141
3-19-84 JS (1)

I-13729

DE-2169-5

DO NOT MICROFILM
COVER

MLM-3135

Milliwatt Generator Heat Source Progress Report: July-December 1983

Emil A. Mershad

March 2, 1984

MASTER

MOUND
Miamisburg, Ohio 45342

Monsanto

operated by
MONSANTO RESEARCH CORPORATION
a subsidiary of Monsanto Company

for the
U. S. DEPARTMENT OF ENERGY

Contract No. DE-AC04-76-DP00053

DISCLAIMER

Printed in the United States of America
Available from
National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

NTIS price codes
Printed Copy: A02
Microfiche copy: A01

DISCLAIMER

MLM--3135

DE84 006207

Milliwatt Generator Heat Source Progress Report: July-December 1983

Emil A. Mershad

Issued: March 2, 1984

DISCLAIMER

MOUND
Miamisburg, Ohio 45342

operated by
MONSANTO RESEARCH CORPORATION
a subsidiary of Monsanto Company

for the
U. S. DEPARTMENT OF ENERGY

Contract No DE-AC04-76-DP00053

Contents

Summary

All LANL hardware requirements were met during the reporting period as scheduled.

Lot 12 of T-111 alloy sheet and Lot 8 of yttrium platelets were procured to meet future WR production needs.

The GEND IP schedule requirements for 49 fueled MC2893 heat sources were met.

Pressure burst surveillance activities continued to be conducted in accordance with SNLA document BB328965.

Final results of evaluations of two pressure-burst capsules were normal, suggesting that the corresponding heat sources should be in good condition.

The hardware production period ended with an overall hardware process yield of 98.4%.

MWG hardware shipments and production

P. E. Teaney, M. J. Shaffer,
M. A. Forrest, and P. A. Parker

All hardware shipments to LANL were made on or ahead of required shipping dates during the reporting period (July-December 1983). WR requirements and shipments for the reporting period are summarized in Table 1. In addition, 187 pieces of example weld hardware were shipped.

Production of hardware for FY83 was completed ahead of schedule. FY84 hardware production was started and is continuing ahead of schedule.

Raw material qualification

P. E. Teaney and R. Mayo

Lot 12 of T-111 alloy sheet material and Lot 8 of yttrium platelets were received from the vendors and are in the initial stages of testing for qualification of the materials for WR production. If the material meets qualification requirements, sufficient material will be on hand to meet known projected program needs.

MC2893 heat source shipments

P. E. Teaney and J. N. Crawford

Forty-nine fueled MC2893 heat sources were shipped as scheduled to fulfill GEND-IP requirements for the reporting period July-December 1983.

Surveillance-related pressure burst tests

MC2893, MC2893A, and MC3599 capsules

J. L. Boston

Seven MC2893A (Serial No. LPBA-02 through LPBA-08) and one MC3599 (Serial No. LPB-08) pressure burst surveillance capsules were welded at LANL, received at Mound, and are in the process of being pressurized and welded into test containers. When containment has been completed, the containers will be placed on high-temperature test in accordance with SNLA Documents 347896 and 368817.

Table 1 - MWG WR HARDWARE REQUIREMENTS AND SHIPMENTS

	Jul	Aug	Sep	Oct	Nov	Dec	Ex. Weld	Total
Liner Shims	30	35	43	50	50	50		258
Liner Caps	40	40	48	55	50	55	1	289
Liner Bodies	35	35	43	50	55	50	24	292
Sm Caps	40	35	43	50	50	50	21	289
Sm Bodies	40	40	48	50	50	50	123	401
Clad Caps	35	35	43	55	50	50	16	284
Clad Bodies	33	22	33	23	59	44	2	216
Yttrium (g)			50	38	38	38		164 g
MC2893A Pellets				8				8
MC3599				3				3

Seven MC3599 pressure burst surveillance capsules (Serial No. LPBA-01 through LPBA-07) were pressurized, welded into test containers, and placed on high-temperature test on September 14 in accordance with SNLA Document BB347897.

MC2893 pressure burst surveillance capsules (PB-7-07 and PB-7-08) were removed from high-temperature test on November 30 and are in the process of being evaluated in accordance with SNLA Document BB328965.

MC2893 pressure-burst evaluations

P. E. Teaney, J. R. McKendree, and L. A. Gibson

Two capsules, the fifth and sixth from a series of long-term surveillance-related tests, were pressure-burst tested and evaluated in accordance with SNLA Document BB309768. The capsules were fabricated on May 22, 1978, from Lot 7 of T-111 alloy and were pressurized to a pressure corresponding to 5193.7 psia at 1010°C. Capsule PB7-12 was aged for 1238 days at 410°C, and capsule PB7-15 was aged for 1147 days at 210°C.

The capsules were pressure-burst tested at 1010°C after being removed from the aging furnaces. Results of the tests are summarized in Table 2 along with results for units that were previously reported. Pressure-burst testing of PB7-12 was terminated without failure after 284.89 hr (168 hr of testing are required). Subsequent investigation indicated that the capsule was beginning to fail by intergranular cracking in the heat-affected zone of the cap-to-body weld (Figure 1). Capsule PB7-15 failed in the cap-to-body weld ramp-down zone after 333.06 hr (Figures 2, 3, and 4). Faint traces of the crack can be seen in Figures 2 and 3. The crack originated at the weld/heat-affected zone interface (Figure 4) and followed grain boundaries through the weld, terminating in the final weld overlap. This mode of failure is typical for most pressure-burst tests.

Subsequent to pressure-burst testing, each capsule was cross-sectioned and metallographically examined. The typical appearance of the sidewall, cap, and dome is shown in Figures 5, 6, and 7 for PB7-12 and Figures 8, 9, and 10 for PB7-15. Compared to previous development capsules, the microstructure

Table 2 - SUMMARY OF SURVEILLANCE RELATED PRESSURE-BURST TESTS

Capsule Number	Surveillance Test Time at Temperature (days at °C)	Pressure-Burst Test Time (hr)	Location Failure
PB7-4[a]	1,148 at 410	140.32	Ramp-down area of cap-to-body weld
PB7-5[a]	1,148 at 210	7.32+	Test terminated after 7.32 hr without failure
PB7-10[a]	1,094 at 410	10.64	Undetermined
PB7-11[a]	1,094 at 210	24.00+	Test terminated without failure
*PB7-12[b]	1,238 at 410	284.89+	Test terminated without failure
*PB7-15[b]	1,147 at 210	333.06	Ramp-down area of cap-to body weld

[a]Capsules fabricated April 26, 1978; pressurized to 5,193 psia at 1010°C.

[b]Capsules fabricated May 22, 1978; pressurized to 5,193 psia at 1010°C.

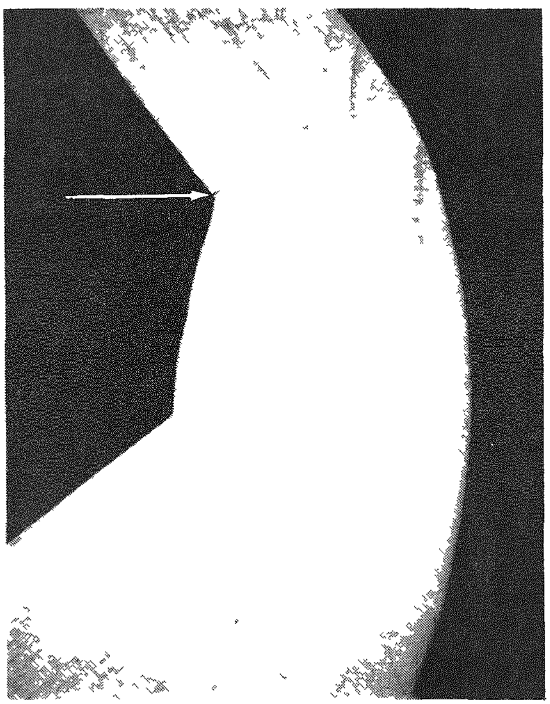

FIGURE 1 - Photomicrograph of cross-sectioned PB7-12 weld zone after pressure burst testing. Arrow points to intergranular crack initiating in the heat-affected zone of the cap-to-body weld. (30X, etched)

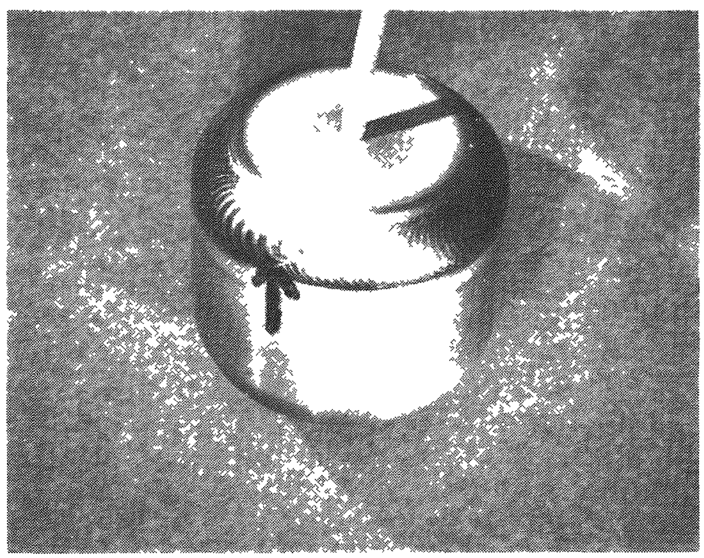

FIGURE 2 - Photomicrograph of PB7-15 showing location of failure (leak) in the weld ramp-down zone. (3X)

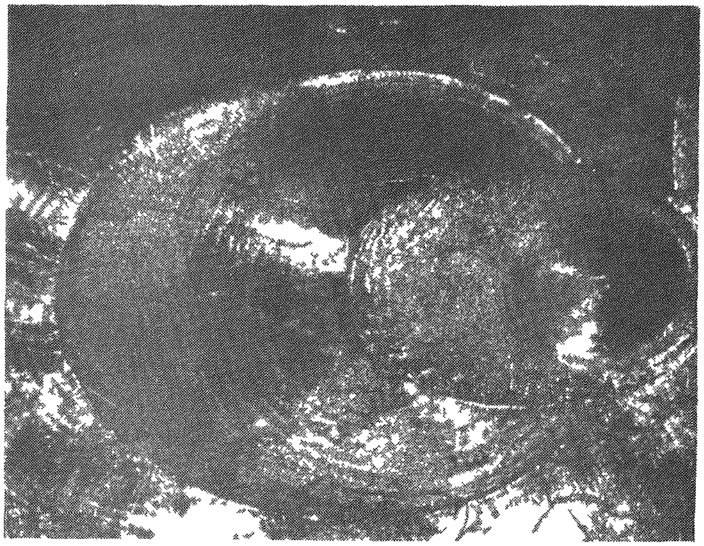

FIGURE 3 - Higher magnification view of the failure location shown in Figure 2. (30X, etched)

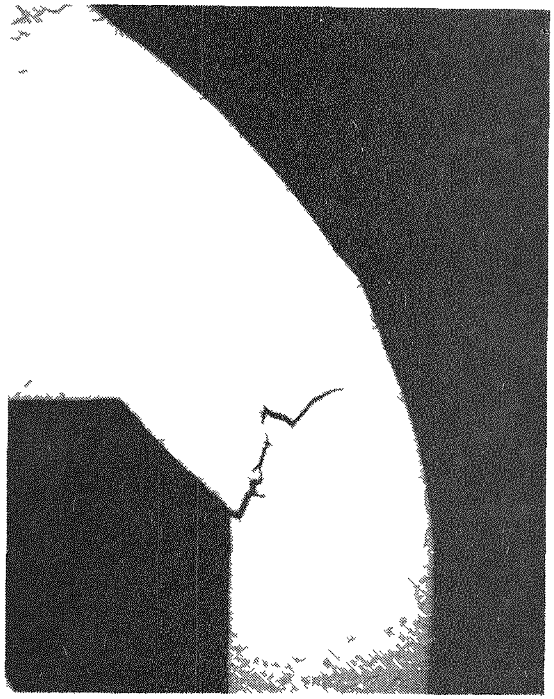

FIGURE 4 - Cross-section of PB7-15 weld overlap showing area of failure. The The crack originated on the body side of the weld underbead, propogated through the weld along grain boundaries, and terminated in the weld overlap. This is a typical mode of failure. (30X, etched)

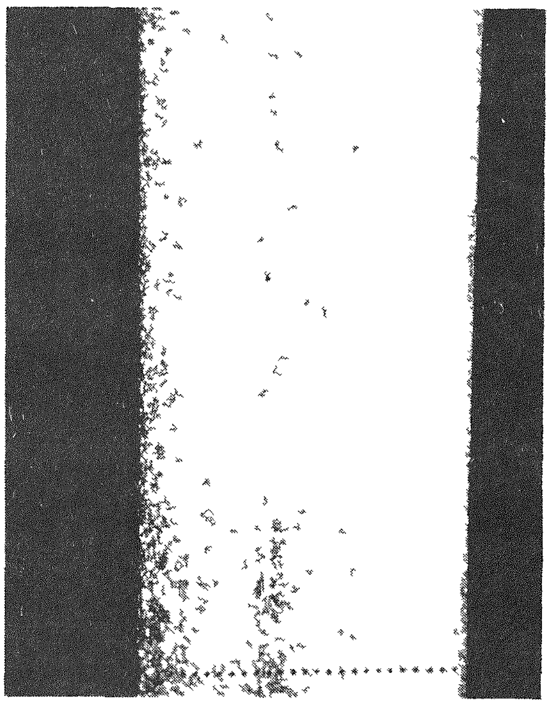

FIGURE 5 - Photomicrograph of PB7-12 showing cross-sectioned sidewall. The microstructure was normal. (50X etched)

FIGURE 6 - Cross-sectioned cap of PB7-12 showing normal microstructure. (50X, etched)

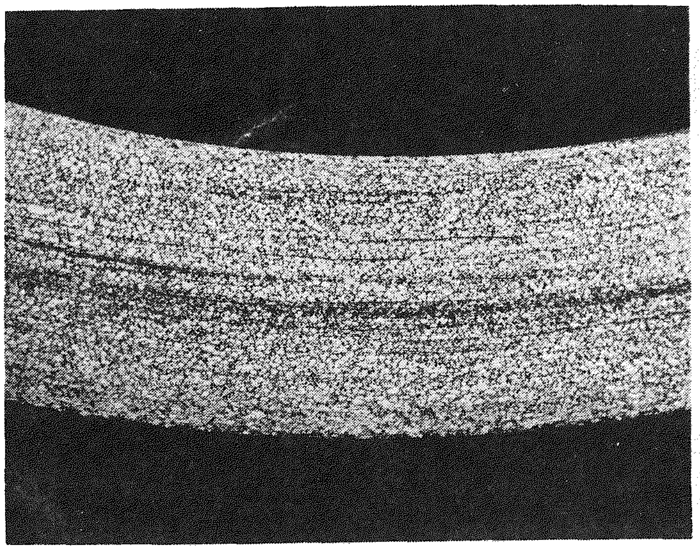

FIGURE 7 - Cross-sectioned dome of PB7-12. Metallographic examination indicated a normal microstructure. (50X, etched)

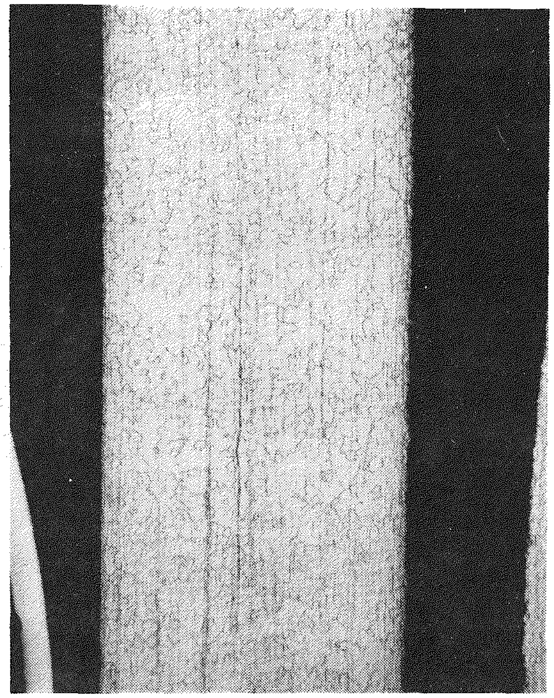

FIGURE 8 - Cross-sectioned sidewall of PB7-15. The microstructure was normal.

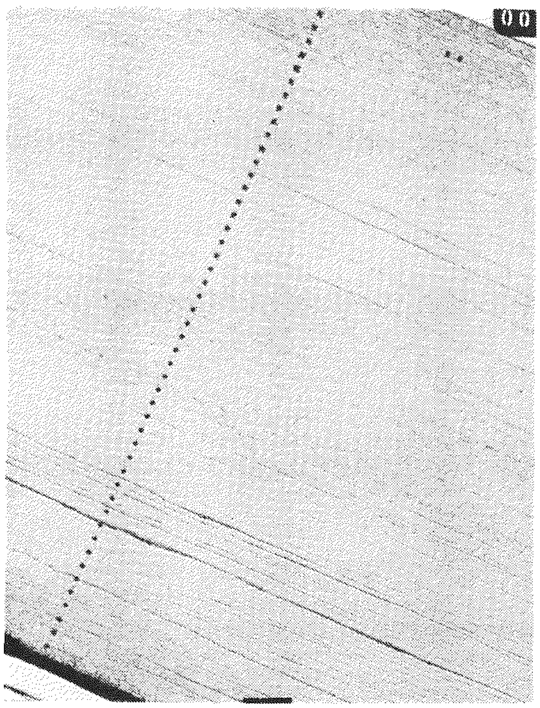

FIGURE 9 - Cross-sectioned cap of PB7-15 appeared to have a normal microstructure. Photomicrograph shows the microhardness traverse. (50X, etched)

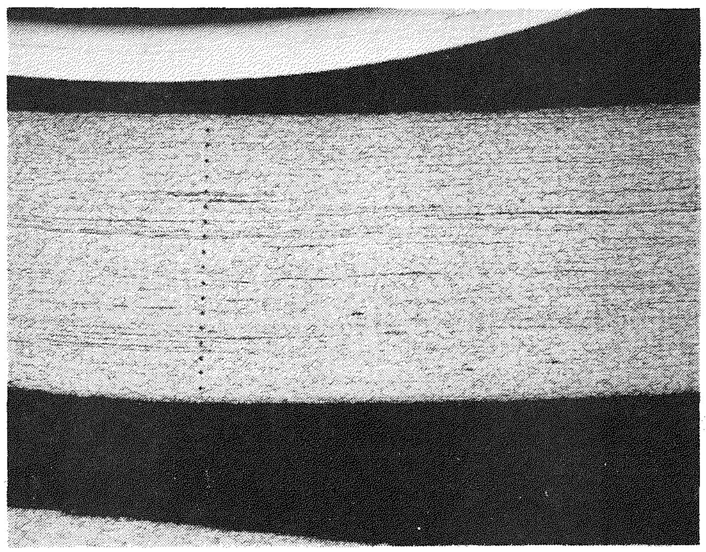

FIGURE 10 - The microstructure of the cross-sectioned dome of PB7-15 was normal. (50X, etched)

appeared normal with no evidence of interstitial contamination of the T-111 alloy.

Microhardness traverses were conducted using a 50-g load at 2-mil intervals across the cap, dome, and sidewall of each cross-sectioned specimen. The results (Figure 11 for PB7-12 and Figure 12 for PB7-15) were normal with no significant microhardness gradients. The average Vickers hardness of the cap, dome, and sidewall of PB7-12 was 242, 258, and 260, respectively. The average hardness across the cap, sidewall, and dome of PB7-15 was 256, 256, and 254, respectively.

Samples of the sidewalls, domes, and caps from each capsule were analyzed for oxygen and nitrogen. Results are summarized in Table 3, along with the average Vickers hardness values for corresponding sample locations. Results for the raw material (Lot 7 T-111 alloy) and results for the four previously evaluated capsules are also shown for comparison. The low values indicate that the integrity of the tests was not compromised by leaks or diffusion of interstitials through the protective Hastelloy-C276 clads. Compared to data from previous development units, the results are normal.

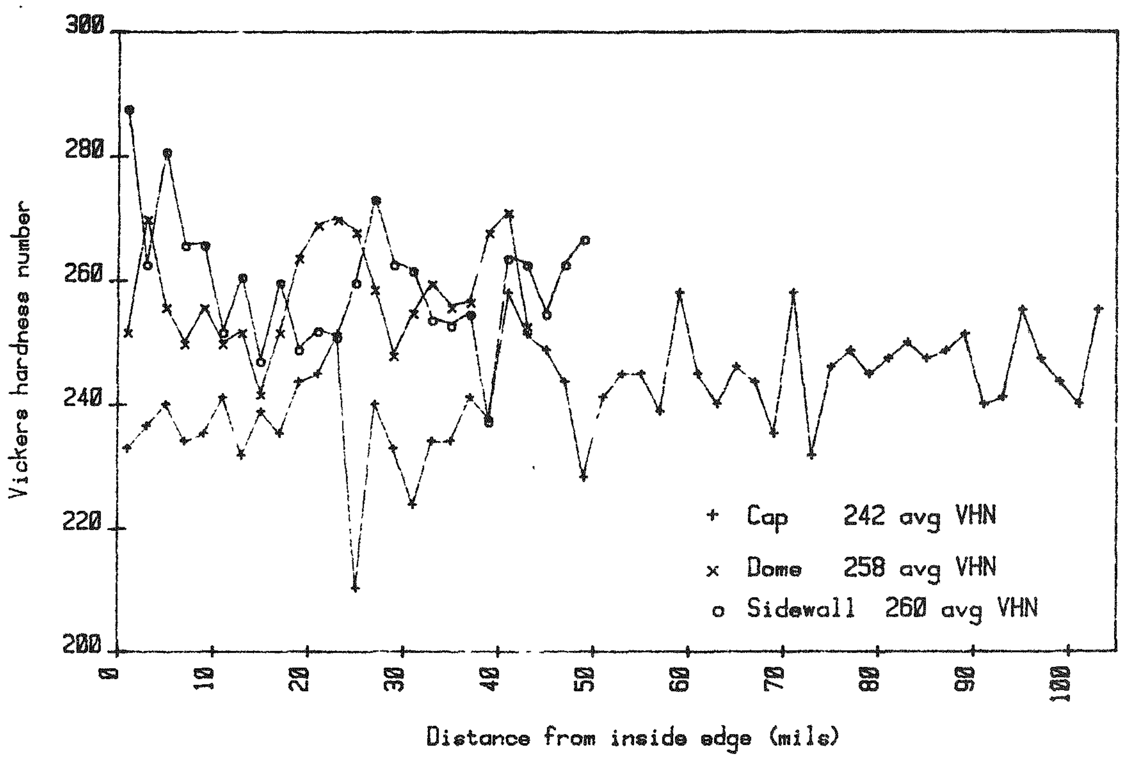

FIGURE 11 - Microhardness results for PB7-12 were normal with no significant microhardness gradients.

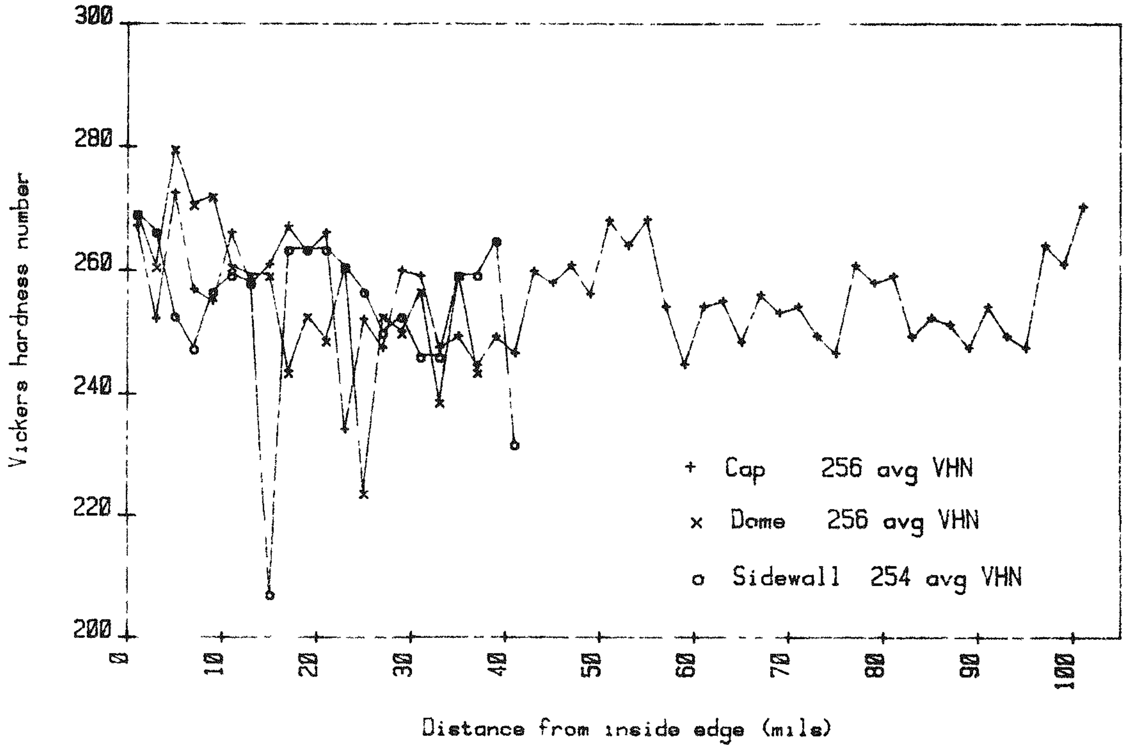

FIGURE 12 - Microhardness results for PB7-15 were normal with no significant microhardness gradients.

Table 3 - SUMMARY OF OXYGEN, NITROGEN, AND AVERAGE VICKERS HARDNESS VALUES FOR SURVEILLANCE RELATED CAPSULES

Capsule Number	Time at Temperature (days at °C)	Sample Location	Oxygen (ppm)	Nitrogen (ppm)	Average Hardness Number (VHN-50 g)
PB7-4	1,148 at 410	Sidewall	85	7	256
		Dome	81	3	260
		Cap	-	-	238
PB7-5	1,148 at 210	Sidewall	86	6	239
		Dome	102	9	250
		Cap	-	-	237
PB7-10	1,094 at 410	Sidewall	88	9	252
		Dome	84	12	263
		Cap	-	-	244
PB7-11	1,094 at 210	Sidewall	64	6	251
		Dome	54	9	270
		Cap	-	-	249
*PB7-12	1,238 at 410	Sidewall	70	27	260
		Dome	92	15	258
		Cap	66	3	242
*PB7-15	1,147 at 210	Sidewall	106	14	254
		Dome	77	26	256
		Cap	78	13	256
Raw Material		Lot 7	42	28	246

In summary, results for capsules PB7-12 and PB7-15 were normal compared to previously evaluated units. No significant interstitial contamination of the T-111 alloy was indicated by the metallographic, oxygen, nitrogen, and Vickers hardness data. Pressure-burst results for the units were normal, suggesting that the corresponding surveillance heat sources should be in good condition.

Hardware fabrication and quality

J. L. Boston and M. D. Christolear

Hardware fabrication continued in an efficient and timely manner with production losses maintained at a minimum level.

Approximately 1800 pieces of hardware were successfully fabricated, satisfying all programatic needs for the second half of 1983. The semiannual quality report for MC2893A and MC3599 hardware is shown in Table 4.

The overall process yield for the period July 1, 1983, through December 31, 1983, is 98.4%. The dollar value of fabricated hardware is approximately 315,270.

A MWG hardware reject summary for the period is shown in Table 5 with reasons for rejection given. This information will be used to improve process yields.

The hardware quality index report shown in Table 6 lists the lot submittals by Mound to DOE/DAO and the quality ratings for the reporting period. The monthly average was 100%.

Table 4 - SEMIANNUAL QUALITY REPORT ON MC2893A/MC3599 HARDWARE

		2nd Half	To Date
Liner Shim 291669-00	Fabricated	270	3165
	Prime	270	3160
	Reject	0	5
	Yield %	100	99.8
Liner Cap 291670-00	Fabricated	110	3110
	Prime	109	3081
	Ex. Weld	1	23
	Reject	0	6
	Yield %	100	99.8
Liner Body 291671-00	Fabricated	195	3162
	Prime	182	2944
	Ex. Weld	9	178
	Reject	4	40
	Yield %	97.9	98.7
St. Mem. Cap 291672-00	Fabricated	90	3432
	Prime	68	3277
	Ex. Weld	13	114
	Reject	9	41
	Yield %	90	98.8
St. Mem. Body 291673-00	Fabricated	436	3507
	Prime	363	3147
	Ex. Weld	66	310
	Reject	7	50
	Yield %	98.4	98.6
Clad Cap 291674-00	Fabricated	449	3134
	Prime	431	3059
	Ex. Weld	16	59
	Reject	2	16
	Yield %	99.6	99.5
Clad Body 291675-00	Fabricated	384	3120
	Prime	372	3049
	Ex. Weld	3	42
	Reject	9	29
	Yield %	97.7	99.1
Overall Process Yield $		98.4	99.2
$ Value of Fabricated Hardware		315272	3241157
Cost of Defectiveness $		5428	31707
$ % Defectiveness		1.7	1.0

Table 5 - MC2893A/MC3599 HARDWARE REJECT SUMMARY
(JULY 1, 1983 - DECEMBER 31, 1983)

Type	Reject Quantity	Reject Reason
Liner Body (291671-00)	2[a]	Dye Penetrant
	1[b]	Inside Length Undersize
	1[b]	Dent
Strength Member Cap (291672-00)	5[b]	Dents in O.D.
	3[b]	Voids in Step Face
	1[b]	Tool Marks in Step Face
Strength Member Body (291673-00)	4[b]	Missing Material, Top Edge
	2[b]	Dent Top Edge
	1[a]	Dye Penetrant
Clad Cap (291674-00)	1[b]	Tenon Height Oversize
	1[b]	Boss Diameter Undersize
Clad Body (291675-00)	9[a]	Dye Penetrant

[a]Material Related

[b]Operator Related

Table 6 - MC2893A/MC3599 HARDWARE QUALITY INDEX REPORT
(JULY 1, 1983 - DECEMBER 31, 1983)

C of I Number	Date Accepted	Component Description	Lot Size	Sample Size	Defectiveness	Major	Minor	Incidental	Index
88-4854	7/ 6/83	Strength Member Body	65	2	0	0	0	0	100
88-4853	7/ 6/83	Clad Body	10	1	0	0	0	0	100
99-4871	7/12/83	Liner Cap	85	5	0	0	0	0	100
88-4868	7/12/83	Liner Body	182	8	0	0	0	0	100
88-4873	7/12/83	Strength Member Cap	68	2	0	0	0	0	100
88-4872	7/12/83	Strength Member Body	38	1	0	0	0	0	100
88-4869	7/12/83	Clad Cap	88	30	0	0	0	0	100
88-4867	7/12/83	Clad Body	12	4	0	0	0	0	100
88-4894	7/25/83	Clad Body	11	4	0	0	0	0	100
88-4896	7/26/83	Liner Cap	34	2	0	0	0	0	100
88-4922	8/ 8/83	Clad Body	11	0	0	0	0	0	100
88-4921	8/ 9/83	Strength Member Body	79	0	0	0	0	0	100
88-4926	8/11/83	Strength Member Body	62	1	0	0	0	0	100
88-4925	8/11/83	Liner Body	75	2	0	0	0	0	100
88-4933	8/17/83	Clad Cap	346	21	0	0	0	0	100
88-4932	8/17/83	Clad Body	11	1	0	0	0	0	100
88-4947	9/ 1/83	Liner	87	0	0	0	0	0	100
88-4948	9/ 1/83	Strength Member Body	119	1	0	0	0	0	100
88-4954	9/12/83	Clad Body	22	3	0	0	0	0	100
88-4955	9/12/83	Clad Body	11	1	0	0	0	0	100
88-4982	10/ 4/83	Clad Body	23	2	0	0	0	0	100
88-5038	11/ 9/83	Clad Body	36	4	0	0	0	0	100
88-5066	11/23/83	Clad Body	12	2	0	0	0	0	100
88-5067	11/23/83	Clad Body	11	1	0	0	0	0	100
88-5080	12/ 2/83	Liner Shim	270	32	0	0	0	0	100
88-5084	12/ 6/83	Clad Body	22	3	0	0	0	0	100
88-5092	12/12/83	Clad Body	22	2	0	0	0	0	100
27 Submittals		TOTAL	1812	135	0	0	0	0	100 (avg)

Distribution

EXTERNAL

TIC, UC-23 (140)
J. O. Avis, Sandia National Laboratories, Albuquerque
R. R. Harnar, Sandia National Laboratories, Albuquerque
C. A. McKever, Sandia National Laboratories, Albuquerque (6)
S. E. Bronisz, Los Alamos National Laboratory
R. Geoffrion, Los Alamos National Laboratory
W. A. Stark, Los Alamos National Laboratory
R. H. Tait, Savannah River Laboratory
H. A. Schneiderman, Monsanto, St. Louis
H. N Hill, DOE, Dayton Area Office
G. R. Gartrell, DOE, Dayton Area Office
J. H. Grayson, DOE, Pinellas
J. E. Bickel, DOE, Albuquerque Operations Office
D. L. Plymale, DOE, Albuquerque Operations Office
G. L. Bennett, DOE, OSNP, Washington
E. H. Wegman, General Electric Neutron Devices, Pinellas
Monsanto Reports Library, R2C, St. Louis

INTERNAL

W. R. Amos
H. F. Anderson
D. R. Bohl
J. L. Boston
W. G. Brotherton
K. F. Chaney
M. D. Christolear
C. F. Draut
C. L. Fellers
D. R. Fidler
D. E. Friedline
D. M. Gabriel
L. A. Gibson
C. J. Goebel
K. C. Good
J. F. Griffin
A. E. Harris
J. D. Hastings
W. B. Hogeman
C. W. Huntington
E. W. Johnson
B. R. Kokenge
J. R. McDougal
E. A. Mershad
R. W. Saylor
W. H. Smith
P. E. Teaney
R. E. Vallee
D. E. Wendeln
W. B. Witmer
Records Center
Library (15)
Publications

Published by Information Services:
Marjorie F. Hauenstein, Editor