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Lightweight Radioisotope Heater Unit (LWRHU) Production for the Cassini Mission

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by

G. H. Rinehart

ABSTRACT

The LWRHU is a $^{238}PuO_2$ fueled heat source designed to provide a ther.mal watt of power for space missions. The LWRHU will be used to maintain the temperature of various components on the spacecraft at the required level. The heat source consists of a $^{238}PuO_2$ fuel pellet, a Pt-30Rh capsule, a pyrolytic graphite insulator, and a woven graphite aeroshell assembly. Los Alamos has fabricated 180 heater units, which will be used on the Cassini mission. This report summarizes the specifications, fabrication processes, and production data for the heat sources fabricated at Los Alamos.

I. INTRODUCTION

The LWRHU is a $^{238}PuO_2$ fueled heat source designed to provide one thermal watt in each of various locations on a spacecraft. The heat sources are required to maintain the temperature of specific conponents within normal operating ranges. Los Alamos National Laboratory was responsible for the design, fabrication, and safety testing of the LWRHU. The heat source consists of a hot-pressed $^{238}PuO_2$ fuel pellet, a Pt-30Rh vented capsule, a pyrolytic graphite (PG) insulator, and a FINE-WEAVE-PIERCED ™ Fabric (FWPF) graphite aeroshell assembly. The heat source assembly is shown in Figure 1. The design of the LWRHU has been described by Tate (Ref. 1). The LWRHU specifications and construction drawings are presented in Appendices I and II, respectively. This report describes the fabrication and the production data for the 180 heat sources that were delivered to the Kennedy Space Center. The production effort included processing the raw PuO_2 feed material from the Savannah River Site (SRS), hot pressing the fuel pellets, encapsulating the pellets in a Pt-30Rh alloy, placing the fueled clads in the aeroshell assemblies, and performing all the associated nondestructive testing (NDT) activities.

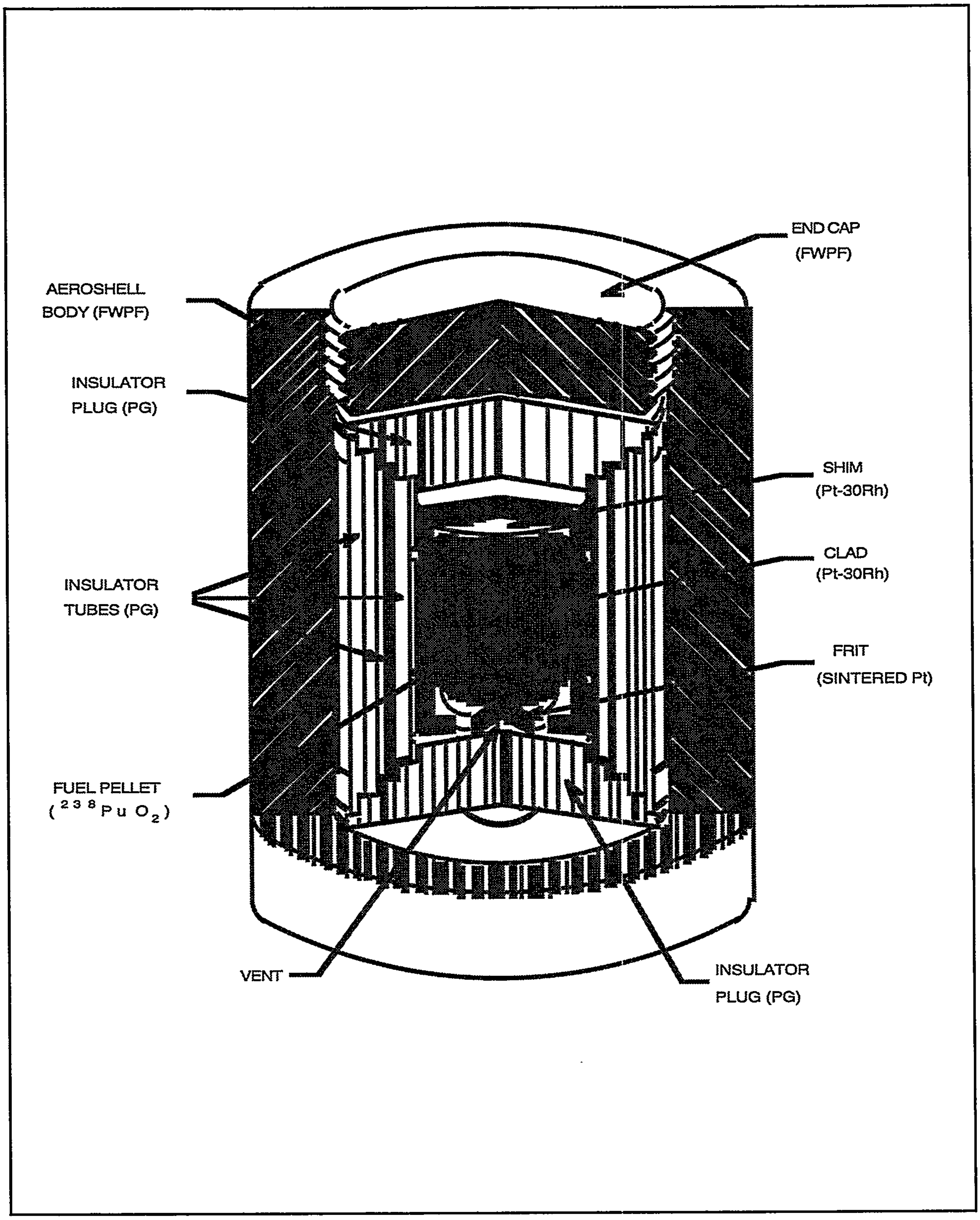


Figure 1. The LWRHU

II. FUEL PROCESSING AND CHARACTERIZATION

A. Fuel Processing

The LWRHU fuel processing flow sheet is shown in Figure 2. Five lots of feed powder, 898 g, from SRS were processed for the LWRHU production effort. The processing yielded 807 g of seasoned granules.

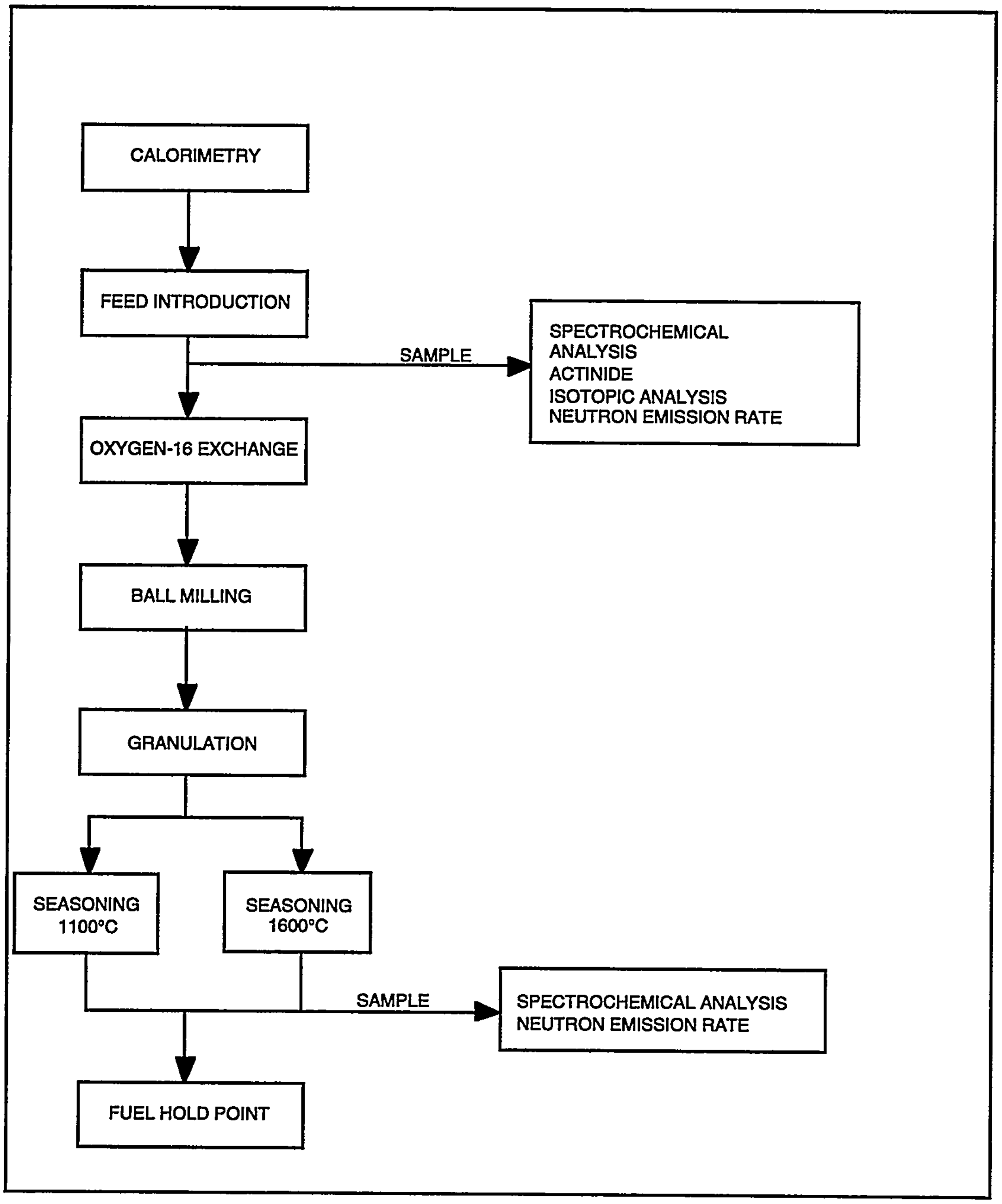


Figure 2. LWRHU Fuel Processing Flow Sheet

B. Fuel Characterization

1. Neutron Emission Data. Neutron emission rate data for the feed lots are listed in Table I. The as-received SRS feed powder had an average neutron emission rate of 15010 n/s-g ± 3040 n/s-g ^{238}Pu. After ^{16}O exchange and other processing, the average neutron emission rate of the fuel granules was 4820 n/s-g ± 1740 n/s-g ^{238}Pu. Fuel lot 285 did not meet the specification of ≤ 6000 n/s-g ^{238}Pu after processing, but the neutron emission rate was expected to drop significantly during pellet fabrication.

TABLE I

NEUTRON EMISSION RATE DATA FOR FUEL LOTS

Fuel Lot ID		Neutron Emission Rate ($ns^{-1}g^{-1}$ ^{238}Pu)	
Los Alamos	SRS	As Received	Processed
272	HB8-07-01	13210	4530
274	HB8-07-02	NA	3920
275	HB8-08-02	13200	4030
285	HB8-16-01AB	19520	6460
286	HB8-13-01	14110	5150
Average		15010 ± 3040	4820 ± 1040

2. Spectrochemical Data. The spectrochemical results for the five as-received SRS feed lots are compared to the impurity levels in the processed fuel granules in Tables II and III. Processed fuel granules from fuel lot 272 did not meet the nickel impurity specification of ≤ 100 ppm; the measured nickel impurity level was 105 ppm. Fuel lot 272 was mixed with other fuel lots to reduce the nickel level in fabricated pellets. Processing tended to significantly increase the aluminum and chromium impurities, but it decreased the calcium and magnesium impurities in the fuel.

3. Isotopic Data. The plutonium isotopic data for the fuel lots are listed in Table IV. The SRS isotopic data in the table have been decayed to the same dates as the Los Alamos analysis. All fuel lots met the isotopic composition specification.

4. Actinide Data. The ^{232}Th, ^{234}U, ^{236}Pu, ^{237}Np, and ^{241}Am contents of the five as-received SRS fuel lots, back-decayed to the date of precipitation at SRS, are listed in Table V. The actinide levels of all lots were well within specifications.

TABLE II

SPECTROCHEMICAL DATA FOR AS-RECEIVED FUEL LOTS FROM SRS (LOS ALAMOS ANALYSIS)

		Los Alamos Fuel Lot ID				
Species	Specification ($\mu g/g$ PuO_2)	272	274	275	285	286
Al		< 5	34	9	6	5
B		< 5	< 5	< 5	< 5	< 5
Ca		1375	1375	1375	250	1375
Cd		< 10	< 10	< 10	< 10	< 10
Cr	200	58	55	35	35	60
Cu		25	5	10	10	10
Fe	800	125	230	160	130	190
Mg		70	70	70	50	100
Mn		20	5	10	15	100
Mo		25	< 20	20	< 20	< 20
Na		< 50	< 50	< 50	< 50	< 50
Ni	100	75	63	65	38	115
Pb		10	90	25	5	20
Si	500	400	265	120	285	400
Sn		< 5	< 5	< 5	< 5	< 5
Zn		< 5	13	< 5	< 5	< 5

TABLE III

SPECTROCHEMICAL DATA FOR PROCESSED GRANULES

		Los Alamos Fuel Lot ID				
Species	Specification ($\mu g/g\ PuO_2$)	272	274	275	285	286
Al		310	< 5	50	25	28
B		< 5	< 5	< 5	< 5	< 5
Ca		250	100	75	225	150
Cd		< 10	< 10	< 10	< 10	< 10
Cr	200	140	10	100	76	81
Cu		50	8	3	138	10
Fe	800	320	115	330	295	165
Mg		25	10	25	20	25
Mn		10	5	7	20	300
Mo		< 20	< 20	< 20	20	50
Na		< 50	< 50	< 50	< 50	< 50
Ni	100	105	< 5	33	73	77
Pb		25	< 5	< 5	5	10
Si	500	150	220	185	400	325
Sn		5	< 5	10	< 5	< 5
Zn		20	< 5	< 5	5	< 5

TABLE IV

ISOTOPIC DATA FOR FUEL LOTS

		Plutonium Isotope (Atom Percent)				
Fuel Lot	Laboratory	238	239	240	241	242
272	SRS	79.41	17.45	2.63	0.27	0.23
	Los Alamos	80.06	16.78	2.63	0.28	0.24
274	SRS	79.41	17.45	2.63	0.27	0.23
	Los Alamos	80.05	16.80	2.63	0.28	0.24
275	SRS	79.22	17.62	2.65	0.28	0.24
	Los Alamos	80.04	16.80	2.64	0.29	0.24
285	SRS	80.32	16.61	2.52	0.29	0.27
	Los Alamos	80.28	16.69	2.49	0.28	0.27
286	SRS	79.98	16.88	2.55	0.30	0.29
	Los Alamos	80.12	16.79	2.52	0.29	0.28
SRS Average		79.67 ± 0.46	17.20 ± 0.43	2.60 ± 0.06	0.28 ± 0.01	0.25 ± 0.03
Los Alamos Average		80.11 ± 0.10	16.77 ± 0.05	2.58 ±0.07	0.28 ± 0.01	0.25 ± 0.02

TABLE V

ACTINIDE IMPURITIES FOR AS-RECEIVED FUEL LOTS
(μg/g Pu)

	Los Alamos Fuel Lot				
Isotope	272	274	275	285	286
^{232}Th	1700	1800	2300	2190	1845
^{234}U	300	190	1070	720	615
^{236}Pu	< 1	< 1	< 1	< 1	< 1
^{237}Np	1030	1060	1460	1500	1545
^{241}Am	46	49	71	29	36

III. HOT PRESSING AND FUEL PELLET CHARACTERIZATION

A. Hot Pressing

The fuel used to fabricate the LWRHU fuel pellets was obtained by blending the < 210 micron granules seasoned at 1100°C (60 wt%) and 1600°C (40 wt%). The blending was accomplished by placing the granules in a ball-mill jar and rolling it for 15 min ± 2 min at 20 rpm ± 2 rpm. No balls were used during the blending process. After blending was completed, the hot press graphite die was loaded with 16 fuel charges, each weighing 2.675 g ± 0.005 g.

The die assembly is shown on drawing 26Y-79818 in Appendix II. It consisted of a cylindrical insert, susceptor, locking pin, 32 punches, and 2 endcaps. The pellets were formed in 16 holes bored through the insert. The susceptor is sized to the insert and the induction coil so as to maximize heating efficiency. Seven blackbody holes in the susceptor served as targets for an optical pyrometer. The insert and susceptor were positioned relative to one another by means of the locking pin. Sixteen punches were introduced into one end of the insert, the charges were loaded, and then sixteen punches were introduced into the other end of the insert.

The Los Alamos hot press system consisted of a Materials Test Systems (MTS) hydraulic system, a vacuum system, and an induction heating system. The hydraulic system powered two main pressing servorams and three actuators. The servorams were mounted vertically and extended into the vacuum system through the axis of the induction coil. The actuators were used to raise and lower the vacuum chamber so that the die assembly could be introduced into the vacuum system. Each of the main servorams was provided with a load cell. The pressing cycle was controlled by an MTS Model 418.91 MicroProfiler programmer and the signal from the load cell located in the master servoram.

The heating system consisted of a 100 kVA motor generator and associated controls. Temperatures were measured by sighting with a Pyro Photo II automatic pyrometer through a quartz optical window into one of the blackbody holes in the susceptor.

The vacuum system consisted of a Varian 102 mm diameter Model M4 diffusion pump backed by an Alcatel Model 2033 mechanical pump. Convoil 20 was used in both pumps. The vacuum chamber pressure was measured by a thermocouple gauge and a Bayard-Alpert ion gauge.

After the graphite die was loaded with the charges, it was positioned in the center of the induction coil, the vacuum chamber was lowered, and the system was evacuated. When the vacuum chamber reached a pressure of $< 6.7 \times 10^{-3}$ Pa, a slight preload, 0.2 kN, was applied to the die. The timer was then started and the motor generator power was activated. When the temperature reached 1300°C, 15 min into the run, the programmed load cycle was initiated. When the susceptor temperature reached 1530°C, 28 min into the run, the motor generator power was adjusted to maintain a temperature of 1530°C for the remainder of the run. The full programmed load, 11.8 kN, was attained at the same time the susceptor temperature reached 1530°C. The die was held at 1530°C under full load for 30 min, although punch closure usually occurred about 15 min after the full load had been applied. At the end of the pressing cycle, the motor generator was turned off, but the full load was maintained on the die assembly. After about a 1 h cooling period, the load was removed from the die assembly, the vacuum system was backfilled with argon, and the die assembly was removed.

B. Post-Press Sintering and Dimensioning of Fuel Pellets

During hot pressing, the plutonia was reduced by the graphite die. After the pellets sat overnight, the plutonia stoichiometry was about $PuO_{1.93}$. In order to oxidize the pellets to a stoichiometry of PuO_2 and increase their density, the pellets were sintered in flowing $Ar\text{-}H_2{}^{16}O$ for 6 h at 1000°C followed by 6 h at 1527°C. Heating and cooling rates were 150°C/h. The pellets were sintered in a platinum boat filled with high-fired thoria powder to prevent stress points that could occur if the pellets were in direct contact with the platinum boat. The use of $Ar\text{-}H_2{}^{16}O$ flow gas during this process decreased the neutron emission rate of the pellets.

After sintering each pellet was weighed, and the length and diameter were measured. Tables VI-XII list the mass, length, diameter, and percent of theoretical density of each of the 224 pellets that were sintered. Three of the sintered pellets did not meet the mass specification of $2.664 \text{ g} \pm 0.030$ g, and two pellets did not meet the length specification of < 9.80 mm. These five pellets were expended for analytical samples or example welds.

TABLE VI

SINTERED PELLET DIMENSIONS FOR PELLET LOTS RU30 AND RU31

	SINTERED DIMENSIONS					
PELLET ID	DIAMETER (mm)	LENGTH (mm)	MASS (g)	THEORETICAL DENSITY (%)	MEETS SPEC?	DISPOSITION?
RU30-1	6.25	9.66	2.655	80.38	YES	FLIGHT
RU30-2	6.25	9.71	2.658	80.05	YES	FLIGHT
RU30-3	6.25	9.68	2.657	80.27	YES	FLIGHT
RU30-4	6.25	9.76	2.699	80.86	NO	EXP WELD
RU30-5	6.25	9.74	2.655	79.71	YES	FLIGHT
RU30-6	6.25	9.74	2.669	80.13	YES	FLIGHT
RU30-7	6.24	9.73	2.667	80.41	YES	FLIGHT
RU30-8	6.25	9.71	2.656	79.99	YES	FLIGHT
RU30-9	6.24	9.69	2.672	80.90	YES	FLIGHT
RU30-10	6.25	9.64	2.671	81.04	YES	FLIGHT
RU30-11	6.26	9.64	2.667	80.66	YES	FLIGHT
RU30-12	6.26	9.81	2.676	79.49	NO	EXP WELD
RU30-13	6.18	9.84	2.673	81.24	NO	SAMPLE
RU30-14	6.26	9.66	2.667	80.49	YES	FLIGHT
RU30-15	6.25	9.74	2.673	80.25	YES	FLIGHT
RU30-16	6.25	9.65	2.601	78.83	NO	EXP WELD
RU31-1	6.30	9.71	2.664	78.95	YES	FLIGHT
RU31-2	6.31	9.70	2.652	78.42	YES	FLIGHT
RU31-3	6.29	9.69	2.675	79.70	YES	FLIGHT
RU31-4	6.29	9.68	2.666	79.51	YES	FLIGHT
RU31-5	6.29	9.71	2.668	79.32	YES	FLIGHT
RU31-6	6.28	9.72	2.665	79.40	YES	FLIGHT
RU31-7	6.29	9.73	2.669	79.18	YES	SAMPLE
RU31-8	6.29	9.70	2.668	79.41	YES	FLIGHT
RU31-9	6.29	9.73	2.672	79.27	YES	FLIGHT
RU31-10	6.29	9.70	2.665	79.32	YES	FLIGHT
RU31-11	6.30	9.72	2.673	79.13	YES	FLIGHT
RU31-12	6.29	9.70	2.673	79.55	YES	FLIGHT
RU31-13	6.29	9.70	2.670	79.46	YES	FLIGHT
RU31-14	6.29	9.71	2.668	79.32	YES	FLIGHT
RU31-15	6.29	9.70	2.671	79.49	YES	FLIGHT
RU31-16	6.29	9.69	2.668	79.49	YES	FLIGHT

TABLE VII

SINTERED PELLET DIMENSIONS FOR PELLET LOTS RU32 AND RU33

	SINTERED DIMENSIONS					
PELLET ID	DIAMETER (mm)	LENGTH (mm)	MASS (g)	THEORETICAL DENSITY (%)	MEETS SPEC?	DISPOSITION?
RU32-1	6.30	9.70	2.660	78.91	YES	FLIGHT
RU32-2	6.31	9.77	2.678	78.61	YES	FLIGHT
RU32-3	6.31	9.73	2.668	78.65	YES	FLIGHT
RU32-4	6.30	9.75	2.673	78.88	YES	FLIGHT
RU32-5	6.31	9.71	2.671	78.90	YES	FLIGHT
RU32-6	6.31	9.77	2.676	78.55	YES	FLIGHT
RU32-7	6.31	9.72	2.670	78.79	YES	FLIGHT
RU32-8	6.30	9.76	2.670	78.71	YES	FLIGHT
RU32-9	6.28	9.79	2.671	79.00	YES	SAMPLE
RU32-10	6.28	9.74	2.667	79.30	YES	FLIGHT
RU32-11	6.29	9.67	2.673	79.81	YES	FLIGHT
RU32-12	6.30	9.63	2.673	79.89	YES	FLIGHT
RU32-13	6.30	9.71	2.676	79.30	YES	FLIGHT
RU32-14	6.30	9.75	2.671	78.82	YES	FLIGHT
RU32-15	6.29	9.69	2.671	79.58	YES	FLIGHT
RU32-16	6.29	9.70	2.674	79.58	YES	FLIGHT
RU33-1	6.25	9.70	2.658	80.13	YES	FLIGHT
RU33-2	6.25	9.73	2.667	80.15	YES	SAMPLE
RU33-3	6.25	9.72	2.671	80.36	YES	FLIGHT
RU33-4	6.24	9.72	2.668	80.53	YES	FLIGHT
RU33-5	6.25	9.72	2.669	80.30	YES	FLIGHT
RU33-6	6.24	9.64	2.665	81.12	YES	FLIGHT
RU33-7	6.23	9.72	2.668	80.79	YES	FLIGHT
RU33-8	6.25	9.65	2.668	80.86	YES	FLIGHT
RU33-9	6.24	9.64	2.670	81.27	YES	FLIGHT
RU33-10	6.24	9.60	2.665	81.47	YES	FLIGHT
RU33-11	6.24	9.59	2.669	81.68	YES	FLIGHT
RU33-12	6.25	9.59	2.665	81.29	YES	FLIGHT
RU33-13	6.23	9.61	2.668	81.74	YES	FLIGHT
RU33-14	6.25	9.56	2.665	81.55	YES	FLIGHT
RU33-15	6.25	9.59	2.665	81.29	YES	FLIGHT
RU33-16	6.24	9.66	2.651	80.52	YES	FLIGHT

TABLE VIII

SINTERED PELLET DIMENSIONS FOR PELLET LOTS RU34 AND RU35

	SINTERED DIMENSIONS					
PELLET ID	DIAMETER (mm)	LENGTH (mm)	MASS (g)	THEORETICAL DENSITY (%)	MEETS SPEC?	DISPOSITION?
RU34-1	6.25	9.60	2.668	81.30	YES	FLIGHT
RU34-2	6.26	9.65	2.669	80.63	YES	SAMPLE
RU34-3	6.25	9.64	2.671	81.04	YES	FLIGHT
RU34-4	6.26	9.63	2.668	80.77	YES	FLIGHT
RU34-5	6.26	9.65	2.672	80.72	YES	FLIGHT
RU34-6	6.25	9.60	2.666	81.23	YES	FLIGHT
RU34-7	6.25	9.60	2.670	81.36	YES	FLIGHT
RU34-8	6.25	9.65	2.669	80.89	YES	FLIGHT
RU34-9	6.26	9.56	2.674	81.56	YES	FLIGHT
RU34-10	6.25	9.65	2.671	80.95	YES	FLIGHT
RU34-11	6.25	9.55	2.674	81.92	YES	FLIGHT
RU34-12	6.25	9.58	2.671	81.56	YES	FLIGHT
RU34-13	6.25	9.60	2.667	81.26	YES	FLIGHT
RU34-14	6.25	9.60	2.673	81.45	YES	FLIGHT
RU34-15	6.25	9.64	2.671	81.04	YES	FLIGHT
RU34-16	6.25	9.63	2.667	81.01	YES	FLIGHT
RU35-1	6.27	9.58	2.669	80.97	YES	FLIGHT
RU35-2	6.27	9.60	2.672	80.89	YES	FLIGHT
RU35-3	6.28	9.60	2.668	80.51	YES	FLIGHT
RU35-4	6.29	9.59	2.671	80.43	YES	FLIGHT
RU35-5	6.29	9.64	2.665	79.82	YES	FLIGHT
RU35-6	6.27	9.58	2.669	80.97	YES	FLIGHT
RU35-7	6.28	9.61	2.666	80.37	YES	FLIGHT
RU35-8	6.27	9.60	2.669	80.80	YES	FLIGHT
RU35-9	6.26	9.57	2.668	81.29	YES	FLIGHT
RU35-10	6.27	9.61	2.669	80.72	YES	FLIGHT
RU35-11	6.27	9.67	2.670	80.23	YES	SAMPLE
RU35-12	6.29	9.61	2.669	80.20	YES	FLIGHT
RU35-13	6.28	9.61	2.666	80.37	YES	FLIGHT
RU35-14	6.27	9.59	2.669	80.89	YES	FLIGHT
RU35-15	6.26	9.63	2.669	80.80	YES	FLIGHT
RU35-16	6.28	9.60	2.668	80.51	YES	FLIGHT

TABLE IX

SINTERED PELLET DIMENSIONS FOR PELLET LOTS RU36 AND RU37

	SINTERED DIMENSIONS					
PELLET ID	DIAMETER (mm)	LENGTH (mm)	MASS (g)	THEORETICAL DENSITY (%)	MEETS SPEC?	DISPOSITION?
RU36-1	6.25	9.41	2.666	82.92	YES	FLIGHT
RU36-2	6.24	9.38	2.665	83.43	YES	FLIGHT
RU36-3	6.24	9.41	2.671	83.34	YES	FLIGHT
RU36-4	6.23	9.41	2.663	83.36	YES	FLIGHT
RU36-5	6.25	9.42	2.666	82.83	YES	FLIGHT
RU36-6	6.23	9.42	2.666	83.36	YES	FLIGHT
RU36-7	6.23	9.40	2.670	83.67	YES	FLIGHT
RU36-8	6.23	9.40	2.666	83.55	YES	FLIGHT
RU36-9	6.24	9.42	2.666	83.09	YES	FLIGHT
RU36-10	6.24	9.42	2.666	83.09	YES	FLIGHT
RU36-11	6.24	9.47	2.665	82.61	YES	SAMPLE
RU36-12	6.25	9.40	2.664	82.94	YES	FLIGHT
RU36-13	6.23	9.39	2.668	83.70	YES	FLIGHT
RU36-14	6.23	9.42	2.665	83.33	YES	FLIGHT
RU36-15	6.24	9.42	2.665	83.06	YES	FLIGHT
RU36-16	6.24	9.37	2.669	83.64	YES	FLIGHT
RU37-1	6.23	9.50	2.676	82.95	YES	FLIGHT
RU37-2	6.21	9.50	2.674	83.43	YES	FLIGHT
RU37-3	6.23	9.49	2.671	82.89	YES	FLIGHT
RU37-4	6.23	9.49	2.670	82.86	YES	FLIGHT
RU37-5	6.22	9.54	2.671	82.71	YES	FLIGHT
RU37-6	6.22	9.58	2.671	82.36	YES	SAMPLE
RU37-7	6.22	9.58	2.671	82.36	YES	FLIGHT
RU37-8	6.23	9.50	2.670	82.77	YES	FLIGHT
RU37-9	6.22	9.49	2.669	83.10	YES	FLIGHT
RU37-10	6.21	9.47	2.670	83.58	YES	FLIGHT
RU37-11	6.23	9.47	2.673	83.13	YES	FLIGHT
RU37-12	6.24	9.45	2.668	82.89	YES	FLIGHT
RU37-13	6.22	9.43	2.667	83.58	YES	FLIGHT
RU37-14	6.24	9.46	2.671	82.89	YES	FLIGHT
RU37-15	6.24	9.50	2.672	82.56	YES	FLIGHT
RU37-16	6.21	9.43	2.668	83.88	YES	FLIGHT

TABLE X

SINTERED PELLET DIMENSIONS FOR PELLET LOTS RU38 AND RU39

	SINTERED DIMENSIONS					
PELLET ID	DIAMETER (mm)	LENGTH (mm)	MASS (g)	THEORETICAL DENSITY (%)	MEETS SPEC?	DISPOSITION?
RU38-1	6.24	9.52	2.667	82.23	YES	FLIGHT
RU38-2	6.23	9.46	2.669	83.10	YES	FLIGHT
RU38-3	6.26	9.48	2.673	82.24	YES	FLIGHT
RU38-4	6.21	9.49	2.672	83.46	YES	FLIGHT
RU38-5	6.24	9.52	2.672	82.38	YES	FLIGHT
RU38-6	6.22	9.50	2.672	83.10	YES	FLIGHT
RU38-7	6.23	9.53	2.671	82.53	YES	FLIGHT
RU38-8	6.24	9.50	2.672	82.56	YES	FLIGHT
RU38-9	6.24	9.50	2.670	82.50	YES	FLIGHT
RU38-10	6.23	9.53	2.671	82.53	YES	FLIGHT
RU38-11	6.23	9.54	2.672	82.47	YES	FLIGHT
RU38-12	6.24	9.49	2.670	82.59	YES	FLIGHT
RU38-13	6.23	9.52	2.671	82.62	YES	FLIGHT
RU38-14	6.24	9.52	2.667	82.23	YES	FLIGHT
RU38-15	6.24	9.51	2.670	82.41	YES	FLIGHT
RU38-16	6.25	9.53	2.669	81.94	YES	SAMPLE
RU39-1	6.26	9.37	2.668	83.07	YES	FLIGHT
RU39-2	6.26	9.39	2.668	82.89	YES	FLIGHT
RU39-3	6.26	9.42	2.668	82.62	YES	FLIGHT
RU39-4	6.25	9.43	2.667	82.77	YES	FLIGHT
RU39-5	6.24	9.40	2.668	83.34	YES	FLIGHT
RU39-6	6.24	9.46	2.669	82.83	YES	FLIGHT
RU39-7	6.22	9.43	2.681	84.02	YES	SAMPLE
RU39-8	6.25	9.41	2.665	82.88	YES	FLIGHT
RU39-9	6.23	9.39	2.665	83.61	YES	FLIGHT
RU39-10	6.26	9.39	2.671	82.98	YES	FLIGHT
RU39-11	6.24	9.38	2.668	83.52	YES	FLIGHT
RU39-12	6.26	9.36	2.671	83.26	YES	FLIGHT
RU39-13	6.28	9.36	2.670	82.69	YES	FLIGHT
RU39-14	6.23	9.41	2.670	83.58	YES	FLIGHT
RU39-15	6.26	9.39	2.669	82.92	YES	FLIGHT
RU39-16	6.24	9.37	2.666	83.55	YES	FLIGHT

TABLE XI

SINTERED PELLET DIMENSIONS FOR PELLET LOTS RU40 AND RU41

	SINTERED DIMENSIONS					
PELLET ID	DIAMETER (mm)	LENGTH (mm)	MASS (g)	THEORETICAL DENSITY (%)	MEETS SPEC?	DISPOSITION?
RU40-1	6.25	9.50	2.663	82.02	YES	FLIGHT
RU40-2	6.25	9.49	2.666	82.20	YES	FLIGHT
RU40-3	6.25	9.52	2.670	82.06	YES	FLIGHT
RU40-4	6.25	9.53	2.669	81.94	YES	FLIGHT
RU40-5	6.26	9.52	2.669	81.76	YES	FLIGHT
RU40-6	6.24	9.53	2.670	82.23	YES	FLIGHT
RU40-7	6.23	9.55	2.670	82.32	YES	FLIGHT
RU40-8	6.23	9.57	2.668	82.09	YES	FLIGHT
RU40-9	6.23	9.53	2.668	82.44	YES	FLIGHT
RU40-10	6.24	9.52	2.670	82.32	YES	FLIGHT
RU40-11	6.25	9.54	2.672	81.94	YES	FLIGHT
RU40-12	6.25	9.49	2.669	82.29	YES	FLIGHT
RU40-13	6.23	9.52	2.668	82.53	YES	FLIGHT
RU40-14	6.25	9.54	2.668	81.82	YES	FLIGHT
RU40-15	6.24	9.52	2.671	82.35	YES	FLIGHT
RU40-16	6.25	9.49	2.656	81.89	YES	SAMPLE
RU41-1	6.22	9.47	2.667	83.21	YES	FLIGHT
RU41-2	6.22	9.48	2.668	83.16	YES	FLIGHT
RU41-3	6.25	9.52	2.668	82.00	YES	FLIGHT
RU41-4	6.24	9.49	2.665	82.44	YES	FLIGHT
RU41-5	6.23	9.50	2.667	82.68	YES	FLIGHT
RU41-6	6.22	9.60	2.668	82.09	YES	FLIGHT
RU41-7	6.24	9.51	2.662	82.16	YES	FLIGHT
RU41-8	6.24	9.50	2.669	82.47	YES	FLIGHT
RU41-9	6.23	9.50	2.665	82.61	YES	FLIGHT
RU41-10	6.24	9.51	2.670	82.41	YES	FLIGHT
RU41-11	6.23	9.50	2.669	82.74	YES	FLIGHT
RU41-12	6.24	9.57	2.666	81.76	YES	FLIGHT
RU41-13	6.27	9.46	2.669	82.03	YES	FLIGHT
RU41-14	6.27	9.46	2.667	81.97	YES	FLIGHT
RU41-15	6.24	9.43	2.666	83.00	YES	FLIGHT
RU41-16	6.24	9.39	2.562	80.11	NO	SAMPLE

TABLE XII

SINTERED PELLET DIMENSIONS FOR PELLET LOTS RU42 AND RU43

	SINTERED DIMENSIONS					
PELLET ID	DIAMETER (mm)	LENGTH (mm)	MASS (g)	THEORETICAL DENSITY (%)	MEETS SPEC?	DISPOSITION?
RU42-1	6.23	9.61	2.669	81.77	YES	FLIGHT
RU42-2	6.24	9.66	2.670	81.10	YES	SAMPLE
RU42-3	6.24	9.62	2.670	81.45	YES	FLIGHT
RU42-4	6.23	9.57	2.667	82.06	YES	FLIGHT
RU42-5	6.25	9.55	2.676	81.98	YES	FLIGHT
RU42-6	6.24	9.49	2.667	82.50	YES	FLIGHT
RU42-7	6.24	9.43	2.669	83.10	YES	FLIGHT
RU42-8	6.24	9.41	2.670	83.31	YES	FLIGHT
RU42-9	6.24	9.45	2.672	83.01	YES	FLIGHT
RU42-10	6.23	9.43	2.665	83.24	YES	FLIGHT
RU42-11	6.23	9.44	2.675	83.46	YES	FLIGHT
RU42-12	6.24	9.50	2.671	82.53	YES	FLIGHT
RU42-13	6.23	9.47	2.676	83.22	YES	FLIGHT
RU42-14	6.23	9.54	2.667	82.32	YES	FLIGHT
RU42-15	6.23	9.61	2.667	81.71	YES	FLIGHT
RU42-16	6.25	9.59	2.671	81.47	YES	FLIGHT
RU43-1	6.22	9.35	2.669	84.37	YES	FLIGHT
RU43-2	6.21	9.37	2.669	84.46	YES	FLIGHT
RU43-3	6.23	9.42	2.671	83.52	YES	FLIGHT
RU43-4	6.22	9.36	2.672	84.38	YES	FLIGHT
RU43-5	6.22	9.40	2.674	84.07	YES	FLIGHT
RU43-6	6.23	9.32	2.670	84.41	YES	FLIGHT
RU43-7	6.22	9.31	2.667	84.68	YES	FLIGHT
RU43-8	6.23	9.33	2.669	84.28	YES	FLIGHT
RU43-9	6.22	9.34	2.674	84.62	YES	FLIGHT
RU43-10	6.23	9.32	2.670	84.41	YES	FLIGHT
RU43-11	6.23	9.27	2.674	85.00	YES	SAMPLE
RU43-12	6.22	9.33	2.668	84.53	YES	FLIGHT
RU43-13	6.24	9.31	2.675	84.39	YES	FLIGHT
RU43-14	6.22	9.29	2.671	85.00	YES	FLIGHT
RU43-15	6.23	9.34	2.671	84.25	YES	FLIGHT
RU43-16	6.23	9.32	2.671	84.44	YES	FLIGHT

C. Analytical Chemistry of Pellet Lots

One pellet from each hot press run was submitted for spectrochemical analysis and neutron emission rate. The cationic impurity levels for the pellet lots are listed in Tables XIII and XIV. All pellet lots met specifications. The neutron emission rates for the pellet lots are listed in Table XV. All pellet lots met the specification of ≤ 6000 n/s-g ^{238}Pu.

TABLE XIII

SPECTROCHEMICAL DATA FOR PELLET LOTS RU30-36

		Pellet Lot						
Species	Specification ($\mu g/g\ PuO_2$)	RU30	RU31	RU32	RU33	RU34	RU35	RU36
Al		41	36	40	49	55	43	50
B		< 5	< 5	< 5	< 5	< 5	< 10	< 10
Ca		5	10	10	50	30	3	4
Cd		< 10	< 10	< 10	< 10	< 10	< 10	< 10
Cr	200	78	62	140	109	93	105	130
Cu		< 5	6	8	10	6	< 1	< 1
Fe	800	155	125	190	185	165	210	260
Mg		15	25	35	35	25	15	15
Mn		2	5	5	8	5	2	3
Mo		< 20	< 20	< 20	< 20	< 20	< 20	< 20
Na		< 50	< 50	< 50	< 50	< 50	< 50	< 50
Ni	100	15	11	17	14	15	22	29
Pb		< 10	—	< 10	10	< 10	60	< 10
Si	500	190	175	280	275	205	260	280
Sn		< 5	< 5	< 5	< 5	< 5	< 5	< 5
Zn		< 5	< 5	< 5	< 5	< 5	< 5	< 5

TABLE XIV

SPECTROCHEMICAL DATA FOR PELLET LOTS RU37-43

		Pellet Lot						
Species	Specification ($\mu g/g\ PuO_2$)	RU37	RU38	RU39	RU40	RU41	RU42	RU43
Al		46	40	47	44	51	55	42
B		< 10	< 10	< 10	< 10	< 10	< 10	< 10
Ca		4	4	4	3	4	4	4
Cd		< 10	< 10	< 10	< 10	< 10	< 10	< 10
Cr	200	120	95	125	73	113	120	125
Cu		< 1	11	8	< 1	< 1	< 1	< 1
Fe	800	275	235	230	225	300	320	280
Mg		15	15	15	15	15	15	15
Mn		15	15	15	10	6	5	7
Mo		< 20	< 20	< 20	< 20	< 20	< 20	< 20
Na		< 50	< 50	< 50	< 50	< 50	< 50	< 50
Ni	100	18	24	13	19	35	27	27
Pb		10	15	< 10	15	< 10	< 10	< 10
Si	500	415	385	320	380	470	495	420
Sn		< 5	< 5	< 5	< 5	< 5	< 5	< 5
Zn		< 5	< 5	< 5	< 5	< 5	< 5	< 5

TABLE XV

NEUTRON EMISSION RATES FOR PELLET LOTS

Pellet Lot	Neutron Emission Rate ($ns^{-1}g^{-1}$ ^{238}Pu)
RU30	4205
RU31	3985
RU32	4810
RU33	4250
RU34	4695
RU35	4465
RU36	4035
RU37	4135
RU38	4190
RU39	4880
RU40	4285
RU41	4105
RU42	3980
RU43	4870
Average	4350 ± 330

IV. WELDING AND NDT OF HEAT SOURCE FUELED CLADS

A. Welding

1. Hardware. All components of the fueled clad, except for the frit vent, were fabricated from Pt-30 Rh tube, sheet, and foil. The frit vent was a pressed and sintered disk of pure platinum powder. Details of the fueled clad design are shown in the drawings in Appendix II. Mound Applied Technologies (MAT) fabricated the components and electron beam welded the frit vent and vent end cap into place before shipping the hardware to Los Alamos. Each piece of hardware was visually inspected at Los Alamos before it was released for production.

2. Equipment. The welding was performed in a helium atmosphere glove box. A gas purifying system was plumbed to the glove box in a closed loop to maintain the atmosphere purity at less than 100 ppm oxygen and less than 250 ppm moisture. A Delta F Corporation Model Type

A Plus oxygen analyzer and an EG&G Model 900 moisture analyzer were used to analyze the glove box atmosphere. Helium entered the glove box on a demand basis to maintain a pressure approximately 0.4 in.–0.8 in. of water negative with respect to the room atmospheric pressure.

The Gas Tungsten Arc (GTA) welding system was a 300-ampere L-TEC Heliarc Model 304i with a Jetstar weld-process controller. The computer-based controller contained the controls to start, downslope, and stop the welding current; set the weld current level; set the torch gas flow rate; and set the fixture rotational direction and speed. A remote pendant was normally used for part setup and welding. The welding fixture consisted of a vertical turntable, which was driven by an Electrocraft E-642 motor/tachometer and a drive reducton gear. A collet, which was bored to accept the diameter of the fueled clad and to allow 2.5 mm of the fueled clad to protrude from the collet, was attached to the top end of the turntable. The torch gas was a 75% helium-25% argon mixture.

The weld-process controller recorded the arc current, torch gas flow rate, and fixture rotational speed for each weld. At the completion of a weld, these data along with the weld ID and weld date were downloaded to a floppy disc for archival storage.

3. Welding Qualification. The welding procedure, equipment, and operator were qualified by consecutively welding four LWRHU fueled clads. These fueled clads were then decontaminated to zero alpha swipe in a nitric acid/hydroflouric acid solution, helium leak checked, dye penetrant inspected, radiographed, and their dimensions measured. The fueled clads were then sectioned and a metallographic examination of the weld area was performed.

4. Production Welding. An example weld was performed before each daily production run. The example weld was sectioned and examined before the production welds were performed. After the fueled clads were welded, they were visually inspected, decontaminated to < 100 dpm alpha swipe in a nitric acid/hydroflouric acid solution, and then submitted for NDT. Figure 3 shows an etched cross section of a typical example weld (CB719).

B. NDT

The welded fueled clads were submitted to the following tests: helium leak check; radiography of the weld area to ensure 100% weld penetration; measurement of the height, diameter, and weld standoff height; neutron emission rate; and thermal power. The gamma and neutron dose rate of each fueled clad was measured at a distance of 20 cm.

1. Helium Leak Check. A Varian Model 938-41 helium leak detector was used to check the GTA welds. The detector had a sensitivity of 1×10^{-9} atm cm^3/sec for helium and was calibrated with a certified standard helium leak. The test fixture was a water-cooled copper unit that could contain a maximum of seven LWRHU assemblies. All assemblies had leak rates $< 1 \times 10^{-8}$ atm cm^3/sec, which was well within the maximum helium leak rate specification of 1×10^{-6} atm cm^3/sec.

2. Thermal Power and Neutron Emission Rate. The thermal power of each fueled clad was measured in one of three MAT designed twin bridge calorimeters. The calorimeters were calibrated with a certified thermal standard each day that measurements were performed. At the one watt level, the calorimeters had a precision of ± 0.001 watt and an accuracy of ± 0.004 watt. A Los Alamos designed thermal neutron counter was used to measure the neutron emission rate of each fueled clad. The instrument was calibrated with a certified neutron source each day that measurements were performed. The neutron counter had a precision of ± 2% and an accuracy of ± 3%. The thermal power and neutron emission rate of each fueled clad are summarized in Table XVI.

3. Gamma and Neutron Dose Rate. A Victoreen Model 440 Low Energy Survey Meter was used to measure the gamma dose rate, and an Eberline Model PRS-2 Portable Rate Meter-Scaler was used to measure the neutron dose rate of each fueled clad at a distance of 20 cm. Both instruments were calibrated against National Institute of Standards (NIST)-traceable standards. The gamma and neutron dose rates for one fueled clad from each pellet lot are summarized in Table XVII.

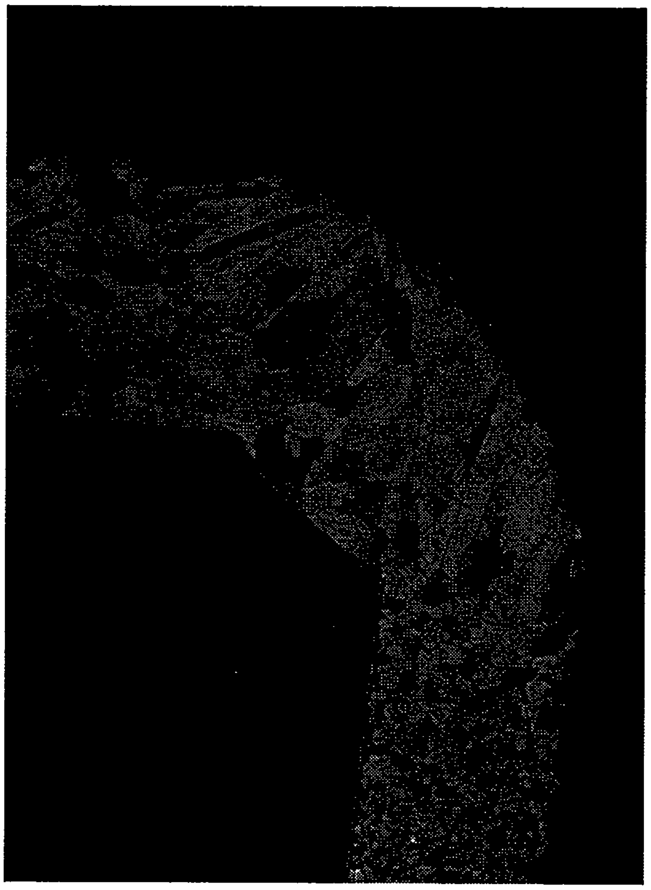


Figure 3. Etched cross section of example weld CB719, 32X.

TABLE XVI

THERMAL POWER AND NEUTRON EMISSION RATES FOR LWRHU FUELED CLADS

Fueled Clad ID	Thermal Power (watts)	Measurement Date	Neutron Emission Rate (n/s)	Measurement Date
628	1.043	6/20/95	7991	7/28/95
629	1.041	6/20/95	8035	7/28/95
630	1.044	6/20/95	7964	7/28/95
631	1.044	6/20/95	7946	7/28/95
632	1.045	6/20/95	8027	7/28/95
633	1.049	6/20/95	7904	7/28/95
634	1.048	6/21/95	7892	7/28/95
635	1.048	6/21/95	8008	7/28/95
636	1.047	6/21/95	7888	7/28/95
637	1.043	6/21/95	7767	7/28/95
638	1.050	6/21/95	7892	7/28/95
639	1.047	6/21/95	7783	7/28/95
640	1.048	6/19/95	7918	7/28/95
641	1.044	6/19/95	7875	7/28/95
642	1.048	6/19/95	7757	7/28/95
643	1.047	6/20/95	7624	7/28/95
644	1.050	6/20/95	7515	7/28/95
645	1.050	6/20/95	7401	7/28/95
648	1.048	6/20/95	7777	7/28/95
649	1.045	6/20/95	7541	7/28/95
651	1.049	6/20/95	7471	7/28/95
653	1.048	6/20/95	7482	7/28/95
654	1.047	6/20/95	9618	7/28/95
655	1.047	6/20/95	9696	7/28/95

TABLE XVI (continued)

THERMAL POWER AND NEUTRON EMISSION RATES FOR LWRHU FUELED CLADS

Fueled Clad ID	Thermal Power (watts)	Measurement Date	Neutron Emission Rate (n/s)	Measurement Date
656	1.046	7/6/95	7994	7/18/95
657	1.048	7/6/95	7755	7/18/95
658	1.048	7/6/95	9644	7/18/95
661	1.047	7/6/95	9477	7/18/95
662	1.049	7/6/95	8829	7/18/95
663	1.048	7/6/95	8521	7/18/95
665	1.049	7/6/95	9210	7/18/95
667	1.048	7/6/95	8858	7/18/95
668	1.049	7/6/95	8569	7/18/95
673	1.042	8/17/95	8320	7/18/95
674	1.048	8/17/95	8245	7/18/95
675	1.047	8/17/95	8070	7/18/95
676	1.048	6/22/95	8302	7/12/95
678	1.047	6/22/95	8259	7/12/95
680	1.048	6/22/95	8280	7/12/95
681	1.048	6/23/95	8170	7/12/95
682	1.050	6/23/95	8098	7/12/95
683	1.047	6/22/95	8065	7/12/95
684	1.049	6/23/95	8050	7/12/95
685	1.047	6/23/95	8042	7/12/95
686	1.049	6/23/95	8194	7/12/95
687	1.048	7/6/95	8114	7/12/95
688	1.048	6/23/95	8099	7/12/95
689	1.041	6/23/95	7887	7/12/95

TABLE XVI (continued)

THERMAL POWER AND NEUTRON EMISSION RATES FOR LWRHU FUELED CLADS

Fueled Clad ID	Thermal Power (watts)	Measurement Date	Neutron Emission Rate (n/s)	Measurement Date
691	1.047	6/23/95	8800	7/17/95
694	1.048	6/27/95	9119	7/17/95
696	1.048	6/29/95	9244	7/17/95
699	1.046	6/29/95	8589	7/17/95
700	1.047	6/29/95	8845	7/17/95
701	1.048	6/29/95	9037	7/17/95
702	1.047	6/29/95	9244	7/17/95
703	1.050	6/29/95	9510	7/17/95
704	1.049	8/3/95	9584	7/17/95
705	1.049	8/3/95	9858	7/17/95
706	1.048	8/3/95	9722	7/17/95
707	1.047	8/3/95	9358	7/17/95
736	1.050	7/6/95	9499	7/17/95
737	1.048	6/27/95	9645	7/17/95
738	1.047	6/27/95	9681	7/17/95
740	1.049	6/27/95	8480	7/17/95
741	1.051	6/28/95	8666	7/17/95
742	1.050	6/28/95	8534	7/17/95
743	1.050	6/28/95	8583	7/17/95
744	1.047	6/29/95	8479	7/17/95
745	1.048	6/29/95	8486	7/17/95
747	1.048	7/6/95	8343	7/17/95
748	1.050	6/28/95	8252	7/17/95
750	1.048	6/29/95	8534	7/17/95

TABLE XVI (continued)

THERMAL POWER AND NEUTRON EMISSION RATES FOR LWRHU FUELED CLADS

Fueled Clad ID	Thermal Power (watts)	Measurement Date	Neutron Emission Rate (n/s)	Measurement Date
751	1.048	8/17/95	8314	7/18/95
752	1.048	8/17/95	8564	7/18/95
753	1.046	8/17/95	8197	7/18/95
754	1.048	8/24/95	8219	7/18/95
755	1.047	8/24/95	8275	7/18/95
756	1.047	8/24/95	8189	7/18/95
757	1.046	8/24/95	8067	7/18/95
758	1.046	8/24/95	8110	7/18/95
759	1.047	8/24/95	7978	7/18/95
760	1.045	8/25/95	7814	7/18/95
761	1.047	8/25/95	8104	7/18/95
762	1.046	8/25/95	8093	7/18/95
764	1.047	9/15/95	8066	7/18/95
765	1.046	9/15/95	7938	7/18/95
766	1.045	9/15/95	7904	7/18/95
767	1.044	9/15/95	7753	7/18/95
768	1.045	9/15/95	7637	7/18/95
769	1.046	9/15/95	7929	7/18/95
770	1.043	9/15/95	7970	7/18/95
772	1.046	9/15/95	7818	7/18/95
775	1.046	9/15/95	7945	7/18/95
776	1.048	9/15/95	8161	7/18/95
777	1.048	9/15/95	8057	7/18/95
778	1.046	9/15/95	8051	7/18/95

TABLE XVI (continued)

THERMAL POWER AND NEUTRON EMISSION RATES FOR LWRHU FUELED CLADS

Fueled Clad ID	Thermal Power (watts)	Measurement Date	Neutron Emission Rate (n/s)	Measurement Date
779	1.048	8/2/95	7898	8/1/95
780	1.047	8/2/95	8144	8/1/95
782	1.049	8/2/95	7866	8/1/95
783	1.048	8/2/95	7894	8/1/95
784	1.048	8/2/95	7928	8/1/95
785	1.048	8/2/95	7803	8/1/95
786	1.049	8/4/95	7890	8/1/95
787	1.050	8/4/95	7886	8/1/95
788	1.047	8/4/95	7956	8/1/95
789	1.049	8/4/95	7908	8/1/95
790	1.048	8/4/95	7942	8/1/95
791	1.048	8/4/95	7954	8/1/95
792	1.049	8/30/95	7989	8/1/95
793	1.046	8/30/95	8162	8/1/95
794	1.048	8/30/95	7981	8/1/95
795	1.049	8/28/95	8005	8/1/95
796	1.049	8/28/95	8145	8/1/95
797	1.048	8/28/95	8062	8/1/95
798	1.048	8/28/95	8039	8/1/95
799	1.048	8/28/95	8034	8/1/95
800	1.048	8/28/95	7996	8/1/95
801	1.046	8/28/95	7909	8/1/95
803	1.049	8/28/95	7781	8/1/95
804	1.049	8/28/95	7864	8/1/95

TABLE XVI (continued)

THERMAL POWER AND NEUTRON EMISSION RATES FOR LWRHU FUELED CLADS

Fueled Clad ID	Thermal Power (watts)	Measurement Date	Neutron Emission Rate (n/s)	Measurement Date
805	1.047	9/12/95	7959	9/21/95
806	1.047	9/12/95	7973	9/21/95
808	1.047	9/12/95	7872	9/21/95
809	1.046	9/12/95	8402	9/21/95
810	1.047	9/12/95	8271	9/21/95
811	1.047	9/25/95	8280	9/21/95
812	1.047	9/25/95	8105	9/21/95
813	1.047	9/25/95	8245	9/21/95
814	1.047	9/25/95	8172	9/21/95
815	1.045	9/25/95	8130	9/21/95
816	1.045	9/25/95	8039	9/21/95
817	1.047	9/25/95	8097	9/21/95
818	1.045	8/31/95	8013	10/6/95
819	1.048	8/31/95	7996	10/6/95
820	1.049	8/31/95	8059	10/6/95
822	1.048	9/6/95	8184	10/6/95
824	1.048	9/6/95	8085	10/6/95
825	1.046	9/6/95	8003	10/6/95
826	1.046	9/7/95	8326	10/6/95
827	1.047	9/7/95	8349	10/6/95
828	1.050	9/7/95	8290	10/6/95
829	1.048	9/7/95	8283	10/6/95
830	1.048	9/7/95	8363	10/6/95
831	1.049	9/7/95	8332	10/6/95

TABLE XVI (continued)

THERMAL POWER AND NEUTRON EMISSION RATES FOR LWRHU FUELED CLADS

Fueled Clad ID	Thermal Power (watts)	Measurement Date	Neutron Emission Rate (n/s)	Measurement Date
832	1.048	9/20/95	8324	9/21/95
833	1.048	9/20/95	8254	9/21/95
834	1.048	9/20/95	8271	9/21/95
835	1.048	9/20/95	8314	9/21/95
836	1.049	9/20/95	8239	9/21/95
837	1.049	9/20/95	8270	9/21/95
838	1.047	9/22/95	8266	9/21/95
839	1.047	9/22/95	8267	9/21/95
840	1.048	9/22/95	8367	9/21/95
841	1.048	9/22/95	8642	9/21/95
842	1.046	9/22/95	8635	9/21/95
843	1.048	9/22/95	8432	9/21/95
844	1.048	9/11/95	8443	10/6/95
845	1.048	9/11/95	8579	10/6/95
846	1.049	9/11/95	8248	10/6/95
847	1.046	9/11/95	8344	10/6/95
848	1.049	9/11/95	8317	10/6/95
849	1.049	9/11/95	8305	10/6/95
850	1.048	9/11/95	8339	10/6/95
851	1.048	9/12/95	8353	9/26/95
852	1.048	9/11/95	8219	9/26/95
854	1.049	9/11/95	8382	9/26/95
855	1.049	9/11/95	8418	9/26/95
856	1.048	9/11/95	8620	9/26/95

TABLE XVI (continued)

THERMAL POWER AND NEUTRON EMISSION RATES FOR LWRHU FUELED CLADS

Fueled Clad ID	Thermal Power (watts)	Measurement Date	Neutron Emission Rate (n/s)	Measurement Date
858	1.049	9/13/95	8362	10/12/95
859	1.048	9/13/95	8265	10/12/95
860	1.052	9/13/05	8625	10/12/95
861	1.047	9/14/95	8426	10/12/95
862	1.049	9/14/95	8474	10/12/95
863	1.049	9/14/95	8453	10/12/95
864	1.049	9/14/95	8454	10/12/95
867	1.046	9/14/95	8410	10/12/95
869	1.050	9/14/95	8376	10/12/95
870	1.049	9/14/95	8344	10/12/95
871	1.050	9/14/95	8497	10/12/95
872	1.047	9/14/95	8359	10/12/95
873	1.050	9/11/95	8356	10/6/95

TABLE XVII

GAMMA AND NEUTRON DOSE RATES AT 20 CM FOR LWRHU FUELED CLADS

Fueled Clad ID	Pellet Lot	Gamma Dose Rate (mR/h)	Neutron Dose Rate (mRem/h)
634	RU30	0.2	0.1
645	RU31	0.2	0.1
658	RU32	0.2	< 0.1
683	RU33	0.2	0.1
701	RU34	0.2	0.1
745	RU35	0.2	0.1
762	RU36	0.1	0.1
786	RU37	0.2	0.1
803	RU38	0.1	0.1
820	RU39	0.1	0.1
830	RU40	0.1	0.1
848	RU41	0.1	0.2
863	RU42	0.1	0.2

V. FINAL ASSEMBLY

A. Vent Activation

After the LWRHU fueled clad had passed the nondestructive tests, it was submitted for final assembly. The pressed and sintered platinum powder frit vent was activated by cutting into the vented end (electron beam welded end) cap of the fueled clad at the center line with a 0.635 ± 0.050 mm diameter end mill to a depth of 0.279 mm to 0.406 mm. The fueled clad was then examined under a microscope to ensure that the frit was visible through the milled hole.

The vent activation was performed with a Servo Products Company Model 7230 vertical micromilling machine. The milling machine was equipped with a Sony Model SR-745 6/150 Digital Position Readout System and Sony Magnescale LF-200-22 Digital Display.

B. Aeroshell Assembly

After a swipe check for loose alpha contamination (< 220 dpm), the fueled clad was placed into the graphite aeroshell (vent end down), and the graphite lid was glued in place. The graphite cement was Union Carbide Corporation "UCAR C-34," which consisted of a graphite powder and a molasses-colored liquid. The cement was prepared by mixing 100 parts (by weight) of powder with 35.3 parts (by weight) of liquid. The graphite aeroshell was heat treated at 100°C ± 5°C for a period of 4.0 h ± 0.5 h followed by heating at 130°C ± 10°C for 16 h ± 1 h to cure the cement. The assembled heater was then swiped check to ensure surface contamination was < 25 dpm. Figure 4 is a photograph of 12 fueled clads and 3 assembled aeroshells.

C. Vacuum Outgassing the Aeroshell Assembly

To ensure that volatile components of the glue did not outgas onto optical instruments on the Cassini spacecraft, each aeroshell assembly was outgassed in a vacuum furnace at a temperature of 325°C ± 10°C for 144 h ± 1 h at a pressure $\leq 2 \times 10^{-5}$ Torr. Typically, after 144 h of outgassing the pressure was $< 5 \times 10^{-7}$ Torr.

D. LWRHU Final Assembly Data and Record of Assembly

The mass, height, diameter, and thermal power (decayed to January 1, 1998) of the final assemblies are summarized in Table XVIII. The record of assembly for each heat source is listed in Table XIX.

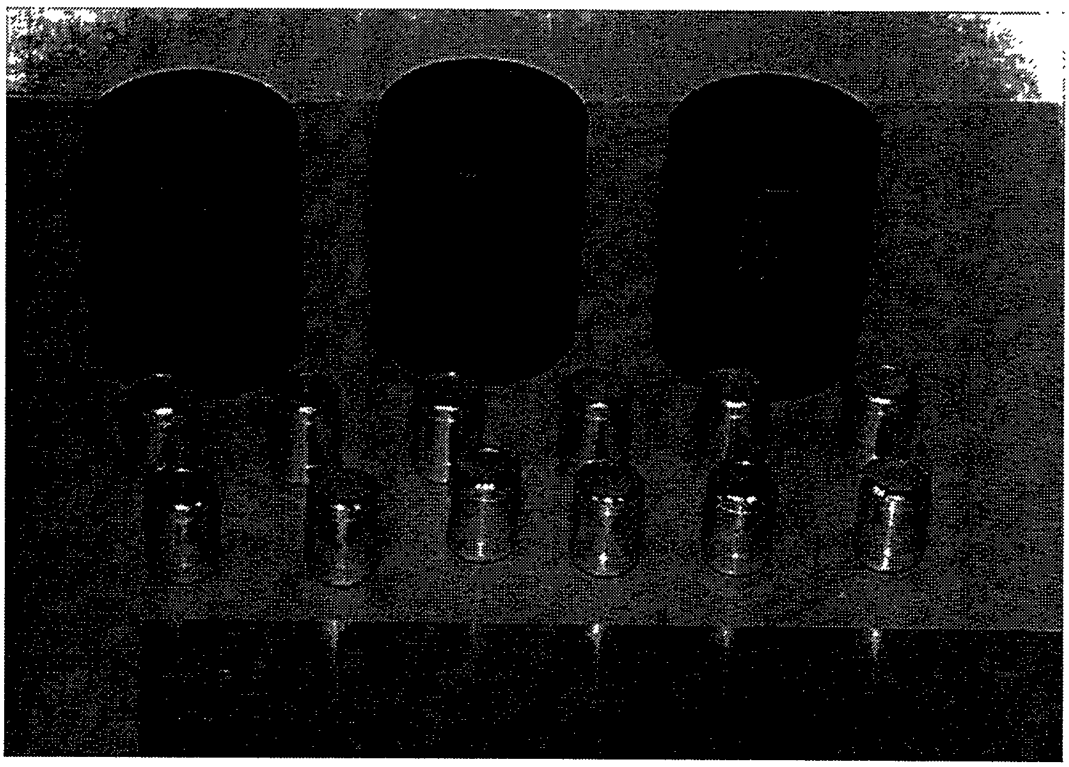


Figure 4. LWRHU vented fueled clads and assembled aeroshells.

TABLE XVIII

FINAL ASSEMBLY DATA

Aeroshell ID	Mass (g)	Length (mm)	Diameter (mm)	Power (W_{th}) (1/1/98)
LRF-101	39.646	31.941	25.943	1.022
LRF-102	39.672	31.946	25.943	1.020
LRF-103	39.549	31.948	25.948	1.023
LRF-104	39.774	31.953	25.946	1.023
LRF-105	39.744	31.944	25.948	1.024
LRF-106	39.580	31.960	25.939	1.028
LRF-107	39.708	31.948	25.942	1.027
LRF-108	39.689	31.948	25.944	1.027
LRF-109	39.613	31.948	25.941	1.026
LRF-110	39.660	31.947	25.946	1.022
LRF-111	39.771	31.937	25.940	1.029
LRF-112	39.733	31.949	25.947	1.026
LRF-113	39.693	31.950	25.940	1.027
LRF-114	39.590	31.955	25.944	1.023
LRF-115	39.497	31.954	25.944	1.027
LRF-116	39.578	31.954	25.944	1.026
LRF-117	39.645	31.950	25.941	1.029
LRF-118	39.606	31.965	25.942	1.029
LRF-119	39.524	31.948	25.940	1.027
LRF-120	39.489	31.951	25.942	1.024
LRF-121	39.399	31.944	25.940	1.028
LRF-122	39.482	31.951	25.949	1.027
LRF-123	39.433	31.949	25.943	1.026
LRF-124	39.607	31.949	25.945	1.026

TABLE XVIII (continued)

FINAL ASSEMBLY DATA

Aeroshell ID	Mass (g)	Length (mm)	Diameter (mm)	Power (W_{th}) (1/1/98)
LRF-125	39.564	31.949	25.943	1.026
LRF-126	39.602	31.955	25.944	1.028
LRF-127	39.754	31.958	25.943	1.028
LRF-128	39.594	31.947	25.944	1.027
LRF-129	40.085	31.948	25.945	1.029
LRF-130	40.022	31.950	25.944	1.028
LRF-131	39.553	31.951	25.945	1.029
LRF-132	39.542	31.964	25.944	1.028
LRF-133	39.558	31.948	25.945	1.029
LRF-134	39.497	31.955	25.946	1.023
LRF-135	39.541	31.953	25.945	1.029
LRF-136	39.754	31.951	25.945	1.028
LRF-137	39.729	31.955	25.946	1.027
LRF-138	39.711	31.955	25.945	1.026
LRF-139	39.783	31.967	25.947	1.027
LRF-140	39.774	31.955	25.947	1.027
LRF-141	39.741	31.957	25.944	1.029
LRF-142	39.759	31.956	25.946	1.026
LRF-143	39.691	31.953	25.944	1.028
LRF-144	39.720	31.950	25.942	1.026
LRF-145	39.760	31.948	25.942	1.028
LRF-146	39.751	31.955	25.941	1.028
LRF-147	39.698	31.952	25.945	1.028
LRF-148	39.642	31.953	25.946	1.027

TABLE XVIII (continued)

FINAL ASSEMBLY DATA

Aeroshell ID	Mass (g)	Length (mm)	Diameter (mm)	Power (W_{th}) (1/1/98)
LRF-149	39.398	31.956	25.945	1.020
LRF-150	39.593	31.967	25.948	1.026
LRF-151	39.721	31.954	25.944	1.027
LRF-152	39.624	31.957	25.947	1.027
LRF-153	39.599	31.955	25.945	1.025
LRF-154	39.622	31.950	25.944	1.026
LRF-155	39.757	31.953	25.947	1.027
LRF-156	39.658	31.963	25.947	1.026
LRF-157	39.559	31.958	25.945	1.029
LRF-158	39.666	31.953	25.950	1.029
LRF-159	39.686	31.951	25.946	1.029
LRF-160	39.514	31.951	25.947	1.028
LRF-161	39.865	31.945	25.952	1.027
LRF-162	39.825	31.969	25.940	1.030
LRF-163	39.862	31.953	25.943	1.027
LRF-164	40.015	31.953	25.945	1.026
LRF-165	39.998	31.959	25.948	1.028
LRF-166	39.969	31.952	25.940	1.030
LRF-167	40.020	31.947	25.943	1.029
LRF-168	40.027	31.945	25.939	1.029
LRF-169	40.059	31.951	25.943	1.026
LRF-174	39.907	31.953	25.935	1.027
LRF-177	39.918	31.953	25.935	1.028
LRF-185	39.872	31.958	25.942	1.029

TABLE XVIII (continued)

FINAL ASSEMBLY DATA

Aeroshell ID	Mass (g)	Length (mm)	Diameter (mm)	Power (W_{th}) (1/1/98)
LRF-187	39.969	31.961	25.942	1.027
LRF-188	39.799	31.945	25.947	1.028
LRF-189	39.838	31.951	25.944	1.027
LRF-190	39.861	31.950	25.944	1.029
LRF-191	39.878	31.949	25.945	1.028
LRF-192	39.940	31.945	25.944	1.028
LRF-193	39.912	31.953	25.946	1.028
LRF-194	39.826	31.948	25.947	1.030
LRF-195	39.868	31.948	25.941	1.027
LRF-196	39.829	31.944	25.944	1.029
LRF-197	39.928	31.946	25.943	1.028
LRF-198	39.902	31.946	25.943	1.030
LRF-199	39.759	31.951	25.941	1.027
LRF-200	39.808	31.950	25.940	1.028
LRF-201	39.794	31.951	25.944	1.027
LRF-202	39.855	31.948	25.946	1.026
LRF-203	39.892	31.954	25.942	1.025
LRF-204	39.792	31.948	25.941	1.026
LRF-205	39.905	31.951	25.942	1.027
LRF-206	39.804	31.951	25.943	1.024
LRF-207	39.824	31.950	25.944	1.027
LRF-208	39.878	31.950	25.942	1.027
LRF-209	39.852	31.951	25.947	1.029
LRF-210	39.912	31.948	25.951	1.029

TABLE XVIII (continued)

FINAL ASSEMBLY DATA

Aeroshell ID	Mass (g)	Length (mm)	Diameter (mm)	Power (W_{th}) (1/1/98)
LRF-211	39.804	31.947	25.949	1.027
LRF-212	39.814	31.949	25.942	1.029
LRF-213	39.930	31.950	25.942	1.030
LRF-214	39.963	31.948	25.943	1.030
LRF-215	39.780	31.953	25.947	1.029
LRF-216	39.821	31.950	25.950	1.029
LRF-217	39.772	31.952	25.947	1.029
LRF-218	39.753	31.952	25.947	1.029
LRF-219	39.779	31.951	25.944	1.027
LRF-220	39.829	31.951	25.944	1.030
LRF-221	39.815	31.955	25.949	1.030
LRF-222	39.738	31.953	25.947	1.028
LRF-223	39.900	31.950	25.943	1.029
LRF-224	39.912	31.950	25.947	1.029
LRF-225	39.926	31.951	25.947	1.027
LRF-226	39.841	31.950	25.948	1.029
LRF-227	39.843	31.954	25.948	1.028
LRF-228	39.810	31.952	25.951	1.028
LRF-229	40.018	31.947	25.938	1.027
LRF-230	40.033	31.958	25.939	1.027
LRF-231	40.025	31.947	25.941	1.028
LRF-232	39.988	31.944	25.944	1.026
LRF-233	40.026	31.948	25.942	1.028
LRF-234	39.979	31.945	25.941	1.027

TABLE XVIII (continued)

FINAL ASSEMBLY DATA

Aeroshell ID	Mass (g)	Length (mm)	Diameter (mm)	Power (W_{th}) (1/1/98)
LRF-235	39.900	31.950	25.944	1.028
LRF-236	39.887	31.957	25.946	1.028
LRF-237	39.841	31.948	25.948	1.027
LRF-238	39.961	31.945	25.949	1.028
LRF-239	39.777	31.946	25.945	1.028
LRF-240	39.882	31.946	25.949	1.028
LRF-241	39.877	31.948	25.942	1.028
LRF-242	39.886	31.946	25.938	1.028
LRF-243	39.685	31.949	25.942	1.026
LRF-244	39.737	31.951	25.944	1.026
LRF-245	39.812	31.950	25.943	1.028
LRF-246	39.772	31.949	25.944	1.026
LRF-247	39.783	31.953	25.943	1.029
LRF-248	39.749	31.952	25.943	1.030
LRF-249	39.780	31.952	25.944	1.029
LRF-250	39.757	31.955	25.943	1.029
LRF-251	39.810	31.948	25.941	1.027
LRF-252	39.752	31.956	25.945	1.027
LRF-253	39.684	31.977	25.942	1.028
LRF-254	39.767	31.952	25.941	1.031
LRF-255	39.870	31.950	25.941	1.029
LRF-256	39.928	31.951	25.940	1.029
LRF-257	39.833	31.956	25.940	1.030
LRF-258	39.860	31.956	25.940	1.029

TABLE XVIII (continued)

FINAL ASSEMBLY DATA

Aeroshell ID	Mass (g)	Length (mm)	Diameter (mm)	Power (W_{th}) (1/1/98)
LRF-259	39.744	31.951	25.941	1.029
LRF-260	39.727	31.954	25.939	1.029
LRF-261	39.865	31.953	25.940	1.029
LRF-262	39.809	31.950	25.941	1.030
LRF-263	39.867	31.953	25.943	1.030
LRF-264	39.873	31.959	25.943	1.028
LRF-265	39.901	31.947	25.943	1.028
LRF-266	39.930	31.948	25.944	1.029
LRF-267	39.943	31.952	25.939	1.029
LRF-268	39.844	31.948	25.941	1.027
LRF-269	39.856	31.951	25.940	1.029
LRF-270	39.819	31.947	25.942	1.029
LRF-271	39.906	31.952	25.944	1.029
LRF-272	39.910	31.953	25.946	1.030
LRF-273	39.874	31.952	25.949	1.027
LRF-274	39.935	31.955	25.950	1.030
LRF-275	39.957	31.955	25.951	1.030
LRF-276	39.881	31.947	25.952	1.029
LRF-277	39.836	31.954	25.948	1.029
LRF-278	39.940	31.948	25.951	1.029
LRF-279	39.767	31.952	25.944	1.030
LRF-280	39.847	31.958	25.941	1.030
LRF-281	39.770	31.947	25.946	1.029
LRF-282	39.840	31.956	25.949	1.030

TABLE XVIII (continued)

FINAL ASSEMBLY DATA

Aeroshell ID	Mass (g)	Length (mm)	Diameter (mm)	Power (W_{th}) (1/1/98)
LRF-283	39.760	31.955	25.943	1.029
LRF-284	39.785	31.947	25.946	1.033
LRF-285	39.733	31.945	25.948	1.028
LRF-286	39.699	31.945	25.947	1.030
LRF-287	39.783	31.944	25.944	1.030
LRF-288	39.791	31.946	25.949	1.030
LRF-289	39.678	31.946	25.944	1.027
LRF-290	39.762	31.957	25.943	1.031
LRF-291	39.687	31.952	25.944	1.030
LRF-292	39.830	31.954	25.944	1.031
LRF-293	39.723	31.954	25.944	1.028
LRF-294	39.738	31.957	25.943	1.031

TABLE XIX

RECORD OF ASSEMBLY

Aeroshell ID	Fueled Clad ID	Pellet ID	LANL Fuel Lot IDs	SRS Fuel Run IDs
LRF-101	628	RU30-01	272/274	HB8-07-01/HB8-07-02
LRF-102	629	RU30-02	272/274	HB8-07-01/HB8-07-02
LRF-103	630	RU30-03	272/274	HB8-07-01/HB8-07-02
LRF-104	631	RU30-08	272/274	HB8-07-01/HB8-07-02
LRF-105	632	RU30-09	272/274	HB8-07-01/HB8-07-02
LRF-106	633	RU30-10	272/274	HB8-07-01/HB8-07-02
LRF-107	634	RU30-11	272/274	HB8-07-01/HB8-07-02
LRF-108	635	RU30-14	272/274	HB8-07-01/HB8-07-02
LRF-109	636	RU31-01	272/274	HB8-07-01/HB8-07-02
LRF-110	637	RU31-02	272/274	HB8-07-01/HB8-07-02
LRF-111	638	RU31-03	272/274	HB8-07-01/HB8-07-02
LRF-112	639	RU31-04	272/274	HB8-07-01/HB8-07-02
LRF-113	640	RU31-05	272/274	HB8-07-01/HB8-07-02
LRF-114	641	RU31-06	272/274	HB8-07-01/HB8-07-02
LRF-115	642	RU31-08	272/274	HB8-07-01/HB8-07-02
LRF-116	643	RU31-10	272/274	HB8-07-01/HB8-07-02
LRF-117	644	RU31-11	272/274	HB8-07-01/HB8-07-02
LRF-118	645	RU31-12	272/274	HB8-07-01/HB8-07-02
LRF-119	648	RU31-13	272/274	HB8-07-01/HB8-07-02
LRF-120	649	RU31-14	272/274	HB8-07-01/HB8-07-02
LRF-121	651	RU31-15	272/274	HB8-07-01/HB8-07-02
LRF-122	653	RU31-16	272/274	HB8-07-01/HB8-07-02
LRF-123	654	RU32-01	272/274	HB8-07-01/HB8-07-02
LRF-124	655	RU32-03	272/274	HB8-07-01/HB8-07-02

TABLE XIX (continued)

RECORD OF ASSEMBLY

Aeroshell ID	Fueled Clad ID	Pellet ID	LANL Fuel Lot IDs	SRS Fuel Run IDs
LRF-125	656	RU30-07	272/274	HB8-07-01/HB8-07-02
LRF-126	657	RU31-09	272/274	HB8-07-01/HB8-07-02
LRF-127	658	RU32-05	272/274	HB8-07-01/HB8-07-02
LRF-128	661	RU32-07	272/274	HB8-07-01/HB8-07-02
LRF-129	662	RU32-11	272/274	HB8-07-01/HB8-07-02
LRF-130	663	RU32-12	272/274	HB8-07-01/HB8-07-02
LRF-131	665	RU32-13	272/274	HB8-07-01/HB8-07-02
LRF-132	667	RU32-15	272/274	HB8-07-01/HB8-07-02
LRF-133	668	RU32-16	272/274	HB8-07-01/HB8-07-02
LRF-134	673	RU33-01	272/274	HB8-07-01/HB8-07-02
LRF-135	674	RU33-03	272/274	HB8-07-01/HB8-07-02
LRF-136	675	RU33-04	272/274	HB8-07-01/HB8-07-02
LRF-137	676	RU33-05	272/274	HB8-07-01/HB8-07-02
LRF-138	678	RU33-06	272/274	HB8-07-01/HB8-07-02
LRF-139	680	RU33-07	272/274	HB8-07-01/HB8-07-02
LRF-140	681	RU33-08	272/274	HB8-07-01/HB8-07-02
LRF-141	682	RU33-09	272/274	HB8-07-01/HB8-07-02
LRF-142	683	RU33-10	272/274	HB8-07-01/HB8-07-02
LRF-143	684	RU33-11	272/274	HB8-07-01/HB8-07-02
LRF-144	685	RU33-12	272/274	HB8-07-01/HB8-07-02
LRF-145	790	RU37-15	272/274/286	HB8-07-01/HB8-07-02/HB8-13-01
LRF-146	686	RU33-13	272/274	HB8-07-01/HB8-07-02
LRF-147	687	RU33-14	272/274	HB8-07-01/HB8-07-02
LRF-148	688	RU33-15	272/274	HB8-07-01/HB8-07-02

TABLE XIX (continued)

RECORD OF ASSEMBLY

Aeroshell ID	Fueled Clad ID	Pellet ID	LANL Fuel Lot IDs	SRS Fuel Run IDs
LRF-149	689	RU33-16	272/274	HB8-07-01/HB8-07-02
LRF-150	691	RU34-01	272/274	HB8-07-01/HB8-07-02
LRF-151	694	RU34-03	272/274	HB8-07-01/HB8-07-02
LRF-152	696	RU34-04	272/274	HB8-07-01/HB8-07-02
LRF-153	699	RU34-05	272/274	HB8-07-01/HB8-07-02
LRF-154	700	RU34-06	272/274	HB8-07-01/HB8-07-02
LRF-155	701	RU34-07	272/274	HB8-07-01/HB8-07-02
LRF-156	702	RU34-08	272/274	HB8-07-01/HB8-07-02
LRF-157	703	RU34-09	272/274	HB8-07-01/HB8-07-02
LRF-158	704	RU34-10	272/274	HB8-07-01/HB8-07-02
LRF-159	705	RU34-11	272/274	HB8-07-01/HB8-07-02
LRF-160	706	RU34-12	272/274	HB8-07-01/HB8-07-02
LRF-161	707	RU34-13	272/274	HB8-07-01/HB8-07-02
LRF-162	736	RU34-14	272/274	HB8-07-01/HB8-07-02
LRF-163	737	RU34-15	272/274	HB8-07-01/HB8-07-02
LRF-164	738	RU34-16	272/274	HB8-07-01/HB8-07-02
LRF-165	740	RU35-01	272/274	HB8-07-01/HB8-07-02
LRF-166	741	RU35-02	272/274	HB8-07-01/HB8-07-02
LRF-167	742	RU35-03	272/274	HB8-07-01/HB8-07-02
LRF-168	743	RU35-04	272/274	HB8-07-01/HB8-07-02
LRF-169	744	RU35-05	272/274	HB8-07-01/HB8-07-02
LRF-174	745	RU35-06	272/274	HB8-07-01/HB8-07-02
LRF-177	747	RU35-07	272/274	HB8-07-01/HB8-07-02
LRF-185	748	RU35-08	272/274	HB8-07-01/HB8-07-02

TABLE XIX (continued)

RECORD OF ASSEMBLY

Aeroshell ID	Fueled Clad ID	Pellet ID	LANL Fuel Lot IDs	SRS Fuel Run IDs
LRF-187	750	RU35-09	272/274	HB8-07-01/HB8-07-02
LRF-188	779	RU37-04	272/274/286	HB8-07-01/HB8-07-02/HB8-13-01
LRF-189	780	RU37-05	272/274/286	HB8-07-01/HB8-07-02/HB8-13-01
LRF-190	782	RU37-07	272/274/286	HB8-07-01/HB8-07-02/HB8-13-01
LRF-191	783	RU37-08	272/274/286	HB8-07-01/HB8-07-02/HB8-13-01
LRF-192	784	RU37-09	272/274/286	HB8-07-01/HB8-07-02/HB8-13-01
LRF-193	785	RU37-10	272/274/286	HB8-07-01/HB8-07-02/HB8-13-01
LRF-194	787	RU37-12	272/274/286	HB8-07-01/HB8-07-02/HB8-13-01
LRF-195	788	RU37-13	272/274/286	HB8-07-01/HB8-07-02/HB8-13-01
LRF-196	789	RU37-14	272/274/286	HB8-07-01/HB8-07-02/HB8-13-01
LRF-197	791	RU37-16	272/274/286	HB8-07-01/HB8-07-02/HB8-13-01
LRF-198	792	RU38-01	274/286	HB8-07-02/HB8-13-01
LRF-199	793	RU38-02	274/286	HB8-07-02/HB8-13-01
LRF-200	764	RU36-07	272/274	HB8-07-01/HB8-07-02
LRF-201	765	RU36-08	272/274	HB8-07-01/HB8-07-02
LRF-202	766	RU36-09	272/274	HB8-07-01/HB8-07-02
LRF-203	767	RU36-10	272/274	HB8-07-01/HB8-07-02
LRF-204	768	RU36-12	272/274	HB8-07-01/HB8-07-02
LRF-205	769	RU36-13	272/274	HB8-07-01/HB8-07-02
LRF-206	770	RU36-14	272/274	HB8-07-01/HB8-07-02
LRF-207	772	RU36-15	272/274	HB8-07-01/HB8-07-02
LRF-208	775	RU36-16	272/274	HB8-07-01/HB8-07-02
LRF-209	776	RU37-01	272/274/286	HB8-07-01/HB8-07-02/HB8-13-01
LRF-210	777	RU37-02	272/274/286	HB8-07-01/HB8-07-02/HB8-13-01

TABLE XIX (continued)

RECORD OF ASSEMBLY

Aeroshell ID	Fueled Clad ID	Pellet ID	LANL Fuel Lot IDs	SRS Fuel Run IDs
LRF-211	778	RU37-03	272/274/286	HB8-07-01/HB8-07-02/HB8-13-01
LRF-212	794	RU38-03	274/286	HB8-07-02/HB8-13-01
LRF-213	795	RU38-04	274/286	HB8-07-02/HB8-13-01
LRF-214	796	RU38-05	274/286	HB8-07-02/HB8-13-01
LRF-215	797	RU38-06	274/286	HB8-07-02/HB8-13-01
LRF-216	798	RU38-07	274/286	HB8-07-02/HB8-13-01
LRF-217	799	RU38-08	274/286	HB8-07-02/HB8-13-01
LRF-218	800	RU38-09	274/286	HB8-07-02/HB8-13-01
LRF-219	801	RU38-10	274/286	HB8-07-02/HB8-13-01
LRF-220	803	RU38-11	274/286	HB8-07-02/HB8-13-01
LRF-221	804	RU38-12	274/286	HB8-07-02/HB8-13-01
LRF-222	805	RU38-13	274/286	HB8-07-02/HB8-13-01
LRF-223	751	RU35-10	272/274	HB8-07-01/HB8-07-02
LRF-224	752	RU35-12	272/274	HB8-07-01/HB8-07-02
LRF-225	753	RU35-13	272/274	HB8-07-01/HB8-07-02
LRF-226	754	RU35-14	272/274	HB8-07-01/HB8-07-02
LRF-227	755	RU35-15	272/274	HB8-07-01/HB8-07-02
LRF-228	756	RU35-16	272/274	HB8-07-01/HB8-07-02
LRF-229	757	RU36-01	272/274	HB8-07-01/HB8-07-02
LRF-230	758	RU36-02	272/274	HB8-07-01/HB8-07-02
LRF-231	759	RU36-03	272/274	HB8-07-01/HB8-07-02
LRF-232	760	RU36-04	272/274	HB8-07-01/HB8-07-02
LRF-233	761	RU36-05	272/274	HB8-07-01/HB8-07-02
LRF-234	762	RU36-06	272/274	HB8-07-01/HB8-07-02

TABLE XIX (continued)

RECORD OF ASSEMBLY

Aeroshell ID	Fueled Clad ID	Pellet ID	LANL Fuel Lot IDs	SRS Fuel Run IDs
LRF-235	806	RU38-14	274/286	HB8-07-02/HB8-13-01
LRF-236	808	RU38-15	274/286	HB8-07-02/HB8-13-01
LRF-237	809	RU39-01	274/275/286	HB8-07-02/HB8-08-02/HB8-13-01
LRF-238	810	RU39-02	274/275/286	HB8-07-02/HB8-08-02/HB8-13-01
LRF-239	811	RU39-03	274/275/286	HB8-07-02/HB8-08-02/HB8-13-01
LRF-240	812	RU39-04	274/275/286	HB8-07-02/HB8-08-02/HB8-13-01
LRF-241	813	RU39-05	274/275/286	HB8-07-02/HB8-08-02/HB8-13-01
LRF-242	814	RU39-06	274/275/286	HB8-07-02/HB8-08-02/HB8-13-01
LRF-243	815	RU39-08	274/275/286	HB8-07-02/HB8-08-02/HB8-13-01
LRF-244	816	RU39-09	274/275/286	HB8-07-02/HB8-08-02/HB8-13-01
LRF-245	817	RU39-10	274/275/286	HB8-07-02/HB8-08-02/HB8-13-01
LRF-246	818	RU39-11	274/275/286	HB8-07-02/HB8-08-02/HB8-13-01
LRF-247	819	RU39-12	274/275/286	HB8-07-02/HB8-08-02/HB8-13-01
LRF-248	820	RU39-13	274/275/286	HB8-07-02/HB8-08-02/HB8-13-01
LRF-249	822	RU39-14	274/275/286	HB8-07-02/HB8-08-02/HB8-13-01
LRF-250	824	RU39-15	274/275/286	HB8-07-02/HB8-08-02/HB8-13-01
LRF-251	825	RU39-16	274/275/286	HB8-07-02/HB8-08-02/HB8-13-01
LRF-252	826	RU40-01	275/285/286	HB8-08-02/HB8-16-01AB/HB8-13-01
LRF-253	827	RU40-02	275/285/286	HB8-08-02/HB8-16-01AB/HB8-13-01
LRF-254	828	RU40-03	275/285/286	HB8-08-02/HB8-16-01AB/HB8-13-01
LRF-255	829	RU40-04	275/285/286	HB8-08-02/HB8-16-01AB/HB8-13-01
LRF-256	830	RU40-05	275/285/286	HB8-08-02/HB8-16-01AB/HB8-13-01
LRF-257	831	RU40-06	275/285/286	HB8-08-02/HB8-16-01AB/HB8-13-01
LRF-258	832	RU40-07	275/285/286	HB8-08-02/HB8-16-01AB/HB8-13-01

TABLE XIX (continued)

RECORD OF ASSEMBLY

Aeroshell ID	Fueled Clad ID	Pellet ID	LANL Fuel Lot IDs	SRS Fuel Run IDs
LRF-259	833	RU40-08	275/285/286	HB8-08-02/HB8-16-01AB/HB8-13-01
LRF-260	834	RU40-09	275/285/286	HB8-08-02/HB8-16-01AB/HB8-13-01
LRF-261	835	RU40-10	275/285/286	HB8-08-02/HB8-16-01AB/HB8-13-01
LRF-262	836	RU40-11	275/285/286	HB8-08-02/HB8-16-01AB/HB8-13-01
LRF-263	837	RU40-12	275/285/286	HB8-08-02/HB8-16-01AB/HB8-13-01
LRF-264	838	RU40-13	275/285/286	HB8-08-02/HB8-16-01AB/HB8-13-01
LRF-265	839	RU40-14	275/285/286	HB8-08-02/HB8-16-01AB/HB8-13-01
LRF-266	840	RU40-15	275/285/286	HB8-08-02/HB8-16-01AB/HB8-13-01
LRF-267	841	RU41-01	275/285	HB8-08-02/HB8-16-01AB
LRF-268	842	RU41-02	275/285	HB8-08-02/HB8-16-01AB
LRF-269	843	RU41-03	275/285	HB8-08-02/HB8-16-01AB
LRF-270	844	RU41-04	275/285	HB8-08-02/HB8-16-01AB
LRF-271	845	RU41-05	275/285	HB8-08-02/HB8-16-01AB
LRF-272	846	RU41-06	275/285	HB8-08-02/HB8-16-01AB
LRF-273	847	RU41-07	275/285	HB8-08-02/HB8-16-01AB
LRF-274	848	RU41-08	275/285	HB8-08-02/HB8-16-01AB
LRF-275	849	RU41-09	275/285	HB8-08-02/HB8-16-01AB
LRF-276	850	RU41-10	275/285	HB8-08-02/HB8-16-01AB
LRF-277	851	RU41-11	275/285	HB8-08-02/HB8-16-01AB
LRF-278	852	RU41-12	275/285	HB8-08-02/HB8-16-01AB
LRF-279	854	RU41-13	275/285	HB8-08-02/HB8-16-01AB
LRF-280	855	RU41-14	275/285	HB8-08-02/HB8-16-01AB
LRF-281	856	RU41-15	275/285	HB8-08-02/HB8-16-01AB
LRF-282	858	RU42-03	275/285	HB8-08-02/HB8-16-01AB

TABLE XIX (continued)

RECORD OF ASSEMBLY

Aeroshell ID	Fueled Clad ID	Pellet ID	LANL Fuel Lot IDs	SRS Fuel Run IDs
LRF-283	859	RU42-04	275/285	HB8-08-02/HB8-16-01AB
LRF-284	860	RU42-05	275/285	HB8-08-02/HB8-16-01AB
LRF-285	861	RU42-06	275/285	HB8-08-02/HB8-16-01AB
LRF-286	862	RU42-07	275/285	HB8-08-02/HB8-16-01AB
LRF-287	863	RU42-08	275/285	HB8-08-02/HB8-16-01AB
LRF-288	864	RU42-09	275/285	HB8-08-02/HB8-16-01AB
LRF-289	867	RU42-10	275/285	HB8-08-02/HB8-16-01AB
LRF-290	869	RU42-11	275/285	HB8-08-02/HB8-16-01AB
LRF-291	870	RU42-12	275/285	HB8-08-02/HB8-16-01AB
LRF-292	871	RU42-13	275/285	HB8-08-02/HB8-16-01AB
LRF-293	872	RU42-14	275/285	HB8-08-02/HB8-16-01AB
LRF-294	873	RU42-15	275/285	HB8-08-02/HB8-16-01AB

REFERENCES

1. R. E. Tate, "The Lightweight Radioisotope Heater Unit (LWRHU): A Technical Decription of the Reference Design," Los Alamos National Laboratory report LA-9078-MS (January 1982).

APPENDIX I

I. MATERIAL SPECIFICATION FOR $^{238}PuO_2$ FUEL GRANULES: LWRHU

1.0 GENERAL

1.1 Scope. This fuel specification defines the chemical and physical requirements for the $^{238}PuO_2$ fuel granules used for preparing the LWRHU pellets.

1.2 Definitions

1.2.1 Feed Lot. The $^{238}PuO_2$ contained in one identifiable SRS primary shipping container.

1.2.2 Fuel Lot. The processed $^{238}PuO_2$ fuel consisting of a single feed lot or a blending of two or more feed lots.

2.0 DOCUMENTS

2.1 Required. Current issues of the following drawings and specifications form a part of this specification where applicable:

26Y-318189 LWRHU Product Specifications.

2.2 Precedence of Documents. In the event of conflict between this fuel specification and any other documents, this specification shall prevail.

2.3 Changes. Changes to this specification shall be handled in accordance with the Department of Energy/Office of Special Applications Isotope Fuel & Safety Program Quality Assurance (QA) Plan, HS-QA-PD-8.

3.0 REQUIREMENTS

3.1 Nonconforming Material. Materials which do not comply with the requirements of this specification shall be handled in accordance with the QA plan, HS-QA-PD-8.

3.2 Feed Lot

3.2.1 ^{238}Pu Content. The ^{238}Pu content shall be 81.0 at.% ± 2.5 at.% of the total plutonium content at the date of analysis at SRS.

3.2.2 ^{236}Pu Content. The ^{236}Pu content shall not exceed 2 ppm of the total plutonium content, back-decayed to the date of fuel precipitation.

3.2.3 Actinide Impurities. The total actinide impurities, ^{241}Am, ^{237}Np, ^{234}U, and Th shall not exceed 1% of the total plutonium content when back decayed to the date of precipitation. On the same basis, no individual actinide impurity shall exceed 0.5%.

3.3 Fuel Lot

3.3.1 Nonactinide Cationic Impurities. The total of all nonactinide cationic impurities shall not exceed 2550 ppm. Iron, chromium, nickel, and silicon shall not exceed 800, 200, 100, and 500 ppm, respectively (by weight). Other individual elements listed below shall be reported in the summary package.

Element
Al B Ca Cd Cr Cu Fe Mg
Mn Mo Na Ni Pb Si Sn Zn

3.3.2 Granule Size. After seasoning, the granules shall pass through a U. S. Standard Sieve, ASTM No. 70 (212 microns).

3.3.3 Granule Seasoning. Approximately 60% of a fuel lot shall be material seasoned at 1100 ± 10°C in flowing $Ar\text{-}H_2{}^{16}O$, and the remainder shall be seasoned at 1600 ± 15°C in flowing $Ar\text{-}H_2{}^{16}O$.

3.3.4 Neutron Emission Rate. The specific neutron emission rate shall not exceed 6000 neutron $s^{-1}\,g^{-1}$ ^{238}Pu on the seasoned fuel lot.

3.4 Records

3.4.1 Retention of Records. All production and analytical data shall be retained in accordance with LWRHU Product Specifications, 26Y-318189.

II. LWRHU PRODUCT SPECIFICATIONS

1.0 GENERAL

1.1 Scope. This specification defines the chemical and physical requirements for $^{238}PuO_2$ (^{16}O-exchanged) pellets for the LWRHU. It also specifies welding of the Pt-30 Rh fueled clads, activation of the vents, and assembly of the graphite components.

2.0 DOCUMENTS

2.1 Required Documents. The current issues of the following documents form a part of this specification:

2.1.1 Los Alamos Documents

HS-QA-PD-11 LWRHU Product Index
HS-QA-PD-8 Heat Source Quality Assurance Plan

2.1.2 Jet Propulsion Laboratory Documents

ES516016 Cassini Spacecraft LWRHU Requirements/Environments and Testing Specification

2.2 Required Drawings. The current issues of the following drawings form a part of this specification:

2.2.1 Los Alamos Drawings

26Y-79818	Die Asymmetrical, Radioisotopic Heater Unit
26Y-200174	Packaging Container - Shipping Fixture LWRHU Assembly
26Y-318189	LWRHU Product Specifications
26Y-318190	LWRHU Assembly
26Y-318191	LWRHU Fueled Capsule
26Y-318192	LWRHU Fuel Pellet
26Y-318193	Material Specification for $^{238}PuO_2$ Fuel Granules, Light Weight Radioisotope Heater Unit (LWRHU)

2.2.2 MAT Drawings.

AYC-790096	Clad Body Assembly
AYC-790101	Shim
AYC-79105	Clad Cap Closure End
AYC-790380	Aeroshell Body
AYC-790381	Insulator Cap
AYC-790382	Outer Insulator Body
AYC-790383	Middle Insulator Body
AYC-790384	Inner Insulator Body
AYC-790385	Aeroshell End Cap

2.3 Precedence of Documents. In the event of conflict between this specification and any other documents, this specification shall prevail.

3.0 CONTROL OF COMPONENTS

3.1 Component Identification. The serial number of each component shall be used to control the part through all preassembly operations and material control.

4.0 LWRHU

4.1 Fuel. The fuel granules shall be $^{238}PuO_2$ meeting the requirements of Los Alamos Specification 26Y-318193.

4.1.1 Granule Mixture. The fuel granules loaded into the hot press die shall consist of 60 wt% ± 0.2 wt% of granules seasoned at 1100°C, and the remaining granules seasoned at 1600°C.

4.1.2 Graphite Die Assembly. Latest revision of Los Alamos Drawing 26Y-79818.

4.1.3 Die Charge. The pellets shall be hot pressed 16 at a time. The charge for each cavity shall be 2.670 g ± 0.005 g.

4.1.4 Hot Press Parameters. The pellets shall be hot pressed 16 at a time in vacuum at 2825 psi ± 50 psi for 15 min ± 2 min at 1530°C ± 30°C. The vacuum shall be 5 x 10^{-5} Torr or better at the start of the run.

4.1.5 Post-Press Sintering. After hot pressing, the pellets shall be sintered in flowing Ar-$H_2{}^{16}O$ (500 sccm) for 360 min ± 5 min at 1000°C ± 10°C, followed by 360 min ± 5 min at 1527°C ± 10°C.

4.2 Pellets

4.2.1 Dimensions for Sintered Pellets. The maximum diameter of the sintered pellets shall be 6.35 mm. The maximum length shall be 9.80 mm. The mass shall be 2.664 g ± 0.030 g. All dimensions shall be determined within 1 week after the pellets are sintered.

4.2.2 Analyses. One pellet from each lot pressed shall be submitted for spectrochemical analysis. Neutron emission rate measurements shall be made on the spectrochemical sample. Material exceeding fuel specification (26Y-318193) shall be deemed nonconforming.

4.2.3 Nonintegral Pellets. Any pellet that is nonintegral after sintering shall be used for analyses or discarded. No nonintegral pellets shall be loaded for flight use.

4.2.4 Thermal Inventory. The fuel pellets shall have a thermal inventory of 1.07 watts ± 0.06 watts back-decayed to the time of pressing.

4.3 Hardware, Welding, and Testing

4.3.1 Hardware

4.3.1.1 Platinum-30 Rhodium Capsules. DOE-accepted capsules furnished to Los Alamos by MAT. All drawings and specifications for the capsules shall be issued by MAT.

4.3.1.2 Graphite Aeroshell and Insulator. DOE accepted assemblies furnished to Los Alamos by MAT. All drawings and specifications for the graphite hardware shall be issued by MAT.

4.3.2 Welding

4.3.2.1 Glove box Atmosphere. The atmosphere of the glove box used for welding shall be monitored before and during welding. The oxygen content shall be less than 100 ppm, and the moisture content shall be less than 250 ppm.

4.3.2.2 Torch Gas. The GTA welds shall be performed with commercial welding-grade gas that is nominally 25% Ar, 75% He.

4.3.2.3 Example Welds. One GTA example weld shall be made as the initial weld for each production run. A production run is one work period where welding is performed by the operators with the same equipment on one capsule design. Example weld hardware shall be representative of the production hardware.

4.3.2.4 Examination of Example Weld. The weld shall be examined visually at 30X for defects, such as cracks, pores, and discoloration. Any presence of irregularities shall be cause to reject the weld and postpone production welding. The example weld capsule shall be opened and defueled. The interior of the weld shall be examined visually for defects. If none is found, production welding may start. A diametral section through the weld shall be prepared metallographically and examined at 30X. Any evidence of unwelded regions in the vertical part of the joint, or of any pore or pores whose aggregate diameter is greater than 0.25 mm, or of any crack in the weld bead longer than 0.1 mm shall cause the production capsules welded in the run to require formal acceptance by the Materials Review Board.

4.3.2.5 Production Welds. When visual inspection indicates that the example weld is satisfactory, the production run may be welded. Welding parameters for the production run will be the same as for the example weld. Each production weld shall be examined at 30X for defects, such as cracks, pores, and discoloration. Any physical irregularities detected shall be referred to the Materials Review Board for evaluation.

4.3.2.6 Decontamination. The production capsules shall be decontaminated by successive immersions in a reagent grade acid solution (5:2:2 of H_2O:HF:HNO_3), distilled water, and reagent grade ethanol. The decontamination shall be considered complete when a swipe count taken at least 24 hours after the final ethanol rinse is less than 220 dpm.

4.3.3 NDT

4.3.3.1 Helium Leak Test. Each welded capsule shall have a leak rate not to exceed 1 x 10^{-6} std cm^3/s helium as determined by a mass-spectrometer-type helium leak detector.

4.3.3.2 Radiography. Each welded capsule shall be radiographed to verify that the weld exhibits complete penetration of the vertical part of the joint and is free of cracks.

4.3.3.3 Neutron Emission Rate Measurement. The neutron emission rate shall be measured for each welded capsule. The rate shall be less than 7000 n/s-g ^{238}Pu. The gamma dose rate at 20 cm will be measured for 1 capsule from each lot.

4.3.3.4 Calorimetry. The thermal inventory of each welded capsule shall be measured. The thermal output shall be 1.07 watts ± 0.06 watts back-decayed to the time of pellet pressing.

4.4 Final Assembly

4.4.1 Vent Activation. The frit vent shall be activated immediately before placing the capsule into the graphite shell. This shall be accomplished by cutting into the vented end of the capsule at the center line with a 0.025 in. ± 0.002 in.-diam endmill. The capsule shall be visually examined to ensure that the frit is visible through the drilled hole.

4.4.2 Assembly into Graphite. After a swipe check (less than 220 dpm), the capsule with the activated vent shall then be placed into the graphite shell, and the graphite lid shall be glued into place with Union Carbide UCAR C-34 cement. The graphite shell shall then be heat treated at 100°C ± 5°C for a period of 4.0 h ± 0.5 h, followed by heating at 130°C ± 10°C for 16.0 h ± 1.0 h to cure the cement.

4.4.3 Vacuum Outgas the Aeroshell Assembly. The aeroshell assembly shall be outgassed in a vacuum furnace at a temperature of 325°C ± 10°C for 144 h ± 1 h in a vacuum of < 2 x 10^{-5} Torr.

4.4.4 Geometry Requirements. The aeroshell assembly shall have a length of 31.95 mm ± 0.05 mm and a diameter of 25.95 mm ± 0.05 mm.

4.4.5 Mass Requirements. The aeroshell assembly shall have a maximum mass of 42.00 g.

4.4.6 Surface Contamination. The assembled heater unit shall be checked for alpha contamination. The alpha swipe count shall be < 25 dpm.

5.0 ADDITIONAL TESTING

Los Alamos shall perform any additional operations or tests which are considered necessary by Los Alamos or DOE to ensure the quality of the completed product. Such work will be documented and available for review at Los Alamos.

6.0 RETENTION OF RECORDS

Appropriate QA records and documentation shall be retained to confirm that all specifications have been met. Records for each heater unit shipped shall be maintained for at least 8 years past mission launch date. These records shall be available for inspection when desired by DOE.

7.0 PACKAGING AND SHIPPING

The fueled heater units shall be packaged and shipped according to Los Alamos procedure RHU-NMT9-PP-5 and applicable Department of Transportation and DOE regulations.

8.0 FABRICATION DATA PACKAGE

8.1 Fabrication Data Package Inclusions The fabrication data package shall include a compilation of the specifications, processing and fabrication parameters, and analytical results as listed below, together with identification of the contents of the shipping container and the appropriate sign offs by Los Alamos QA.

8.2 $^{238}PuO_2$ Fuel

8.2.1 Fuel Lot ID. The fuel lot ID, traceable to the original SRS lot ID, will be listed for each encapsulated pellet.

8.2.2 Parameters and Dimensions. The feed processing and pellet fabrication parameters, together with the sintered pellet dimensions, will be listed for each pellet lot included in the shipment.

8.2.3 Analytical Data. Spectrochemical, actinide content, and isotopic composition data shall be summarized for those pellets included in the shipment.

8.3 Welding

8.3.1 Identification. The pellet ID numbers will be listed and related to the capsule ID numbers.

8.3.2 Welding Parameters. The weld parameters for each fueled clad will be stored on a computer disk. The oxygen and moisture contents of the glove box at the time of welding will be summarized.

8.3.3 Photomicrographs of Example Welds. Photomicrographs of example weld capsules will be included in the data package.

8.4 NDT

8.4.1 Alpha Swipe Count. The surface alpha contamination will be listed for each capsule.

8.4.2 Radiography. Radiographs will be included for each welded capsule.

8.4.3 Calorimetry. The thermal inventory for each capsule will be listed as of the date of measurement.

8.4.4 Leak Check. The helium leak rate shall be listed for each capsule.

8.4.5 Neutron Emission Rate. The neutron emission rate shall be listed for each capsule.

8.4.6 Gamma Dose Rate. The gamma dose rate at 20 cm will be listed for 1 welded capsule from each pellet lot.

8.4.7 Welded Capsule Dimensions. The mass, diameter (across machined standoffs), overall length, and weld standoff length shall be listed for each welded capsule.

8.5 Graphite Aeroshell Assembly

8.5.1 Identification. The welded capsule ID numbers will be listed and related to the graphite aeroshell ID numbers.

8.5.2 Cement Cure Cycle. The time-temperature profile record of the cement cure cycle will be retained for each glued aeroshell assembly.

8.5.3 Vacuum Outgas Cycle. The time-temperature profile record of the vacuum outgas cycle will be retained for each aeroshell assembly.

8.5.4 Dimensions. The length and diameter of each aeroshell assembly will be listed.

8.5.5 Mass. The mass of each aeroshell assembly will be listed.

8.5.6 Surface Contamination. The alpha swipable surface contamination of each aeroshell assembly will be listed.

9.0 MATERIALS REVIEW BOARD

A Materials Review Board shall be appointed by the Project Leader to review all deviant production items and to determine the disposition of these items. When this board decides that an item is acceptable for flight use, its action and the reasons for it shall be documented and made part of the data package submitted for DOE acceptance. The Board's members shall include a representative from the Los Alamos Quality Assurance Group.

10.0 SHIPMENT DATA PACKAGE

10.1 Shipment Data Package Inclusions The shipment data package shall include a compilation of the specifications, a table of fabrication parameters as listed below, a record of assembly for each heat source, Material Review Board actions, and Certificates of Inspection for each heat source.

10.2 Specifications and Drawings The following Los Alamos documents and drawings will be included in the shipment data package.

HS-QA-PD-11	LWRHU Product Index
26Y-318189	LWRHU Product Specifications
26Y-318190	LWRHU Assembly
26Y-318191	LWRHU Fueled Capsule
26Y-318192	LWRHU Fuel Pellet
26Y-318193	Material Specification for $^{238}PuO_2$ Fuel Granules, Light Weight Radioisotope Heater Unit (LWRHU)

10.3 Record of Assembly The record of assembly for each aeroshell assembly shall include the aeroshell assembly ID, the welded capsule ID, the pellet ID, the Los Alamos fuel lot ID, and the SRS feed lot ID.

10.4 Table of Data for Each Aeroshell Assembly

10.4.1 Identification. The graphite aeroshell ID will be listed.

10.4.2 Calorimetry. The thermal inventory for each aeroshell assembly will be listed as of the date of measurement together with the value calculated (corrected for decay) for the shipping date.

10.4.3 Neutron Emission Rate. The neutron emission rate shall be listed for each aeroshell assembly.

10.4.4 Gamma Dose Rate. The gamma dose rate at 20 cm will be listed for 1 aeroshell assembly from each pellet lot.

10.4.5 Dimensions. The length and diameter of each aeroshell assembly will be listed.

10.4.6 Mass. The mass of each aeroshell assembly will be listed.

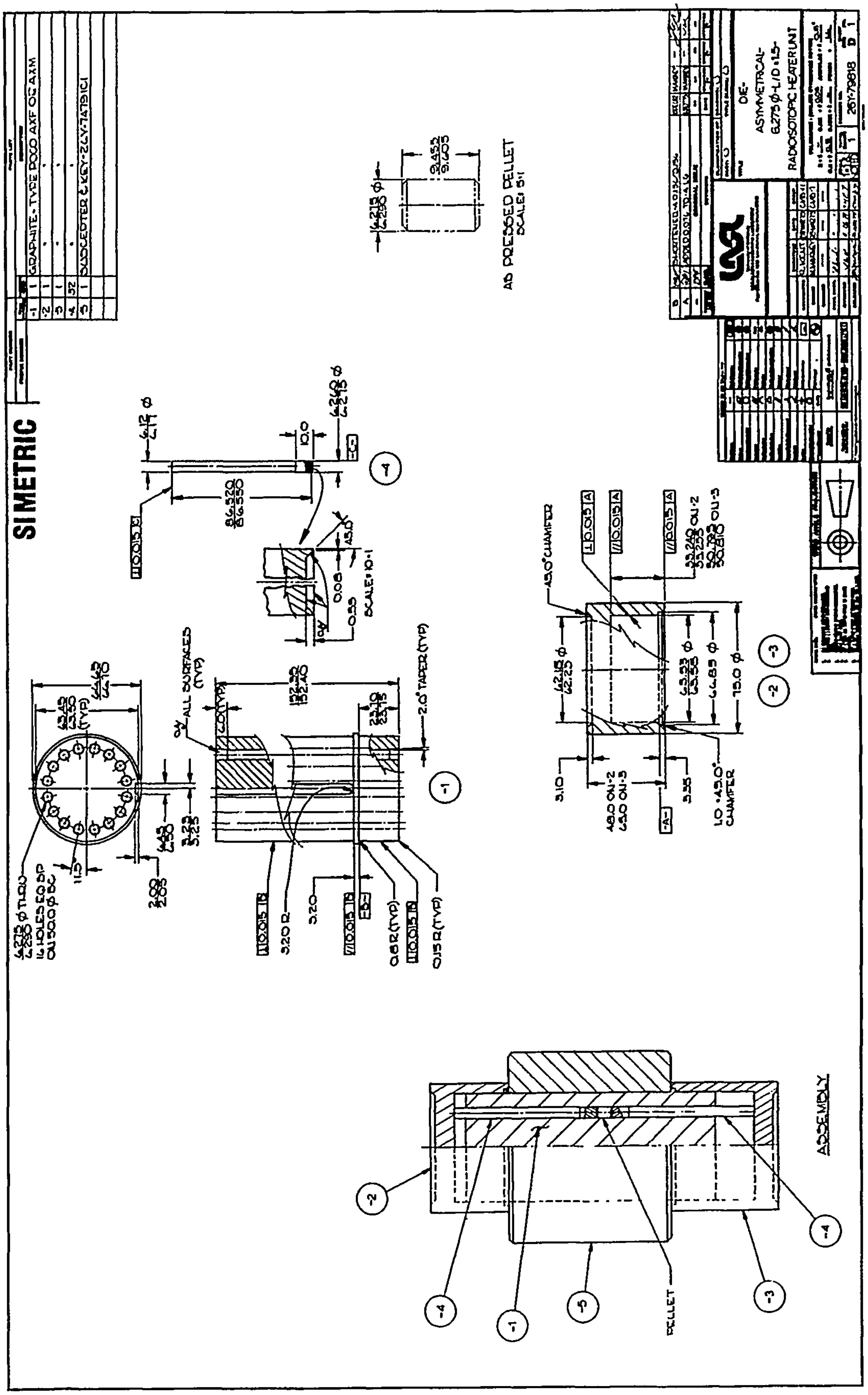
10.4.7 Surface Contamination. The alpha swipable surface contamination of each aeroshell assembly will be listed.

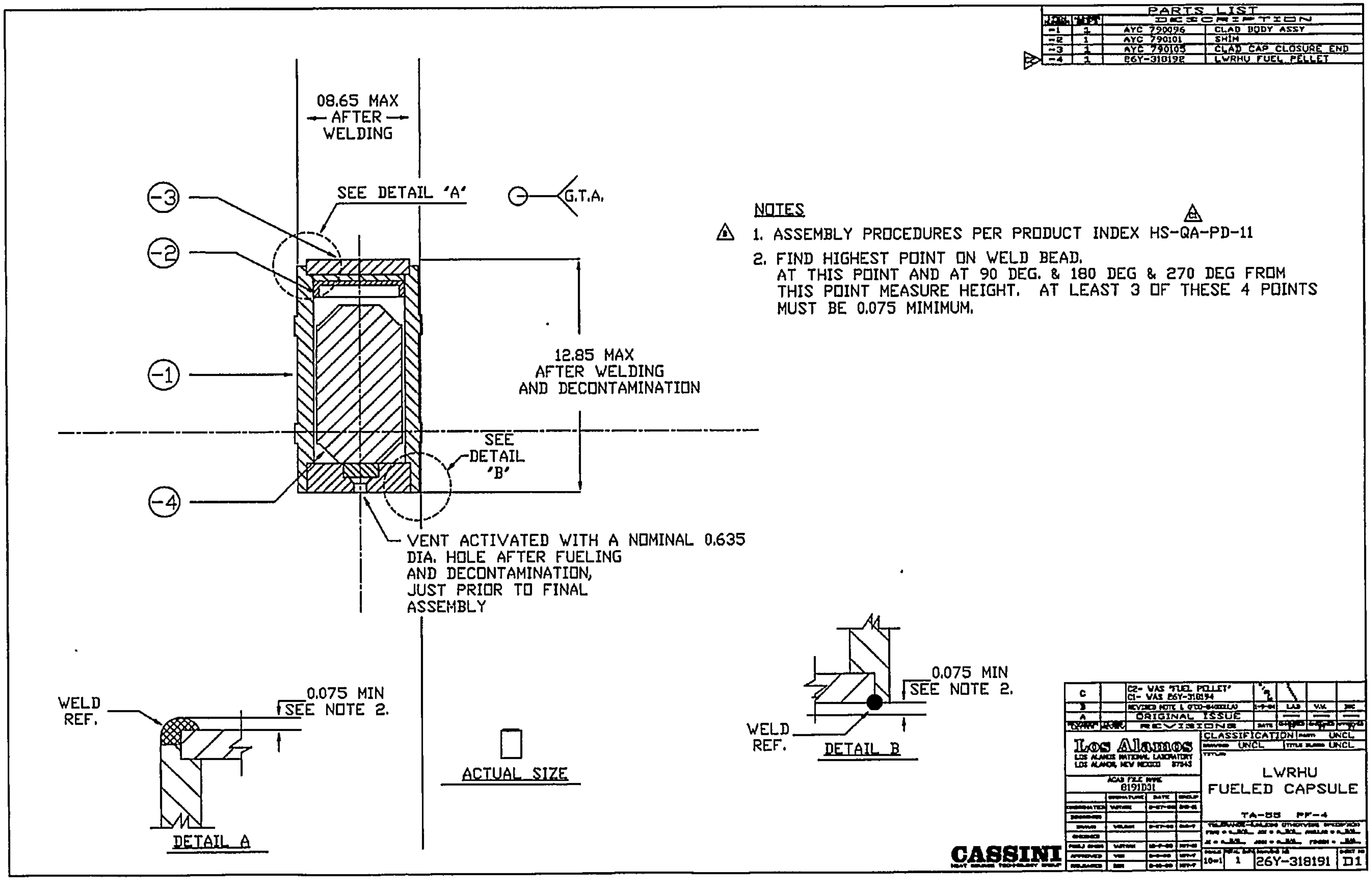
APPENDIX II

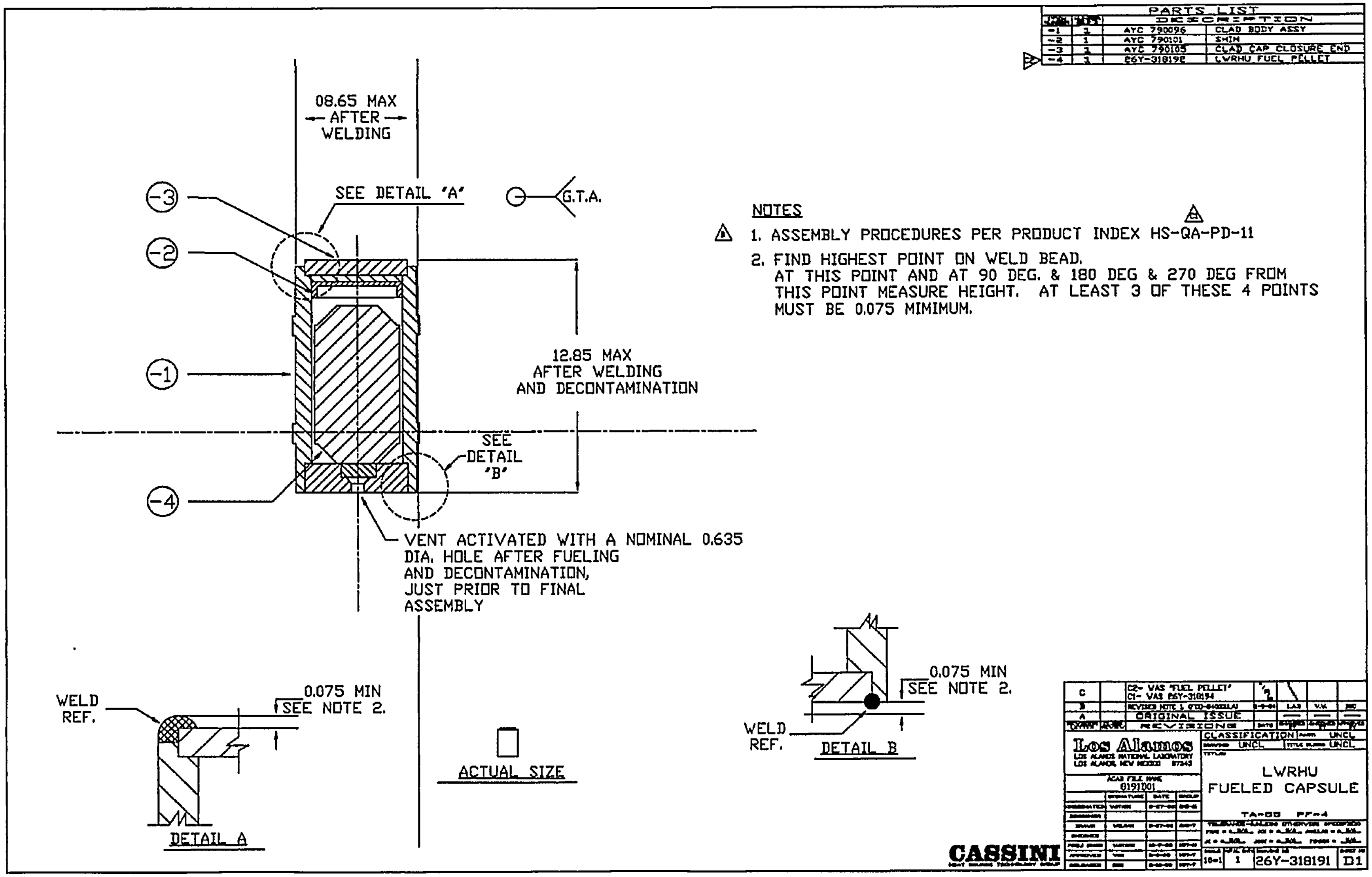
CONSTRUCTION DRAWINGS

This appendix consists of copies of the Los Alamos construction drawings for the LWRHU.

1. 26Y-079818 Die Assymetrical, Radioisotopic Heater Unit
2. 26Y-318190 LWRHU Assembly
3. 26Y-318191 LWRHU Fueled Capsule
4. 26Y-318192 LWRHU Fuel Pellet


SI METRIC
GRAPHITE - TYPE POCO AXF Q2 AXM
AS PRESSED PELLET
SCALE: 5:1
ASSEMBLY
PELLET
DIE-
ASYMMETRICAL-
6.275 φ-L/D ≈1.5-
RADIOISOTOPIC HEATER UNIT
26Y-79818

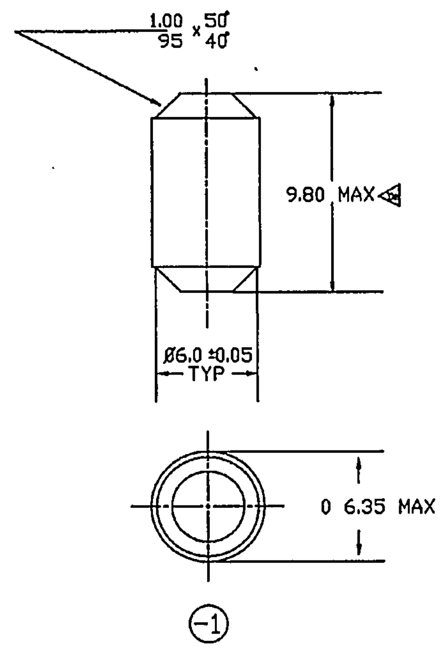

PARTS LIST
DESCRIPTION
-1 1 AYC 790096 CLAD BODY ASSY
-2 1 AYC 790101 SHIM
-3 1 AYC 790105 CLAD CAP CLOSURE END
-4 1 86Y-318192 LWRHU FUEL PELLET
Ø8.65 MAX AFTER WELDING
SEE DETAIL 'A'
G.T.A.
-3
-2
-1
-4
12.85 MAX AFTER WELDING AND DECONTAMINATION
SEE DETAIL 'B'
VENT ACTIVATED WITH A NOMINAL 0.635 DIA. HOLE AFTER FUELING AND DECONTAMINATION, JUST PRIOR TO FINAL ASSEMBLY
NOTES
1. ASSEMBLY PROCEDURES PER PRODUCT INDEX HS-QA-PD-11
2. FIND HIGHEST POINT ON WELD BEAD. AT THIS POINT AND AT 90 DEG. & 180 DEG & 270 DEG FROM THIS POINT MEASURE HEIGHT. AT LEAST 3 OF THESE 4 POINTS MUST BE 0.075 MIMIMUM.
WELD REF.
0.075 MIN SEE NOTE 2.
DETAIL A
ACTUAL SIZE
WELD REF.
0.075 MIN SEE NOTE 2.
DETAIL B
ORIGINAL ISSUE
REVISIONS
CLASSIFICATION UNCL
Los Alamos
LWRHU FUELED CAPSULE
TA-55 PF-4
CASSINI
26Y-318191
D1



PARTS LIST

			DESCRIPTION
-1	1	AYC 790096	CLAD BODY ASSY
-2	1	AYC 790101	SHIM
-3	1	AYC 790105	CLAD CAP CLOSURE END
-4	1	26Y-318192	LWRHU FUEL PELLET

ITEM	QTY	PARTS LIST DESCRIPTION
-1	1	238 PU O_2 ; 1.07 ± 0.06 WATT PER 26Y-318189



NOTES

1. DIMENSIONS ARE TOOL CONTROLLED
2. SEE PRODUCT INDEX HS-QA-PD-11 FOR REQUIRED SPECIFICATIONS AND PROCEDURES

D	D2- VAS 9.37 REF; D1- VAS 8.625 REF
C	C2- VAS 1.10; C1- VAS 26Y-318194
B	REVISED NOTE
A	ORIGINAL ISSUE

REVISIONS

CLASSIFICATION UNCL

Los Alamos
LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS NEW MEXICO 87545

ACAD FILE NAME 8192D01

LWRHU FUEL PELLET

TA-55 PF-4

SCALE 10=1 | 1 | 26Y-318192 | D1

CASSINI