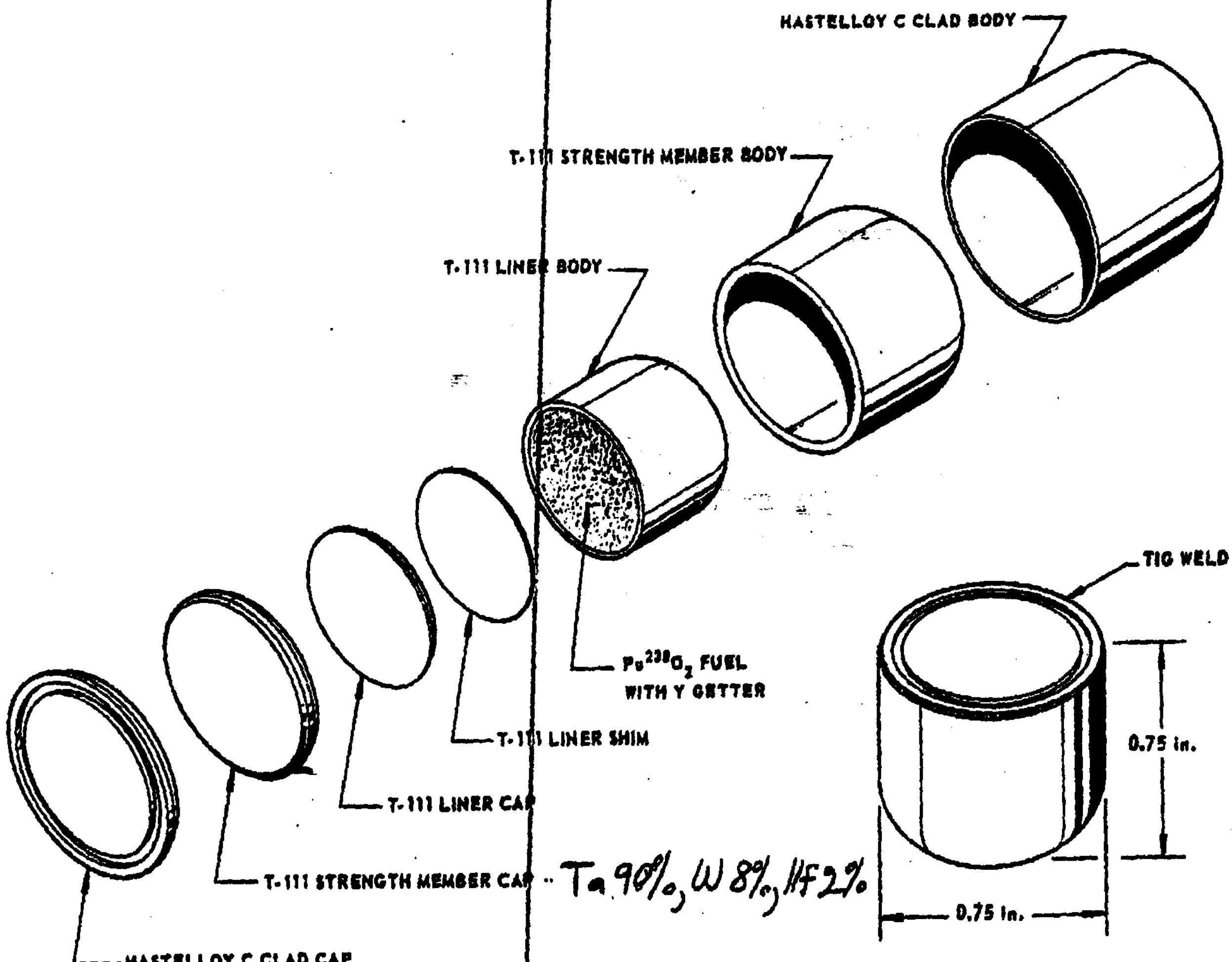
(4) Some distortion of the clad end cap near weld.

(5) No detectable damage to the clad weld.

(6) Helium leak check - 5.3×10^{-9} cc/sec.

MILLIWATT GENERATOR

STD1491



Ta 90%, W 8%, Hf 2%

Co 2.5, Cr 16, Fe 5, Mo 17, Ni 53.9, W 4%

Haynes 25
Co 52.9, Cr 20, Fe 3, Mn 1.5, Ni 10, W 15

MILLIWATT GENERATOR

Fuel Data	
Fuel Form	$^{238}Pu^{16}O_2$ Shards
Fuel Required	
Weight Pu^{238}/Source (grams)	6.1
Weight Fuel/Source (grams)	8.7
Heat Sources	
Number Fabricated	200 to date
Watts (th)/Source	3.5
Operating Temperature °C	400
Materials of Construction	
Liner	T-111
Strength Member	T-111
Clad	Hastalloy C
Geometry	Right circular cylinder 0.75" X 0.75" O.D.
Weight/Fueled Source (pounds)	0.10
Dimensions	
Shim	
Diameter	0.503
Thickness	0.010
Liner	
Length (inches)	0.538
Diameter (inches)	1.607
Wall Thickness (inches)	0.020
Cap Thickness (inches)	0.020
Strength Member	
Length (inches)	0.628
Diameter (inches)	0.697
Wall Thickness (inches)	0.040
Cap Thickness (inches)	0.060
Clad	
Length (inches)	0.744
Diameter (inches)	0.753
Wall Thickness (inches)	0.020
Cap Thickness (inches)	0.060
Fabrication	
All GTA Welds	