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Milliwatt Generator Project

April—September 1981

Compiled by

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Contributors

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ABSTRACT

This formal biannual report covers the effort related to the Milliwatt Generator Project (MWG) carried out for the Department of Energy, Office of Military Applications, by the Los Alamos National Laboratory.

Most of the studies discussed here are of a continuing nature. Results and conclusions may change as the work continues. Published reference to the results cited in this report should not be made without the explicit permission of the person in charge of the work.

I. SCHEDULE

A. General

The main tasks to be accomplished prior to the initiation of WR production at Los Alamos are shown in Figs. I-1 through I-3. This schedule has been agreed to in a series of meetings between Los Alamos personnel and representatives from DOE/ALO, Sandia National Laboratories Albuquerque (SNLA), Mound Facility (MF), and the General Electric Nuclear Division (GEND). This schedule differs somewhat from those reported previously¹⁻³ because Los Alamos will fabricate the MC 3599 heat source (4.5 W) for the MC 3500 radioisotopic thermoelectric generator (RTG) in addition to the MC 2893A heat source (4.0 W) for the MC 2730 RTG

originally planned. In addition, during FY 1981, SNLA personnel requested the fabrication of more test units than were scheduled originally.

During the second half of FY 1981, the primary tasks at Los Alamos were to (1) continue training of personnel, (2) continue surveillance activities, (3) fabricate and ship 18 end-of-life simulant test units to MF, (4) fabricate and ship 21 pressure burst-test units to MF, (5) fabricate 46 fueled test units for GEND, (6) fabricate 39 shelf-life test and miscellaneous fueled test units, (7) begin evaluation of the Los Alamos-fueled compatibility test units, and (8) begin Tool Made Sample (TMS) activities. Each of these tasks has been accomplished.

B. TMS Activities

The TMS evaluation consists of an in-depth review and examination by the design agency (SNLA) of the production procedures and operations at Los Alamos. The TMS activities were initiated on July 1, 1981, and by the end of September 1981, all but four Los Alamos procedures had been reviewed and approved. Final approval of the TMS activities is also dependent on the successful completion of various tests performed with representative Los Alamos heat sources.

1. Compatibility Tests. Twelve representative heat sources were placed in furnaces for testing at three different temperatures. Fabrication of the heat sources and the test matrix are described in Sec. IV. The preliminary results are discussed in Sec. V. In addition, four heat sources fueled with $^{238}\text{PuO}_2$, spiked with specific impurities, were placed in test. These are described in Sec. IV.

2. TMS Fuel Lot. One lot of $^{238}\text{PuO}_2$ feed from the Savannah River Plant (SRP) was processed as the official Los Alamos TMS feed lot. This lot (Los Alamos Lot 64) is discussed in Sec. IV.

3. TMS Heat Sources. Fifteen MC 3599 (4.5 W) heat sources were made using the TMS feed lot. Two of these, randomly selected by SNLA personnel, were sectioned and subjected to metallographic and chemical analyses. One of these two was successfully impacted at 150 m/s and 450°C prior to being sectioned. The remaining heat sources were sent to GEND for testing. The fabrication of the TMS heat source lot is described in Sec. IV. The preliminary results for the sectioned heat sources is discussed in Sec. V.

DATE: October, 1981

Fig. I-1. MWG project schedule, part 1.

DATE: October 1981

Fig. I-2. MWG project schedule, Part 2.

[illegible]

Fig. I-3. MWG project schedule, part 3.

II. HEAT SOURCE FABRICATION AND INSPECTION FLOW CHART

The Los Alamos fabrication and inspection flow chart for Milliwatt Generator Project (MWG) heat sources is shown schematically in Fig. II-1. In addition to the processing and inspection steps, most of the Quality Assurance (QA) operating procedures and data forms are also listed. The production flow chart is summarized pictorially in Figs. II-2 and II-3.

All equipment required for the production of MWG heat sources at Los Alamos has been purchased and installed.

III. FUEL PROCESSING AND CHARACTERIZATION

A. Processing

During the second half of FY 1981, five lots of SRP feed powder (1 100 g PuO_2) were processed using the flow chart shown in Fig. II-1. A total of 12 lots of SRP feed powder (2 650 g PuO_2) was processed in FY 1981.

B. Characterization

1. Neutron Emission Data. Neutron emission rate data for the 12 feed lots processed in FY 1981 are listed in Table III-1. The as-received SRP feed powder has an average neutron emission rate of about 17 000 n/s-g ^{238}Pu . After the ^{16}O -exchange reaction and other processing steps, the average neutron emission rate for heat sources fueled at Los Alamos is about 4 000 n/s-g ^{238}Pu .

2. Particle Size Data. Particle size data for the 12 lots of as-received SRP feed powder are listed in Table III-2. Data are also listed for nine of these lots after they had been ball-milled 44 h to normalize the particle size prior to forming the <500- μm granules.

3. Spectrochemical Data. Spectrochemical data for the 12 lots of as-received SRP feed powder are listed in Table III-3. All of the cation impurity levels are within specification limits except for calcium, silicon, and occasionally aluminum. Data for six lots of feed material processed at Los Alamos are listed in Table III-4. These data indicate that, with exception of silicon, the feed processing steps generally reduce the amount of cation impurities present.

4. Isotopic Data. The plutonium isotopic data for the 12 lots of as-received SRP feed powders are listed in Table III-5. For comparison, the Savannah River values were corrected for decay to the dates of the Los Alamos analyses.

Fig. II-1. MWG fabrication and inspection flow sheet.

Fig. II-1. (cont)

Fig. II-1. (cont)

Fig. II-1. (cont)

Fig. II-1. (cont)

Fig. II-1. (cont)

888 PuO₂ - FUEL PROCESSING Los Alamos

Fig. II-2. MWG fuel processing.

Fig. II-3. MWG assembly, welding, and testing.

TABLE III-1
NEUTRON EMISSION RATE DATA FOR FEED LOTS

ID Numbers			n/s-g ²³⁸ Pu		
Los Alamos	SRP		As		
Lot	Lot	Run	Received	Processed	Loaded ^a
48	438	905911	16 078	-	5 680
49	446	908953	18 191	-	4 534
51	453	910986	18 980	-	4 125
54	465	002006	18 388	-	5 249
55	475	006117	17 590	-	4 737
59	475	006120	17 321	4 574	4 708
62	486	009167	16 451	-	4 078
63	498	012206	17 441	4 447	-
64	498	012207	17 309	4 061	4 209
65	498	012208	17 988	4 156	-
66	498	012209	17 309	3 653	3 780
67	477	007124	18 322	4 348	4 383
			17 614	4 207	4 423
			± 823	± 330	± 439

^aBased on measurements of fueled heat sources, specification is 6 000 n/s-g ²³⁸Pu.

TABLE III-2
PARTICLE SIZE DATA FOR FEED LOTS

Lot	Mass Median Diameter (μm)	
	As Received	Ball-Milled 44 h
48	3.77	
49	4.85	
51	4.33	0.74
54	4.03	0.76
55	3.78	0.87
59	3.57	
62	3.77	0.84
63	3.20	0.70
64	2.39	0.72
65	2.53	0.92
66	2.86	0.98
67	4.29	1.13
3.61		0.85
±0.75		±0.14

TABLE III-3
SPECTROCHEMICAL DATA FOR FEED LOTS
AS RECEIVED FROM SRP
(ppm by weight)

Species	Specification	Sensitivity	Los Alamos Lot ID												Av
		Limit	48	51	54	55	59	62	63	64	65	66	67		
Al	70	5	100	300	10	20	9	40	280	5	120	55	50	90	
B	10	1	< ^a	3	<	<	5	<	<	<	<	<	<	<	
Be	25	2	<	15	<	<	<	<	<	<	<	<	<	1	
Bi	25	1	<	<	<	<	<	<	<	<	<	<	<	<	
Ca	250	3	300	20	750	50	500	200	2000	2000	2000	1000	800	875	
Cd	25	10	<	<	<	<	<	<	<	<	<	<	<	<	
Co	50	2	<	<	<	<	5	<	<	<	<	<	<	<	
Cr	150	5	30	100	40	30	25	30	120	15	55	30	80	50	
Cu	50	1	15	3	<	5	5	<	1	1	1	3	3	3	
Fe	500	5	170	490	140	120	250	110	250	75	160	180	280	202	
Mn	50	1	15	4	3	3	10	25	2	1	2	4	10	7	
Ni	100	5	20	60	30	30	30	20	130	15	65	30	45	43	
Pb	50	5	15	10	50	5	5	10	25	25	20	20	40	20	
Si	100	5	80	240	100	150	85	75	140	40	95	90	180	109	
Sn	50	5	10	5	5	5	5	10	<	<	<	<	<	3	
Zn	100	5	10	20	15	15	8	15	5	5	5	20	8	11	

^aLess than sensitivity limit, not detected in sample.

TABLE III-4
SPECTROCHEMICAL DATA FOR FEED LOTS
PROCESSED AT LOS ALAMOS
(ppm by weight)

Species	Sensitivity		Los Alamos Lot ID						
	Specification	Limit	62	63	64	65	66	67	Av
Al	70	5	35	150	35	9	8	25	44
B	10	1	< ^a	<	<	<	<	<	<
Be	25	2	<	<	<	<	<	<	<
Bi	25	1	<	<	<	<	<	<	<
Ca	250	3	50	50	50	10	25	100	48
Cd	25	10	<	<	<	<	<	<	<
Co	50	2	<	<	<	<	<	<	<
Cr	150	5	<	85	<	15	15	80	33
Cu	50	1	1	<	<	<	1	<	<
Fe	500	5	110	540	95	160	140	350	233
Mn	50	1	1	1	<	1	2	5	1
Ni	100	5	<	<	<	<	<	<	<
Pb	50	5	<	<	<	<	<	<	<
Si	100	5	210	280	260	170	210	290	237
Sn	50	5	<	<	<	<	<	<	<
Zn	100	5	<	<	<	5	<	10	3

^aLess than sensitivity limit, not detected in sample.

TABLE III-5
ISOTOPIC DATA FOR FEED LOTS
(weight percent)

Feed Lot	Lab	Plutonium Isotope				
		238	239	240	241	242
48	SR ^a	83.23	14.13	2.05	0.47	0.13
	Los Alamos	83.19	14.15	2.06	0.47	0.12
49	SR	83.56	13.93	1.95	0.42	0.14
	Los Alamos	83.51	13.98	1.94	0.42	0.14
51	SR	83.04	14.26	2.03	0.43	0.15
	Los Alamos	82.91	14.45	2.05	0.44	0.15
54	SR	83.26	14.13	2.03	0.44	0.14
	Los Alamos	83.20	14.18	2.05	0.43	0.14
59	SR	83.17	14.21	2.05	0.43	0.15
	Los Alamos	83.19	14.16	2.06	0.43	0.15
62	SR	83.43	14.01	2.01	0.41	0.14
	Los Alamos	83.38	14.05	2.01	0.41	0.15
63	SR	83.25	14.15	2.03	0.41	0.15
	Los Alamos	83.24	14.17	2.04	0.41	0.15
64	SR	83.23	14.17	2.04	0.41	0.15
	Los Alamos	83.18	14.21	2.05	0.41	0.15
65	SR	83.24	14.16	2.04	0.41	0.15
	Los Alamos	83.19	14.20	2.04	0.41	0.15
66	SR	83.23	14.17	2.04	0.41	0.15
	Los Alamos	83.22	14.19	2.04	0.41	0.15
67	SR	82.96	14.37	2.09	0.43	0.15
	Los Alamos	82.98	14.35	2.08	0.43	0.15
Los Alamos Average		83.20	14.19	2.04	0.42	0.15
		±0.16	±0.13	±0.04	±0.02	±0.01

^aSR value corrected for decay to dates of Los Alamos measurements.

IV. FABRICATION AND SHIPMENT OF TEST UNITS

A. Fueled Test Units

1. Fabrication. During the second half of FY 1981, 55 liners were loaded with PuO_2 fuel and welded. During this same period, 75 fueled liners were encapsulated in strength members and 86 fueled strength members were encapsulated in the outer clad assemblies. For the entire FY 1981, 152 liners were fueled and welded. Of these, 137 were encapsulated in strength members, and in turn, 130 strength members were encapsulated in the outer clad assemblies. Data for the 152 liner assemblies are summarized in Tables IV-1 through IV-8. Data for the 137 strength member assemblies are summarized in Tables IV-9 through IV-15. Data for the 130 outer clad assemblies are summarized in Tables IV-16 through IV-22.

2. GEND Test Units. During the second half of FY 1981, 36 MC 3599 and 8 MC 2893A heat sources were sent to GEND for testing. In total, 46 MC 3599 and 14 MC 2893A heat sources were sent to GEND during FY 1981. Neutron emission and thermal power data for the MC 3599 heat sources, together with capsule identification numbers, are summarized in Table IV-23. Data for the MC 2893A heat sources sent to GEND are listed in Table IV-24.

3. Shelf Life and Miscellaneous Test Units. During the second half of FY 1981, 15 MC 3599 and 10 MC 2893A heat sources were made for shelf life tests and 10 MC 3599 heat sources were made for miscellaneous Los Alamos tests. For the entire FY 1981, 19 MC 3599 heat sources were made for shelf life tests and 17 were shipped to SNLA. Data for these heat sources are summarized in Table IV-25. Data for the 13 MC 2893A heat sources made during FY 1981 for shelf life tests are listed in Table IV-26. Data for the 10 MC 3599 heat sources made for miscellaneous tests are listed in Table IV-27.

4. TMS Heat Sources. As part of the TMS activities described in Sec. I, 15 MC 3599 heat sources were fabricated using Los Alamos TMS feed lot 64. Thirteen of these units were sent to GEND and are described in Table IV-23. One unit was successfully impacted at 150 m/s and 450°C and is described in Table IV-31 and in Sec. V. The remaining unit was sectioned for metallographic and chemical analyses as described in Sec. V.

5. Compatibility Test Units. During FY 1981, 12 MC 2893A heat sources were placed in furnaces for compatibility tests. Data for these units are listed in Table IV-28. Heat source LASL-63 was not measured in the calorimeter prior to being put into the furnace so that the tests could begin on schedule.

TABLE IV-1
FUELED LINER WELDS 1-20

Liner ID			Type	Fuel		V (g)	Weldbox Atmosphere (ppm)			To Strength Member	Purpose	Disposition/Comments
Cap	Body	Shim		Lot	PuO ₂ (g)		O ₂	H ₂ O	N ₂			
1592	1629	1507		43 ^a	11.205	0.64	<1	3	25	---	Test Weld	Sectioned
1593	1630	1508		43	11.205	0.64	<1	3	25	---	Test Weld	Sectioned
1604	1631	1509		43	10.323	--	<1	3	25	---	Test Weld	Sectioned
1609	1632	1510		43	10.323	--	<1	3	25	1808	Test Weld	
1610	1633	1511		43	10.323	--	<1	3	25	1809	Test Weld	
1611	1635	1512	3599	48	11.205	0.61	<1	3	44	1812	Calorimetry Std	
1612	1636	1513	3599	48	11.205	0.61	<1	3	44	---	Test Weld	Sectioned
1613	1638	1514	3599	48	11.205	0.61	<1	3	44	1813	Impact Test	
1614	1639	1515	2893	48	9.960	0.54	<1	3	44	---	Test Weld	Sectioned
1615	1640	1516	2893	48	9.960	0.54	<1	2	44	1810	Impact Test	
1616	1641	1517	2893	48	9.960	0.54	<1	2	44	1811	Impact Test	
1617	1642	1518	3599	48	11.205	0.61	<1	<1	16	---	Test Weld	Sectioned
1618	1643	1519	3599	48	11.205	0.61	<1	<1	16	1814	Impact Test	
1619	1644	1520	3599	48	11.205	0.61	<1	<1	16	1815	Shelf Life Test	
1620	1645	1521	3599	48	11.205	0.61	<1	<1	16	1816	Impact Test	
1621	1646	1522	3599	48	11.205	0.61	<1	3	100	---	Test Weld	Sectioned
1622	1647	1523	3599	48	11.205	0.61	<1	3	100	---	Test Weld	Sectioned
1623	1648	1524	3599	48	11.205	0.61	<1	3	96	---	Test Weld	Sectioned
1624	1649	1525	3599	48	11.205	0.61	<1	<1	96	---	Test Weld	Sectioned
1625	1650	1526	3599	48	11.205	0.61	<1	<1	96	---	Test Weld	Sectioned

^aFuel lot 43 was enriched at 80 at.% ²³⁸Pu. This lot was used for practice only.

TABLE IV-2
FUELED LINER WELDS 21-40

Liner ID			Type	Fuel		Weldbox Atmosphere (ppm)			To Strength Member	Purpose	Disposition/Comments
Cap	Body	Shim		Lot	PuO ₂ (g)	Y (g)	O ₂	H ₂ O	N ₂		
1626	1651	1527	3599	49	11.108	0.61	<1	<1	96	1778	GEND Test
1627	1652	1528	3599	49	11.108	0.61	<1	<1	96	1779	GEND Test
1628	1653	1529	3599	49	11.108	0.61	<1	<1	96	1780	GEND Test
1629	1654	1530	3599	49	11.108	0.61	<1	<1	96	1781	GEND Test
1630	1655	1531	3599	49	11.108	0.61	<1	<1	96	1782	GEND Test
1631	1656	1532	3599	49	11.108	0.61	<1	<1	96	1783	GEND Test
1651	1659	1535	2893	49	9.874	0.54	<1	<1	12	1710	Compatibility Test
1652	1660	1536	2893	49	9.874	0.54	<1	<1	12	1711	Compatibility Test
1653	1661	1537	2893	49	9.874	0.54	<1	<1	12	1712	Compatibility Test
1694	1662	1538	2893	49	9.874	0.54	<1	<1	12	1713	Compatibility Test
1695	1663	1539	2893	49	9.874	0.54	<1	<1	12	1714	Compatibility Test
1654	1664	1540	2893	49	9.874	0.54	<1	<1	12	1715	Compatibility Test
1658	1668	1544	2893	51	9.709	0.53	<1	<1	17	1786	GEND Test
1659	1669	1545	2893	51	9.709	0.53	<1	<1	17	1787	GEND Test
1660	1671	1546	2893	51	9.709	0.53	<1	<1	17	1788	GEND Test
1661	1672	1547	2893	51	9.709	0.53	<1	<1	17	1789	GEND Test
1662	1678	1548	2893	51	9.709	0.53	<1	<1	17	1790	GEND Test
1663	1679	1549	2893	51	9.709	0.53	<1	<1	17	1791	GEND Test
1664	1680	1550	2893	51	9.709	0.53	<1	<1	17	1792	Compatibility Test
1665	1681	1551	2893	51	9.709	0.53	<1	<1	17	1801	Shelf Life Test

TABLE IV-3
FUELED LINER WELDS 41-60

Liner ID			Fuel				Weldbox Atmosphere (ppm)			To Strength Member	Purpose	Disposition/Comments
Cap	Body	Shim	Type	Lot	PuO ₂ (g)	Y (g)	O ₂	H ₂ O	N ₂			
1667	1683	1553	2893	51	9.709	0.53	<1	<1	16	1802	Compatibility Test Compatibility Test Calorimeter Std Compatibility Test Compatibility Test Compatibility Test GENO Test Shelf Life Test GENO Test	Reject/Light weight ^a
1670	1686	1556	2893	51	9.709	0.53	<1	<1	16	1793		
1671	1687	1557	2893	51	9.709	0.53	<1	<1	16	1794		
1672	1688	1558	2893	51	(9.709) ^a	0.53	<1	<1	16	1805		
1673	1690	1559	2893	51	9.709	0.53	<1	<1	16	1795		
1674	1691	1554	2893	51	9.709	0.53	<1	<1	16	1796		
1675	1692	1555	2893	51	9.709	0.53	<1	<1	16	1797		
1678	1698	1542	3599	51	10.922	0.60	<1	<1	11	1798		
1679	1699	1543	3599	51	10.922	0.60	<1	<1	11	1799		
1680	1700	1544	3599	51	10.922	0.60	<1	<1	11	1800		
1691	1712	1568	3599	49	10.901	0.60	<2	<1	10	1845	GENO Test	Defective liner weld SM failed ^b Liner failed leak check SM failure Defective liner weld
1692	1713	1569	3599	49/51	10.924	0.60	<2	<1	10	1846		
1693	1714	1570	3599	49	10.901	0.60	<2	<1	10	1847		
1696	1715	1571	3599	54	10.885	0.60	<2	<1	10	1848		
1697	1716	1572	3599	54	10.885	0.60	<2	<1	10	---		
1698	1718	1573	3599	54	10.885	0.60	<1	<1	14	1849		
1699	1719	1574	3599	54	10.885	0.60	<1	<1	14	1850		
1700	1720	1575	3599	54	10.885	0.60	<1	<1	14	1851		
1701	1721	1576	3599	54	10.885	0.60	<1	<1	14			
1702	1722	1577	3599	55	10.885	0.59	<1	<1	14			

^aLiner 1672 was not fueled with full charge, and unit subsequently was used as a calorimetry standard.

^bSM = strength member.

TABLE IV-4
FUELED LINER WELDS 61-80

Liner ID			Type	Fuel		Y (g)	Weldbox Atmosphere (ppm)			To Strength Member	Purpose	Disposition/Comments
Cap	Body	Shim		Lot	PuO ₂ (g)		O ₂	H ₂ O	N ₂			
1794	1827	1587	3599	55	10.860	0.60	<1	<1	19	2002	Shelf Life Test	
1795	1828	1588	3599	55	10.860	0.60	<1	<1	19	1986	Shelf Life Test	
1796	1829	1589	3599	55	10.860	0.50	<1	<1	19	1987	GENO Test	
1797	1830	1590	3599	55	10.860	0.60	<1	<1	19	1988	Shelf Life Test	
1798	1831	1591	3599	55	10.860	0.60	<1	<1	19	1989	GENO Test	
1799	1832	1592	3599	55	10.860	0.60	<1	<1	19	1990	GENO Test	
1800	1833	1593	3599	55	10.860	0.60	<1	<1	19	1991	GENO Test	
1801	1824	1594	3599	55	10.860	0.60	<1	<1	19	1992	GENO Test	
1802	1835	1595	3599	55	10.860	0.60	<1	<1	19	1993	Calorimetry Std	
1803	1836	1596	3599	55	10.860	0.60	<1	<1	19	1994	GENO Test	
1840	1837	1597	3599	55	10.860	0.60	<1	<1	19	1995	GENO Test	
1841	1838	1598	3599	55	10.860	0.60	<1	<1	19	1996	GENO Test	
1843	1840	1600	3599	55	10.860	0.60	<1	<1	12			Liner body was cracked
1844	1841	1601	3599	55	10.860	0.60	<1	<1	12	1997	GENO Test	
1845	1842	1602	3599	55	10.860	0.60	<1	<1	12	2003	Shelf Life Test	
1846	1843	1603	3599	55	10.860	0.60	<1	<1	12	1998	GENO Test	
1848	1869	1604	3599	54/55	10.882	0.60	<1	<1	12	1999	GENO Test	
1855	1884	1615	2893	59	9.646	0.53	<2	<1	20	2013	GENO Test	
1856	1885	1616	2893	59	9.646	0.53	<2	<1	20	2014	GENO Test	
1857	1887	1617	2893	59	9.646	0.53	<2	<1	20	2015	GENO Test	

TABLE IV-5
FUELED LINER WEI.DS 81-100

Liner ID			Type	Lot	Fuel	Y (g)	Weldbox Atmosphere (ppm)			To Strength Member	Purpose	Disposition/Comments
Cap	Body	Shim			PuC ₂ (g)		O ₂	H ₂ O	N ₂			
1858	1888	1618	2893	59	9.646	0.53	<2	<1	20	2016	GENO Test	
1859	1889	1619	2893	59	9.646	0.53	<2	<1	20	2017	GENO Test	
1860	1890	1620	2893	59	9.646	0.53	<2	<1	20	2018	GENO Test	
1861	1891	1621	2893	59	9.646	0.53	<2	<1	20	2019	GENO Test	
1862	1892	1622	2893	59	9.646	0.53	<2	<1	20	2020	GENO Test	
1863	1893	1623	2893	59	9.646	0.53	<2	<1	20	2021	GENO Test	
1864	1894	1624	2893	59	9.646	0.53	<2	<1	20	2022	GENO Test	
1865	1895	1625	2893	59	9.646	0.53	<2	<1	20	2023	GENO Test	
1866	1896	1626	2893	59	9.646	0.53	<2	<1	20	2024	GENO Test	
1868	1900	1629	2893	62	9.643	0.53	<1	<1	103	2026	Shelf Life Test	
1869	1902	1630	2893	62	9.643	0.53	<1	<1	103	2027	Shelf Life Test	
1870	1903	1631	2893	62	9.643	0.53	<1	<1	103	2028	Shelf Life Test	
1871	1904	1632	2893	62	9.643	0.53	<1	<1	103	2029	Shelf Life Test	
1872	1906	1633	2893	62	9.643	0.53	<1	<1	103	2030	Shelf Life Test	
1873	1907	1634	2893	62	9.643	0.53	<1	<1	103	2031	Shelf Life Test	
1874	1908	1635	2893	62	9.643	0.53	<1	<1	103	2032	Shelf Life Test	
1875	1910	1636	2893	62	9.643	0.53	<1	<1	103	2033	Shelf Life Test	
1917	1921	1638	3599	48	11.041	0.61	<1	<1	35	2043	Shelf Life Test	
1918	1922	1639	3599	48	11.041	0.61	<1	<1	35	2044	Shelf Life Test	
1919	1924	1640	3599	62	10.854	0.60	<1	<1	35	2045	Shelf Life Test	

TABLE IV-6
FUELED LINER WELDS 101-120

Liner ID			Type	Fuel		Y (g)	Weldbox Atmosphere (ppm)			To Strength Member	Purpose	Disposition/Comments
Cap	Body	Shim		Lot	PuO ₂ (g)		O ₂	H ₂ O	N ₂			
1920	1925	1641	3599	62	10.854	0.60	<1	<1	35	2046	Shelf Life Test	
1921	1926	1642	3599	62	10.854	0.60	<1	<1	35	2047	Shelf Life Test	
1922	1927	1643	3599	62	10.854	0.60	<1	<1	35	2048	Shelf Life Test	
1924	1928	1644	3599	62	10.854	0.60	<1	<1	35	2049	Shelf Life Test	
1925	1929	1645	3599	62	10.854	0.60	<1	<1	35	2050	Shelf Life Test	
1926	1930	1646	3599	62	10.854	0.60	<1	<1	35	2051	Shelf Life Test	
1927	1931	1647	3599	62	10.854	0.60	<1	<1	35	2052	Calorimeter Std	
1928	1933	1648	3599	62	10.854	0.60	<1	<1	35	2053	Shelf Life Test	
1929	1934	1649	3599	62	10.854	0.60	<1	<1	35	2054	Shelf Life Test	
1936	1936	1651	3599	62	10.854	0.60	<1	<1	38	2056	Shelf Life Test	
1937	1937	1652	3599	62	10.854	0.60	<1	<1	38	2057	Shelf Life Test	
1938	1938	1653	3599	62	10.854	0.60	<1	<1	38	2059	Shelf Life Test	
1945	1954	1685	3599	64	10.830	0.59	<1	<1	2	2071	Los Alamos TMS	
1946	1955	1686	3599	64	10.829	0.59	<1	<1	2	2072	Los Alamos TMS	
1947	1956	1687	3599	64	10.828	0.59	<1	<1	2	2073	Los Alamos TMS	
1948	1957	1688	3599	64	10.828	0.59	<1	<1	2	2074	Los Alamos TMS	
1949	1958	1689	3599	64	10.830	0.59	<1	<1	2	2075	Los Alamos TMS	
1950	1959	1690	3599	64	10.828	0.59	<1	<1	2	2076	Los Alamos TMS	
1951	1960	1691	3599	64	10.829	0.59	<1	<1	2	2077	Los Alamos TMS	
1952	1961	1692	3599	64	10.828	0.59	<1	<1	2	2078	Los Alamos TMS	

TABLE IV-7
FUELED LINER WELDS 121-140

Liner ID			Type	Fuel		Y (g)	Weldbox Atmosphere (ppm)			To Strength Member	Purpose	Disposition/Comments
Cap	Body	Shim		Lot	PuO ₂ (g)		O ₂	H ₂ O	N ₂			
1953	1962	1693	3599	64	10.828	0.59	<1	2	19	2079	Los Alamos TMS	
1954	1964	1694	3599	64	10.831	0.59	<1	2	19	2081	Los Alamos TMS	
1955	1965	1695	3599	64	10.831	0.59	<1	2	19	2082	Los Alamos TMS	
1956	1966	1696	3599	64	10.828	0.59	<1	2	19	2083	Los Alamos TMS	
1957	1967	1697	3599	64	10.829	0.59	<1	2	18	2085	Los Alamos TMS	
1958	1968	1698	3599	64	10.828	0.59	<1	2	18	2088	Los Alamos TMS	
1959	1969	1699	3599	64	10.830	0.59	<1	2	18	2089	Los Alamos TMS	
1961	1971	1700	3599	66	10.876	0.60	<1	3	23	2092	Los Alamos Test	
1962	1972	1701	3599	66	10.877	0.60	<1	3	23	2094	Los Alamos Test	
1963	1973	1702	3599	66	10.876	0.60	<1	3	23	2095	Los Alamos Test	
1964	1974	1703	3599	66	10.877	0.60	<1	3	23	2099	Los Alamos Test	
1965	1975	1704	3599	66	10.879	0.60	<1	3	23	2101	Los Alamos Test	
1966	1978	1705	3599	66	10.877	0.60	<1	3	23	2102	Los Alamos Test	
1967	1982	1706	3599	66	10.877	0.60	<1	3	23	2103	Los Alamos Test	
1968	1984	1707	3599	66	10.877	0.60	<1	3	23	2104	Los Alamos Test	
1969	1986	1708	3599	66	10.878	0.60	<1	3	23	2107	Los Alamos Test	
1970	1990	1709	3599	66	10.878	0.60	<1	3	23	2108	Los Alamos Test	
1973	1996	1710	3599	67	10.920	0.60	<1	3	98	2117	GENO Test	
1974	1999	1760	3599	67	10.919	0.60	<1	3	98	2118	GENO Test	
1975	2003	1761	3599	67	10.919	0.60	<1	3	98	2119	GENO Test	

TABLE IV-8
FUELED LINER WELDS 141-152

Liner ID			Type	Fuel		Y (g)	Weldbox Atmosphere (ppm)			To Strength Member	Purpose	Disposition/Comments
Cap	Body	Shim		Lot	PuO ₂ (g)		O ₂	H ₂ O	N ₂			
1976	2005	1762	3599	67	10.919	0.60	<1	3	98	2120	GENO Test	
1977	2006	1763	3599	67	10.918	0.60	<1	2	31	2121	GENO Test	
1978	2007	1764	3599	67	10.919	0.60	<1	2	31	2122	GENO Test	
1979	2016	1765	3599	67	10.920	0.60	<1	2	31	2124	GENO Test	
1980	2018	1766	3599	67	10.919	0.60	<1	2	31	2125	GENO Test	
1981	2020	1767	3599	67	10.919	0.60	<1	2	31	2126	GENO Test	
1982	2022	1768	3599	67	10.920	0.60	<1	2	31	2127	GENO Test	
1983	2023	1769	3599	67	10.920	0.60	<1	2	31	2128	GENO Test	
1985	2025	1771	3599	66	10.887	0.60	<1	2	55	2132	Compatibility Test	Doped with Al
1986	2026	1772	3599	66	10.887	0.60	<1	2	55	2133	Compatibility Test	Doped with Ca
1987	2027	1773	3599	66	10.887	0.60	<1	2	55	2134	Compatibility Test	Doped with Si
1988	2028	1774	3599	66	10.887	0.60	<1	2	55	2136	Compatibility Test	Doped with Al, Ca, and Si

TABLE IV-9
FUELED STRENGTH MEMBER WELDS 1-20

SM 10 ^a		Liner Cap	Type	Weldbox Atmosphere (ppm)			To Clad	Purpose	Disposition/Comments
Cap	Body			O ₂	H ₂ O	N ₂			
1710	1768	1651	2893	<1	<1	14	1841	Compatibility Test	
1711	1769	1652	2893	<1	<1	14	1842	Compatibility Test	
1712	1770	1653	2893	<1	<1	14	1843	Compatibility Test	
1713	1771	1694	2893	<1	<1	14	1844	Compatibility Test	
1714	1772	1695	2893	<1	<1	14	1845	Compatibility Test	
1715	1773	1654	2893	<1	<1	14	1846	Compatibility Test	
1778	1785	1626	3599	<1	<1	5	1641	GENO Test	
1779	1786	1627	3599	<1	<1	5	1631	GENO Test	
1780	1787	1628	3599	<1	<1	5	1632	GENO Test	
1781	1788	1629	3599	<1	<1	5	1633	GENO Test	
1782	1789	1630	3599	<1	<1	5	1634	GENO Test	
1783	1790	1631	3599	<1	<1	5	1635	GENO Test	
1786	1793	1658	2893	<1	<1	<5	1848	GENO Test	
1787	1794	1659	2893	<1	<1	<5	1849	GENO Test	
1788	1795	1660	2893	<1	<1	<5	1850	GENO Test	
1789	1796	1661	2893	<1	<1	<5	1851	GENO Test	
1790	1797	1662	2893	<1	<1	<5	1852	GENO Test	
1791	1798	1663	2893	<1	<1	<5	1853	GENO Test	
1792	1799	1664	2893	<1	<1	<5	1854	Compatibility Test	
1793	1800	1670	2893	<1	<1	<5	1855	Compatibility Test	

^aSM = strength member.

TABLE IV-10
FUELED STRENGTH MEMBER WELDS 21-40

SM ID		Liner Cap	Type	Weldbox Atmosphere (ppm)			To Clad	Purpose	Disposition/Comments
Cap	Body			O ₂	H ₂ O	N ₂			
1794	1801	1671	2893	<1	<1	<5	1856	Compatibility Test	
1795	1802	1673	2893	<1	<1	<5	1857	Compatibility Test	
1796	1803	1674	2893	<1	<1	<5	1858	Compatibility Test	
1797	1804	1675	2893	<1	<1	<5	1859	Compatibility Test	
1798	1805	1678	2893	<1	<1	<5	1665	GENO Test	
1799	1806	1679	2893	<1	<1	<5	1666	Shelf Life Test	
1800	1807	1680	2893	<1	<1	<5	1683	GENO Test	
1801	1817	1665	2893	<1	<1	<5	1662	Shelf Life Test	
1802	1818	1667	2893	<1	<1	<5	1663		
1805	1821	1672	2893	<1	<1	<5	1664	Calorimetry Std	
1808	1824	1609	2893	<1	<1	<5	1860	Test Weld	
1809	1825	1610	2893	<1	<1	<5	1861	Test Weld	
1810	1826	1615	2893	<1	<1	<5	1862	Impact Test	
1811	1827	1616	2893	<1	<1	<5	1863	Impact Test	
1812	1828	1611	3599	<1	<1	<5	1647	Calorimetry Std	
1813	1829	1613	3599	<1	<1	<5	1648	Impact Test	
1814	1830	1618	3599	<1	<1	<5	1649	Impact Test	
1815	1831	1619	3599	<1	<1	<5	1650	Shelf Life Test	
1816	1832	1620	3599	<1	<1	<5	1651	Impact Test	
1845	1857	1691	3599	<1	<1	<5	1735	GENO Test	

TABLE IV-11

FUELED STRENGTH MEMBER WELDS 41-60

SM ID		Liner Cap	Type	Weldbox Atmosphere (ppm)			To Clad	Purpose	Disposition/Comments
Cap	Body			O ₂	H ₂ O	N ₂			
1846	1858	1692	3599	<1	<1	33	1736	Shelf Life Test	
1847	1859	1693	3599	<1	<1	33	1737	Shelf Life Test	
1848	1860	1696	3599	<1	<1	33	1738	Shelf Life Test	SM failed swipe check
1849	1861	1698	3599	<1	<1	33	1739	GENO Test	
1850	1862	1699	3599	<1	<1	33			SM failed during heat treat
1851	1863	1701	3599	<1	<1	33			SM failed dye-pen. test
1986	1966	1795	3599	<1	<1	7	1765	Los Alamos Test	
1987	1967	1796	3599	<1	<1	7	1766	GENO Test	
1988	1968	1797	3599	<1	<1	7	2007	Shelf Life Test	
1989	1969	1798	3599	<1	<1	7	1768	GENO Test	
1990	1970	1799	3599	<1	<1	7	1769	GENO Test	
1991	1971	1800	3599	<1	<1	16	1770	GENO Test	
1992	1972	1801	3599	<1	<1	16	1771	GENO Test	
1993	1973	1802	3599	<1	<1	16	1890	Calorimetry Std	
1994	1974	1803	3599	<1	<1	16	1773	GENO Test	
1995	1975	1840	3599	<1	<1	16	1774	GENO Test	
1996	1976	1841	3599	<1	<1	16	1775	GENO Test	
1997	1977	1844	3599	<1	<1	16	1776	GENO Test	
1998	1978	1846	3599	<1	<1	12	1777	GENO Test	
1999	1979	1848	3599	<1	<1	12	1778	GENO Test	

TABLE IV-12

FUELED STRENGTH MEMBER WELDS 61-80

SM ID		Liner Cap	Type	Weldbox Atmosphere (ppm)			To Clad	Purpose	Disposition/Comments
Cap	Body			O ₂	H ₂ O	N ₂			
2002	1982	1794	3599	<1	<1	12	1921	Calorimetry Std	
2003	1983	1845	3599	<1	<1	12	1780	GEND Test	
2013	2034	1855	2893	<1	<1	10	1781	GEND Test	
2014	2035	1856	2893	<1	<1	10	1782	GEND Test	
2015	2036	1857	2893	<1	<1	10	1874	GEND Test	
2016	2037	1858	2893	<1	<1	10	1876	Shelf Life Test	
2017	2038	1859	2893	<1	<1	10	1877	GEND Test	
2018	2039	1860	2893	<1	<1	10	1878	Shelf Life Test	
2019	2040	1861	2893	<1	<1	10	1879	Shelf Life Test	SM failed diameter gaging
2020	2041	1862	2893	<1	<1	10	1880	GEND Test	
2021	2042	1863	2893	<1	<1	10	1881	GEND Test	
2022	2045	1864	2893	<1	<1	10	1882	GEND Test	
2023	2046	1865	2893	<1	<1	10	1883	GEND Test	
2024	2048	1866	2893	<1	<1	10	1884	Shelf Life Test	
2026	2050	1868	2893	<1	<1	10	1885	Shelf Life Test	
2027	2051	1869	2893	<1	<1	10	1886	Shelf Life Test	
2028	2054	1870	2893	<1	<1	10	1887	Shelf Life Test	
2029	2056	1871	2893	<1	<1	10	1888	Shelf Life Test	
2030	2057	1872	2893	<1	<1	10	1889	Shelf Life Test	
2031	2058	1873	2893	<1	<1	10			SM failed radiography

TABLE IV-13
FUELED STRENGTH MEMBER WELDS 81-100

SM ID		Liner Cap	Type	Weldbox Atmosphere (ppm)			To Clad	Purpose	Disposition/Comments
Cap	Body			O ₂	H ₂ O	N ₂			
2032	2059	1874	2893	<1	<1	20	1891	Shelf Life Test	
2033	2060	1875	2893	<1	<1	20	1892	Shelf Life Test	
2043	2062	1917	3599	<1	<1	31	1904	Shelf Life Test	
2044	2063	1918	3599	<1	<1	31	1905	Shelf Life Test	
2045	2064	1919	3599	<1	<1	8	1922	Shelf Life Test	
2046	2065	1920	3599	<1	<1	31	1907	Shelf Life Test	
2047	2066	1921	3599	<1	<1	31	1908	Shelf Life Test	
2048	2067	1922	3599	<1	<1	31	1909	Shelf Life Test	
2049	2068	1924	3599	<1	<1	31	1910	Shelf Life Test	
2050	2069	1925	3599	<1	<1	31	1911	Shelf Life Test	
2051	2070	1926	3599	<1	<1	31	1912	Shelf Life Test	
2052	2072	1927	3599	<1	<1	31	1913	Calorimetry Std	
2053	2073	1928	3599	<1	<1	31	1914	Shelf Life Test	
2054	2074	1929	3599	<1	<1	31	1915	Shelf Life Test	
2056	2076	1936	3599	<1	<1	8	1923	Shelf Life Test	
2057	2077	1937	3599	<1	<1	50	1917	Shelf Life Test	
2059	2078	1938	3599	<1	<1	50	1918	Shelf Life Test	
2071	2095	1945	3599	<1	3	21	1934	Los Alamos TMS	
2072	2127	1946	3599	<1	3	21	1935	Los Alamos TMS	
2073	2128	1947	3599	<1	3	21	1936	Los Alamos TMS	

TABLE IV-14

FUELED STRENGTH MEMBER WELDS 101-120

SM ID		Liner Cap	Type	Weldbox Atmosphere (ppm)			To Clad	Purpose	Disposition/Comments
Cap	Body			O ₂	H ₂ O	N ₂			
2074	2129	1948	3599	<1	3	21	1937	Los Alamos TMS	
2075	2130	1949	3599	<1	3	21	1938	Los Alamos TMS	
2076	2131	1950	3599	<1	3	21	1939	Los Alamos TMS	
2077	2132	1951	3599	<1	3	21	1940	Los Alamos TMS	
2078	2134	1952	3599	<1	3	21	1941	Los Alamos TMS	
2079	2135	1953	3599	<1	3	21	1942	Los Alamos TMS	
2081	2136	1954	3599	<1	3	21	1943	Los Alamos TMS	
2082	2137	1955	3599	<1	3	21	1944	Los Alamos TMS	
2083	2138	1956	3599	<1	3	21	1945	Los Alamos TMS	
2085	2140	1957	3599	<1	3	23	1947	Los Alamos TMS	
2088	2141	1958	3599	<1	2	10	1961	Los Alamos TMS	
2089	2142	1959	3599	<1	3	23	1949	Los Alamos TMS	
2092	2144	1961	3599	<1	2	10	1951	Los Alamos Test	
2094	2145	1962	3599	<1	2	10	1952	Los Alamos Test	
2095	2146	1963	3599	<1	2	10	1953	Los Alamos Test	
2099	2147	1964	3599	<1	2	10	1954	Los Alamos Test	
2101	2148	1965	3599	<1	2	10	1955	Los Alamos Test	
2102	2149	1966	3599	<1	2	10	1956	Los Alamos Test	
2103	2150	1967	3599	<1	2	10	1957	Los Alamos Test	
2104	2151	1968	3599	<1	2	10	1958	Los Alamos Test	

TABLE IV-15
FUELED STRENGTH MEMBER WELDS 121-137

SM ID		Liner Cap	Type	Weldbox Atmosphere (ppm)			To Clad	Purpose	Disposition/Comments
Cap	Body			O ₂	H ₂ O	N ₂			
2107	2152	1969	3599	<1	2	10	1959	Los Alamos Test	
2108	2153	1970	3599	<1	2	10	1960	Los Alamos Test	
2117	2158	1973	3599	<1	<1	6		GEND Test	
2118	2159	1974	3599	<1	<1	6	1964	GEND Test	
2119	2161	1975	3599	<1	<1	6	1965	GEND Test	
2120	2162	1976	3599	<1	<1	6	1998	GEND Test	
2121	2164	1977	3599	<1	<1	6	1999	GEND Test	
2122	2165	1978	3599	<1	<1	6	2000	GEND Test	
2124	2166	1979	3599	<1	<1	6	2001	GEND Test	
2125	2124	1980	3599	<1	<1	6	2002	GEND Test	
2126	2125	1981	3599	<1	<1	6	2003	GEND Test	
2127	2126	1982	3599	<1	<1	6	2004	GEND Test	
2128	2167	1983	3599	<1	<1	6	2005	GEND Test	
2132	2169	1985	3599	<1	<1	10		Compatibility Test	Doped with Al
2133	2170	1986	3599	<1	<1	10		Compatibility Test	Doped with Ca
2134	2171	1987	3599	<1	<1	10		Compatibility Test	Doped with Si
2136	2177	1988	3599	<1	<1	10		Compatibility Test	Doped with Al, Ca, and Si

TABLE IV-16

FUELED CLAD WELDS 1-20

Clad ID	Cap ID Numbers			Type	Weldbox Atmosphere (ppm)			Purpose	Disposition/Comments
	Clad	SM	Liner		O ₂	H ₂ O	N ₂		
LASL-51	1841	1710	1651	2893	<1	<1	12	Compatibility Test	In Test at 900°C
LASL-52	1842	1711	1652	2893	<1	<1	12	Compatibility Test	In Test at 600°C
LASL-53	1843	1712	1653	2893	<1	<1	12	Compatibility Test	In Test at 600°C
LASL-54	1844	1713	1694	2893	<1	<1	12	Compatibility Test	In Test at 600°C
LASL-55	1845	1714	1695	2893	<1	<1	12	Compatibility Test	In Test at 900°C
LASL-56	1846	1715	1654	2893	<1	<1	12	Compatibility Test	End test after 60 days at 600°C
UAS-003T	1632	1780	1628	3599	<1	<1	5	GEND Vibration Test	At GEND
UAS-004T	1633	1781	1627	3599	<1	<1	5	GEND Vibration Test	At GEND
UAS-005T	1634	1782	1630	3599	<1	<1	5	GEND Vibration Test	At GEND
UAS-006T	1635	1783	1631	3599	<1	<1	5	GEND Vibration Test	At GEND
UAS-007T	1641	1778	1626	3599	<1	<1	5	GEND Vibration Test	At GEND
UAS-008T	1631	1779	1627	3599	<1	<1	5	GEND Vibration Test	At GEND
LASL-57	1848	1786	1658	2893	12	3	27	GEND Vibration Test	At GEND
LASL-58	1849	1787	1659	2893	12	3	27	GEND Vibration Test	At GEND
LASL-59	1850	1788	1660	2893	12	3	27	GEND Vibration Test	At GEND
LASL-60	1851	1789	1661	2893	12	3	27	GEND Vibration Test	At GEND
LASL-61	1852	1790	1662	2893	12	3	27	GEND Vibration Test	At GEND
LASL-62	1853	1791	1663	2893	12	3	27	GEND Vibration Test	At GEND
LASL-63	1854	1792	1664	2893	12	3	27	Compatibility Test	In Test at 900°C
LASL-64	1855	1793	1670	2893	12	3	27	Compatibility Test	End test after 60 days at 900°C

TABLE IV-17
FUELED CLAD WELDS 21-40

Clad ID	Cap ID Numbers			Type	Weldbox Atmosphere (ppm)			Purpose	Disposition/Comments
	Clad	SM	Liner		O ₂	H ₂ O	N ₂		
LASL-65	1856	1794	1671	2893	12	3	27	Compatibility Test	In Test at 1100°C
LASL-66	1857	1795	1673	2893	12	3	27	Compatibility Test	In Test at 1100°C
LASL-67	1858	1796	1674	2893	12	3	27	Compatibility Test	End test after 60 days at 1100°C
LASL-68	1859	1797	1675	2893	12	3	27	Compatibility Test	In Test at 1100°C
LASL-69	1860	1808	1609	2893	<1	<1	5	Test Weld	
LASL-70	1861	1809	1610	2893	<1	<1	5	Test Weld	
LASL-71	1862	1810	1615	2893	<1	<1	5	Impact Test	Survived 150 m/s impact at 450°C
LASL-72	1863	1811	1616	2893	<1	<1	5	Impact Test	Survived 150 m/s impact at 450°C
UAS-009T	1647	1812	1611	3599	<1	<1	5	Calorimetry Std	At MF
UAS-010T	1648	1813	1613	3599	<1	<1	5	Impact Test	Survived 150 m/s impact at 450°C
UAS-011T	1649	1814	1618	3599	<1	<1	5	Impact Test	Survived 150 m/s impact at 450°C
UAS-012T	1650	1815	1619	3599	<1	<1	5	Shelf Life Test	
UAS-013T	1651	1816	1620	3599	<1	<1	5	Impact Test	Survived 150 m/s impact at 450°C
UAS-014T	1665	1798	1678	3599	<1	<1	3	GEND Test	At GEND
UAS-015T	1666	1799	1679	3599	<1	<1	3	Shelf Life Test	
UAS-016T	1683	1800	1680	3599	<1	<1	3	GEND Test	At GEND
LASL-73	1662	1801	1665	2893	<1	<1	13	Shelf Life Test	
LASL-74	1663	1802	1667	2893	<1	<1	13	Shelf Life Test	
LASL-75	1664	1805	1672	2893	<1	<1	13	Calorimetry Std	At MF
UAS-017T	1735	1845	1691	3599	<1	<1	<10	GEND Test	At GEND

TABLE IV-18
FUELED CLAD WELDS 41-60

Clad ID	Cap ID Numbers			Type	Weldbox Atmosphere (ppm)			Purpose	Disposition/Comments
	Clad	SM	Liner		O ₂	H ₂ O	N ₂		
UAS-018T	1736	1846	1692	3599	<1	<1	10	Shelf Life Test	At SNLA
UAS-019T	1737	1847	1693	3599	<1	<1	10	Shelf Life Test	At SNLA
UAS-020T	1738	1848	1696	3599	<1	<1	10	Shelf Life Test	Sectioned for metallography
UAS-021T	1739	1849	1698	3599	<1	<1	10	GEND Test	At GEND
UAS-022T	1765	1986	1795	3599	<1	<1	9	Los Alamos Test	Sectioned for metallography
UAS-023T	1766	1987	1796	3599	<1	<1	9	GEND Test	At GEND
UAS-025T	1768	1989	1798	3599	<1	<1	9	GEND Test	At GEND
UAS-026T	1769	1990	1799	3599	<1	<1	9	GEND Test	At GEND
UAS-027T	1770	1991	1800	3599	<1	<1	9	GEND Test	At GEND
UAS-028T	1771	1992	1801	3599	<1	<1	9	GEND Test	At GEND
UAS-030T	1773	1994	1803	3599	<1	<1	9	GEND Test	At GEND
UAS-031T	1774	1995	1840	3599	<1	<1	9	GEND Test	At GEND
UAS-032T	1775	1996	1841	3599	<1	<1	9	GEND Test	At GEND
UAS-033T	1776	1997	1844	3599	<1	<1	9	GEND Test	At GEND
UAS-034T	1777	1998	1846	3599	<1	<1	17	GEND Test	At GEND
UAS-035T	1778	1999	1848	3599	<1	<1	17	GEND Test	At GEND
UAS-037T	1780	2003	1845	3599	<1	<1	17	GEND Test	At GEND
LASL-86	1781	2013	1855	2893	<1	<1	22	GEND Test	At GEND
LASL-87	1782	2014	1856	2893	<1	<1	22	GEND Test	At GEND
LASL-88	1874	2015	1857	2893	<1	<1	22	GEND Test	At GEND

TABLE IV-19
FUELED CLAD WELDS 61-80

Clad ID	Cap ID Numbers			Type	Weldbox Atmosphere (ppm)			Purpose	Disposition/Comments
	Clad	SM	Liner		O ₂	H ₂ O	N ₂		
LASL-89	1876	2016	1858	2893	<1	<1	22	Shelf Life Test	
LASL-90	1877	2017	1859	2893	<1	<1	22	GEND Test	At GEND
LASL-91	1878	2018	1860	2893	<1	<1	22	Shelf Life Test	
LASL-92	1879	2019	1861	2893	<1	<1	22	Shelf Life Test	Clad diameter too large
LASL-93	1880	2020	1862	2893	<1	<1	22	GEND Test	At GEND
LASL-94	1881	2021	1863	2893	<1	<1	22	GEND Test	At GEND
LASL-95	1882	2022	1864	2893	<1	<1	22	GEND Test	At GEND
LASL-96	1883	2023	1865	2893	<1	<1	22	GEND Test	At GEND
LASL-97	1884	2024	1866	2893	<1	<1	22	Shelf Life Test	
LASL-98	1885	2026	1868	2893	<1	<1	20	Shelf Life Test	
LASL-99	1886	2027	1869	2893	<1	<1	20	Shelf Life Test	
LASL-100	1887	2028	1870	2893	<1	<1	20	Shelf Life Test	
LASL-101	1888	2029	1871	2893	<1	<1	20	Shelf Life Test	
LASL-102	1889	2030	1872	2893	<1	<1	20	Shelf Life Test	
LASL-103	1890	1993	1802	2893	<1	<1	8	Calorimetry Std	
LASL-104	1891	2032	1874	2893	<1	<1	20	Shelf Life Test	
LASL-105	1892	2033	1875	2893	<1	<1	20	Shelf Life Test	
LASL-106	1921	2002	1794	2893	<1	<1	8	Calorimetry Std	
UAS-038T	1904	2043	1917	3599	<1	<1	31	Shelf Life Test	At SNLA
UAS-039T	1905	2044	1918	3599	<1	<1	31	Shelf Life Test	At SNLA

TABLE IV-20
FUELED CLAD WELDS 81-100

Clad ID	Cap ID Numbers			Type	Weldbox Atmosphere (ppm)			Purpose	Disposition/Comments
	Clad	SM	Liner		O ₂	H ₂ O	N ₂		
UAS-041T	1907	2046	1920	3599	<1	<1	31	Shelf Life Test	At SNLA
UAS-042T	1908	2047	1921	3599	<1	.1	31	Shelf Life Test	At SNLA
UAS-043T	1909	2048	1922	3599	<1	<1	31	Shelf Life Test	At SNLA
UAS-044T	1910	2049	1924	3599	<1	<1	31	Shelf Life Test	At SNLA
UAS-045T	1911	2050	1925	3599	<1	<1	31	Shelf Life Test	At SNLA
UAS-046T	1912	2051	1926	3599	<1	<1	31	Shelf Life Test	At SNLA
UAS-047T	1913	2052	1927	3599	<1	<1	31	Calorimetry Std	
UAS-048T	1914	2053	1928	3599	<1	<1	31	Shelf Life Test	At SNLA
UAS-049T	1915	2054	1929	3599	<1	<1	31	Shelf Life Test	At SNLA
UAS-051T	1917	2057	1937	3599	<1	<1	50	Shelf Life Test	At SNLA
UAS-052T	1918	2059	1938	3599	<1	<1	50	Shelf Life Test	At SNLA
UAS-053T	1922	2045	1919	3599	<1	<1	8	Shelf Life Test	At SNLA
UAS-054T	1923	2056	1926	3599	<1	<1	8	Shelf Life Test	At SNLA
UAS-063T	2007	1988	1797	3599	<1	<1	6	Shelf Life Test	
UAS0001	1935	2071	1945	3599	<1	3	21	Los Alamos TMS	At GEND
UAS0002	1935	2072	1946	3599	<1	3	21	Los Alamos TMS	At GEND
UAS0003	1936	2073	1947	3599	<1	3	21	Los Alamos TMS	At GEND
UAS0004	1937	2074	1948	3599	<1	3	21	Los Alamos TMS	At GEND
UAS0005	1938	2075	1949	3599	<1	3	21	Los Alamos TMS	At GEND
UAS0006	1939	2076	1950	3599	<1	3	21	Los Alamos TMS	Survived 150 m/s impact at 450°C

TABLE IV-21
FUELED CLAD WELDS 101-120

Clad ID	Cap ID Numbers			Type	Weldbox Atmosphere (ppm)			Purpose	Disposition/Comments
	Clad	SM	Liner		O ₂	H ₂ O	N ₂		
UAS0007	1940	2077	1951	3599	<1	3	21	Los Alamos TMS	At GEND
UAS0008	1941	2078	1952	3599	<1	3	21	Los Alamos TMS	At GEND
UAS0009	1942	2079	1953	3599	<1	3	21	Los Alamos TMS	At GEND
UAS0010	1943	2081	1954	3599	<1	3	21	Los Alamos TMS	At GEND
UAS0011	1944	2082	1955	3599	<1	3	21	Los Alamos TMS	At GEND
UAS0012	1945	2083	1956	3599	<1	3	21	Los Alamos TMS	At GEND
UAS0013	1947	2085	1957	3599	<1	3	23	Los Alamos TMS	At GEND
UAS0015	1949	2089	1959	3599	<1	3	23	Los Alamos TMS	Sectioned for metallography
UAS0016	1961	2088	1958	3599	<1	2	10	Los Alamos TMS	
00001	1951	2092	1961	3599	<1	2	10	Los Alamos Test	
00002	1952	2094	1962	3599	<1	2	10	Los Alamos Test	
00003	1953	2095	1963	3599	<1	2	10	Los Alamos Test	
00004	1954	2099	1964	3599	<1	2	10	Los Alamos Test	
00005	1955	2101	1965	3599	<1	2	10	Los Alamos Test	
00006	1956	2102	1966	3599	<1	2	10	Los Alamos Test	
00007	1957	2103	1967	3599	<1	2	10	Los Alamos Test	
00008	1958	2104	1968	3599	<1	2	10	Los Alamos Test	
00009	1959	2107	1969	3599	<1	2	10	Los Alamos Test	Compatibility Test Control
00010	1960	2108	1970	3599	<1	2	10	Los Alamos Test	
UAS0018	1964	2118	1974	3599	<1	<1	6	GEND Test	

TABLE IV-22
FUELED CLAD WELDS 121-130

Clad ID	Cap ID Numbers			Type	Weldbox Atmosphere (ppm)			Purpose	Disposition/Comments
	Clad	SM	Liner		O ₂	H ₂ O	N ₂		
UAS0019	1965	2119	1975	3599	<1	<1	6	GEND Test	
UAS0020	1998	2120	1976	3599	<1	<1	6	GEND Test	
UAS0021	1999	2121	1977	3599	<1	<1	6	GEND Test	
UAS0022	2000	2122	1978	3599	<1	<1	6	GEND Test	
UAS0023	2001	2123	1979	3599	<1	<1	6	GEND Test	
UAS0024	2002	2125	1980	3599	<1	<1	6	GEND Test	
UAS0025	2003	2126	1981	3599	<1	<1	6	GEND Test	
UAS0026	2004	2127	1982	3599	<1	<1	6	GEND Test	
UAS0027	2005	2128	1983	3599	<1	<1	6	GEND Test	
UAS0028	2009	2117	1973	3599	<1	<1	20	GEND Test	

TABLE IV-23
4.5 WATT TEST UNITS FOR GEMO

ID Number			Fuel Lot	Neutron Emission (n/s)	Watts
Clad	Strength Member	Liner			
UAS-003T	1780	1628	49	36 809	4.60
UAS-004T	1781	1629	49	36 973	4.60
UAS-005T	1782	1630	49	37 096	4.60
UAS-006T	1783	1631	49	37 019	4.60
UAS-007T	1778	1626	49	37 024	4.60
UAS-008T	1779	1627	49	37 001	4.60
				36 987	4.60
				± 96	± 0.00
UAS-014T	1798	1678	51	32 984	4.50
UAS-016T	1800	1680	51	32 964	4.48
UAS-017T	1845	1691	49	37 222	4.51
UAS-021T	1849	1698	54	41 940	4.50
				36 178	4.50
				± 274	± 0.01
UAS-023T	1987	1796	55	37 385	4.49
UAS-025T	1989	1798	55	37 799	4.48
UAS-026T	1990	1799	55	37 867	4.48
UAS-027T	1991	1800	55	37 361	4.48
UAS-028T	1992	1801	55	37 746	4.49
UAS-030T	1994	1803	55	37 967	4.48
UAS-031T	1995	1840	55	38 169	4.48
UAS-032T	1996	1841	55	37 923	4.49
UAS-033T	1997	1844	55	37 367	4.45
UAS-034T	1998	1846	55	37 631	4.49
UAS-035T	1999	1848	55	40 770	4.46
UAS-037T	2003	1845	55	37 643	4.48
				37 969	4.48
				± 918	± 0.01
UAS0001	2071	1945	64 ^a	33 585	4.48
UAS0002	2072	1946	64	33 530	4.49
UAS0003	2073	1947	64	33 698	4.48
UAS0004	2074	1948	64	33 355	4.49
UAS0005	2075	1949	64	33 445	4.49
UAS0007	2077	1951	64	33 495	4.49
UAS0008	2078	1952	64	33 434	4.48
UAS0009	2079	1953	64	33 573	4.49
UAS0010	2081	1954	64	33 514	4.49
UAS0011	2082	1955	64	33 260	4.48
UAS0012	2083	1956	64	33 180	4.48
UAS0013	2085	1957	64	33 269	4.48
UAS0016	2088	1958	64	33 141	4.48
				33 421	4.48
				± 169	± 0.01
UAS0018	2118	1974	67	35 169	4.49
UAS0019	2119	1975	67	35 077	4.50
UAS0020	2120	1976	67	35 189	4.49
UAS0021	2121	1977	67	34 985	4.49
UAS0022	2122	1978	67	35 034	4.50
UAS0023	2124	1979	67	35 083	4.49
UAS0024	2125	1980	67	34 920	4.48
UAS0025	2126	1981	67	34 935	4.50
UAS0026	2127	1982	67	34 758	4.49
UAS0027	2128	1983	67	34 815	4.49
UAS0028	2117	1973	67	35 078	4.49
				35 004	4.49
				± 137	± 0.01

^aLos Alamos TMS Lot.

TABLE IV-24

4.0 WATT TEST UNITS FOR GEND

<u>Clad</u>	<u>ID Number</u>		<u>Fuel Lot</u>	<u>Neutron Emission (n/s)</u>	<u>Watts</u>
	<u>Strength</u>	<u>Liner</u>			
	<u>Member</u>				
LASL-57	1786	1658	51	29 433	3.99
LASL-58	1787	1659	51	29 543	3.99
LASL-59	1788	1660	51	29 528	4.03
LASL-60	1789	1661	51	29 238	3.98
LASL-61	1790	1662	51	29 438	4.01
LASL-62	1791	1663	51	29 551	3.98
				29 455	4.00
				± 118	±0.02
LASL-86	2013	1855	59	33 712	3.98
LASL-87	2014	1856	59	33 501	3.98
LASL-88	2015	1857	59	33 229	3.98
LASL-90	2017	1859	59	33 375	3.98
LASL-93	2020	1862	59	33 178	3.97
LASL-94	2021	1863	59	33 623	3.98
LASL-95	2022	1864	59	33 114	3.98
LASL-96	2023	1865	59	33 020	3.98
				33 344	3.98
				± 250	±0.01

TABLE IV-25
4.5 WATT SHELF LIFE UNITS

Clad	ID Number		Fuel Lot	Neutron Emission (n/s)	Watts
	Strength Member	Liner			
UAS-012T	1815	1619	48	46 614	4.60
UAS-038T	2043	1917	48	48 518	4.52 ^a
UAS-039T	2044	1918	48	50 502	4.52 ^a
				48 545	4.55
				±1 944	±0.04
UAS-019T	1847	1693	49	36 863	4.46 ^a
UAS-018T	1846	1692	49/51	33 078	4.46 ^a
UAS-015T	1799	1679	51	31 536	4.41 ^a
UAS-063T	1988	1797	55	38 001	4.47
UAS-041T	2046	1920	62	32 361	4.50 ^a
UAS-042T	2047	1921	62	32 282	4.50 ^a
UAS-043T	2048	1922	62	32 160	4.50 ^a
UAS-044T	2049	1924	62	32 470	4.50 ^a
UAS-045T	2050	1925	62	32 308	4.50 ^a
UAS-046T	2051	1926	62	32 533	4.50 ^a
UAS-048T	2053	1928	62	32 680	4.50 ^a
UAS-049T	2054	1929	62	32 646	4.50 ^a
UAS-051T	2057	1937	62	32 677	4.51 ^a
UAS-052T	2059	1938	62	32 676	4.50 ^a
UAS-053T	2045	1919	62	32 226	4.47 ^a
UAS-054T	2056	1936	62	32 592	4.50 ^a
				32 468	4.50
				± 193	±0.01

^aAt SNLA.

TABLE IV-26

4.0 WATT SHELF LIFE UNITS

<u>Clad</u>	<u>ID Number</u>		<u>Fuel Lot</u>	<u>Neutron Emission (n/s)</u>	<u>Watts</u>
	<u>Strength</u>	<u>Liner</u>			
	<u>Member</u>				
LASL-73	1801	1665	51	29 041	3.98
LASL-74	1802	1667	51	28 949	3.98
				28 995	3.98
				± 65	±0.00
LASL-89	2016	1858	59	33 472	3.97
LASL-91	2018	1860	59	33 038	3.98
LASL-92	2019	1861	59	33 021	3.98
LASL-97	2024	1866	59	33 279	3.98
				33 203	3.98
				± 215	±0.01
LASL-98	2026	1868	62	29 518	4.00
LASL-99	2027	1869	62	29 194	3.99
LASL-100	2028	1870	62	28 965	4.00
LASL-101	2029	1871	62	29 122	3.99
LASL-102	2030	1872	62	29 008	3.98
LASL-104	2032	1874	62	28 846	4.00
LASL-105	2033	1875	62	28 695	3.99
				29 050	3.99
				± 265	±0.01

TABLE IV-27

4.5 WATT LOS ALAMOS TEST UNITS

<u>Clad</u>	<u>ID Number</u>		<u>Fuel Lot</u>	<u>Neutron Emission (n/s)</u>	<u>Watts</u>
	<u>Strength</u>	<u>Liner</u>			
	<u>Member</u>				
00001	2092	1961	66	30 207	4.51
00002	2094	1962	66	30 115	4.50
00003	2095	1963	66	30 173	4.51
00004	2099	1964	66	30 124	4.50
00005	2101	1965	66	30 221	4.50
00006	2102	1966	66	30 137	4.50
00007	2103	1967	66	30 192	4.51
00008	2104	1968	66	30 083	4.49
00009	2107	1969	66	30 218	4.50
00010	2108	1970	66	30 212	4.50
				30 168	4.50
				± 50	±0.01

TABLE IV-28

4.0 WATT COMPATIBILITY TEST UNITS

<u>Clad</u>	<u>ID Number</u>		<u>Fuel Lot</u>	<u>Neutron Emission (n/s)</u>	<u>Watts</u>
	<u>Strength</u>	<u>Liner</u>			
	<u>Member</u>				
LASL-51	1710	1651	49	32 676	4.09
LASL-52	1711	1652	49	32 500	4.09
LASL-53	1712	1653	49	32 834	4.09
LASL-54	1713	1694	49	33 339	4.06
LASL-55	1714	1695	49	33 351	4.06
LASL-56	1715	1654	49	33 352	4.08
				33 009	4.08
				± 386	±0.01
LASL-63	1792	1664	51	29 542	
LASL-64	1793	1670	51	29 317	3.98
LASL-65	1794	1671	51	29 442	3.98
LASL-66	1795	1673	51	29 358	3.98
LASL-67	1796	1674	51	29 562	4.00
LASL-68	1797	1675	51	29 617	3.87
				29 473	3.96
				± 120	±0.05

It will be measured when the compatibility tests are concluded. The compatibility test matrix is shown in Table IV-29. During the second half of FY 1981, the three units in test for 60 days were removed from the furnaces and examined. Preliminary data for these units are discussed in Sec. V.

The data listed in Table III-3 indicate that many of the feed lots received from SRP contain calcium, silicon, and aluminum in amounts exceeding the specification limits. The data listed in Table III-4 indicate that processing the fuel removes the calcium and usually the aluminum, but the silicon content remains above the specification limit. Thus, during the second half of FY 1981, four heat sources were made with fuel "doped" with specific impurities. These units were encapsulated in strength members and then in Hastelloy X containers and placed in furnaces for compatibility testing for 60 days at 900°C. The dopants for these compatibility test units are summarized in Table IV-30.

6. Impact Test Units. During FY 1981, three MC 3599 and two MC 2893A heat sources were fabricated and impacted. Data for these units, together with data for the impact-tested MC 3599 heat source from the Los Alamos TMS lot, are listed in Table IV-31.

7. Neutron Emission Rates. The data listed in Tables IV-23 through IV-28 and in Table IV-31 indicate that the neutron emission rate varies from feed lot to feed lot depending on light element impurity levels. However, all of the heat sources made and transferred for the various tests meet the specifications, 46 000 n/s for the MC 2893A heat source and 52 000 n/s for the MC 3599 heat source.

B. Simulant-Fueled Test Units.

1. End-of-Life Test Units. During the second half of FY 1981, eight liner assemblies were fueled with a 50/50 mixture (by weight) of molybdenum and tungsten powders and the caps were welded. Each assembly had a 0.10-mm-diam hole drilled through the liner cap. Each liner assembly was then encapsulated in a strength member assembly having a 0.10-mm-diam hole drilled through the cap. These assemblies were pressurized to 1 250 psi with helium and the holes in the strength member caps were sealed with a laser. The pressurized assemblies were then encapsulated in outer clad assemblies and shipped to MF for testing under conditions simulating end-of-life helium pressures. In addition, three pressurized strength member assemblies, described in the previous report,³ were shipped to MF without being encapsulated in the outer clad assemblies.

TABLE IV-29
COMPATIBILITY TEST MATRIX

Test Temperature	Number of Heat Sources Tested		
	60 days	240 days	2 years ^a
600°C	1	1	2
900°C	1	1	2
1100°C	1	1	2

^aAt end of test, one heat source will be sectioned, the other will be impacted and then sectioned.

TABLE IV-30
SPECTROCHEMICAL DATA FOR DOPED COMPATIBILITY UNITS

Clad ID	Cap ID Number			Impurity Content (ppm by weight)			Comments
	Clad	SM	Liner	Al	Ca	Si	
0009	1959	2107	1969	30	400	220	Control capsule
-	-	2132	1985	220	500	310	Doped with Al
-	-	2133	1986	20	1000	280	Doped with Ca
-	-	2134	1987	20	250	1000	Doped with Si
-	-	2136	1988	100	2000	780	Doped with Al, Ca, & Si

TABLE IV-31
IMPACT TEST UNITS

<u>Clad</u>	<u>ID Number Strength Member</u>	<u>Liner</u>	<u>Fuel Lot</u>	<u>Neutron Emission (n/s)</u>	<u>Watts</u>
LASL-71	1810	1615	48	39 610	4.10
LASL-72	1811	1616	48	39 157	4.11
				39 384	4.11
				± 320	±0.01
UAS-010T	1813	1613	48	43 888	4.61
UAS-011T	1814	1614	48	47 079	4.60
UAS-013T	1816	1620	48	46 883	4.57
				45 950	4.59
				±1 788	±0.02
UAS0006	2076	1950	64 ^a	33 695	4.48

^aLos Alamos TMS Lot.

During FY 1981, a total of 28 end-of-life liner and strength member assemblies were pressurized and sealed. Eighteen of the pressurized units were encapsulated in outer clad assemblies. Data for the liner units are summarized in Tables IV-32 and IV-33. Data for the strength member units are listed in Tables IV-34 and IV-35. Data for the outer clad assemblies are listed in Table IV-36. Eighteen pressurized end-of-life units encapsulated in outer clad assemblies and three pressurized units encapsulated in strength members described in Table IV-37 were shipped to MF in FY 1981.

2. Pressure Burst-Test Capsules. Each lot of T-111 must be qualified by pressure-burst testing. This test is to ensure that the strength member will be rupture free at the end of capsule life or when there is a maximum internal helium pressure due to plutonium-238 alpha decay.

The pressure-burst capsule consists of a strength member body containing a tantalum pellet to simulate the volume of the liner assembly and fuel. The strength member cap is provided with a tantalum tube (1.52-mm-diam, 101.6-mm-long, with a 0.25-mm orifice) that is electron beam-welded through the center of the cap. This tube is used to pressurize the strength member assembly with helium and the tube is sealed. The amount of helium introduced is such that a preset pressure, about 8 000 psi, is attained when the assembly is heated to about 1000°C.

During the second half of FY 1981, 21 pressure burst-test capsules were made and shipped to MF for testing. To date, a total of 71 pressure burst-test capsules have been made and 50 have been shipped to MF. Data for these units are summarized in Tables IV-36 through IV-41.

3. Compatibility Test Units. We noted in the last report³ that, when strength member 1850, containing liner 1699 fueled at 4.5 W was heated at 1350°C (to reduce the PuO₂ with Y), the assembly breached, releasing about 1 µg of plutonia into the furnace chamber. We also reported that several containers of yttrium chips received from MF contained small amounts of plastic and/or glass. As a result, we now ultrasonically clean all yttrium chips in ethanol before use. In addition, an experiment was designed to determine any effects of plastic or glass chips in the fuel. Two liners were fueled with depleted UO₂ and Y. The fuel in one liner was doped with glass chips, fuel in the other with pieces of polyethylene. Depleted UO₂ simulant was used instead of PuO₂ to prevent contamination of the furnace if the capsule breached during heating.

TABLE IV-32
END-OF-LIFE LINER WELDS 1-20

Liner ID			Fuel ^a		Y (g)	Weldbox Atmosphere (ppm)			To Strength Member	Disposition/Comments
Cap	Body	Shim	Lot	wt (g)		O ₂	H ₂ O	N ₂		
1681	1702	1562	OFS-3	11.251	0.60	<1	<1	120	1817	
1682	1703	1563	OFS-4	11.252	0.60	<1	<1	120	1818	
1683	1704	1564	OFS-5	11.255	0.54	<1	<1	120	1819	
1684	1706	1565	OFS-6	11.254	0.54	<1	<1	120	1820	
1685	1707	1566	OFS-7	11.250	0.54	<1	<1	120	1821	
1709	1709	1585	OFS-8	11.150	-	<1	<1	43	1822	Sealed at liner cap, 1245 psi nominal
1710	1811	1579	OFS-9	11.256	-	<1	<1	43	1823	Sealed at liner cap, 1245 psi nominal
1711	1812	1580	OFS-10	11.253	-	<1	<1	43	1827	Sealed at liner cap, 1245 psi nominal
1712	1813	1581	1	11.201	-	<1	<1	43	1828	Sealed at liner cap, 1245 psi nominal
1713	1814	1582	2	11.201	-	<1	<1	43	1829	Sealed at liner cap, 1245 psi nominal
1686	1816	1583	3	11.200	-	<1	<1	43	1903	
1687	1817	1584	4	11.200	-	<1	<1	43	1904	
1777	1874	1606	5	11.202	-	<1	<1	8	1856	
1778	1875	1607	6	11.203	-	<1	<1	8	1857	
1779	1876	1608	7	11.200	-	<1	<1	8	1858	
1780	1877	1609	8	11.201	-	<1	<1	8	1859	
1781	1878	1610	9	11.200	-	<1	<1	8	1860	
1782	1879	1611	10	11.202	-	<1	<1	8	1898	
1783	1880	1612	11	11.200	-	<1	<1	8	1899	
1784	1881	1613	12	11.200	-	<1	<1	8	1902	

^aSimulant fuel is 50/50 mixture (by weight) of molybdenum and tungsten powders.

TABLE IV-33
END-OF-LIFE LINER WELDS 21-28

Liner ID			Fuel ^a		Y (g)	Weldbox Atmosphere (ppm)			To Strength Member	Disposition/Comments
Cap	Body	Shim	Lot	wt (g)		O ₂	H ₂ O	N ₂		
1908	1939	1654	13	11.200	0.60	<1	<1	4	2034	
1909	1940	1676	14	11.201	0.60	<1	<1	4	2035	
1910	1941	1677	15	11.201	0.60	<1	<1	4	2036	
1911	1942	1678	16	11.202	0.60	<1	<1	4	2037	
1912	1944	1679	17	11.200	0.60	<1	<1	4	2038	
1913	1945	1680	18	11.200	0.60	<1	<1	4	2039	
1914	1946	1681	19	11.200	0.60	<1	<1	4	2040	
1915	1947	1682	20	11.201	0.60	<1	<1	4	2041	

^aSimulant fuel is a 50/50 mixture (by weight) of molybdenum and tungsten powders.

TABLE IV-34

END-OF-LIFE STRENGTH MEMBER WELDS 1-20

SM ID ^a		Liner Cap	Weldbox Atmosphere (ppm)			To Clad	Disposition/Comments
Cap	Body		O ₂	H ₂ O	N ₂		
1817	1836	1681	<1	<1	38	1869	Sealed at SM cap, 1250 psi nominal
1818	1837	1682	<1	<1	38	1870	Sealed at SM cap, 1250 psi nominal
1819	1838	1683	<1	<1	38	1871	Sealed at SM cap, 1250 psi nominal
1820	1839	1684	<1	<1	38	1872	Sealed at SM cap, 1250 psi nominal
1821	1840	1685	<1	<1	38	1873	Sealed at SM cap, 1250 psi nominal
1822	1866	1709	<1	<1	40	1745	
1823	1867	1710	<1	<1	40	1746	
1827	1868	1711	<1	<1	40	1747	
1828	1869	1712	<1	<1	40	1748	
1829	1870	1713	<1	<1	40	1751	
1856	1984	1777	<1	<1	6		Sealed at SM cap, 1250 psi nominal
1857	1985	1778	<1	<1	6		Sealed at SM cap, 1250 psi nominal
1858	1986	1779	<1	<1	6		Sealed at SM cap, 1250 psi nominal
1859	1987	1780	<1	<1	6		Sealed at SM cap, 1250 psi nominal
1860	1988	1781	<1	<1	6		Sealed at SM cap, 1250 psi nominal
1898	1989	1782	<1	<1	6		Sealed at SM cap, 1250 psi nominal
1899	1990	1783	<1	<1	6		Sealed at SM cap, 1250 psi nominal
1902	1991	1784	<1	<1	6		Failed He leak check
1903	1992	1786	<1	<1	6		Sealed at SM cap, 1250 psi nominal
1904	1993	1687	<1	<1	6		Sealed at SM cap, 1250 psi nominal

^aSM = strength member.

TABLE IV-35
END-OF-LIFE STRENGTH MEMBER WELDS 21-28

SM ID ^a		Liner Cap	Weldbox Atmosphere (ppm)			To Clad	Disposition/Comments
Cap	Body		O ₂	H ₂ O	N ₂		
2034	2079	1908	<1	<1	6	1925	Sealed at SM cap, 1250 psi nominal
2035	2080	1909	<1	<1	6	1926	Sealed at SM cap, 1250 psi nominal
2036	2081	1910	<1	<1	6	1927	Sealed at SM cap, 1250 psi nominal
2037	2082	1911	<1	<1	6	1928	Sealed at SM cap, 1250 psi nominal
2038	2083	1912	<1	<1	6	1929	Sealed at SM cap, 1250 psi nominal
2039	2084	1913	<1	<1	6	1930	Sealed at SM cap, 1250 psi nominal
2040	2085	1914	<1	<1	6	1931	Sealed at SM cap, 1250 psi nominal
2041	2086	1915	<1	<1	6	1932	Sealed at SM cap, 1250 psi nominal

^aSM = strength member.

TABLE IV-36
END-OF-LIFE CLAD WELDS 1-18

Clad ID	Cap ID Numbers			Weldbox Atmosphere (ppm)			Disposition/Comments
	Clad	SM	Liner	O ₂	H ₂ O	N ₂	
LASL-76	1869	1817	1681	<1	<1	13	At Mound Facility
LASL-77	1870	1818	1682	<1	<1	13	At Mound Facility
LASL-78	1871	1819	1683	<1	<1	13	At Mound Facility
LASL-79	1872	1820	1684	<1	<1	13	At Mound Facility
LASL-80	1873	1821	1685	<1	<1	13	At Mound Facility
LASL-81	1745	1822	1709	<1	<1	14	At Mound Facility
LASL-82	1746	1823	1710	<1	<1	14	At Mound Facility
LASL-83	1747	1827	1711	<1	<1	14	At Mound Facility
LASL-84	1748	1828	1712	<1	<1	14	At Mound Facility
LASL-85	1751	1829	1713	<1	<1	14	At Mound Facility
UAS-055T	1925	2034	1908	<1	3	16	At Mound Facility
UAS-056T	1926	2035	1909	<1	3	16	At Mound Facility
UAS-057T	1927	2036	1910	<1	3	16	At Mound Facility
UAS-058T	1928	2037	1911	<1	3	16	At Mound Facility
UAS-059T	1929	2038	1912	<1	3	16	At Mound Facility
UAS-060T	1930	2039	1913	<1	3	16	At Mound Facility
UAS-061T	1931	2040	1914	<1	3	16	At Mound Facility
UAS-062T	1932	2041	1915	<1	3	16	At Mound Facility

TABLE IV-37
END-OF-LIFE UNITS FOR MF

<u>Clad</u>	<u>Strength Member</u>	<u>Liner</u>	<u>Weight Gain on Filling (g)</u>
LASL-76	1817	1681	0.024
LASL-77	1818	1682	0.024
LASL-78	1819	1683	0.024
LASL-79	1820	1684	0.026
LASL-80	1821	1685	0.026
			<hr/>
			0.025 ^a
			±0.001
LASL-81	1822	1709	0.025
LASL-82	1823	1710	0.025
LASL-83	1827	1711	0.023
LASL-84	1828	1712	0.021
LASL-85	1829	1713	0.023
			<hr/>
			0.023 ^b
			±0.002
-	1859	1780	0.023
-	1860	1781	0.027
-	1899	1783	0.031
			<hr/>
			0.027 ^a
			±0.004
UAS-055T	2034	1908	0.024
UAS-056T	2035	1909	0.024
UAS-057T	2036	1910	0.024
UAS-058T	2037	1911	0.022
UAS-059T	2038	1912	0.021
UAS-060T	2039	1913	0.028
UAS-061T	2040	1914	0.025
UAS-062T	2041	1915	0.022
			<hr/>
			0.024 ^a
			±0.002

^aFilled with helium at 1250 psi and sealed at strength member cap.

^bFilled with helium at 1245 psi and sealed at liner cap.

TABLE IV-38
PRESSURE BURST-TEST CAPSULES 1-20

ID Numbers			Weldbox Atmosphere (ppm)			He Leak Rate (cm ³ /s x 10 ⁻⁴)	Radiography	Disposition/Comments
Capsule ^a	Body	Pellet	O ₂	H ₂ O	N ₂			
LASL-01	1906	1F	2	3	155	<1	OK	Sectioned, good weld
LASL-02	1902	8F	1	3	155	-	-	Sectioned, weld off center, reuse pellet in LASL-036
LASL-03	1903	9F	1	3	105	-	-	Sectioned, incomplete weld
LASL-04	1904	10F	1	3	105	<1	-	Sectioned, good weld
LASL-05	1905	11F	1	3	94	<1	OK	Body marked by collet
LASL-06	1907	12F	1	3	122	<1	OK	Body marked by collet
LASL-07	1908	14F	1	3	104	<1	OK	Body marked by collet
LASL-08	1909	16F	1	3	99	<1	-	Body marked by collet
LASL-09	1910	17F	1	3	117	<1	OK	Body marked by collet
LASL-10	1911	19F	3	3	146	<1	OK	Body marked by collet
LASL-11	1912	20F	2	3	146	<1	OK	Body marked by collet
LASL-12	1913	21F	2	3	146	<1	OK	Body marked by collet
LASL-13	1914	23F	2	3	146	<1	-	Sectioned, good weld
LASL-14	1916	25F	3	2	100	<2	-	Sectioned, incomplete weld
LASL-15	1917	26F	10	2	144	<10	OK	Sectioned, good weld, reuse pellet in LASL-38
LASL-16	1918	66F	<1	3	18	<1	OK	
LASL-17	1919	80F	<1	2	18	<1	OK	At Mound Facility
LASL-18	1920	81F	<1	2	17	<1	OK	At Mound Facility
LASL-19	1921	82F	<1	2	16	<1	OK	At Mound Facility
LASL-20	1922	83F	<1	2	16	<1	OK	At Mound Facility

^aCapsule number is the same as the lid number.

TABLE IV-39
PRESSURE BURST-TEST CAPSULES 21-40

ID Numbers			Weldbox Atmosphere (ppm)			He Leak Rate (cm ³ /s x 10 ⁻⁴)	Radiography	Disposition/Comments
Capsule ^a	Body	Pellet	O ₂	H ₂ O	N ₂			
LASL-21	1923	84f	<1	2	16	<1	OK	At Mound Facility
LASL-22	1924	85f	<1	2	16	<1	OK	At Mound Facility
LASL-23	1925	86f	<1	2	16	<1	OK	At Mound Facility
LASL-24	1926	87f	<1	2	16	<1	OK	At Mound Facility
LASL-25	1927	88f	<1	2	16	<1	OK	At Mound Facility
LASL-26	1928	002	<1	2	16	<1	OK	At Mound Facility
LASL-27	1929	003	<1	2	16	<1	OK	At Mound Facility
LASL-28	1930	006	<1	2	16	<1	OK	At Mound Facility
LASL-29	1931	007	<1	2	16	<1	OK	At Mound Facility
LASL-30	1932	008	<1	2	16	<1	OK	At Mound Facility
LASL-31	1933	009	<1	2	12	<1	OK	At Mound Facility
LASL-32	1948	082	<1	2	12	<1	OK	At Mound Facility
LASL-33	1949	081	<1	2	12	<1	OK	At Mound Facility
LASL-34	1950	083	<1	2	12	<1	OK	At Mound Facility
LASL-35	1951	084	<1	2	12	<1	OK	At Mound Facility
LASL-36	1952	8f	<1	2	21	<1	-	Sectioned, good weld
LASL-37	1953	25f	<1	2	16	<1	-	Sectioned, good weld
LASL-38	1954	26f	<1	2	12	<1	-	Sectioned, good weld
LASL-39	1947	080	<1	2	12	<1	OK	At Mound Facility
LASL-40	1934	010	<1	2	12	<1	OK	At Mound Facility

^aCapsule number is the same as the lid number.

TABLE IV-40
PRESSURE BURST-TEST CAPSULES 41-60

ID Numbers			Weldbox Atmosphere (ppm)			He Leak Rate (cm ² /s x 10 ⁻⁴)	Radiography	Disposition/Comments
Capsule ^a	Body	Pellet	O ₂	H ₂ O	N ₂			
LASL-41	1935	011	1	2	12	<1	Incomplete	Radiography questionable, sectioned, weld OK
LASL-42	1936	012	1	2	12	<1	OK	At Mound facility
LASL-43	1937	013	1	2	12	-	-	Lid tipped during weld, lost capsule
LASL-44	1938	014	1	2	12	<1	OK	At Mound facility
LASL-45	1939	015	<1	2	12	<1	OK	At Mound facility
LASL-46	1940	016	<1	2	12	<1	OK	At Mound facility
LASL-47	1942	076	<1	2	12	<1	OK	At Mound facility
LASL-48	1944	077	<1	2	12	<1	OK	At Mound facility
LASL-49	1945	078	<1	2	12	<1	OK	At Mound facility
LASL-50	1946	079	<1	2	12	<1	OK	At Mound facility
LASL-116	2226	S-20	<1	4	14	<1	OK	At Mound facility
LASL-117	2206	S-01	<1	3	6	<1	OK	At Mound facility
LASL-118	2207	S-02	<1	3	6	<1	OK	At Mound facility
LASL-119	2208	S-03	<1	3	6	<1	OK	At Mound facility
LASL-120	2209	S-04	<1	3	6	<1	OK	At Mound facility
LASL-121	2210	S-05	<1	3	6	<1	OK	At Mound facility
LASL-122	2211	S-06	<1	3	6	<1	OK	At Mound facility
LASL-123	2212	S-07	<1	3	6	<1	OK	At Mound facility
LASL-124	2213	S-08	<1	3	6	<1	OK	At Mound facility
LASL-125	2214	S-09	<1	3	6	<1	OK	At Mound facility

^aCapsule number is the same as the lid number.

TABLE IV-41
PRESSURE BURST-TEST CAPSULES 61-71

ID Numbers			Weldbox Atmosphere (ppm)			He Leak Rate (cm ³ /s x 10 ⁻¹¹)	Radiography	Disposition/Comments
Capsule ^a	Body	Pellet	O ₂	H ₂ O	N ₂			
LASL-126	2215	S-10	<1	3	6	<1	OK	At Mound Facility
LASL-127	2227	S-21	<1	4	14	<1	OK	At Mound Facility
LASL-128	2216	S-11	<1	3	6	<1	OK	At Mound Facility
LASL-129	2217	S-12	<1	3	6	<1	OK	At Mound Facility
LASL-130	2219	S-13	<1	4	14	<1	OK	At Mound Facility
LASL-131	2220	S-14	<1	4	14	<1	OK	At Mound Facility
LASL-132	2221	S-15	<1	4	14	<1	OK	At Mound Facility
LASL-133	2222	S-16	<1	4	14	<1	OK	At Mound Facility
LASL-134	2223	S-17	<1	4	14	<1	OK	At Mound Facility
LASL-135	2224	S-18	<1	4	14	<1	OK	At Mound Facility
LASL-137	2225	S-19	<1	4	14	<1	OK	At Mound Facility

^aCapsule number is the same as the lid number.

The liners were encapsulated in strength members and then heated for 1 h at 1350°C in vacuum. The capsules were then sectioned and examined. No evidence of fuel/liner reaction or weld degradation was observed for either capsule. Data for these compatibility capsules are listed in Table IV-42.

TABLE IV-42
SIMULANT COMPATIBILITY TEST CAPSULES

<u>SM ID No.</u>		<u>Liner ID No.</u>			<u>Fuel</u>		<u>Dopant</u>
<u>Cap</u>	<u>Body</u>	<u>Cap</u>	<u>Body</u>	<u>Shim</u>	<u>UO₂</u> <u>(g)</u>	<u>Y</u> <u>(g)</u>	
2110	2155	1941	1950	1683	5.00	0.60	1.2 mg glass
2112	2156	1942	1951	1684	5.00	0.60	0.3 mg polyethylene

V. DESTRUCTIVE TESTING

A. Impact Tests

During the first half of FY 1981, seven heat sources (two Los Alamos 4.0-W units, three Los Alamos 4.5-W units, and two surveillance units made at MF) were impacted at 150 m/s and 450°C. As reported previously,³ all seven units survived the impact test. The data for all MWG heat sources impacted at Los Alamos are summarized in Table V-1. During the second half of FY 1981, the detailed analyses of these seven units were completed.

1. Los Alamos 4.0 W. Photomicrographs for heat source LASL-71 are shown in Figs. V-1 and V-2. Hardness numbers, plotted as a function of position are shown for the liner in Fig. V-3 and for the strength member in Fig. V-4. Photomicrographs for LASL-72 are shown in Figs. V-5 and V-6. Hardness numbers for LASL-72, plotted as a function of position, are shown for the liner in Fig. V-7 and the strength member in Fig. V-8.

2. Los Alamos 4.5 W. Photomicrographs for heat source UAS-010T are shown in Figs. V-9 and V-10. Hardness numbers for UAS-010T, as a function of position, are shown for the liner in Fig. V-11 and for the strength member in Fig. V-12. Photomicrographs for heat source UAS-011T are shown in Figs. V-13 and V-14. Hardness numbers for UAS-011T, as a function of position, are shown for the liner in Fig. V-15 and the strength member in Fig. V-16. Photomicrographs for UAS-013T are shown in Figs. V-17 and V-18. Hardness numbers for UAS-013T, as a

TABLE V-1
IMPACT TEST RESULTS

ID Number	Type	Impact Velocity m/s	Percent Diametral Strain		Results		Comments
			Height	Width	Clad	SM ^a	
MAD-801	2893	150	25.0	17.1	Breach	Intact	Used for Los Alamos start-up test
MAD-802	2893	148	26.2	16.4	Breach	Intact	Used for Los Alamos start-up test
MAD-804	2893	150	25.6	14.0	Breach	Intact	Used for Los Alamos start-up test
WYMT-01	Simulant	149	25.0	17.1	Breach	Intact	Used for Los Alamos start-up test
MAD-026	2893	149	25.1	15.6	Breach	Intact	Surveillance test (liner failed)
MAD-128	2893	148	24.5	15.7	Breach	Intact	Surveillance test (liner failed)
LASL-71	2893A	151	23.8	15.4	Breach	Intact	Los Alamos 4.0-watt test unit
LASL-72	2893A	151	25.6	16.8	Breach	Intact	Los Alamos 4.0-watt test unit
UAS-010T	3599	150	23.8	17.4	Breach	Intact	Los Alamos 4.5-watt test unit
UAS-011T	3599	150	23.7	16.1	Breach	Intact	Los Alamos 4.5-watt test unit
UAS-013T	3599	150	27.0	18.9	Breach	Intact	Los Alamos 4.5-watt test unit
UAS0006	3599	150	27.1	17.7	Breach	Intact	Los Alamos TMS 4.5-watt unit
			25.2	16.5			
			± 1.2	± 1.3			

^aSM = strength member.

Fig. V-1. Cross section of LASL-71 after impact showing liner inside strength member, AP, 4- $\frac{1}{2}$ X.

Fig. V-2. Dome of LASL-71, after impact, AE, 50X.

Fig. V-3. Hardness data for LASL-71, liner.

Fig. V-4. Hardness data for LASL-71, strength member.

Fig. V-5. Cross section of LASL-72 after impact, showing liner inside strength member, AP, 4- $\frac{1}{2}$ X.

Fig. V-6. Dome of LASL-72, after impact, AE, 50X.

Fig. V-7. Hardness data for LASL-72, liner.

Fig. V-8. Hardness data for LASL-72, strength member.

Fig. V-9. Cross section of UAS-010T after impact, showing liner inside strength member, AP, $4\frac{1}{2}X$.

Fig. V-10. Dome of UAS-010T, after impact, AE, 50X.

Fig. V-11. Hardness data for UAS-010T, liner.

Fig. V-12. Hardness data for UAS-010T, strength member.

Fig. V-13. Cross section of UAS-011T after impact, showing liner inside strength member, AP, $4\frac{1}{2}X$.

Fig. V-14. Dome of UAS-011T, after impact, AE, 50X.

Fig. V-15. Hardness data for UAS-011T, liner.

Fig. V-16. Hardness data for UAS-011T, strength member.

Fig. V-17. Cross section of UAS-013T after impact, showing liner inside strength member, AP, 4- $\frac{1}{2}$ X.

Fig. V-18. Dome of UAS-013T, after impact, AE, 50X.

function of position, are shown for the liner in Fig. V-19 and the strength member Fig. V-20.

3. Surveillance Units. Photomicrographs for MF unit MAD-026-J77 are shown in Figs. V-21 through V-23. Hardness numbers for MAD-026-J77 are shown for the liner in Fig. V-24 and the strength member in Fig. V-25. Photomicrographs for MAD-128-K77 are shown in Figs. V-26 through V-28. Hardness numbers are shown for the liner in Fig. V-29 and the strength member in Fig. V-30. The strength member welds remained intact but the liner welds failed. This is the first instance of liner welds failing in an impact test at Los Alamos. The failure may be due to the presence of aluminum and plutonium found in the grain boundaries of the weld area by means of microprobe analyses.

B. Compatibility Tests

Twelve Los Alamos 4.0-W heat sources (see Table IV-28) were placed in test on January 26, 1981, four each at 600, 900, and 1100°C. After 60 days, one heat source heated at each temperature was removed from the furnace and examined.

1. 600°C Test. Heat source LASL-56 was examined after 60 days at 600°C. No reaction was noted between the liner and the fuel. Hardness numbers for LASL-56, plotted as a function of position, are shown for the liner in Fig. V-31 and for the strength member in Fig. V-32.

2. 900°C Test. Heat source LASL-64 was examined after 60 days at 900°C. The Hastelloy C outer clad was shiny and was stuck lightly both to the Hastelloy X outer can and to the T-111 strength member. There was no apparent reaction between the liner and the fuel. However, the photomicrographs in Figs. V-33 and V-34 indicate that cracks did form in the liner. Hardness numbers are shown for the liner in Fig. V-35 and for the strength member in Fig. V-36. The hardness data indicate no appreciable degradation of the strength member.

3. 1100°C Test. Heat source LASL-67 was examined after 60 days at 1100°C. The Hastelloy C clad was darkened as if oxidized, suggesting that the weld on the Hastelloy X outer can may have leaked. As shown in Fig. V-37, this was an apparent transfer of material from the outer clad to the strength member. This was confirmed by microprobe analyses and has also been observed at MF.* The micrograph for the liner is shown in Fig. V-38. Hardness data are shown for the liner in Fig. V-39 and for the strength member in Fig. V-40. No reaction was

*P. Teaney, Mound Facility, Personal Communication, June 1981.

Fig. V-19. Hardness data for UAS-013T, liner.

Fig. V-20. Hardness data for UAS-013T, strength member.

Fig. V-21. Liner weld for MAD-026-J77, after impact, 10X.

Fig. V-22. Cross section of MAD-026-J77, after impact, showing liner inside strength member, AP, 4- $\frac{1}{2}$ X.

Fig. V-23. Dome of MAD-026-J77, after impact, AE, 50X.

Fig. V-24. Hardness data for MAD-026-J77, liner.

Fig. V-25. Hardness data for MAD-026-J77, strength member.

Fig. V-26. Liner weld for MAD-128-K77, after impact, 10X.

Fig. V-27. Cross section for MAD-128-K77, after impact, showing liner inside strength member, AP, 4- $\frac{1}{2}$ X.

Fig. V-28. Liner weld for MAD-128-K77, after impact,
AE, 50X.

Fig. V-29. Hardness data for MAD-128-K77, liner.

Fig. V-30. Hardness data for MAD-128-K77, strength member.

Fig. V-31. Hardness data for LASL-56, liner.

Fig. V-32. Hardness data for LASL-56, strength member.

Fig. V-33. Cross section of liner for LASL-64 after 60 days at 900°C, AP, 4-½.

Fig. V-34. Liner for LASL-64 after 60 days at 900°C, AE, 100X.

Fig. V-35. Hardness data for LASL-64, liner.

Fig. V-36. Hardness data for LASL-64, strength member.

Fig. V-37. Strength member for LASL-67 after 60 days 1100°C, 2X. Nonheated strength member on right.

Fig. V-38. Cross section of liner for LASL-67 after 60 days at 1100°C, AP, 4- $\frac{1}{2}$.

Fig. V-39. Hardness data for LASL-67, 1iner.

Fig. V-40. Hardness data for LASL-67, strength member.

apparent between the liner and the fuel, but hardness numbers in the dome area were high for both the liner and the strength member. The increased hardness of the liner is probably due to the liner picking up oxygen from the fuel. The increased hardness of the strength member is believed to be due to nitrogen diffusing through both the Hastelloy X outer can and the Hastelloy C clad. This nitrogen diffusion at 1100°C has also been observed at MF.*

C. TMS Heat Sources

The Los Alamos TMS lot consisted of 15 MC 3599 heat sources fabricated using the Los Alamos TMS fuel lot 64. Two of the heat sources, selected at random by SNLA personnel, were sectioned and examined, one of them after first being impacted.

1. Example Welds. As part of TMS, one welded liner (1952), two welded strength members (2070 and 2084), and two welded clads (1933 and 1946) were sectioned and examined as example weld units. The photomicrograph for the liner, 1952, is shown in Fig. V-41. The photomicrograph for strength member 2070 is shown in Fig. V-42 and that for clad 1946 is shown in Fig. V-43. Hardness data for all five example welds are presented in Fig. V-44. These data indicate excellent welds.

2. Impacted Capsule. Heat source UAS0006 was impacted side-on at 150 m/s and 590°C. The impact results are summarized above in Table V-1. Macrographs for the impacted capsule are shown in Figs. V-45 through V-48. Hardness data for the liner are shown in Fig. V-49, those for the strength member in Fig. V-50.

3. Nonimpacted Capsule. Heat source UAS0015 was sectioned without being impacted. The macrograph for the liner is shown in Fig. V-51, that for the strength member is Fig. V-52. Hardness data for the liner are shown in Fig. V-53, those for the strength member in Fig. V-54.

D. Analyses of Test Units

Fourteen heat sources have been sectioned and analyzed for oxygen and nitrogen contents, the amount of <20- μ m PuO₂ fines, and for hardness. Seven of these heat sources were MC 2893 units made at MF, five for tests at Los Alamos during startup, and two surveillance units. Two of the seven Los Alamos heat sources were MC 2893A units, the remainder were MC 3599 units. Two of the MC 3599 units were from the Los Alamos TMS lot. Overall, the analytical data are similar for units made at MF and at Los Alamos and indicate that Los Alamos is

Fig. V-41. Cross section of TMS example-weld liner 1952, AP, 4-1/2X.

Fig. V-42. Cross section of TMS example-weld strength member 2070, AP, 4-1/2X.

Fig. V-43. Cross section of IMN example-weld clad
1946, AP, 4-1/2X.

Fig. V-44. Hardness data for Los Alamos TMS example welds.

Fig. V-45. Impact face of UAS0006 (TMS) after impact, 2X, simulant capsule WYMT-02 on right.

Fig. V-46. UAS0006 (TMS) after impact, 90° to impact face, 2X, simulant capsule WYMT-02 on right.

Fig. V-47. Cross section of UAS0006 (TMS) after impact, showing liner inside strength member, AP, 4- $\frac{1}{2}$ X.

Fig. V-48. Dome of UAS0006 (TMS) after impact, AE, 100X.

Fig. V-49. Hardness data for UAS0006 (TMS), liner.

Fig. V-50. Hardness data for UAS0006 (TMS), strength member.

Fig. V-51. Cross section of liner for UAS0015 (TMS), AP, 4- $\frac{1}{2}$ X.

Fig. V-52. Cross section of strength member for UAS0015 (TMS), AP, 4- $\frac{1}{2}$ X.

Fig. V-53. Hardness data for UAS0015 (TMS), liner.

Fig. V-54. Hardness data for UAS0015, strength member.

making units equivalent to the WR units made at MF. The results for the analyses are listed in Table V-2 (oxygen), V-3 (nitrogen), V-4 (PuO₂ fines), and V-5 (hardness).

In addition, three Los Alamos MC 2893A heat sources were analyzed after being in test for 60 days, one each at 600, 900, and 1100°C. The data for these units are compared in Table V-6 to the averages obtained for the seven Los Alamos units and listed in Tables V-2 through V-5.

VI. QUALITY ASSURANCE

A. Drawings

A block of Los Alamos Drawing numbers, 26Y-318000 to 26Y-318199, has been allocated for use with the MWG Project. To date, seven drawings have been generated at Los Alamos. These are as follows.

26Y-318000, "Material Specifications for Plutonium-238 Dioxide Particles,
MC 2893A, MC 3599 Heat Sources"

26Y-318001, "Product Acceptance Specification, MC 2893A"

26Y-318002, "Product Acceptance Specification, MC 3599"

26Y-318020, "MC 2893A Heat Source"

26Y-318021, "Heat Source - Subassembly (MC 2893A)"

26Y-318160, "MC 3599 Heat Source"

26Y-318161, "Heat Source - Subassembly (MC 3599)"

B. Documents and Procedures

To date, more than 90 QA documents and procedures have been written and approved. Those dealing specifically with MWG production and inspection are listed above in Fig. II-1. Those not listed in the flow chart consist of planning documents and procedures related to such "housekeeping" chores as glovebox maintenance and the packaging and shipment of residues.

VII. MEETINGS

On April 9, 1981, R. T. Jankowski and T. J. Young (SNLA) visited Los Alamos.

On May 21, 1981, R. T. Jankowski, T. J. Young, P. Syroid, and R. Pacheco (SNLA) visited Los Alamos.

On June 11, 1981, a MWG Review Meeting was held at SNLA. Los Alamos attendees were W. A. Stark, Jr., G. H. Rinehart, C. C. Land, J. A. Pattillo, J. H. Kottmann, and R. A. Kent.

On June 18, 1981, P. Syroid (SNLA) visited Los Alamos.

On June 19, 1981, R. T. Jankowski, T. J. Young, and W. J. Kass (SNLA) visited Los Alamos.

TABLE V-2
OXYGEN ANALYSES FOR SECTIONED MWG HEAT SOURCES
(ppm by weight)

ID Number	Type	Liner			Strength Member			Comments
		Body	Dome	Weld	Body	Dome	Weld	
MAD-800	2893	350	180	35	35	30	35	MF WR test unit
MAD-801 ^a	2893	110	680	30	20	20	35	MF WR test unit
MAD-802 ^a	2893	120	180	40	30	25	30	MF WR test unit
MAD-804 ^a	2893	120	240	35	20	30	20	MF WR test unit
MAD-805 ^a	2893	90	190	70	35	35	40	MF WR test unit
MAD-026 ^a	2893	100	180	55	30	45	45	MF WR surveillance unit
MAD-128 ^a	2893	140	130	96	20	25	30	MF WR surveillance unit
		159	254	51	27	30	34	
LASL-71 ^a	2893A	10	9	29	9	8	17	Los Alamos impact test unit
LASL-72 ^a	2893A	10	20	35	15	20	25	Los Alamos impact test unit
UAS-010T ^a	3599	11	11	18	9	9	18	Los Alamos impact test unit
UAS-011T ^a	3599	30	15	45	15	15	25	Los Alamos impact test unit
UAS-013T ^a	3599	20	10	25	15	15	20	Los Alamos impact test unit
UAS0006 ^a	3599	<10	25	20	15	<10	30	Los Alamos TMS unit
UAS0015	3599	<10	20	<10	20	15	<10	Los Alamos TMS unit
		14	16	26	14	13	21	

^aImpact tested prior to sectioning.

TABLE V-3
NITROGEN ANALYSES FOR SECTIONED MWG HEAT SOURCES

(ppm by weight)

ID Number	Type	Liner			Strength Member			Comments
		Body	Dome	Weld	Body	Dome	Weld	
MAD-800	2893	130	155	105	70	65	55	MF WR test unit
MAD-801 ^a	2893	45	50	55	42	27	33	MF WR test unit
MAD-802 ^a	2893	25	20	45	25	25	25	MF WR test unit
MAD-804 ^a	2893	40	-	35	30	25	30	MF WR test unit
MAD-805	2893	30	25	20	60	45	15	MF WR test unit
MAD-026 ^a	2893	-	-	-	-	-	-	MF WR surveillance unit
MAD-128 ^a	2893	-	-	-	-	-	-	MF WR surveillance unit
		54	63	52	45	37	32	
LASL-71 ^a	2893A	10	9	29	9	8	17	Los Alamos impact test unit
LASL-72 ^a	2893A	10	20	35	15	20	25	Los Alamos impact test unit
UAS-010T ^a	3599	11	11	18	9	9	18	Los Alamos impact test unit
UAS-011T ^a	3599	30	15	45	15	15	25	Los Alamos impact test unit
UAS-013T ^a	3599	20	10	25	15	15	20	Los Alamos impact test unit
UAS0006 ^a	3599	<10	25	20	15	<10	30	Los Alamos TMS unit
UAS0015	3599	<10	20	<10	20	15	<10	Los Alamos TMS unit
		14	16	26	14	13	21	

^aImpact tested prior to sectioning.

TABLE V-4
FINES CONTENT FOR SECTIONED
MWG HEAT SOURCES

<u>ID Number</u>	<u>Type</u>	<u><20-μm PuO₂ Fines (g)</u>		<u>Comments</u>
		<u>Not Impacted</u>	<u>Impacted</u>	
MAD-800	2893	0.03		MF WR test unit
MAD-801	2893		3.56	MF WR test unit
MAD-802	2893		3.19	MF WR test unit
MAD-804	2893		3.81	MF WR test unit
MAD-805	2893	0.11		MF WR test unit
MAD-026	2893		3.40	MF WR surveillance unit
MAD-128	2893		3.63	MF WR surveillance unit
		<u>0.07</u>	<u>3.52</u>	
LASL-71	2893A		2.57	Los Alamos test unit
LASL-72	2893A		2.01	Los Alamos test unit
UAS-010T	3599		2.93	Los Alamos test unit
UAS-011T	3599		2.07	Los Alamos test unit
UAS-013T	3599		2.71	Los Alamos test unit
UAS0006	3599		2.76	Los Alamos TMS unit
UAS0015	3599	<u>0.14</u>		Los Alamos TMS unit
		<u>0.14</u>	<u>2.51</u>	

TABLE V-5

AVERAGE HARDNESS FOR SECTIONED MWG HEAT SOURCES

(VHN)

ID Number	Type	Liner			Strength Member			Comments
		Body	Dome	Weld	Body	Dome	Weld	
MAD-800	2893	254	251	243	244	251	242	MF WR test unit
MAD-801 ^a	2893	263	270	259	256	262	262	MF WR test unit
MAD-802 ^a	2893	259	260	263	268	263	262	MF WR test unit
MAD-804	2893	254	264	245	256	276	255	MF WR test unit
MAD-805	2893	269	267	259	245	250	245	MF WR test unit
MAD-026 ^a	2893	269	265	258	261	262	257	MF WR surveillance unit
MAD-128	2893	280	267	284	268	257	278	MF WR surveillance unit
		264	263	259	255	262	257	
LASL-71 ^a	2893A	246	227	244	217	236	224	Los Alamos impact test unit
LASL-72 ^a	2893A	285	263	280	265	243	285	Los Alamos impact test unit
UAS-010T ^a	3599	260	267	256	245	262	265	Los Alamos impact test unit
UAS-011T ^a	3599	240	242	223	227	239	219	Los Alamos impact test unit
UAS-013T ^a	3599	272	273	264	251	263	265	Los Alamos impact test unit
UAS0006 ^a	3599	268	275	253	249	274	268	Los Alamos TMS unit
UAS0015	3599	242	254	254	262	259	254	Los Alamos TMS unit
		259	257	253	245	254	254	

^aImpact tested prior to sectioning.

TABLE V-6
ANALYTICAL DATA FOR LOS ALAMOS COMPATIBILITY
UNITS AFTER 60 DAYS

<u>Measurement</u>	<u>Capsule ID and Test Temperature</u>			<u>Av for other Los Alamos Test Units</u>
	<u>LASL-56 600°C</u>	<u>LASL-64 900°C</u>	<u>LASL-67 1100°C</u>	
<u>Oxygen (ppm by weight)</u>				
Liner Body	90	770	3800	14
Liner Dome	240	2000	3800	16
Liner Weld	95	100	1100	26
SM ^a Body	45	60	60	14
SM Dome	65	60	50	13
SM Weld	45	50	110	21
<u>Nitrogen (ppm by weight)</u>				
Liner Body	11	12	20	14
Liner Dome	10	11	18	16
Liner Weld	35	34	24	26
SM Body	13	30	1022	14
SM Dome	13	45	32	13
SM Weld	20	32	535	21
<u>Hardness (VHN)</u>				
Liner Body	256	659	248	259
Liner Dome	287	826	253	257
Liner Weld	252	262	264	253
SM Body	254	350	334	245
SM Dome	248	375	300	254
SM Weld	260	249	288	254

^aSM = strength member.

On July 1, 1981, R. T. Jankowski, W. J. Kass, R. Harnar, and R. Pacheco (SNLA) officially initiated TMS overchecking activities at Los Alamos.

On July 23-24, 1981, R. T. Jankowski, W. J. Kass, R. Harnar, and R. Pacheco (SNLA) observed TMS activities at Los Alamos.

On August 6, 1981, R. T. Jankowski and R. Harnar (SNLA) observed TMS activities at Los Alamos.

On August 24, 1981, R. T. Jankowski and R. Harnar (SNLA) observed TMS activities at Los Alamos.

REFERENCES

1. "Milliwatt Generator Project, October 1979-April 1980," Los Alamos Scientific Laboratory report LA-8406-PR (June 1980).
2. "Milliwatt Generator Project, April-September 1980," Los Alamos Scientific Laboratory report LA-8673-PR (January 1981).
3. "Milliwatt Generator Project, October 1980-March 1981," Los Alamos National Laboratory report LA-8881-PR (June 1981).