

# **RERTR-10 Irradiation Summary Report**

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May 2011



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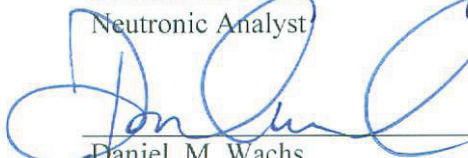
Approved by:



Danielle M. Perez  
Neutronic Analyst

5/2/2011

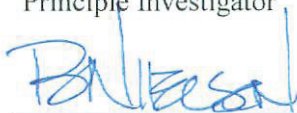
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5/4/2011

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## **SUMMARY**

The Reduced Enrichment for Research and Test Reactor (RERTR) experiment RERTR-10 was designed to further test the effectiveness of modified fuel/clad interfaces in monolithic fuel plates. The experiment was conducted in two campaigns: RERTR-10A and RERTR-10B. The fuel plates tested in RERTR-10A were all fabricated by Hot Isostatic Pressing (HIP) and were designed to evaluate the effect of various Si levels in the interlayer and the thickness of the Zr interlayer (0.001") using 0.010" and 0.020" nominal foil thicknesses. The fuel plates in RERTR-10B were fabricated by Friction Bonding (FB) with two different thickness Si layers and Nb and Zr diffusion barriers.<sup>1</sup>

The following report summarizes the life of the RERTR-10A/B experiment through end of irradiation, including as-run neutronic analysis results, thermal analysis results and hydraulic testing results.

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## ACRONYMS

Al	aluminum
ATR	Advanced Test Reactor
BOC	beginning of cycle
EFPD	effective full power days
EOC	end of cycle
FB	friction bonding
HIP	hot isostatic pressing
L2AR	local-to-average ration
LEU	low enriched uranium
MCNP	Monte Carlo N-Particle
Mo	molybdenum
Nb	niobium
RERTR	Reduced Enrichment Research and Test Reactor
Si	silicon
U	uranium
U-Mo	uranium-molybdenum
Zr	zirconium



# **RERTR-10 Irradiation Summary Report**

## **1. EXPERIMENT GOALS**

The Reduced Enrichment Research and Test Reactor (RERTR)-10A/B test assembly holds 4 capsules, designated as A, B, C and D, with A at the top of the assembly and D at the bottom. Each capsule has 2 levels, with 4 plate positions per level, for a total of 8 plate positions per capsule and 32 plate positions per assembly. Within each capsule the 8 plate positions are azimuthally designated as 1 through 4 in the upper level and 5 through 8 in the lower level. The loading diagram for the RERTR-10A/B Experiment Matrix is shown in Table 1.

The RERTR-10 experiment was designed to further test the effectiveness of modified fuel/clad interfaces in monolithic fuel plates. The experiment was conducted in two campaigns: RERTR-10A and RERTR-10B. The fuel plates tested in RERTR-10A were all fabricated by Hot Isostatic Pressing (HIP) and were designed to evaluate the effect of various Si levels in the interlayer and the thickness of the Zr interlayer (0.001”) using 0.010” and 0.020” nominal foil thicknesses. The fuel plates in RERTR-10B were fabricated by Friction Bonding (FB) with two different thickness Si layers and Nb and Zr diffusion barriers.<sup>1</sup>

Table 1. RERTR-10A/B experiment matrix loading diagram.1RERTR-10A/B Experiment Matrix

Capsule	Column 1	Column 2	Column 3	Column 4
A-Top	A1	A2	A3	A4
	Zr Co-Roll HIP 0.001” Thick Layer <b>L1P30Z</b>	Al-12 Si alloy HIP 0.001” Thick Layer <b>L1P256</b>	Zr Co-Roll HIP Thick Foil Constrained Plate <b>L2P15Z</b>	Al-2 Si alloy HIP 0.001” Thick Layer <b>L1P135</b>
A-Bottom	A5	A6	A7	A8
	Al-3.5 Si/Al+5 Si HIP 0.001” Thick Layer <b>L1P234</b>	Al+1.5 Si/Al+2 Si HIP 0.001” Thick Layer <b>L1P213</b>	Al+0 Si/Al+1 Si HIP 0.001” Thick Layer <b>L1P192</b>	thin Si/thick Si HIP <b>L1P171</b>
B-Top	B1	B2	B3	B4
	Blank <b>DUMMY</b>	Thin Si/thick Si FB Heat Treat <b>L1F401</b>	Thin Si/thick Si FB No Heat Treat <b>L1F417</b>	Blank <b>DUMMY</b>
B-Bottom	B5	B6	B7	B8
	Blank <b>DUMMY</b>	Zr Co-Roll FB Thick Foil <b>L2F46Z</b>	Nb Co-Roll FB <b>L1F44N</b>	Blank <b>DUMMY</b>
C-Top	C1	C2	C3	C4
	Zr Co-Roll HIP 0.001” Thick Layer <b>L1P12Z</b>	Al-12 Si alloy HIP 0.001” Thick Layer <b>L1P266</b>	Zr Co-Roll HIP Thick Foil Constrained Plate <b>L2P16Z</b>	Al-2 Si alloy HIP 0.001” Thick Layer <b>L1P145</b>
C-Bottom	C5	C6	C7	C8
	Al-3.5 Si/Al+5 Si HIP 0.001” Thick Layer <b>L1P244</b>	Al+1.5 Si/Al+2 Si HIP 0.001” Thick Layer <b>L1P223</b>	Al+0 Si/Al+1 Si HIP 0.001” Thick Layer <b>L1P202</b>	thin Si/thick Si HIP <b>L1P181</b>
D-Top	D1	D2	D3	D4
	Blank <b>DUMMY</b>	Zr Co-Roll FB <b>L1F381</b>	Nb Co-Roll FB <b>L1F427</b>	Blank <b>DUMMY</b>
D-Bottom	D5	D6	D7	D8
	Blank <b>DUMMY</b>	Zr Co-Roll FB Thick Foil <b>L2F45Z</b>	Zr Co-Roll FB <b>L2F47Z</b>	Blank <b>DUMMY</b>

## 2. CONSTITUENT MASSES AND DENSITIES

Table 2. RERTR-10A/B constituent masses and densities.<sup>2,3</sup>

Fuel Plate ID	Fuel Plate #	Fuel Constituent Masses			Constituent Densities		
		Total-U (g)	U-235 (g)	Mo (g)	Total U Density (g/cc)	U-235 Density (g/cc)	Mo (g/cc)
A1	L1P30Z	5.968	3.998	0.670	13.023	8.724	1.462
A2	L1P256	6.080	4.073	0.682	15.253	10.218	1.711
A3	L2P15Z	11.522	3.845	1.298	14.258	4.758	1.606
A4	L1P135	6.234	4.177	0.759	15.279	10.238	1.860
A5	L1P234	6.669	4.468	0.747	15.144	10.146	1.696
A6	L1P213	6.261	4.195	0.698	15.268	10.230	1.702
A7	L1P192	6.553	4.390	0.730	15.522	10.398	1.729
A8	L1P171	6.230	4.174	0.696	15.285	10.241	1.708
B1	Blank	--	--	--	--	--	--
B2	L1F401	5.624	3.768	0.630	14.578	9.767	1.633
B3	L1F417	5.730	3.839	0.648	14.326	9.598	1.620
B4	Blank	--	--	--	--	--	--
B5	Blank	--	--	--	--	--	--
B6	L2F46Z	10.365	3.431	1.160	13.154	4.354	1.472
B7	L1F44N	5.419	3.631	0.605	12.449	8.341	1.390
B8	Blank	--	--	--	--	--	--
C1	L1P12Z	6.009	4.026	0.470	12.492	8.370	0.977
C2	L1P266	6.164	4.130	0.691	14.832	9.938	1.663
C3	L2P16Z	11.354	3.789	1.278	13.676	4.564	1.539
C4	L1P145	6.265	4.197	0.703	15.041	10.076	1.688
C5	L1P244	6.293	4.217	0.703	15.182	10.173	1.696
C6	L1P223	6.352	4.256	0.712	15.335	10.275	1.719
C7	L1P202	6.406	4.292	0.718	15.585	9.772	1.635
C8	L1P181	6.202	4.155	0.692	15.067	10.094	1.681
D1	Blank	--	--	--	--	--	--
D2	L1F381	5.624	3.768	0.630	14.997	10.048	1.680
D3	L1F427	5.707	3.824	0.642	14.983	10.039	1.685
D4	Blank	--	--	--	--	--	--
D5	Blank	--	--	--	--	--	--
D6	L2F45Z	10.510	3.507	1.189	19.716	6.579	2.231
D7	L2F47Z	10.651	3.554	1.205	13.603	4.539	1.539
D8	Blank	--	--	--	--	--	--

### 3. EXPERIMENT HARDWARE

The experiment hardware configuration is identical to that used in the RERTR-7A, -7B, -8, -9A, and -9B experiments. A list of irradiation hardware drawings used for analysis is given in Table 3.

Table 3. RERTR-10 Irradiation Hardware Drawing List.<sup>4</sup>

Drawing Number	Drawing Title
DWG-630223	RERTR ATR Large B-Position Irradiation Experiment Assembly
DWG-630233	ATR Large B-Position Basket
DWG-630231	ATR Top Spacer Assembly
DWG-630225	ATR Upper Spacer Assembly
DWG-630229	ATR Bottom Spacer Assembly
DWG-630227	ATR Large B-Position Fuel Capsule Assembly
DWG-630237	Fuel Capsule
DWG-630239	Capsule Cap
DWG-630244	RERTR Mini-Plate
DWG-630245	Fuel Plate, 0.020 Monolithic

The RERTR miniplate irradiation assembly<sup>4</sup>, (see Figure 1) shows the main components of the test assembly, which include the bottom spacer, upper and top spacers, experiment capsules and basket. The bottom spacer elevates the experiment capsules to the correct location in the core. The upper and top spacers allow the operators to assure that the experiment is seated fully into the basket. All spacers are similar to the capsule design except the spacers do not have the grooves for the plates. The capsules hold the fuel plates; a capsule cap is welded onto the top of the capsule to keep the plates from sliding out during handling and irradiation. The fuel plate drawings for monolithic and thick monolithic plates (DWG-630244 and DWG-630245, respectively) and RERTR miniplate capsule assembly<sup>4</sup> are shown in Figure 2, Figure 3 and Figure 4, respectively. Each capsule has a notch at the top and a groove at the bottom which allow the capsules to stack and align properly into the core. The basket holds the test assembly in the reactor during irradiation, the notches on the outer wall allow for bypass coolant flow to cool the outer wall. The basket has two guide bars on the inside wall to guide the assembly into the baskets.



Figure 1 RERTR miniplate irradiation Assembly.<sup>4</sup>







Figure 4. RERTR capsule assembly.<sup>4</sup>



## 4. IRRADIATION HISTORY

The RERTR-10A test assembly was irradiated in cycle 142B in the large-B position B-9 and Cycle 143A in the large-B position B-11. The RERTR-10B test assembly was irradiated in Cycle 143A in the large-B position B-11. The RERTR-10A/B test assembly is the combined 10A and 10B test assemblies. The power of position B-9 is represented by the north lobe power which is the average of the NW, C and NE lobe powers,  $N = (NW + C + NE)/3$ . The power of position B-11 is represented by the south lobe power which is the average of the SW, C and SE lobe powers,  $S = (SW + C + SE)/3$ . Cycle 142B ran for 52 EFPDs at 25.3 MW and cycle 143A ran for a total of 48.9 EFPDs at 24.4 MW. RERTR-10A failed (Plate L1P145) during cycle 143A and was removed after 26 EFPDs, RERTR-10B continued irradiation for an additional 22.9 days.

There were two Mid-Cycle SCRAMs during Cycle 142B with a duration of 3 days and 2 days, from dates 07/06/08 – 07/09/08 and 08/05/08 – 08/07/08 respectively. There were also two Mid-Cycle SCRAMs during Cycle 143A with duration of 20 days and 5 days, from the dates 10/16/08 – 11/05/08 and 12/21/08 – 12/26/08 respectively. This information is tabulated in Table 4.

Table 4. Irradiation history for RERTR-10.

ATR CYCLE	RERTR-10A/B Test ID	RERTR-10 Capsules Irradiated	Dates Irradiated	Cycle EFPDs	Mid-Cycle Scram Decay Days	Post-Cycle Decay Days	North Lobe Source Power (MW)	South Lobe Source Power (MW)
142B	RERTR-10A	A,C	07/04/2008 – 08/30/2008	52	5	25	22.1	--
143A-1	RERTR-10A/B	A,B,C,D	09/24/2008 – 12/06/2008	26.0	25	--	--	25.4
143A-2	RERTR-10B	B,D		22.9		17	--	25.4

## 5. AS-RUN NUCLEAR ANALYSIS

### 5.1 Neutronics

The as-run calculations were performed using the irradiation history in Table 4 and the Monte Carlo N-Particle (MCNP) code. The calculated as-run fission heat rates, fission densities, and as-run U-235 burnup results for the fueled miniplates reported have an uncertainty band ( $1\sigma$ ) of 2.5%.<sup>5</sup> The time intervals used to calculate the average plate power and burnup is shown in Table 5. The end of cycle average plate power and burnup for cycles 142B and 143A are shown in Table 6. The average plate power and burnup for the time intervals for each cycle are shown in Table 7 through Table 13. The plots of the power and fission density as a function of the ATR Cycle time interval are in Appendix A.

Table 5. Cycle breakdown.

Time Interval	142B (days)	143A (days)
01	1.00E-04	1.00E-04
02	16	15
03	13.7	11
04	22.3	11
05	1.00E-04	11.9
06	--	1.00E-04
EFPDs	52	48.9

Table 6. End of cycle average plate power and burnup.

Position ID	Plate ID	142B 52.0 EFPD (EOC)					143A 26.0 EFPD (EOC for RERTR-10A)					143A 48.9 EFPD (EOC for RERTR-10B)				
		Fission Heat Rate (W/g)	Fission Power Density (w/cm <sup>3</sup> )	Heat Flux (w/cm <sup>2</sup> )	U-235 Burnup u-235/u-235 <sub>initial</sub> (%)	Fission Density (f/cc)	Fission Heat Rate (W/g)	Fission Power Density (w/cm <sup>3</sup> )	Heat Flux (w/cm <sup>2</sup> )	U-235 Burnup u-235/u-235 <sub>initial</sub> (%)	Fission Density (f/cc)	Fission Heat Rate (W/g)	Fission Power Density (w/cm <sup>3</sup> )	Heat Flux (w/cm <sup>2</sup> )	U-235 Burnup u-235/u-235 <sub>initial</sub> (%)	Fission Density (f/cc)
A1	L1P30Z	821.40	11401.91	166.47	8.99%	1.70E+21	1099.96	14806.39	216.17	15.17%	2.88E+21	--	--	--	--	--
A2	L1P256	684.15	11207.49	145.14	7.45%	1.64E+21	928.89	14828.31	192.03	12.72%	2.81E+21	--	--	--	--	--
A3	L2P15Z	340.31	5304.89	144.82	7.55%	7.78E+20	463.15	7126.35	194.55	12.88%	1.34E+21	--	--	--	--	--
A4	L1P135	820.48	13486.86	176.68	8.88%	1.98E+21	1136.69	18104.54	237.17	15.33%	3.42E+21	--	--	--	--	--
A5	L1P234	949.02	15214.06	210.71	10.35%	2.29E+21	1331.66	20568.00	284.87	17.77%	3.94E+21	--	--	--	--	--
A6	L1P213	788.96	12854.57	168.39	8.66%	1.91E+21	1129.86	17842.64	233.74	14.96%	3.31E+21	--	--	--	--	--
A7	L1P192	797.99	13213.14	177.72	8.71%	1.96E+21	1136.23	18229.56	245.19	15.05%	3.39E+21	--	--	--	--	--
A8	L1P171	999.24	16128.87	208.87	10.79%	2.41E+21	1396.15	21670.62	280.63	18.52%	4.15E+21	--	--	--	--	--
B1	Blank	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B2	L1F401	--	--	--	--	--	1892.10	29075.16	357.62	11.15%	2.42E+21	2096.89	30619.84	376.62	21.14%	4.58E+21
B3	L1F417	--	--	--	--	--	1898.52	28688.84	364.35	11.22%	2.39E+21	2184.18	31295.20	397.45	21.63%	4.61E+21
B4	Blank	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B5	Blank	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B6	L2F46Z	--	--	--	--	--	1004.61	14269.85	360.31	12.34%	1.20E+21	1072.37	14835.00	374.58	23.09%	2.25E+21
B7	L1F44N	--	--	--	--	--	2066.83	26963.40	373.44	12.26%	2.28E+21	2341.33	28846.91	399.53	23.30%	4.34E+21
B8	Blank	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C1	L1P12Z	1175.14	14868.69	230.46	12.63%	2.32E+21	1729.95	20833.42	322.92	21.96%	4.04E+21	--	--	--	--	--
C2	L1P266	956.51	14999.26	194.24	10.64%	2.30E+21	1420.50	21400.87	277.14	18.62%	4.03E+21	--	--	--	--	--
C3	L2P16Z	484.92	7190.58	192.71	11.03%	1.09E+21	698.60	10153.41	272.11	19.14%	1.91E+21	--	--	--	--	--
C4	L1P145	1152.20	18142.24	242.20	12.66%	2.79E+21	1714.03	25701.43	343.11	22.15%	4.91E+21	--	--	--	--	--
C5	L1P244	1092.63	17404.31	229.74	12.09%	2.69E+21	1579.83	24057.65	317.56	20.84%	4.67E+21	--	--	--	--	--
C6	L1P223	894.78	14554.25	192.12	9.99%	2.23E+21	1325.31	20766.44	274.12	17.44%	3.90E+21	--	--	--	--	--
C7	L1P202	914.03	14134.78	196.47	10.06%	2.13E+21	1346.40	20049.97	278.69	17.61%	3.75E+21	--	--	--	--	--
C8	L1P181	1139.17	17977.59	237.30	12.37%	2.73E+21	1646.89	24802.49	327.39	21.54%	4.78E+21	--	--	--	--	--
D1	Blank	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
D2	L1F381	--	--	--	--	--	1719.78	27320.47	333.31	10.21%	2.26E+21	1946.23	29488.28	359.76	19.53%	4.33E+21
D3	L1F4127	--	--	--	--	--	1757.60	27885.63	340.20	10.30%	2.29E+21	2035.30	30729.74	374.90	20.06%	4.47E+21
D4	Blank	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
D5	Blank	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
D6	L2F45Z	--	--	--	--	--	644.52	13888.14	336.79	7.83%	1.12E+21	724.63	15339.81	371.99	15.12%	2.19E+21
D7	L2F47Z	--	--	--	--	--	736.74	10924.97	269.30	8.86%	8.87E+20	846.70	12293.89	303.04	17.46%	1.75E+21
D8	Blank	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 7. Cycle 142B 02 average plate power and burnup.

Position ID	Plate ID	142B 16.0 EFPD						
		Fission Heat Rate (W/g)	Fission Power Density (w/cm <sup>3</sup> )	Heat Flux (w/cm <sup>2</sup> )	U-235 Burnup u-235/u-235 <sub>initial</sub> (%)	LEUeq Burnup (%)	Fission Density (f/cc)	Fission Rate (f/cc·s)
A1	L1P30Z	770.84	11018.69	160.87	2.82%	9.45%	5.40E+20	3.91E+14
A2	L1P256	635.02	10656.73	138.00	2.33%	7.81%	5.14E+20	3.72E+14
A3	L2P15Z	320.49	5056.48	138.04	2.30%	3.84%	2.43E+20	1.76E+14
A4	L1P135	760.17	12861.48	168.49	2.78%	9.31%	6.22E+20	4.50E+14
A5	L1P234	898.01	14890.05	206.23	3.35%	11.22%	7.34E+20	5.31E+14
A6	L1P213	732.86	12277.63	160.84	2.75%	9.21%	6.15E+20	4.45E+14
A7	L1P192	744.97	12687.99	17.65	2.74%	9.18%	6.21E+20	4.49E+14
A8	L1P171	928.78	15528.47	201.09	3.47%	11.62%	7.72E+20	5.58E+14
B1	Blank	--	--	--	--	--	--	--
B2	L1F401	--	--	--	--	--	--	--
B3	L1F417	--	--	--	--	--	--	--
B4	Blank	--	--	--	--	--	--	--
B5	Blank	--	--	--	--	--	--	--
B6	L2F46Z	--	--	--	--	--	--	--
B7	L1F44N	--	--	--	--	--	--	--
B8	Blank	--	--	--	--	--	--	--
C1	L1P12Z	1113.38	14689.89	227.69	4.29%	14.37%	7.80E+20	5.64E+14
C2	L1P266	904.48	14675.00	190.04	3.53%	11.83%	7.64E+20	5.53E+14
C3	L2P16Z	464.35	7006.12	187.76	3.68%	6.14%	3.57E+20	2.58E+14
C4	L1P145	1092.94	17923.88	239.28	4.22%	14.14%	9.28E+20	6.71E+14
C5	L1P244	1040.14	17226.34	227.39	3.99%	13.37%	8.97E+20	6.49E+14
C6	L1P223	850.65	14286.10	188.58	3.27%	10.95%	7.37E+20	5.33E+14
C7	L1P202	842.38	13452.64	186.99	3.35%	11.22%	7.10E+20	5.14E+14
C8	L1P181	1065.58	17506.17	231.08	4.06%	13.60%	9.01E+20	6.52E+14
D1	Blank	--	--	--	--	--	--	--
D2	L1F381	--	--	--	--	--	--	--
D3	L1F4127	--	--	--	--	--	--	--
D4	Blank	--	--	--	--	--	--	--
D5	Blank	--	--	--	--	--	--	--
D6	L2F45Z	--	--	--	--	--	--	--
D7	L2F47Z	--	--	--	--	--	--	--
D8	Blank	--	--	--	--	--	--	--

Table 8. Cycle 142B 03 average plate power and burnup.

Position ID	Plate ID	142B 29.7 EFPD						
		Fission Heat Rate (W/g)	Fission Power Density (w/cm <sup>3</sup> )	Heat Flux (w/cm <sup>2</sup> )	U-235 Burnup u-235/u-235 <sub>initial</sub> (%)	LEUeq Burnup (%)	Fission Density (f/cc)	Fission Rate (f/cc-s)
A1	L1P30Z	751.70	10625.64	155.13	5.19%	17.39%	9.86E+20	3.84E+14
A2	L1P256	623.64	10369.17	134.28	4.32%	14.47%	9.45E+20	3.68E+14
A3	L2P15Z	311.87	4897.55	133.70	4.35%	7.26%	4.48E+20	1.75E+14
A4	L1P135	742.40	12423.16	162.74	5.15%	17.25%	1.14E+21	4.44E+14
A5	L1P234	860.20	14080.95	192.02	6.08%	20.37%	1.34E+21	5.22E+14
A6	L1P213	715.37	11858.03	155.34	5.04%	16.88%	1.11E+21	4.33E+14
A7	L1P192	723.07	12182.80	163.86	5.07%	16.98%	1.13E+21	4.40E+14
A8	L1P171	904.24	14918.99	193.20	6.29%	21.07%	1.40E+21	5.46E+14
B1	Blank	--	--	--	--	--	--	--
B2	L1F401	--	--	--	--	--	--	--
B3	L1F417	--	--	--	--	--	--	--
B4	Blank	--	--	--	--	--	--	--
B5	Blank	--	--	--	--	--	--	--
B6	L2F46Z	--	--	--	--	--	--	--
B7	L1F44N	--	--	--	--	--	--	--
B8	Blank	--	--	--	--	--	--	--
C1	L1P12Z	1075.32	13963.82	216.44	7.55%	25.29%	1.37E+21	5.34E+14
C2	L1P266	872.27	13970.45	180.92	6.32%	21.17%	1.36E+21	5.30E+14
C3	L2P16Z	445.61	6678.12	178.97	6.50%	10.85%	6.41E+20	2.50E+14
C4	L1P145	1040.78	16801.73	224.30	7.55%	25.29%	1.65E+21	6.43E+14
C5	L1P244	993.96	16217.71	214.07	7.18%	24.05%	1.59E+21	6.20E+14
C6	L1P223	814.88	13517.89	178.44	5.89%	19.73%	1.32E+21	5.14E+14
C7	L1P202	826.20	13035.00	181.19	5.95%	19.93%	1.25E+21	4.87E+14
C8	L1P181	1028.18	16635.27	219.59	7.31%	24.49%	1.61E+21	6.27E+14
D1	Blank	--	--	--	--	--	--	--
D2	L1F381	--	--	--	--	--	--	--
D3	L1F4127	--	--	--	--	--	--	--
D4	Blank	--	--	--	--	--	--	--
D5	Blank	--	--	--	--	--	--	--
D6	L2F45Z	--	--	--	--	--	--	--
D7	L2F47Z	--	--	--	--	--	--	--
D8	Blank	--	--	--	--	--	--	--

Table 9. Cycle 142B 04 (EOC) average plate power and burnup.

Position ID	Plate ID	142B 52.0 EFPD (EOC)						
		Fission Heat Rate (W/g)	Fission Power Density (w/cm <sup>3</sup> )	Heat Flux (w/cm <sup>2</sup> )	U-235 Burnup u-235/u-235initial (%)	LEUeq Burnup (%)	Fission Density (f/cc)	Fission Rate (f/cc-s)
A1	L1P30Z	821.40	11401.91	166.47	8.99%	30.12%	1.70E+21	3.78E+14
A2	L1P256	684.15	11207.49	145.14	7.45%	24.96%	1.64E+21	3.65E+14
A3	L2P15Z	340.31	5304.89	144.82	7.55%	12.60%	7.78E+20	1.73E+14
A4	L1P135	820.48	13486.86	176.68	8.88%	29.75%	1.98E+21	4.41E+14
A5	L1P234	949.02	15214.06	210.71	10.35%	34.67%	2.29E+21	5.10E+14
A6	L1P213	788.96	12854.57	168.39	8.66%	29.01%	1.91E+21	4.25E+14
A7	L1P192	797.99	13213.14	177.72	8.71%	29.18%	1.96E+21	4.36E+14
A8	L1P171	999.24	16128.87	208.87	10.79%	36.15%	2.41E+21	5.36E+14
B1	Blank	--	--	--	--	--	--	--
B2	L1F401	--	--	--	--	--	--	--
B3	L1F417	--	--	--	--	--	--	--
B4	Blank	--	--	--	--	--	--	--
B5	Blank	--	--	--	--	--	--	--
B6	L2F46Z	--	--	--	--	--	--	--
B7	L1F44N	--	--	--	--	--	--	--
B8	Blank	--	--	--	--	--	--	--
C1	L1P12Z	1175.14	14868.69	230.46	12.63%	42.31%	2.32E+21	5.16E+14
C2	L1P266	956.51	14999.26	194.24	10.64%	35.64%	2.30E+21	5.12E+14
C3	L2P16Z	484.92	7190.58	192.71	11.03%	18.40%	1.09E+21	2.43E+14
C4	L1P145	1152.20	18142.24	242.20	12.66%	42.41%	2.79E+21	6.21E+14
C5	L1P244	1092.63	17404.31	229.74	12.09%	40.50%	2.69E+21	5.99E+14
C6	L1P223	894.78	14554.25	192.12	9.99%	33.47%	2.23E+21	4.96E+14
C7	L1P202	914.03	14134.78	196.47	10.06%	33.70%	2.13E+21	4.74E+14
C8	L1P181	1139.17	17977.59	237.30	12.37%	41.44%	2.73E+21	6.08E+14
D1	Blank	--	--	--	--	--	--	--
D2	L1F381	--	--	--	--	--	--	--
D3	L1F4127	--	--	--	--	--	--	--
D4	Blank	--	--	--	--	--	--	--
D5	Blank	--	--	--	--	--	--	--
D6	L2F45Z	--	--	--	--	--	--	--
D7	L2F47Z	--	--	--	--	--	--	--
D8	Blank	--	--	--	--	--	--	--

Table 10. Cycle 143A 02 average plate power and burnup.

Position ID	Plate ID	143A 15.0 EFPD						
		Fission Heat Rate (W/g)	Fission Power Density (w/cm3)	Heat Flux (w/cm2)	U-235 Burnup u-235/u-235initial (%)	LEUeq Burnup (%)	Fission Density (f/cc)	Fission Rate (f/cc-s)
A1	L1P30Z	1100.79	15009.19	219.13	12.57%	42.11%	2.39E+21	1.84E+15
A2	L1P256	924.16	14914.49	193.14	10.50%	35.18%	2.32E+21	1.79E+15
A3	L2P15Z	464.21	7182.75	196.09	10.66%	17.79%	1.10E+21	8.49E+14
A4	L1P135	1138.27	18373.72	240.70	12.66%	42.41%	2.82E+21	2.18E+15
A5	L1P234	1334.04	20928.28	289.86	14.69%	49.21%	3.25E+21	2.51E+15
A6	L1P213	1124.03	17985.55	235.61	12.29%	41.17%	2.72E+21	2.10E+15
A7	L1P192	1128.95	18355.72	246.88	12.39%	41.51%	2.79E+21	2.15E+15
A8	L1P171	1397.32	22046.38	285.50	15.32%	51.32%	3.43E+21	2.65E+15
B1	Blank	--	--	--	--	--	--	--
B2	L1F401	1891.78	29712.48	365.46	6.67%	22.34%	1.45E+21	1.12E+15
B3	L1F417	1897.60	29316.37	372.32	6.71%	22.48%	1.43E+21	1.10E+15
B4	Blank	--	--	--	--	--	--	--
B5	Blank	--	--	--	--	--	--	--
B6	L2F46Z	1016.01	14603.54	368.74	7.35%	12.16%	7.24E+20	5.59E+14
B7	L1F44N	2068.96	27642.50	382.85	7.35%	24.62%	1.38E+21	1.06E+15
B8	Blank	--	--	--	--	--	--	--
C1	L1P12Z	1730.80	21271.59	329.71	18.18%	60.90%	3.34E+21	2.58E+15
C2	L1P266	1411.11	21613.49	279.89	15.36%	51.46%	3.33E+21	2.57E+15
C3	L2P16Z	700.00	10259.28	274.95	15.79%	26.35%	1.58E+21	1.22E+15
C4	L1P145	1719.43	26310.81	351.25	18.28%	61.24%	4.05E+21	3.13E+15
C5	L1P244	1583.06	24560.79	324.20	17.31%	57.99%	3.86E+21	2.98E+15
C6	L1P223	1316.51	20952.04	276.57	14.40%	48.24%	3.22E+21	2.48E+15
C7	L1P202	1337.17	20223.16	281.10	14.54%	48.71%	3.09E+21	2.38E+15
C8	L1P181	1651.65	25359.69	334.75	17.79%	59.60%	3.95E+21	3.05E+15
D1	Blank	--	--	--	--	--	--	--
D2	L1F381	1718.07	27846.18	339.72	6.10%	20.44%	1.35E+21	1.04E+15
D3	L1F427	1757.01	28450.25	347.09	6.10%	20.44%	1.36E+21	1.05E+15
D4	Blank	--	--	--	--	--	--	--
D5	Blank	--	--	--	--	--	--	--
D6	L2F45Z	647.07	14050.07	340.71	4.57%	7.63%	6.65E+20	5.13E+14
D7	L2F47Z	743.47	11119.70	274.10	5.25%	8.76%	5.24E+20	4.04E+14
D8	Blank	--	--	--	--	--	--	--

Table 11. Cycle 143A 03 average plate power burnup.

Position ID	Plate ID	143A 26.0 EFPD						
		Fission Heat Rate (W/g)	Fission Power Density (w/cm3)	Heat Flux (w/cm2)	U-235 Burnup u-235/u-235initial (%)	LEUeq Burnup (%)	Fission Density (f/cc)	Fission Rate (f/cc-s)
A1	L1P30Z	1099.96	14806.39	216.17	15.17%	50.82%	2.88E+21	1.28E+15
A2	L1P256	928.89	14828.31	192.03	12.72%	42.61%	2.81E+21	1.25E+15
A3	L2P15Z	463.15	7126.35	194.55	12.88%	21.49%	1.34E+21	5.97E+14
A4	L1P135	1136.69	18104.54	237.17	15.33%	51.36%	3.42E+21	1.52E+15
A5	L1P234	1331.66	20568.00	284.87	17.77%	59.53%	3.94E+21	1.75E+15
A6	L1P213	1129.86	17842.64	233.74	14.96%	50.12%	3.31E+21	1.47E+15
A7	L1P192	1136.23	18229.56	245.19	15.05%	50.42%	3.39E+21	1.51E+15
A8	L1P171	1396.15	21670.62	280.63	18.52%	62.04%	4.15E+21	1.85E+15
B1	Blank	--	--	--	--	--	--	--
B2	L1F401	1892.10	29075.16	357.62	11.15%	37.35%	2.42E+21	1.08E+15
B3	L1F417	1898.52	28688.84	364.35	11.22%	37.59%	2.39E+21	1.06E+15
B4	Blank	--	--	--	--	--	--	--
B5	Blank	--	--	--	--	--	--	--
B6	L2F46Z	1004.61	14269.85	360.31	12.34%	20.42%	1.20E+21	5.34E+14
B7	L1F44N	2066.83	26963.40	373.44	12.26%	41.07%	2.28E+21	1.01E+15
B8	Blank	--	--	--	--	--	--	--
C1	L1P12Z	1729.95	20833.42	322.92	21.96%	73.57%	4.04E+21	1.80E+15
C2	L1P266	1420.50	21400.87	277.14	18.62%	62.38%	4.03E+21	1.79E+15
C3	L2P16Z	698.60	10153.41	272.11	19.14%	31.94%	1.91E+21	8.50E+14
C4	L1P145	1714.03	25701.43	343.11	22.15%	74.20%	4.91E+21	2.19E+15
C5	L1P244	1579.83	24057.65	317.56	20.84%	69.81%	4.67E+21	2.08E+15
C6	L1P223	1325.31	20766.44	274.12	17.44%	58.42%	3.90E+21	1.74E+15
C7	L1P202	1346.40	20049.97	278.69	17.61%	58.99%	3.75E+21	1.67E+15
C8	L1P181	1646.89	24802.49	327.39	21.54%	72.16%	4.78E+21	2.13E+15
D1	Blank	--	--	--	--	--	--	--
D2	L1F381	1719.78	27320.47	333.31	10.21%	34.20%	2.26E+21	1.01E+15
D3	L1F427	1757.60	27885.63	340.20	10.30%	34.51%	2.29E+21	1.02E+15
D4	Blank	--	--	--	--	--	--	--
D5	Blank	--	--	--	--	--	--	--
D6	L2F45Z	644.52	13888.14	336.79	7.83%	13.06%	1.12E+21	4.99E+14
D7	L2F47Z	736.74	10924.97	269.30	8.86%	14.78%	8.87E+20	3.95E+14
D8	Blank	--	--	--	--	--	--	--



Table 12. Cycle 143A 04 average plate power burnup.

Position ID	Plate ID	143A 37.0 EFPD						
		Fission Heat Rate (W/g)	Fission Power Density (w/cm3)	Heat Flux (w/cm2)	U-235 Burnup u-235/u-235initial (%)	LEUeq Burnup (%)	Fission Density (f/cc)	Fission Rate (f/cc-s)
A1	L1P30Z	--	--	--	--	--	--	--
A2	L1P256	--	--	--	--	--	--	--
A3	L2P15Z	--	--	--	--	--	--	--
A4	L1P135	--	--	--	--	--	--	--
A5	L1P234	--	--	--	--	--	--	--
A6	L1P213	--	--	--	--	--	--	--
A7	L1P192	--	--	--	--	--	--	--
A8	L1P171	--	--	--	--	--	--	--
B1	Blank	--	--	--	--	--	--	--
B2	L1F401	2098.77	31470.48	387.09	16.03%	53.70%	3.47E+21	1.09E+15
B3	L1F417	2192.97	32299.29	410.20	16.31%	54.64%	3.47E+21	1.09E+15
B4	Blank	--	--	--	--	--	--	--
B5	Blank	--	--	--	--	--	--	--
B6	L2F46Z	1090.63	15295.55	386.21	17.58%	29.09%	1.71E+21	5.35E+14
B7	L1F44N	2351.60	29844.92	413.35	17.69%	59.26%	3.28E+21	1.03E+15
B8	Blank	--	--	--	--	--	--	--
C1	L1P12Z	--	--	--	--	--	--	--
C2	L1P266	--	--	--	--	--	--	--
C3	L2P16Z	--	--	--	--	--	--	--
C4	L1P145	--	--	--	--	--	--	--
C5	L1P244	--	--	--	--	--	--	--
C6	L1P223	--	--	--	--	--	--	--
C7	L1P202	--	--	--	--	--	--	--
C8	L1P181	--	--	--	--	--	--	--
D1	Blank	--	--	--	--	--	--	--
D2	L1F381	1945.30	30210.41	368.57	14.76%	49.45%	3.27E+21	1.02E+15
D3	L1F427	2039.90	31604.56	385.58	15.09%	50.55%	3.35E+21	1.05E+15
D4	Blank	--	--	--	--	--	--	--
D5	Blank	--	--	--	--	--	--	--
D6	L2F45Z	729.75	15591.28	378.09	11.33%	18.90%	1.64E+21	5.13E+14
D7	L2F47Z	858.90	12608.23	310.79	13.07%	21.81%	1.31E+21	4.10E+14
D8	Blank	--	--	--	--	--	--	--

Table 13. Cycle 143A 05 (EOC) average plate power and burnup.

Position ID	Plate ID	143A 48.9 EFPD (EOC)						
		Fission Heat Rate (W/g)	Fission Power Density (w/cm3)	Heat Flux (w/cm2)	U-235 Burnup u-235/u-235initial (%)	LEUeq Burnup (%)	Fission Density (f/cc)	Fission Rate (f/cc-s)
A1	L1P30Z	--	--	--	--	--	--	--
A2	L1P256	--	--	--	--	--	--	--
A3	L2P15Z	--	--	--	--	--	--	--
A4	L1P135	--	--	--	--	--	--	--
A5	L1P234	--	--	--	--	--	--	--
A6	L1P213	--	--	--	--	--	--	--
A7	L1P192	--	--	--	--	--	--	--
A8	L1P171	--	--	--	--	--	--	--
B1	Blank	--	--	--	--	--	--	--
B2	L1F401	2096.89	30619.84	376.62	21.14%	70.82%	4.58E+21	1.08E+15
B3	L1F417	2184.18	31295.20	397.45	21.63%	72.46%	4.61E+21	1.09E+15
B4	Blank	--	--	--	--	--	--	--
B5	Blank	--	--	--	--	--	--	--
B6	L2F46Z	1072.37	14835.00	374.58	23.09%	38.21%	2.25E+21	5.33E+14
B7	L1F44N	2341.33	28846.91	399.53	23.30%	78.06%	4.34E+21	1.03E+15
B8	Blank	--	--	--	--	--	--	--
C1	L1P12Z	--	--	--	--	--	--	--
C2	L1P266	--	--	--	--	--	--	--
C3	L2P16Z	--	--	--	--	--	--	--
C4	L1P145	--	--	--	--	--	--	--
C5	L1P244	--	--	--	--	--	--	--
C6	L1P223	--	--	--	--	--	--	--
C7	L1P202	--	--	--	--	--	--	--
C8	L1P181	--	--	--	--	--	--	--
D1	Blank	--	--	--	--	--	--	--
D2	L1F381	1946.23	29488.28	359.76	19.53%	65.43%	4.33E+21	1.02E+15
D3	L1F427	2035.30	30729.74	374.90	20.06%	67.20%	4.47E+21	1.06E+15
D4	Blank	--	--	--	--	--	--	--
D5	Blank	--	--	--	--	--	--	--
D6	L2F45Z	724.63	15339.81	371.99	15.12%	25.23%	2.19E+21	5.18E+14
D7	L2F47Z	846.70	12293.89	303.04	17.46%	29.13%	1.75E+21	4.14E+14
D8	Blank	--	--	--	--	--	--	--

## 5.2 Gradients

The MCNP-calculated power gradients in the transverse and axial directions are represented by the thermal neutron flux and fission rate local-2-average ratios (L2ARs) as a function of position along the plate. Figures 1 and 2 depict the power gradient in the transverse direction and Figures 3 and 4 depict the power gradient in the axial direction.

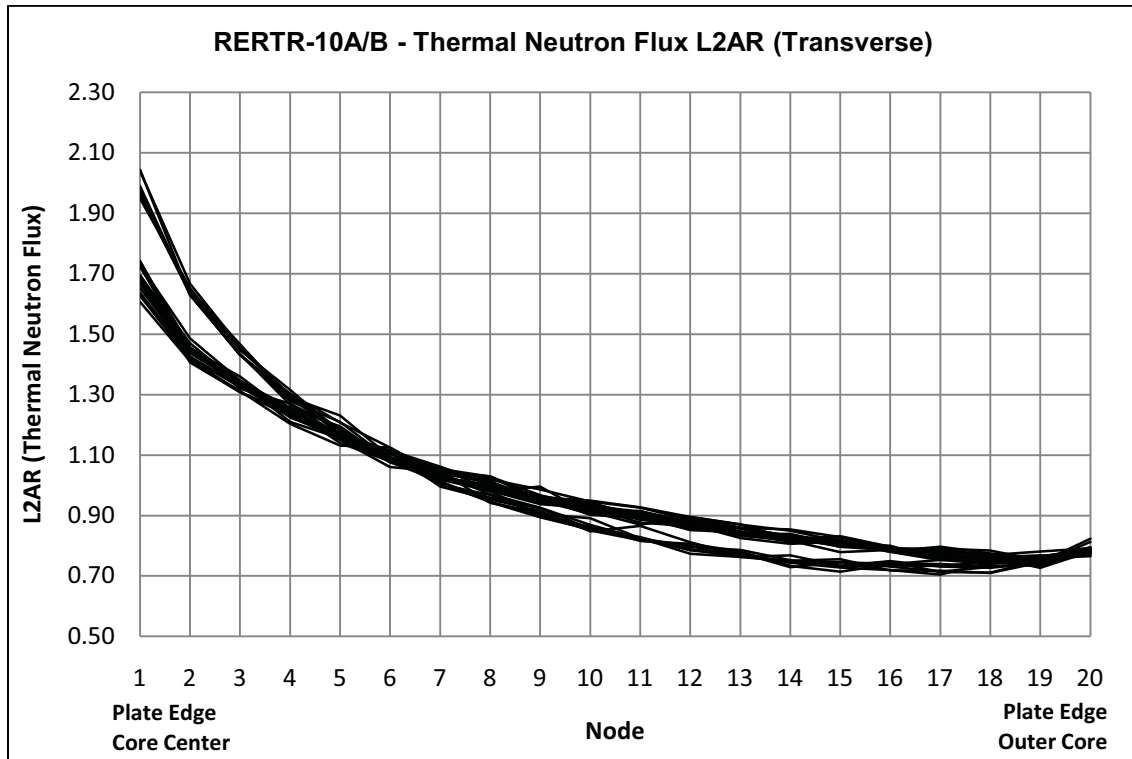


Figure 5. RERTR-10 fuel meat thermal neutron flux L2ARs in transverse direction.<sup>6</sup>

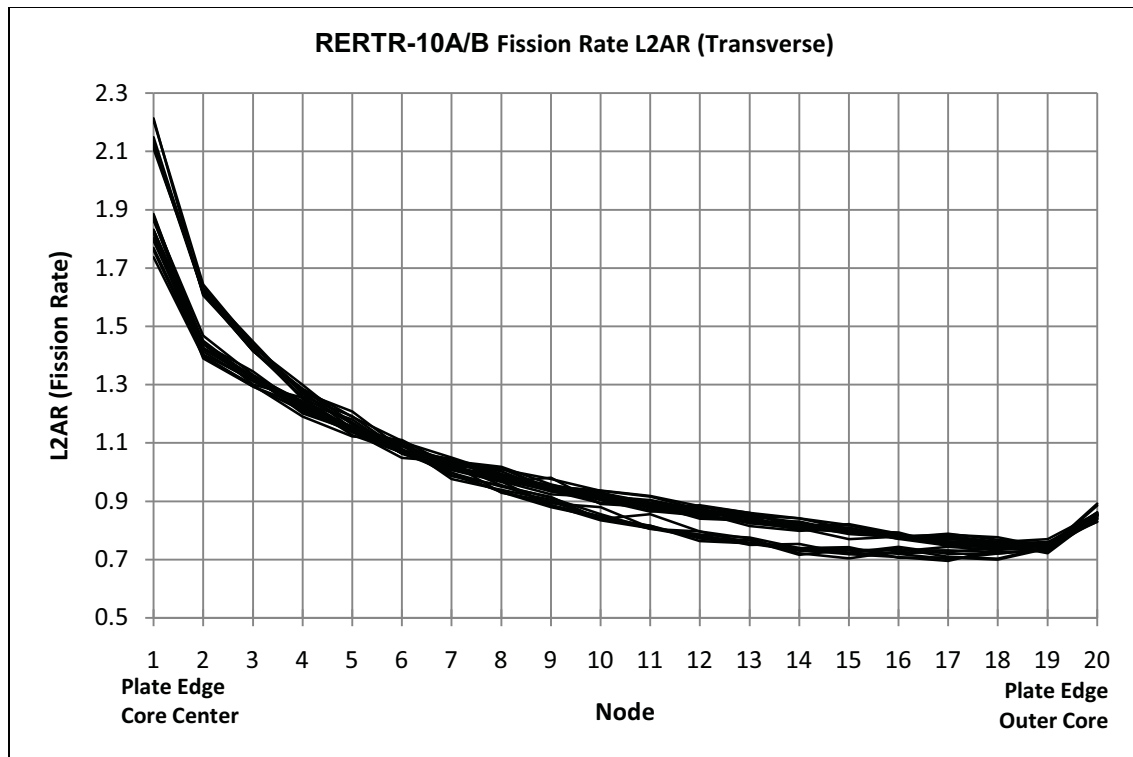


Figure 6. RERTR-10 fuel meat fission rate L2ARs in transverse direction.<sup>6</sup>

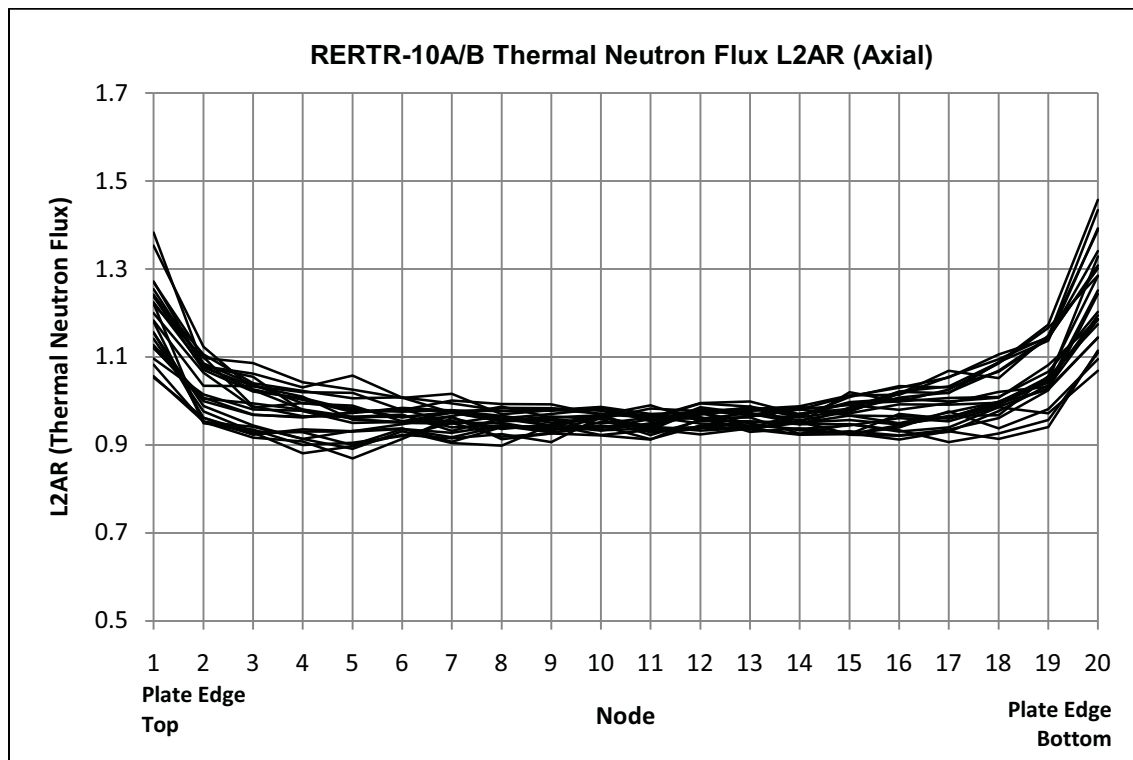


Figure 7. RERTR-10 fuel meat thermal neutron flux L2ARs in axial direction.<sup>6</sup>

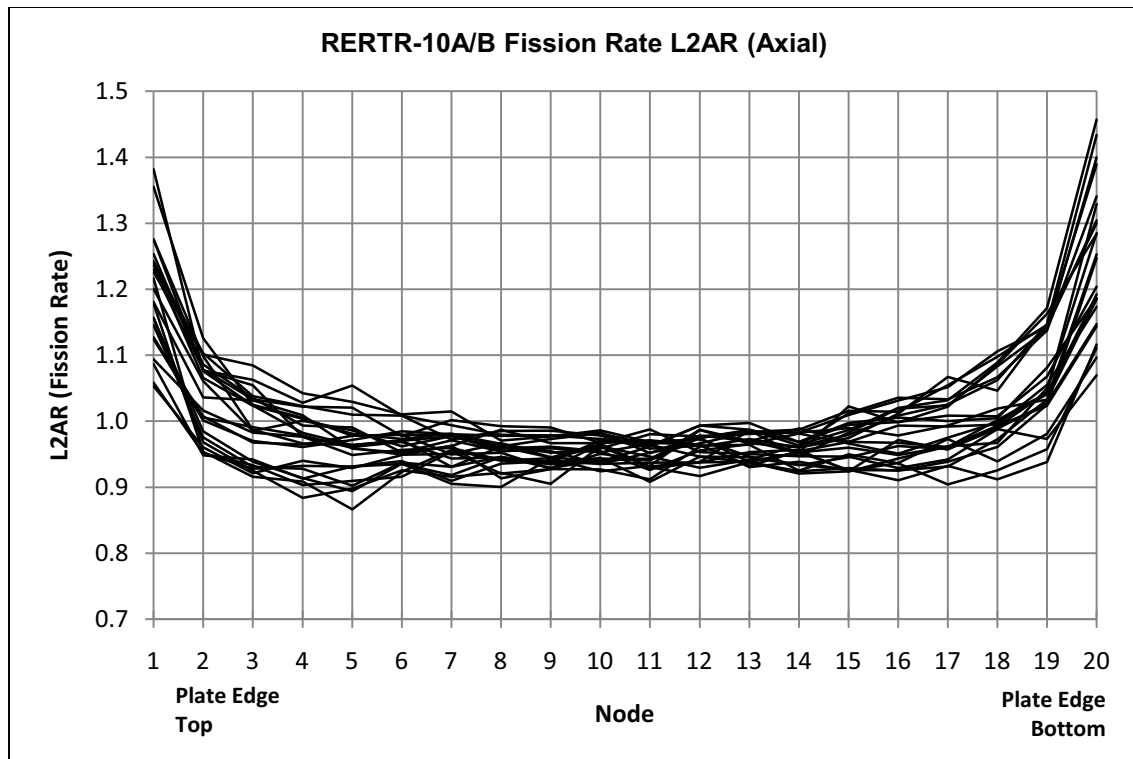


Figure 8. RERTR-10 fuel meat fission rate L2ARs in axial direction.<sup>6</sup>

## 6. HYDRAULIC TESTING

A fully assembled irradiation test vehicle (with simulated fuel plates) was used for testing. The test vehicle was fabricated such that the orifice plates could be easily changed. The hydraulic resistance of the RERTR Large B-Position irradiation test vehicle with various orifice plate sizes were calculated, the results are shown in Table 14.

Table 14. Loss coefficients for the RERTR Irradiation Test Vehicle components.<sup>7</sup>

Orifice Dia. (mm)	$K/A^2$ ( $1/m^4$ )	ATR Coolant Flow Rate ( $cm^3/sec$ )
10	$5.3041 \times 10^8$	1252
9	$8.2181 \times 10^8$	1046
8	$1.6961 \times 10^9$	757
7.32	$2.9022 \times 10^9$	588
7	$3.0058 \times 10^9$	579
6	$4.0784 \times 10^9$	500
5	$101743 \times 10^{10}$	298
Bypass	$2.7958 \times 10^8$	--
Vehicle	$1.4161 \times 10^8$	2727

Based on the results from the hydraulic testing, the orifice was removed leaving the capsule in the “Vehicle” configuration to provide an ATR coolant flow rate through the capsules of  $2727 \text{ cm}^3/\text{sec}$ .<sup>8</sup>

## 7. AS-RUN THERMAL ANALYSIS

The MCNP-calculated heat flux, nominal coolant flow rate, as-built plate thickness and ABAQUS were used to calculate the coolant and plate surface temperatures.

### 7.1 Coolant Temperature as a function of Location

The coolant temperature was analyzed at the five flow channels in the test assembly, with Channel 1 at the right of the assembly. For each cycle interval, the coolant temperature was plotted as a function of location along the test assembly with 0 inches being at the top of the assembly. These plots are show in Figure 9 through Figure 17.

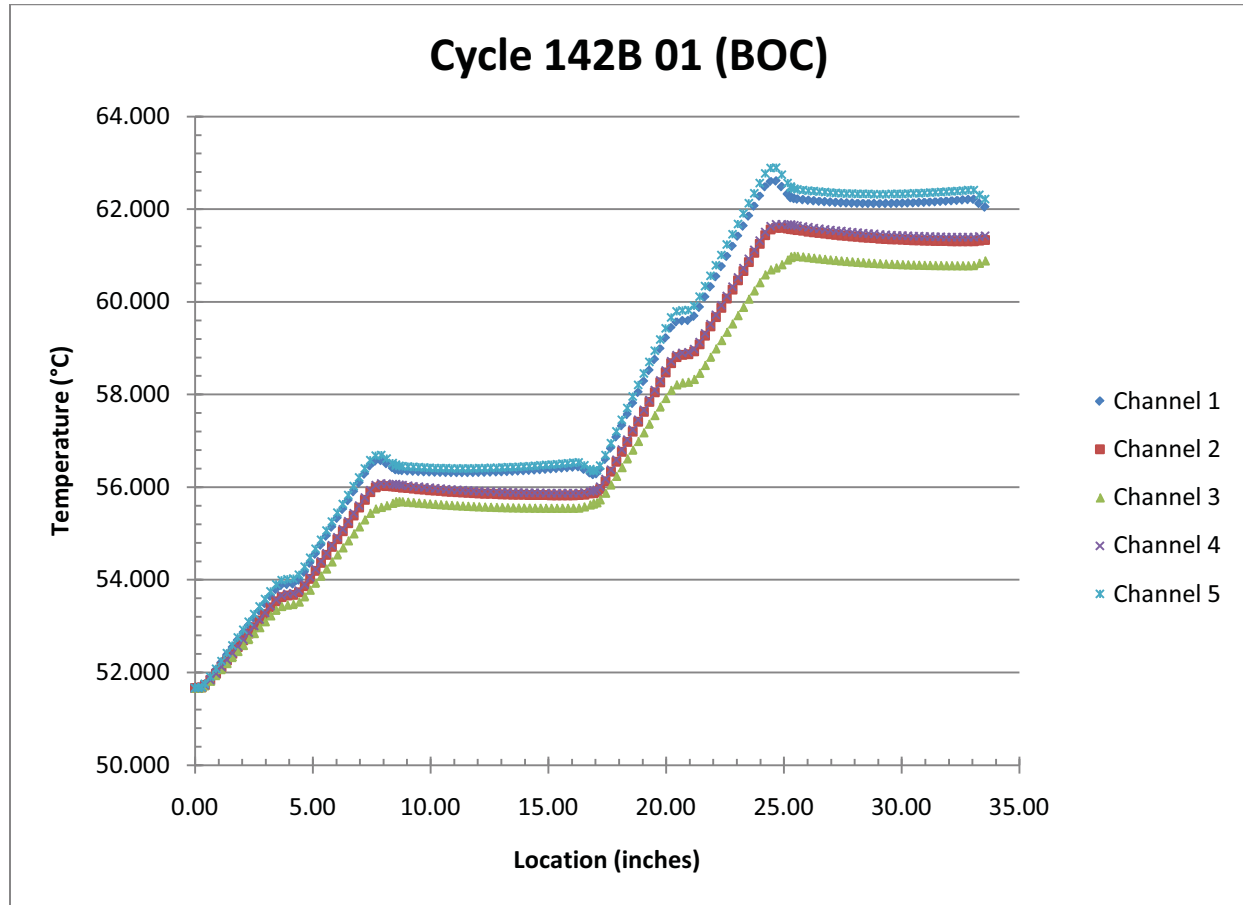


Figure 9. Coolant temperature as a function of location along the test assembly for Cycle 142B 01 (BOC).<sup>9</sup>

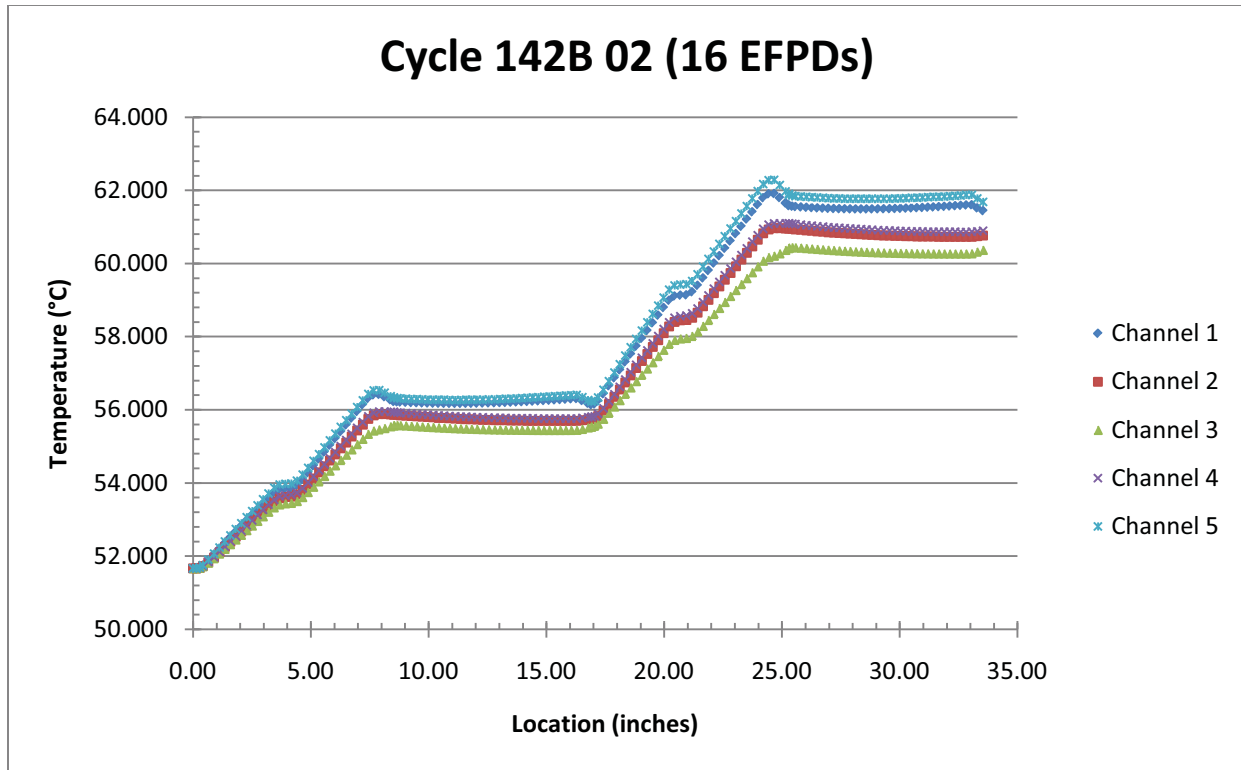


Figure 10. Coolant temperature as a function of location along the test assembly for Cycle 142B 02.<sup>9</sup>

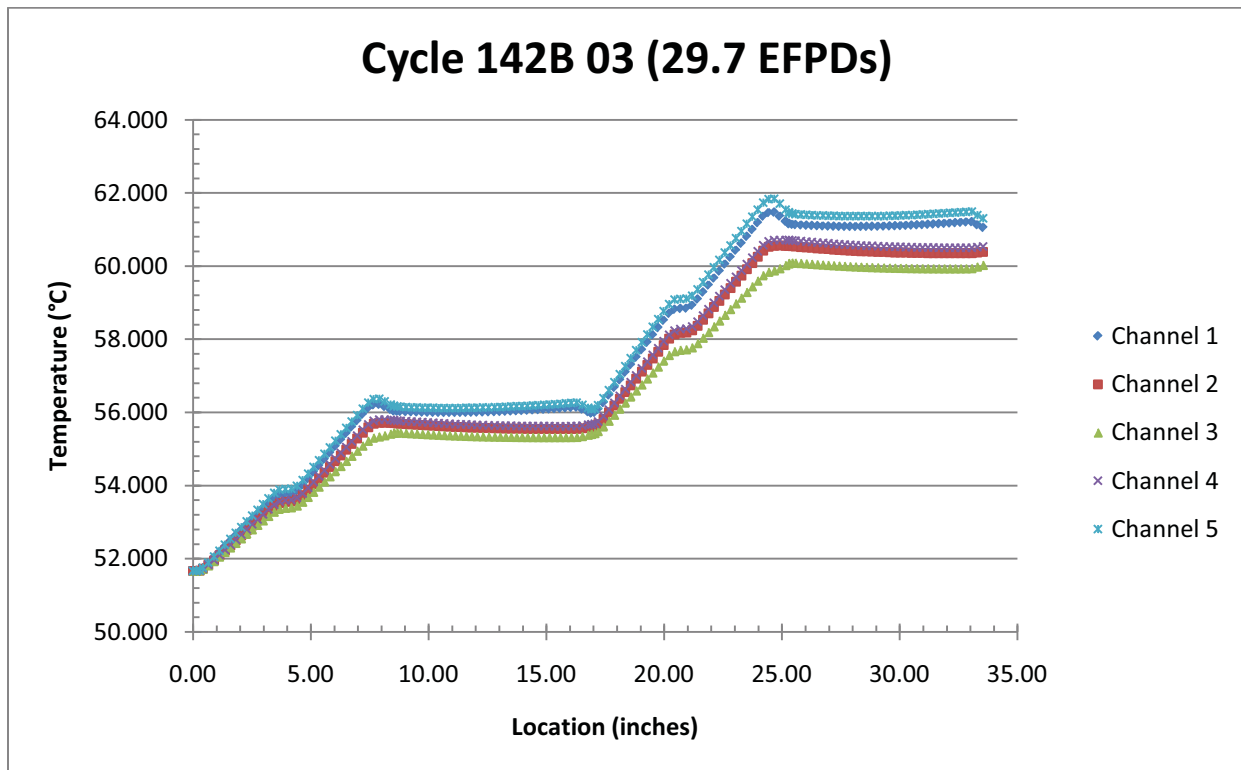


Figure 11. Coolant temperature as a function of location along the test assembly for Cycle 142B 03.<sup>9</sup>



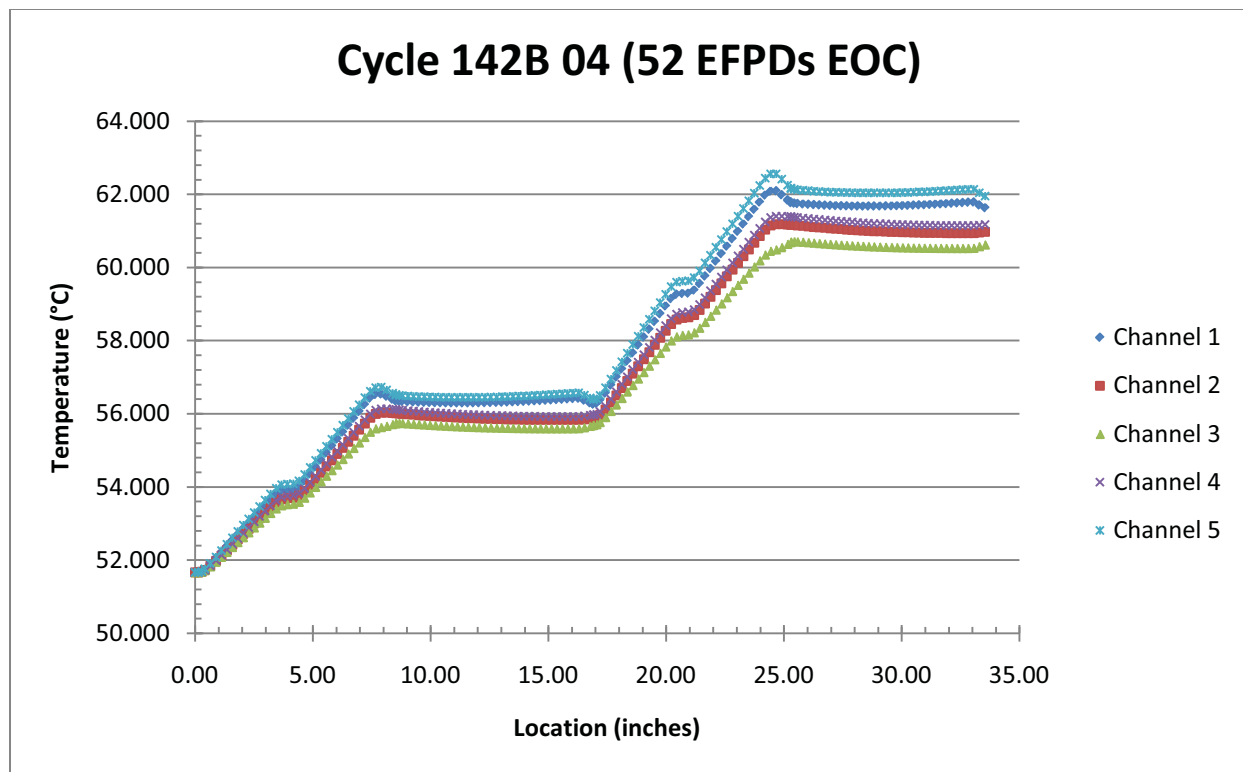


Figure 12. Coolant temperature as a function of location along the test assembly for Cycle 142B 04 (EOC).<sup>9</sup>

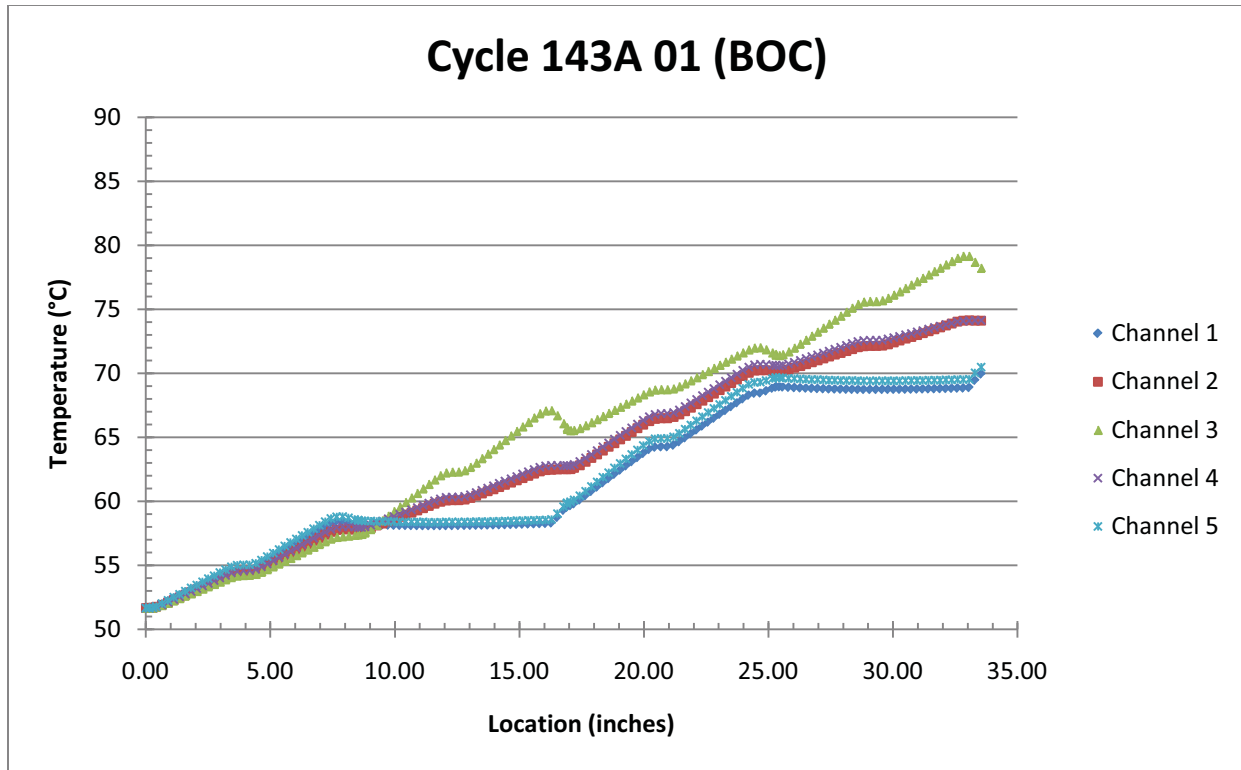


Figure 13. Coolant temperature as a function of location along the test assembly for Cycle 143A 01 (BOC).<sup>9</sup>

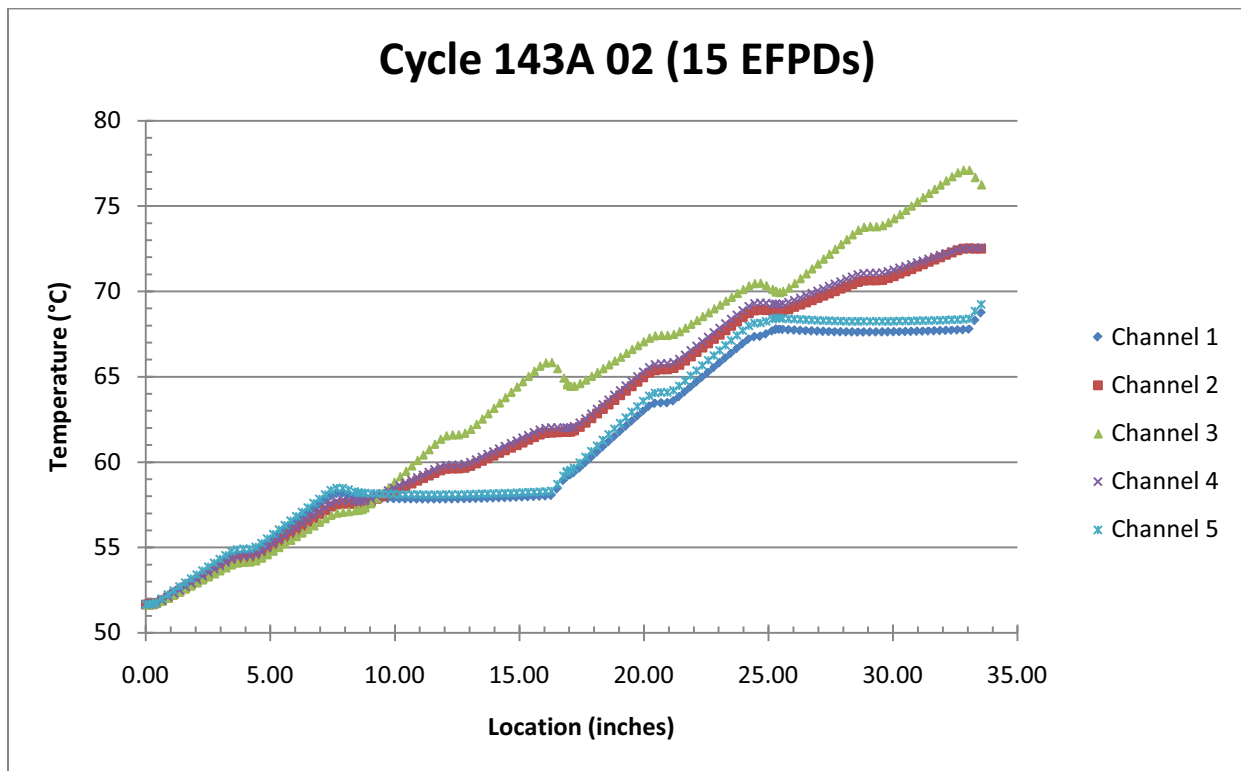


Figure 14. Coolant temperature as a function of location along the test assembly for Cycle 143A 02.<sup>9</sup>

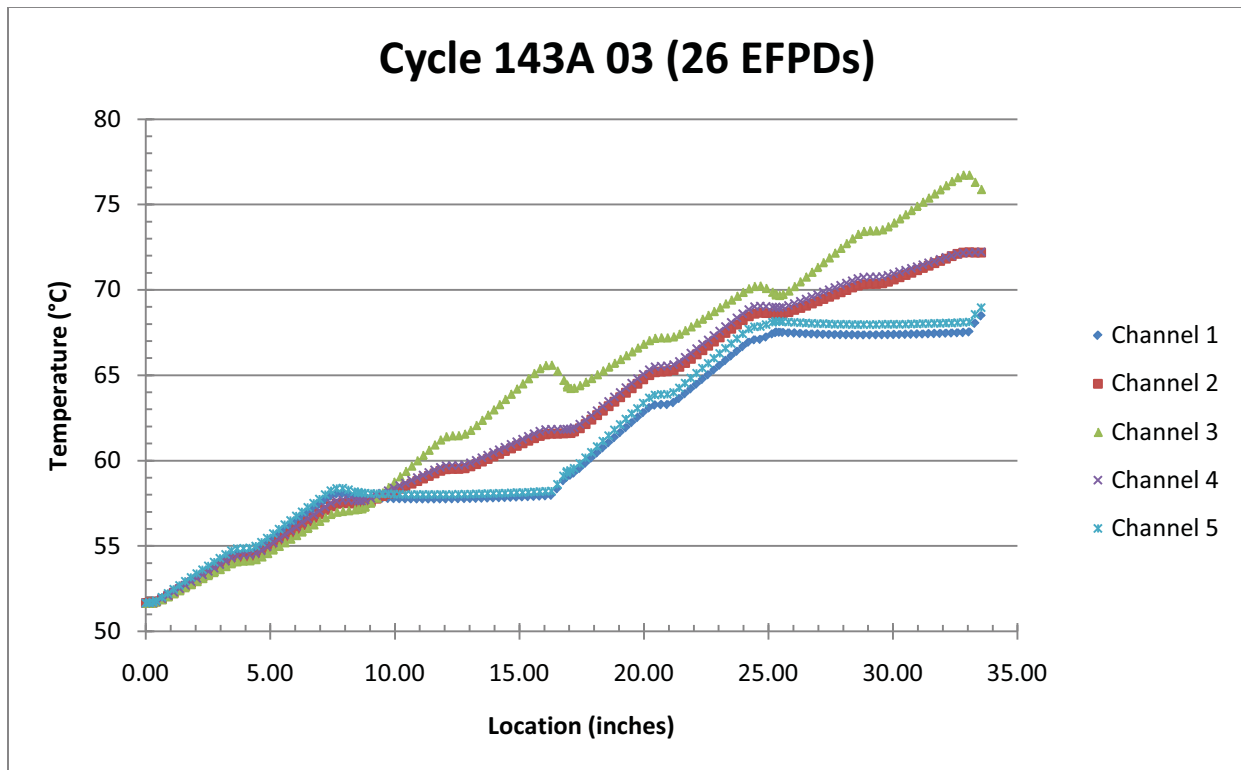


Figure 15. Coolant temperature as a function of location along the test assembly for Cycle 143A 03.<sup>9</sup>

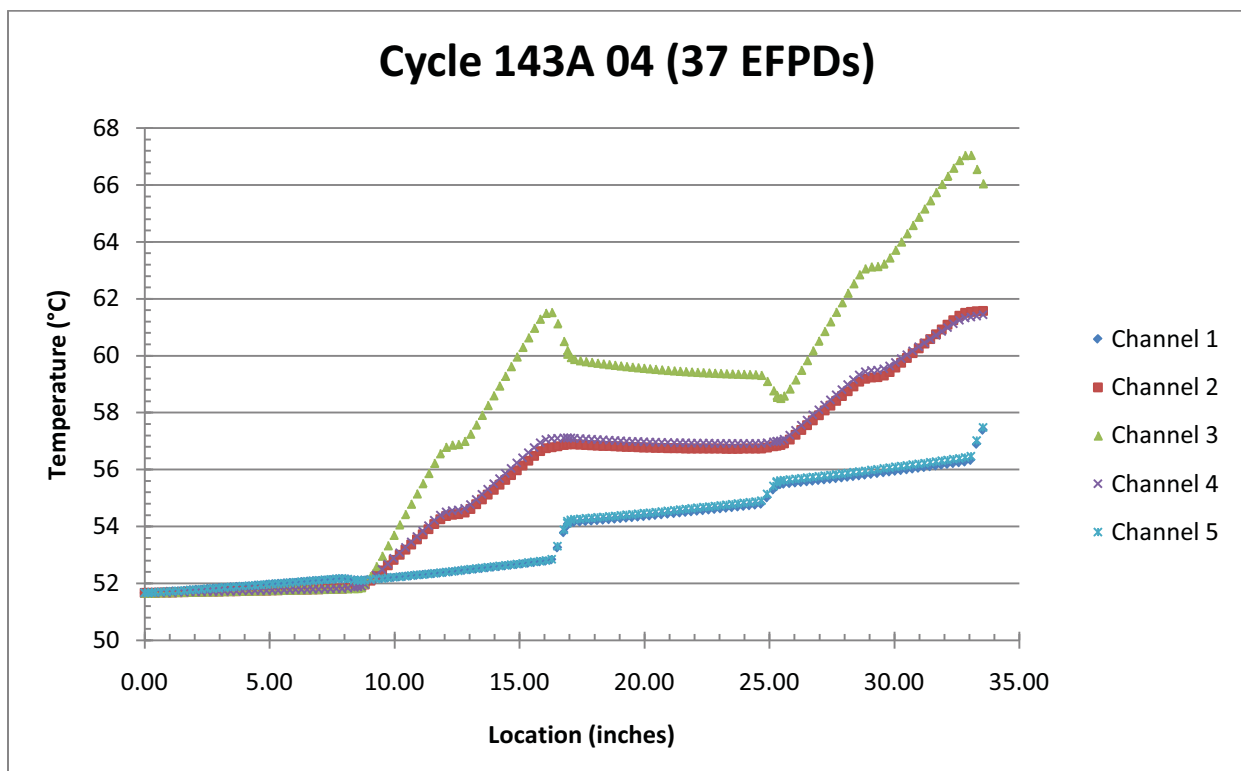


Figure 16. Coolant temperature as a function of location along the test assembly for Cycle 143A 04.<sup>9</sup>

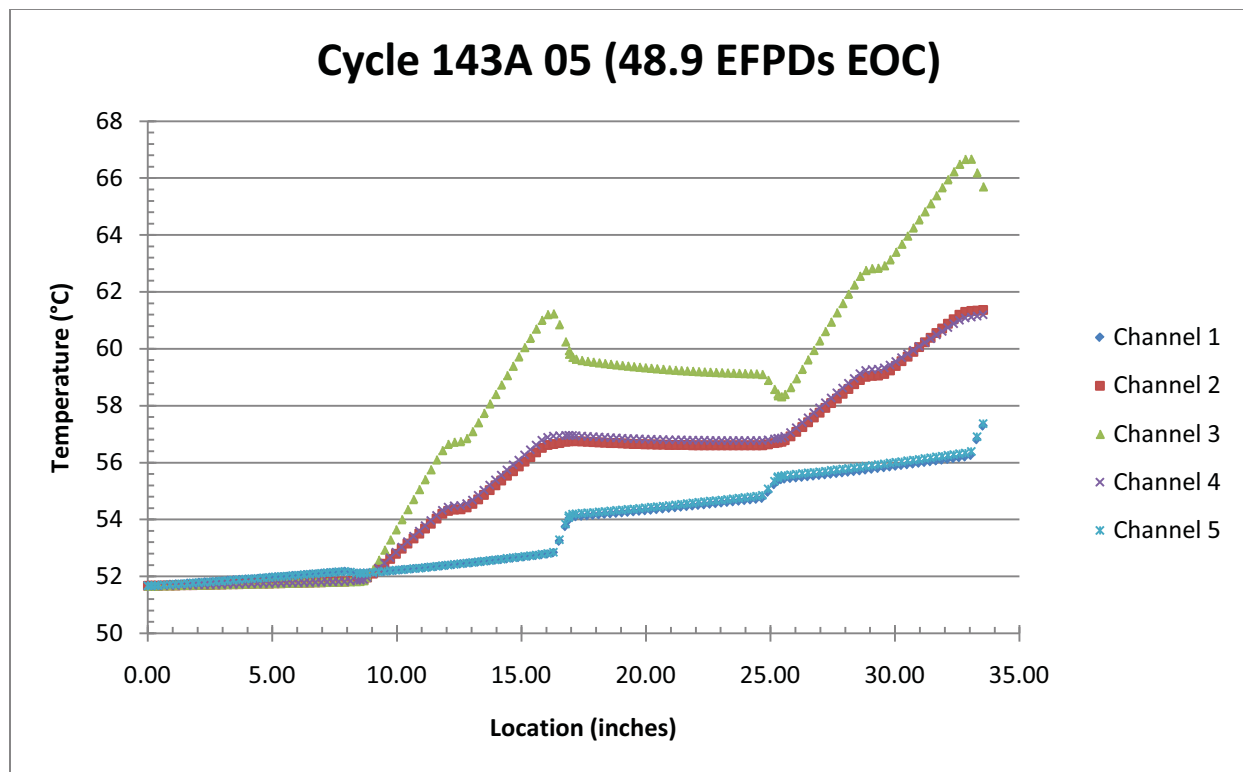


Figure 17. Coolant temperature as a function of location along the test assembly for Cycle 143A 05 (EOC).<sup>9</sup>

## 7.2 Plate Surface Temperature

The maximum, minimum, and average plate temperatures for each cycle interval are provided in Table 15 through Table 23.

Table 15. Plate surface temperatures for Cycle 142B 01 (BOC).<sup>9</sup>

Fuel Plate	Plate ID	BOC (0 EFPDs)		
		Max Temp (°C)	Min Temp (°C)	Ave Temp (°C)
A-1	L1P30Z	83.405	52.622	68.629
A-2	L1P256	77.503	52.565	65.899
A-3	L2P15Z	77.459	52.564	65.893
A-4	L1P135	84.365	52.633	70.762
A-5	L1P234	92.528	54.632	73.599
A-6	L1P213	83.646	54.352	69.448
A-7	L1P192	84.576	54.356	69.918
A-8	L1P171	92.096	54.695	73.415
B-1	DUMMY	--	--	--
B-2	L1F401	--	--	--
B-3	L1F417	--	--	--
B-4	DUMMY	--	--	--
B-5	DUMMY	--	--	--
B-6	L2F46Z	--	--	--
B-7	L1F44N	--	--	--
B-8	DUMMY	--	--	--
C-1	L1P12Z	100.586	57.463	79.602
C-2	L1P266	91.158	56.928	75.169
C-3	L2P16Z	90.237	56.924	74.704
C-4	L1P145	101.672	57.553	80.148
C-5	L1P244	102.166	60.010	81.057
C-6	L1P223	92.733	59.322	76.589
C-7	L1P202	93.184	59.308	76.792
C-8	L1P181	102.554	60.111	81.286
D-1	DUMMY	--	--	--
D-2	L1F381	--	--	--
D-3	L1F427	--	--	--
D-4	DUMMY	--	--	--
D-5	DUMMY	--	--	--
D-6	L2F45Z	--	--	--
D-7	L2F47Z	--	--	--
D-8	DUMMY	--	--	--

Table 16. Plate surface temperatures for Cycle 142B 02.<sup>9</sup>

Fuel Plate	Plate ID	16 EFPDs		
		Max Temp (°C)	Min Temp (°C)	Ave Temp (°C)
A-1	L1P30Z	82.565	52.609	68.176
A-2	L1P256	77.156	52.556	65.689
A-3	L2P15Z	77.189	52.558	65.733
A-4	L1P135	83.848	52.625	68.801
A-5	L1P234	91.286	54.572	72.932
A-6	L1P213	82.273	54.318	68.723
A-7	L1P192	83.758	54.326	69.474
A-8	L1P171	90.619	54.655	72.646
B-1	DUMMY	--	--	--
B-2	L1F401	--	--	--
B-3	L1F417	--	--	--
B-4	DUMMY	--	--	--
B-5	DUMMY	--	--	--
B-6	L2F46Z	--	--	--
B-7	L1F44N	--	--	--
B-8	DUMMY	--	--	--
C-1	L1P12Z	96.345	57.249	77.365
C-2	L1P266	88.359	56.754	73.587
C-3	L2P16Z	88.109	56.769	73.455
C-4	L1P145	98.245	57.356	78.323
C-5	L1P244	98.487	59.576	79.006
C-6	L1P223	90.054	58.974	75.028
C-7	L1P202	89.918	58.992	74.957
C-8	L1P181	99.299	59.747	79.474
D-1	DUMMY	--	--	--
D-2	L1F381	--	--	--
D-3	L1F427	--	--	--
D-4	DUMMY	--	--	--
D-5	DUMMY	--	--	--
D-6	L2F45Z	--	--	--
D-7	L2F47Z	--	--	--
D-8	DUMMY	--	--	--

Table 17. Plate surface temperatures for Cycle 142B 03.<sup>9</sup>

Fuel Plate	Plate ID	29.7 EFPDs		
		Max Temp (°C)	Min Temp (°C)	Ave Temp (°C)
A-1	L1P30Z	81.611	52.590	67.653
A-2	L1P256	76.543	52.542	65.348
A-3	L2P15Z	76.480	52.542	64.228
A-4	L1P135	82.902	52.614	68.291
A-5	L1P234	89.499	54.499	71.990
A-6	L1P213	81.354	54.256	68.216
A-7	L1P192	82.665	54.261	68.874
A-8	L1P171	89.338	54.581	71.955
B-1	DUMMY	--	--	--
B-2	L1F401	--	--	--
B-3	L1F417	--	--	--
B-4	DUMMY	--	--	--
B-5	DUMMY	--	--	--
B-6	L2F46Z	--	--	--
B-7	L1F44N	--	--	--
B-8	DUMMY	--	--	--
C-1	L1P12Z	94.474	57.067	76.330
C-2	L1P266	86.889	56.579	72.721
C-3	L2P16Z	86.679	56.614	72.623
C-4	L1P145	95.817	57.175	77.025
C-5	L1P244	96.193	59.300	77.741
C-6	L1P223	88.356	58.726	74.029
C-7	L1P202	88.839	58.742	74.270
C-8	L1P181	97.278	59.449	78.329
D-1	DUMMY	--	--	--
D-2	L1F381	--	--	--
D-3	L1F427	--	--	--
D-4	DUMMY	--	--	--
D-5	DUMMY	--	--	--
D-6	L2F45Z	--	--	--
D-7	L2F47Z	--	--	--
D-8	DUMMY	--	--	--

Table 18. Plate surface temperatures for Cycle 142B 04 (EOC).<sup>9</sup>

Fuel Plate	Plate ID	EOC (52 EFPDs)		
		Max Temp (°C)	Min Temp (°C)	Ave Temp (°C)
A-1	L1P30Z	83.490	52.626	68.670
A-2	L1P256	78.300	52.582	66.316
A-3	L2P15Z	78.288	52.582	66.334
A-4	L1P135	85.184	52.645	69.514
A-5	L1P234	92.027	54.654	73.360
A-6	L1P213	83.488	54.419	69.406
A-7	L1P192	84.905	54.430	70.121
A-8	L1P171	91.890	54.762	73.352
B-1	DUMMY	--	--	--
B-2	L1F401	--	--	--
B-3	L1F417	--	--	--
B-4	DUMMY	--	--	--
B-5	DUMMY	--	--	--
B-6	L2F46Z	--	--	--
B-7	L1F44N	--	--	--
B-8	DUMMY	--	--	--
C-1	L1P12Z	96.871	57.380	77.693
C-2	L1P266	89.076	56.906	73.487
C-3	L2P16Z	88.952	56.933	73.993
C-4	L1P145	98.824	57.520	78.701
C-5	L1P244	98.973	59.739	79.330
C-6	L1P223	90.705	59.166	75.469
C-7	L1P202	91.439	59.194	75.840
C-8	L1P181	100.414	59.942	80.125
D-1	DUMMY	--	--	--
D-2	L1F381	--	--	--
D-3	L1F427	--	--	--
D-4	DUMMY	--	--	--
D-5	DUMMY	--	--	--
D-6	L2F45Z	--	--	--
D-7	L2F47Z	--	--	--
D-8	DUMMY	--	--	--



Table 19. Plate surface temperature for Cycle 143A 01 (BOC).<sup>9</sup>

Fuel Plate	Plate ID	BOC (0 EFPDs)		
		Max Temp (°C)	Min Temp (°C)	Ave Temp (°C)
A-1	L1P30Z	93.458	52.858	74.176
A-2	L1P256	86.752	52.828	71.090
A-3	L2P15Z	87.105	52.837	71.308
A-4	L1P135	96.589	52.896	75.769
A-5	L1P234	106.825	55.586	81.275
A-6	L1P213	94.900	55.288	75.867
A-7	L1P192	96.982	55.323	60.247
A-8	L1P171	106.747	55.801	81.352
B-1	DUMMY	--	--	--
B-2	L1F401	119.004	58.296	90.275
B-3	L1F417	120.060	58.372	90.937
B-4	DUMMY	--	--	--
B-5	DUMMY	--	--	--
B-6	L2F46Z	123.609	61.466	93.078
B-7	L1F44N	125.757	61.603	94.296
B-8	DUMMY	--	--	--
C-1	L1P12Z	118.990	61.758	91.723
C-2	L1P266	111.233	63.856	88.622
C-3	L2P16Z	110.584	63.995	88.407
C-4	L1P145	122.179	62.063	93.457
C-5	L1P244	120.921	65.654	93.790
C-6	L1P223	113.261	67.060	90.773
C-7	L1P202	113.911	67.261	91.227
C-8	L1P181	123.170	66.181	95.108
D-1	DUMMY	--	--	--
D-2	L1F381	125.149	70.121	98.685
D-3	L1F427	125.579	70.330	98.876
D-4	DUMMY	--	--	--
D-5	DUMMY	--	--	--
D-6	L2F45Z	126.891	72.594	100.162
D-7	L2F47Z	118.089	72.820	95.762
D-8	DUMMY	--	--	--

Table 20. Plate surface temperature for Cycle 143A 02.<sup>9</sup>

Fuel Plate	Plate ID	15 EFPDs		
		Max Temp (°C)	Min Temp (°C)	Ave Temp (°C)
A-1	L1P30Z	91.888	52.834	73.318
A-2	L1P256	85.793	52.806	70.559
A-3	L2P15Z	86.295	52.817	70.844
A-4	L1P135	95.192	52.875	74.992
A-5	L1P234	104.549	55.462	80.076
A-6	L1P213	93.889	55.196	75.283
A-7	L1P192	95.504	55.238	76.122
A-8	L1P171	104.169	55.133	80.009
B-1	DUMMY	--	--	--
B-2	L1F401	113.760	58.034	87.323
B-3	L1F417	114.635	58.103	87.875
B-4	DUMMY	--	--	--
B-5	DUMMY	--	--	--
B-6	L2F46Z	117.104	60.961	89.457
B-7	L1F44N	118.863	61.109	90.455
B-8	DUMMY	--	--	--
C-1	L1P12Z	114.215	61.245	88.935
C-2	L1P266	107.378	63.092	86.242
C-3	L2P16Z	106.764	63.214	86.036
C-4	L1P145	117.503	61.528	90.694
C-5	L1P244	116.374	64.830	91.014
C-6	L1P223	109.408	66.061	88.298
C-7	L1P202	110.029	66.243	88.724
C-8	L1P181	118.327	65.333	92.171
D-1	DUMMY	--	--	--
D-2	L1F381	119.681	69.012	95.237
D-3	L1F427	120.617	69.207	95.695
D-4	DUMMY	--	--	--
D-5	DUMMY	--	--	--
D-6	L2F45Z	122.305	71.270	97.095
D-7	L2F47Z	114.111	71.500	93.030
D-8	DUMMY	--	--	--

Table 21. Plate surface temperature for Cycle 143A 03.<sup>9</sup>

Fuel Plate	Plate ID	26 EFPDs		
		Max Temp (°C)	Min Temp (°C)	Ave Temp (°C)
A-1	L1P30Z	91.433	52.828	73.069
A-2	L1P256	85.619	52.801	70.459
A-3	L2P15Z	86.058	52.812	70.712
A-4	L1P135	94.663	52.867	74.703
A-5	L1P234	103.779	55.428	79.676
A-6	L1P213	93.598	55.176	75.120
A-7	L1P192	95.237	55.215	75.970
A-8	L1P171	103.409	55.648	79.612
B-1	DUMMY	--	--	--
B-2	L1F401	112.683	57.972	86.714
B-3	L1F417	113.546	58.039	87.256
B-4	DUMMY	--	--	--
B-5	DUMMY	--	--	--
B-6	L2F46Z	115.899	60.838	88.776
B-7	L1F44N	117.546	60.982	89.715
B-8	DUMMY	--	--	--
C-1	L1P12Z	113.166	61.124	88.324
C-2	L1P266	106.838	62.935	85.848
C-3	L2P16Z	106.210	63.052	85.668
C-4	L1P145	116.275	61.397	89.988
C-5	L1P244	115.299	64.646	90.376
C-6	L1P223	108.888	65.864	87.931
C-7	L1P202	109.515	66.037	88.354
C-8	L1P181	117.143	65.128	91.468
D-1	DUMMY	--	--	--
D-2	L1F381	118.649	68.792	94.583
D-3	L1F427	119.529	68.978	95.003
D-4	DUMMY	--	--	--
D-5	DUMMY	--	--	--
D-6	L2F45Z	121.544	71.007	96.566
D-7	L2F47Z	113.205	71.227	92.420
D-8	DUMMY	--	--	--

Table 22. Plate surface temperature for Cycle 143A 04.<sup>9</sup>

Fuel Plate	Plate ID	37 EFPDs		
		Max Temp (°C)	Min Temp (°C)	Ave Temp (°C)
A-1	L1P30Z	--	--	--
A-2	L1P256	--	--	--
A-3	L2P15Z	--	--	--
A-4	L1P135	--	--	--
A-5	L1P234	--	--	--
A-6	L1P213	--	--	--
A-7	L1P192	--	--	--
A-8	L1P171	--	--	--
B-1	DUMMY	--	--	--
B-2	L1F401	112.952	53.901	58.304
B-3	L1F417	115.854	53.971	58.388
B-4	DUMMY	--	--	--
B-5	DUMMY	--	--	--
B-6	L2F46Z	116.010	56.680	58.443
B-7	L1F44N	119.376	56.828	58.524
B-8	DUMMY	--	--	--
C-1	L1P12Z	--	--	--
C-2	L1P266	--	--	--
C-3	L2P16Z	--	--	--
C-4	L1P145	--	--	--
C-5	L1P244	--	--	--
C-6	L1P223	--	--	--
C-7	L1P202	--	--	--
C-8	L1P181	--	--	--
D-1	DUMMY	--	--	--
D-2	L1F381	115.055	59.255	88.372
D-3	L1F427	117.186	59.391	89.368
D-4	DUMMY	--	--	--
D-5	DUMMY	--	--	--
D-6	L2F45Z	119.067	61.601	90.746
D-7	L2F47Z	110.632	61.571	86.494
D-8	DUMMY	--	--	--

Table 23. Plate surface temperature for Cycle 143B 05 (EOC).<sup>9</sup>

Fuel Plate	Plate ID	EOC (48.9 EFPDs)		
		Max Temp (°C)	Min Temp (°C)	Ave Temp (°C)
A-1	L1P30Z	--	--	--
A-2	L1P256	--	--	--
A-3	L2P15Z	--	--	--
A-4	L1P135	--	--	--
A-5	L1P234	--	--	--
A-6	L1P213	--	--	--
A-7	L1P192	--	--	--
A-8	L1P171	--	--	--
B-1	DUMMY	--	--	--
B-2	L1F401	111.551	53.866	58.145
B-3	L1F417	114.186	53.929	58.223
B-4	DUMMY	--	--	--
B-5	DUMMY	--	--	--
B-6	L2F46Z	114.382	56.578	58.284
B-7	L1F44N	117.503	56.712	58.359
B-8	DUMMY	--	--	--
C-1	L1P12Z	--	--	--
C-2	L1P266	--	--	--
C-3	L2P16Z	--	--	--
C-4	L1P145	--	--	--
C-5	L1P244	--	--	--
C-6	L1P223	--	--	--
C-7	L1P202	--	--	--
C-8	L1P181	--	--	--
D-1	DUMMY	--	--	--
D-2	L1F381	113.755	59.087	87.622
D-3	L1F427	115.666	59.210	88.492
D-4	DUMMY	--	--	--
D-5	DUMMY	--	--	--
D-6	L2F45Z	118.064	61.389	90.133
D-7	L2F47Z	109.369	61.349	85.738
D-8	DUMMY	--	--	--

## 8. REFERENCES

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4. N. E. Woolstenhulme to D. M. Perez, Interoffice Memorandum "Description of RERTR Test Train" N. E. Woolstenhulme Letter File NEW-04-10.
5. J. R. Mitchell, G. S. Chang, "As-Run Neutronics Analysis of the RERTR-10 Capsules in the ATR B-9 and B-11 Positions," ECAR-856, February 2010.
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7. D.M. Wachs, "RERTR-Large-B Position Irradiation Vehicle Flow Test" EDF-8292, July 2007.
8. Wachs, D. M., 2007, "Thermal Analysis of the RERTR-9B Irradiation Test," EDF-8083, July 2007.
9. Roth, G. A., "RERTR-10 As-Run Data," to D. M. Perez, April 2010 (see Appendix B).

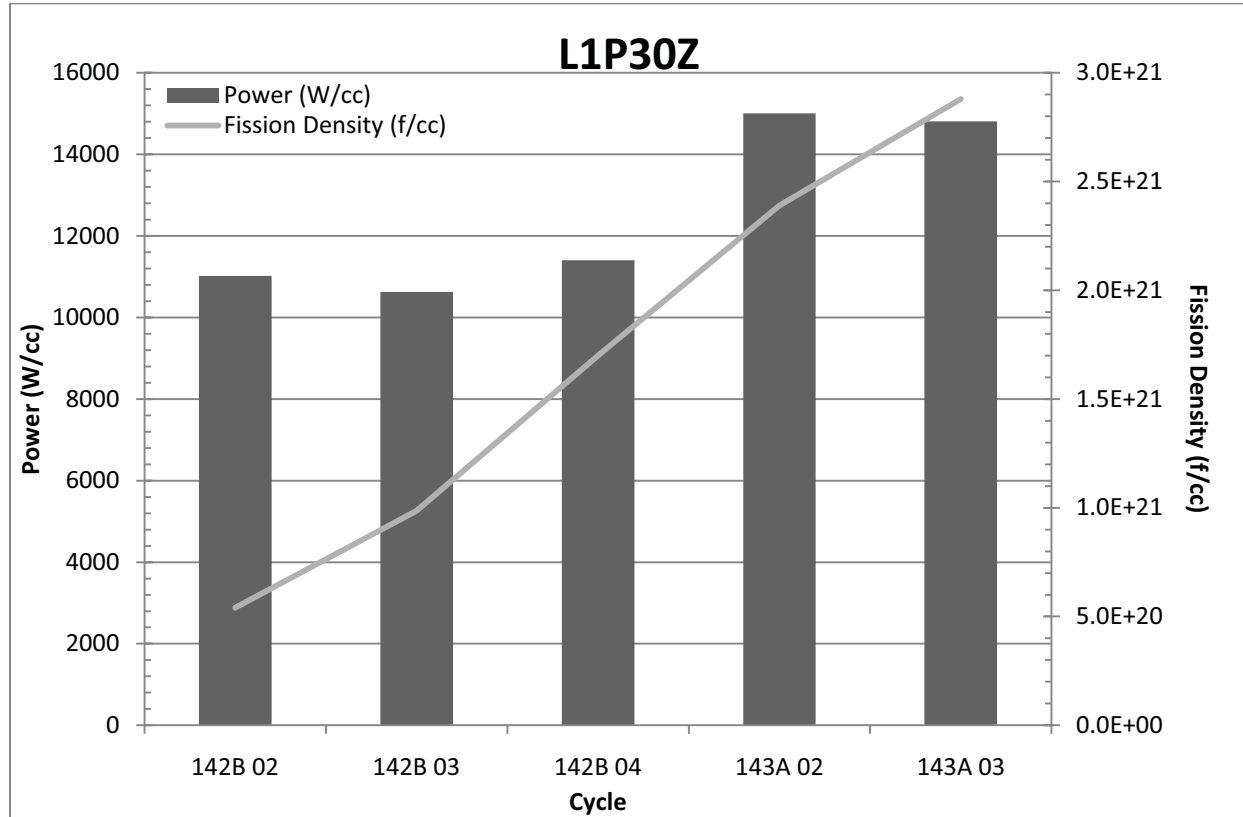
## **Appendix A**

### **Individual Plate Power and Fission Density Plots**

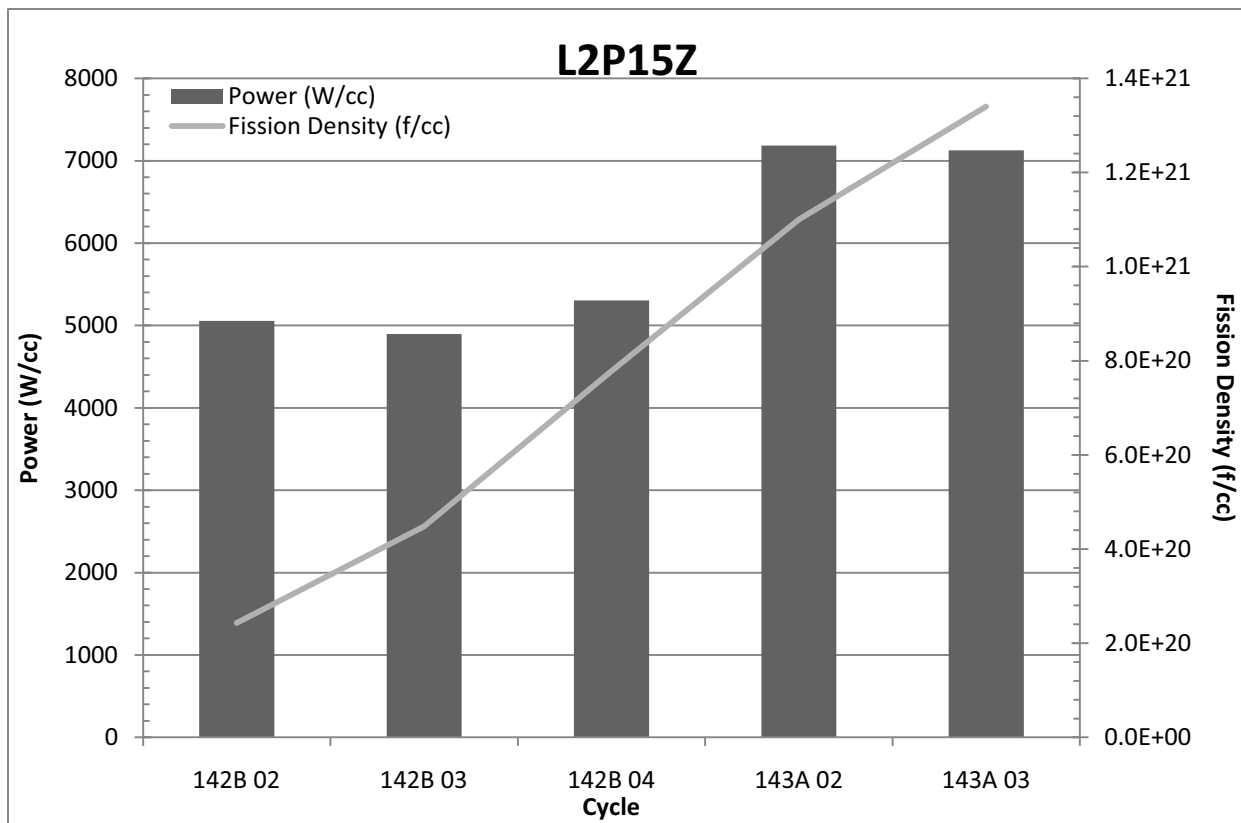
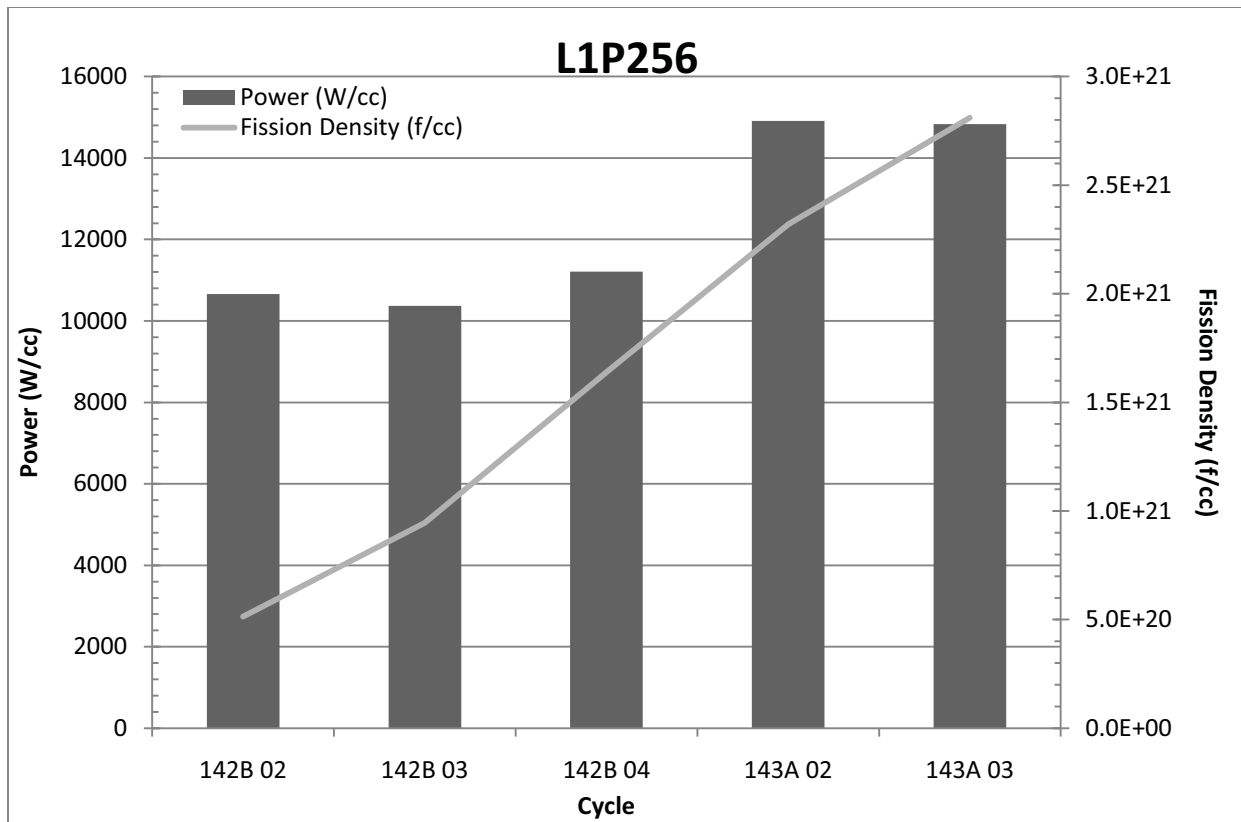
# Appendix A

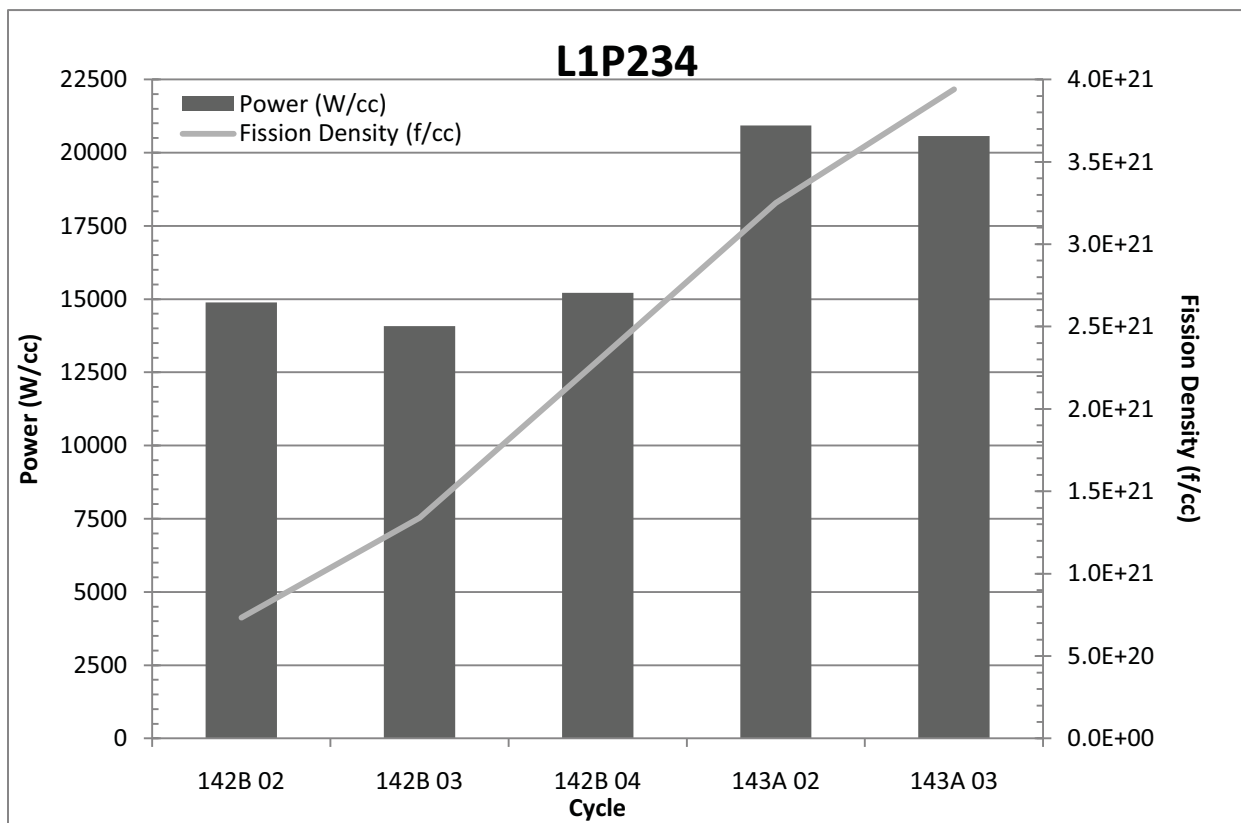
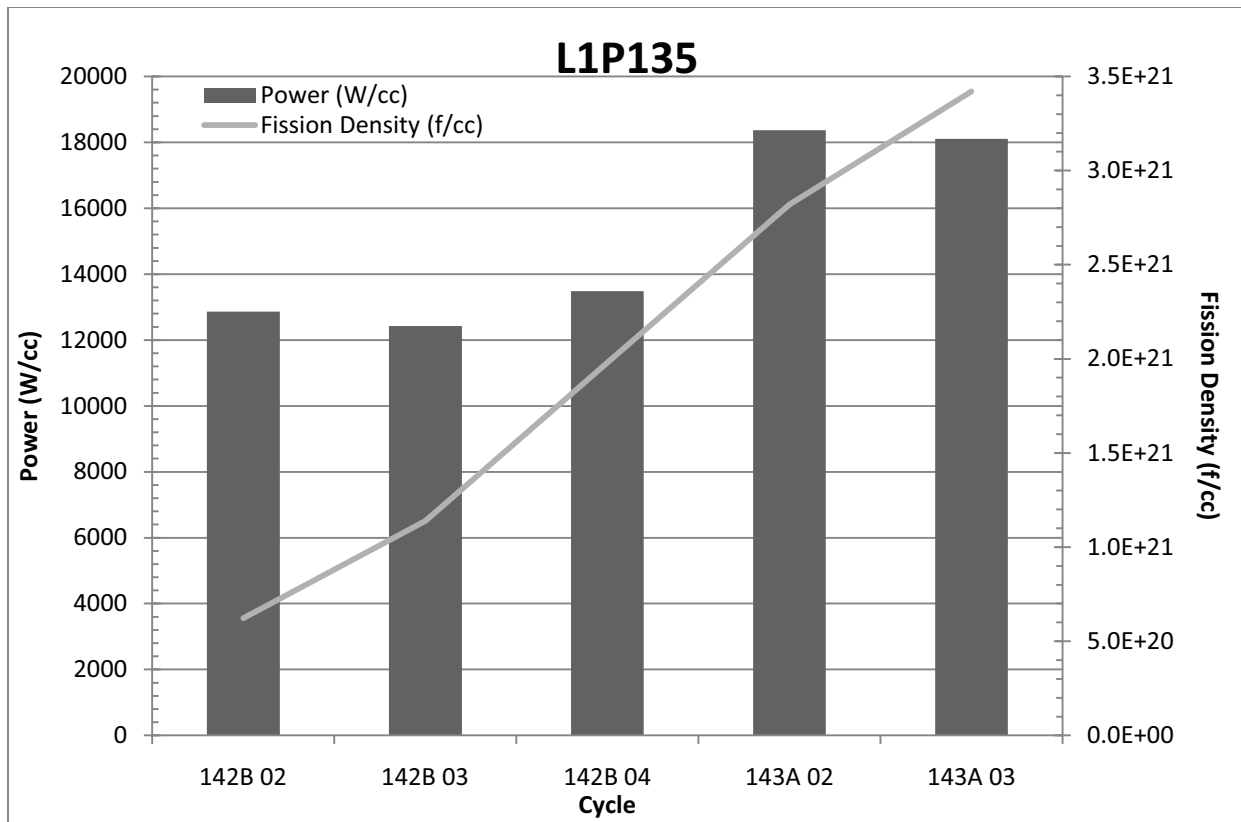
## Individual Plate Power and Fission Density Plots

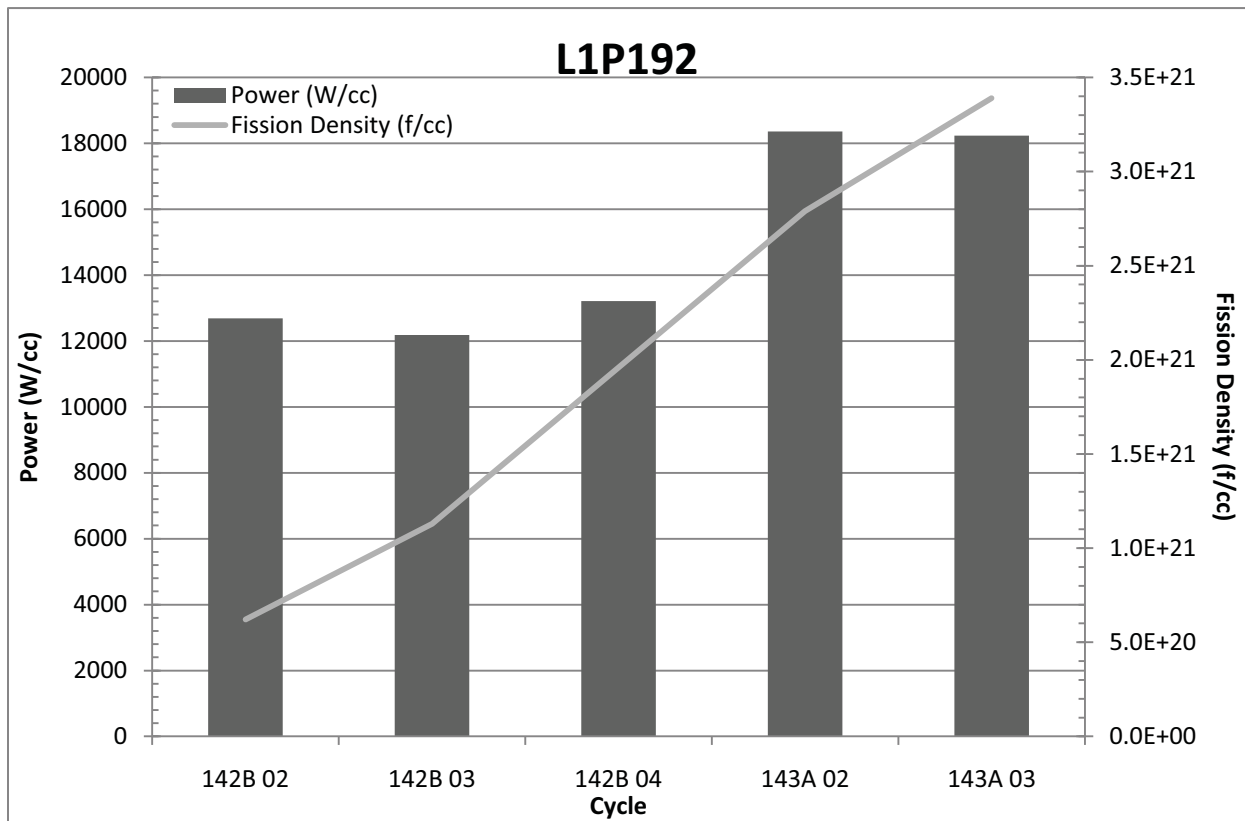
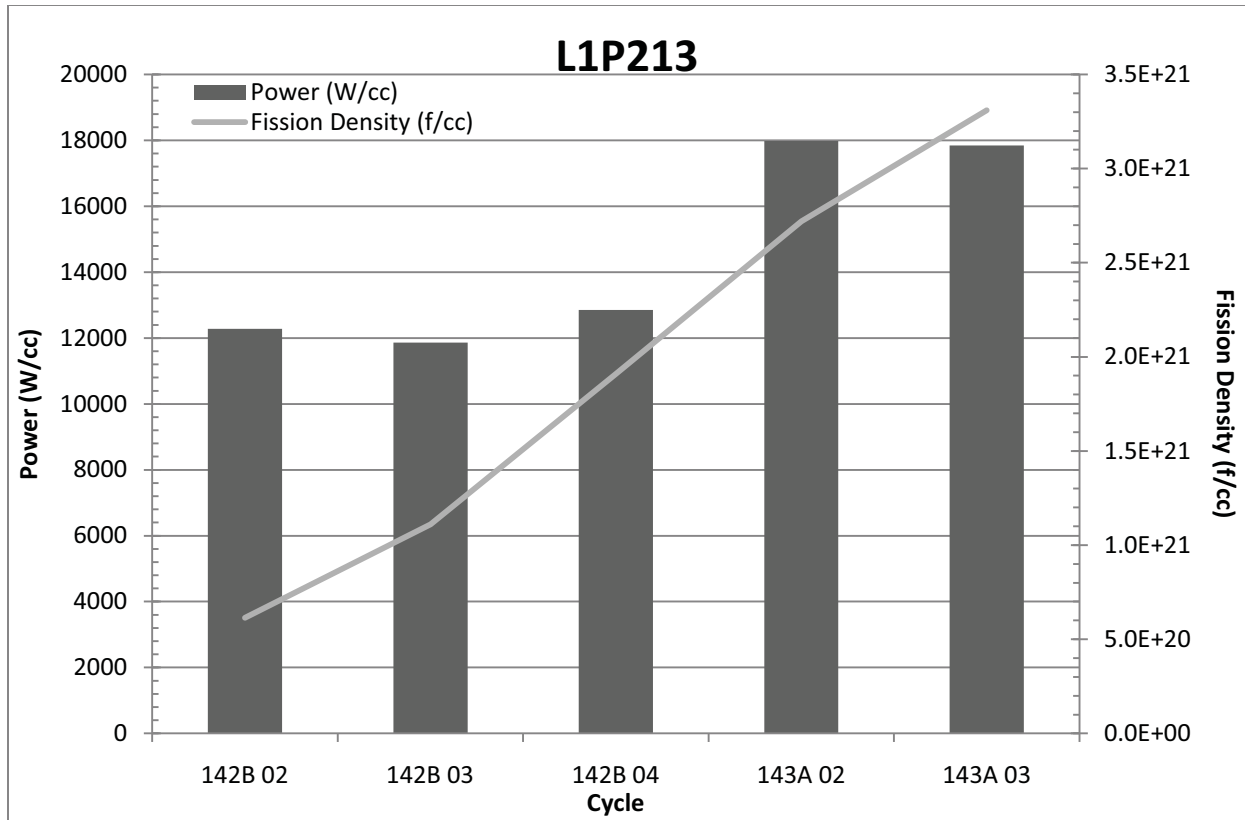
### A-1. RERTR-10A

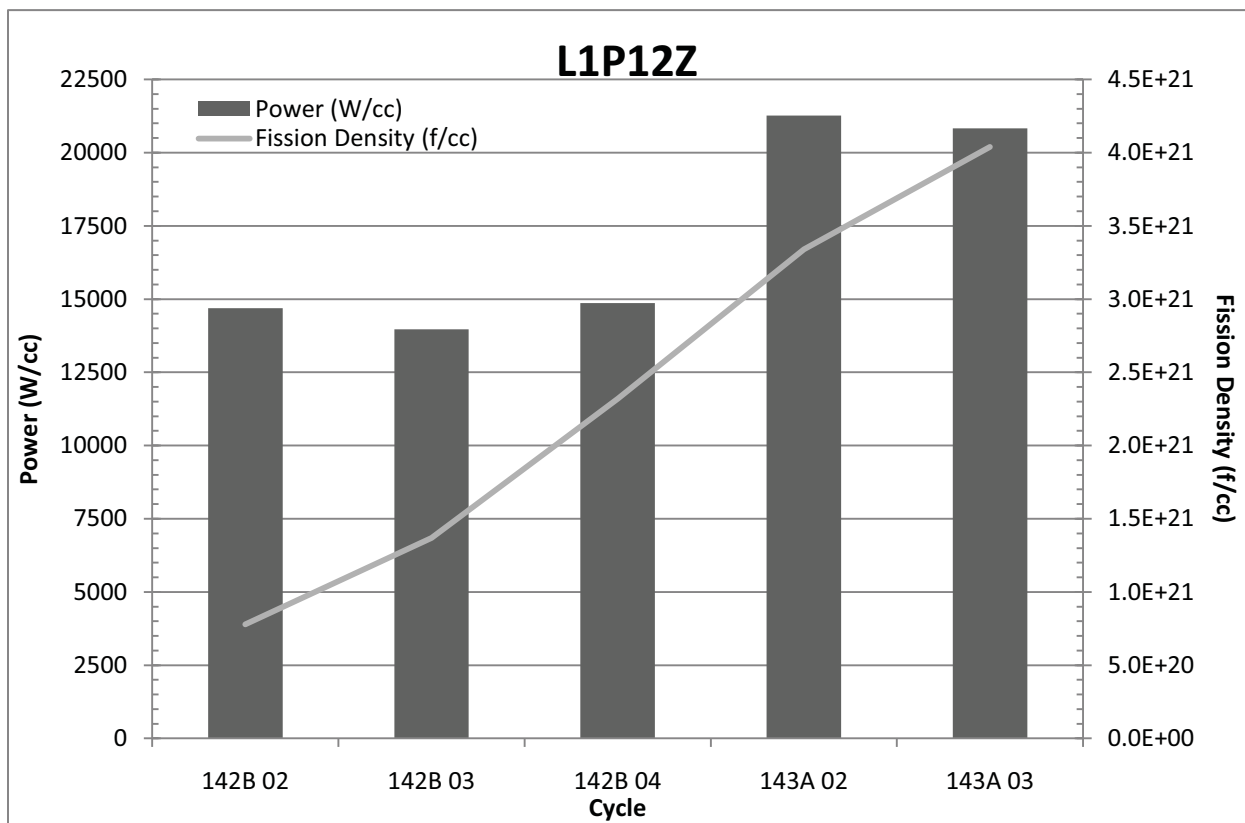
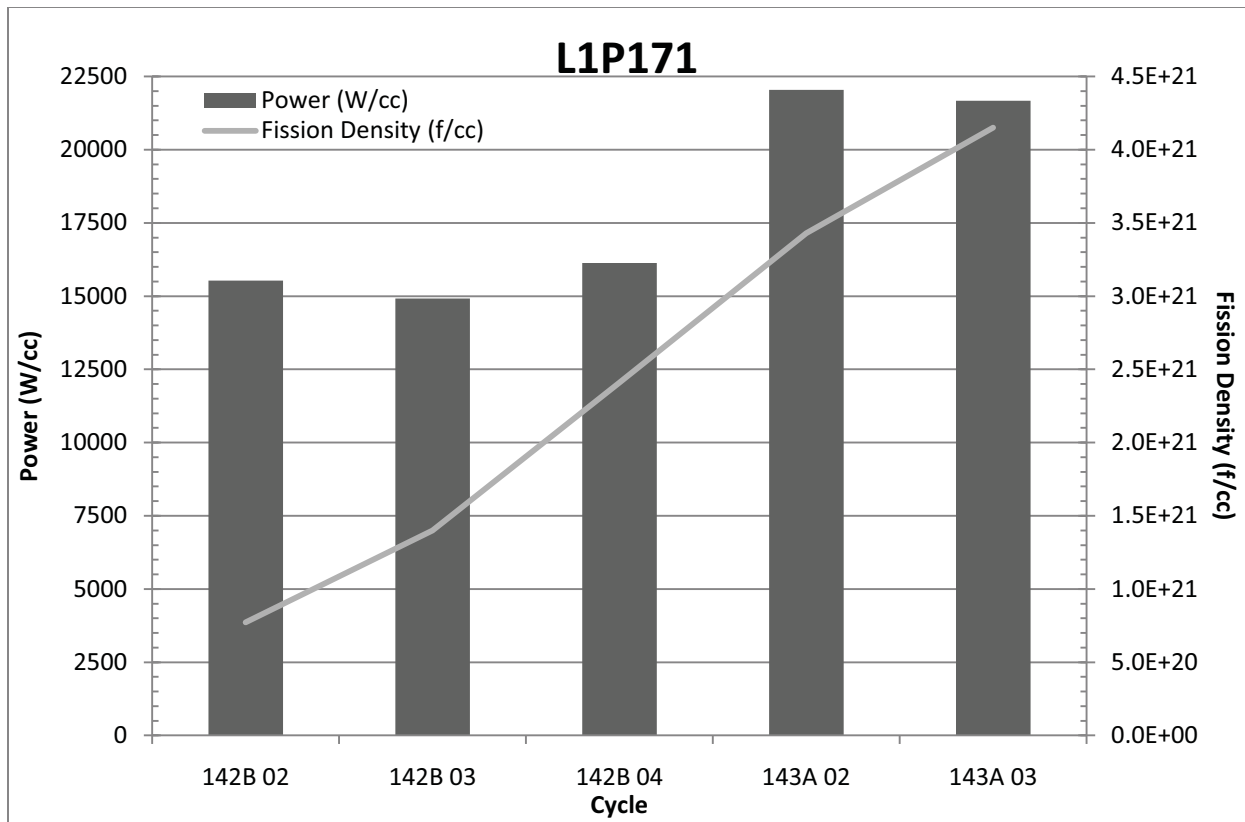


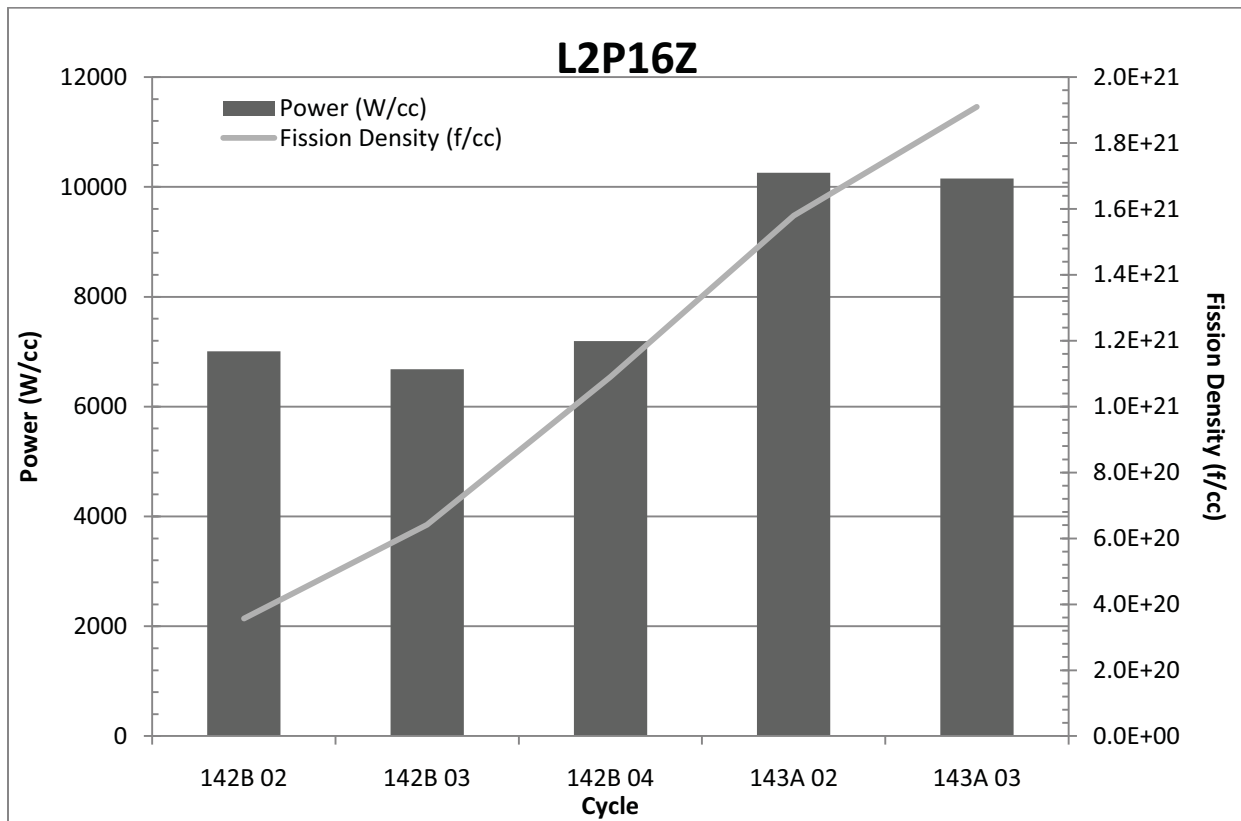
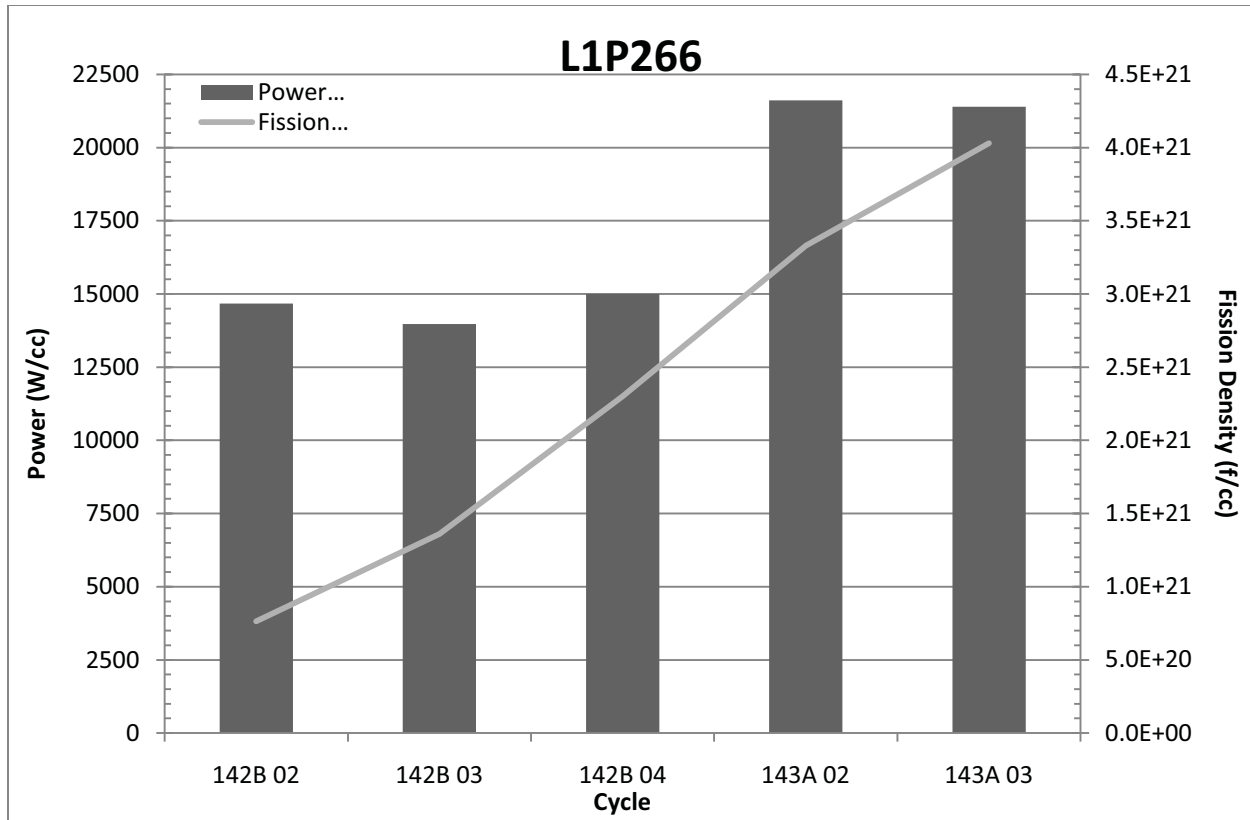


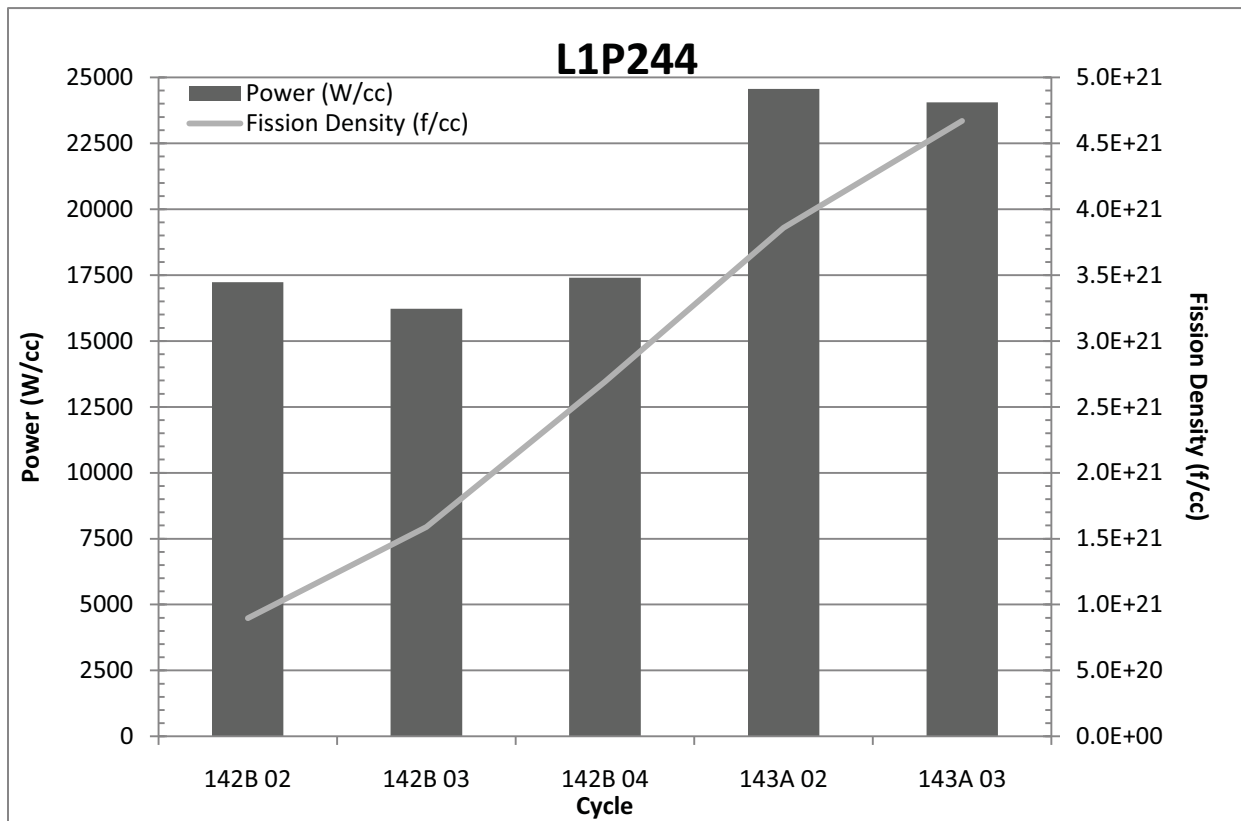
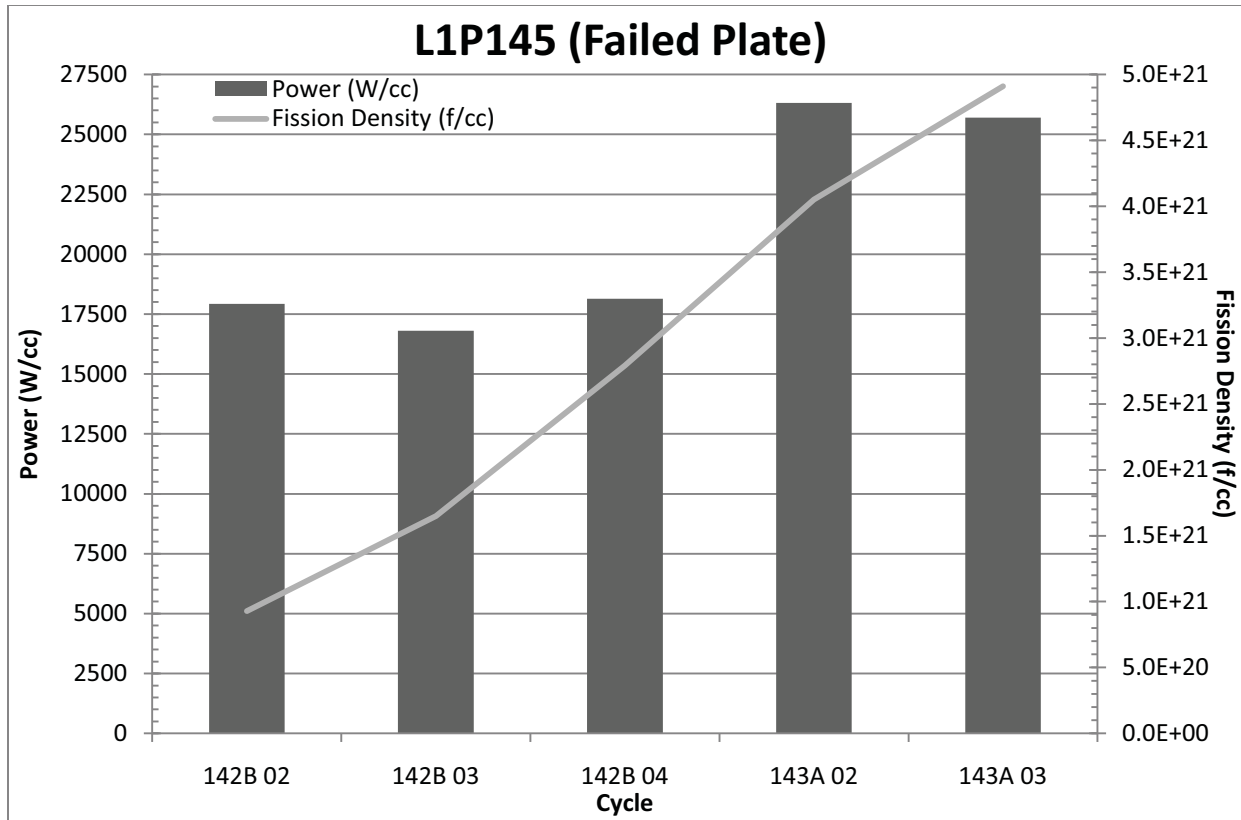


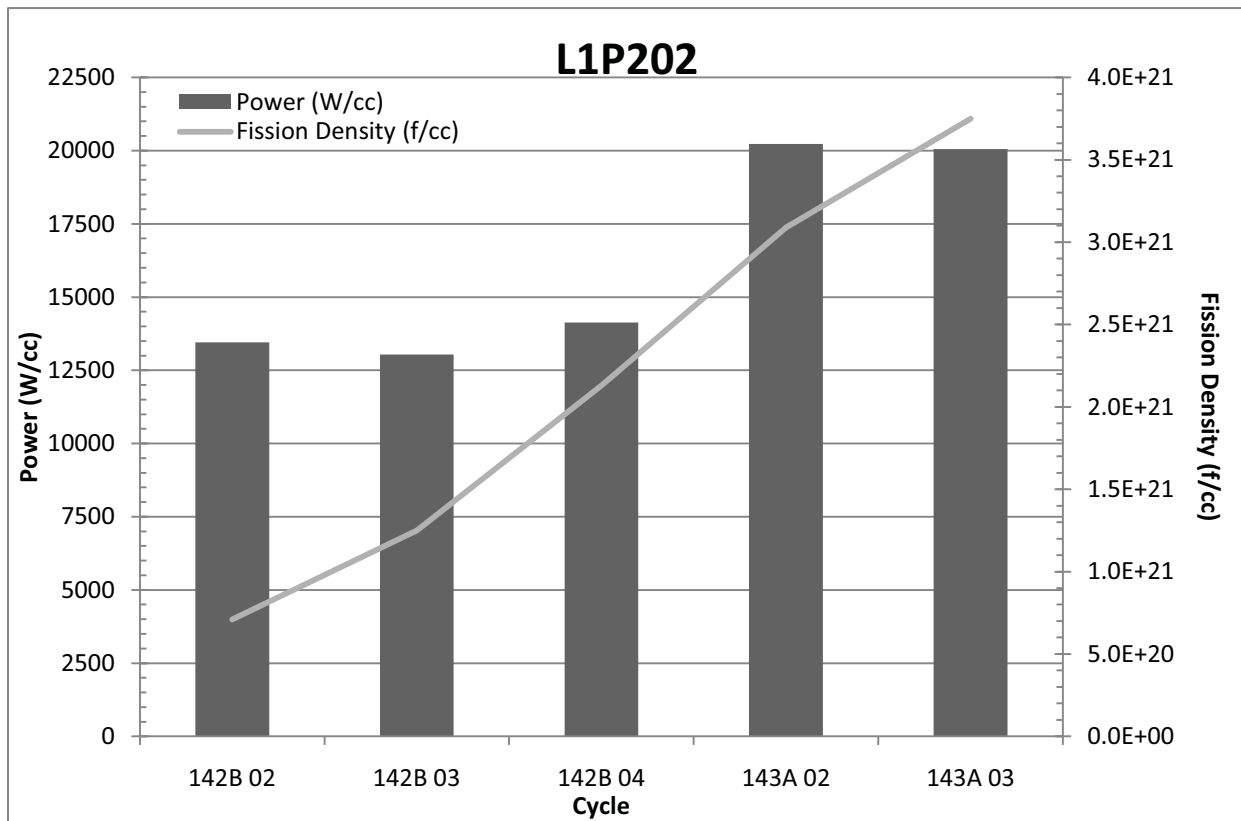
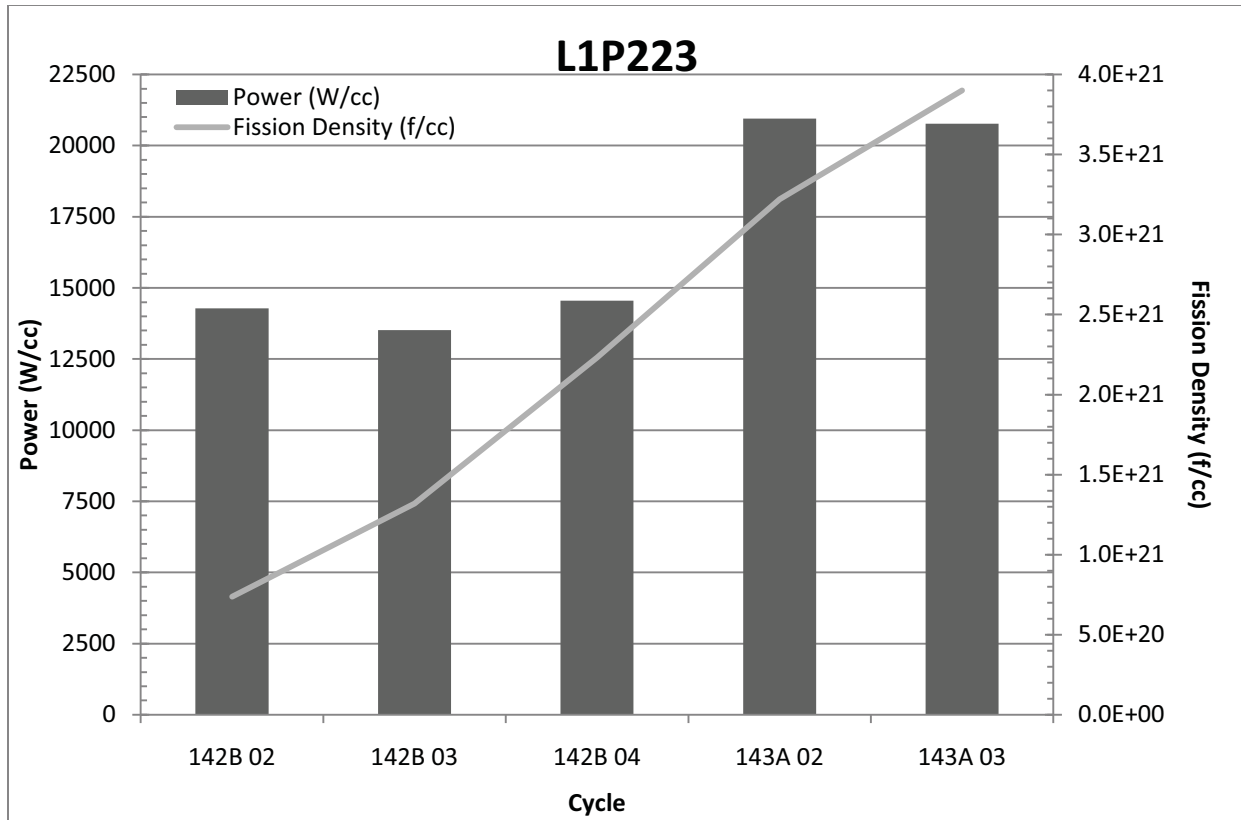


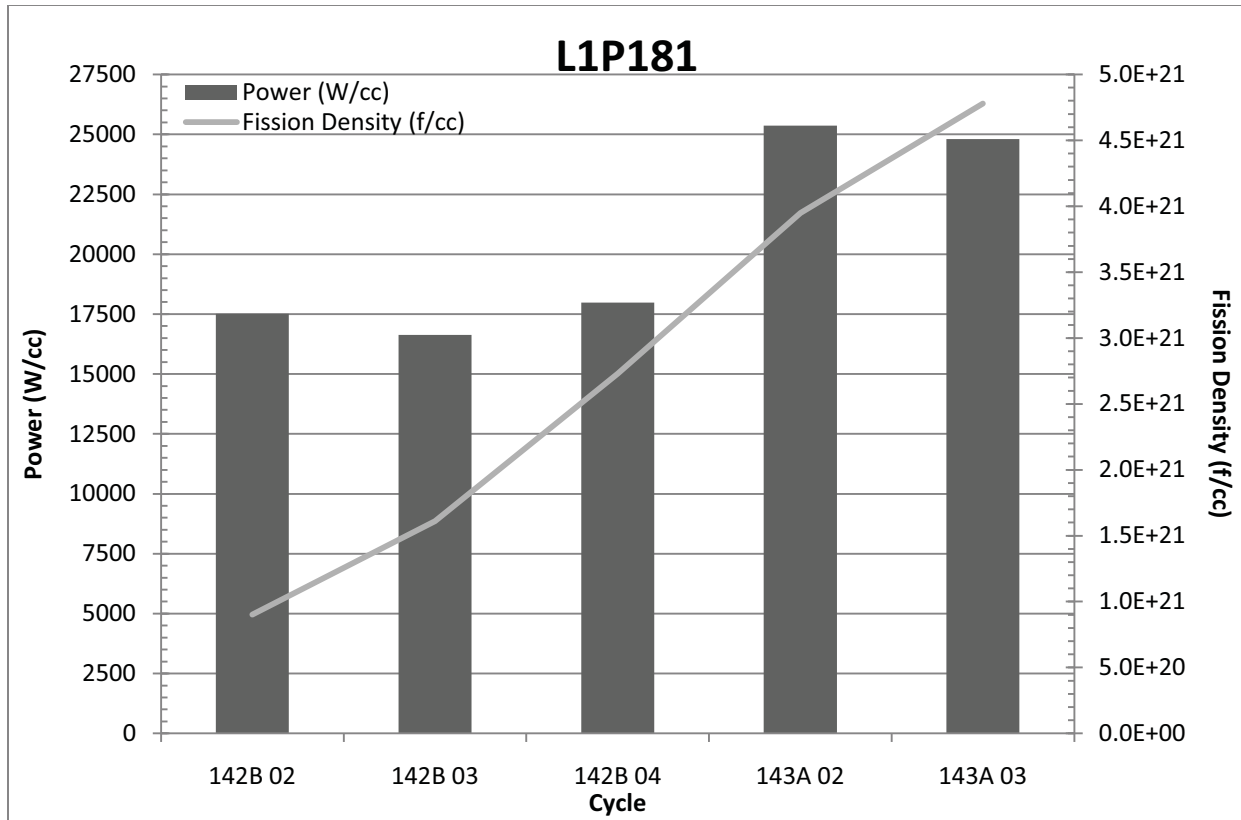




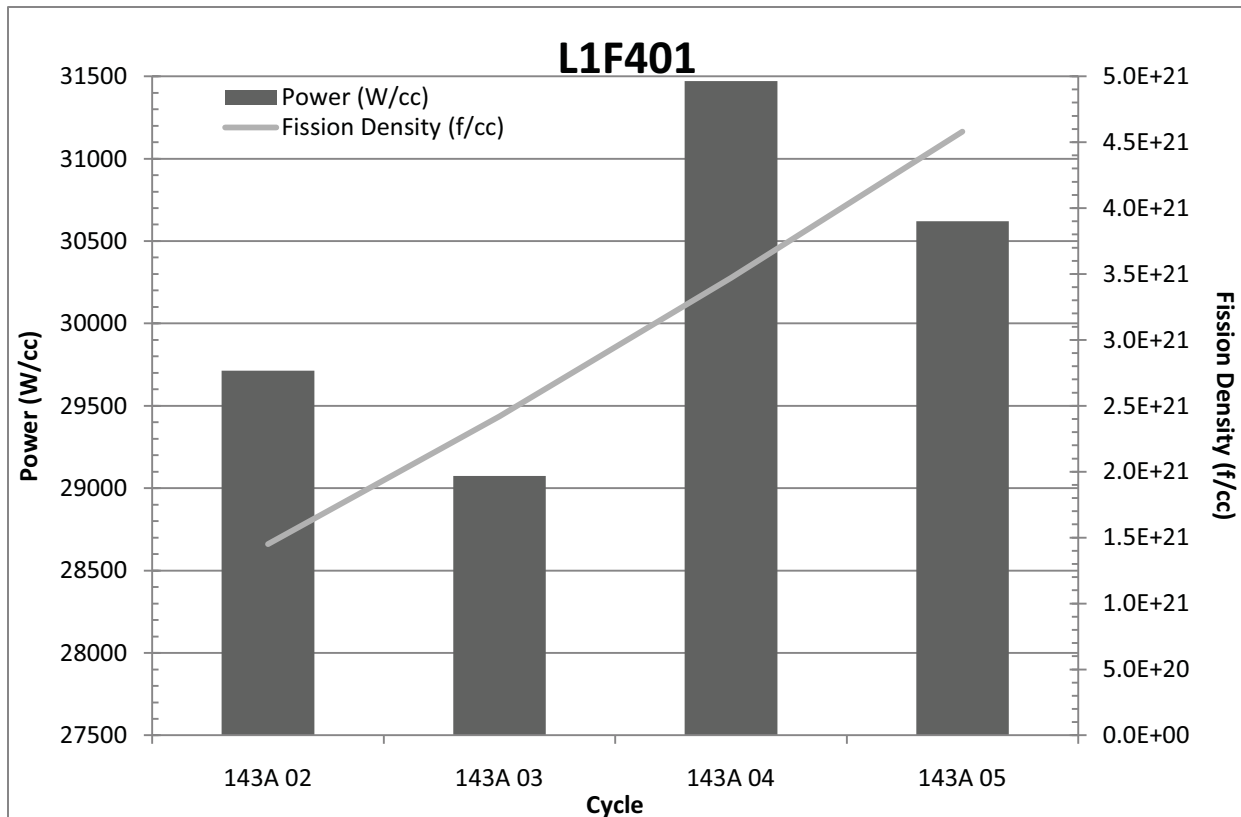




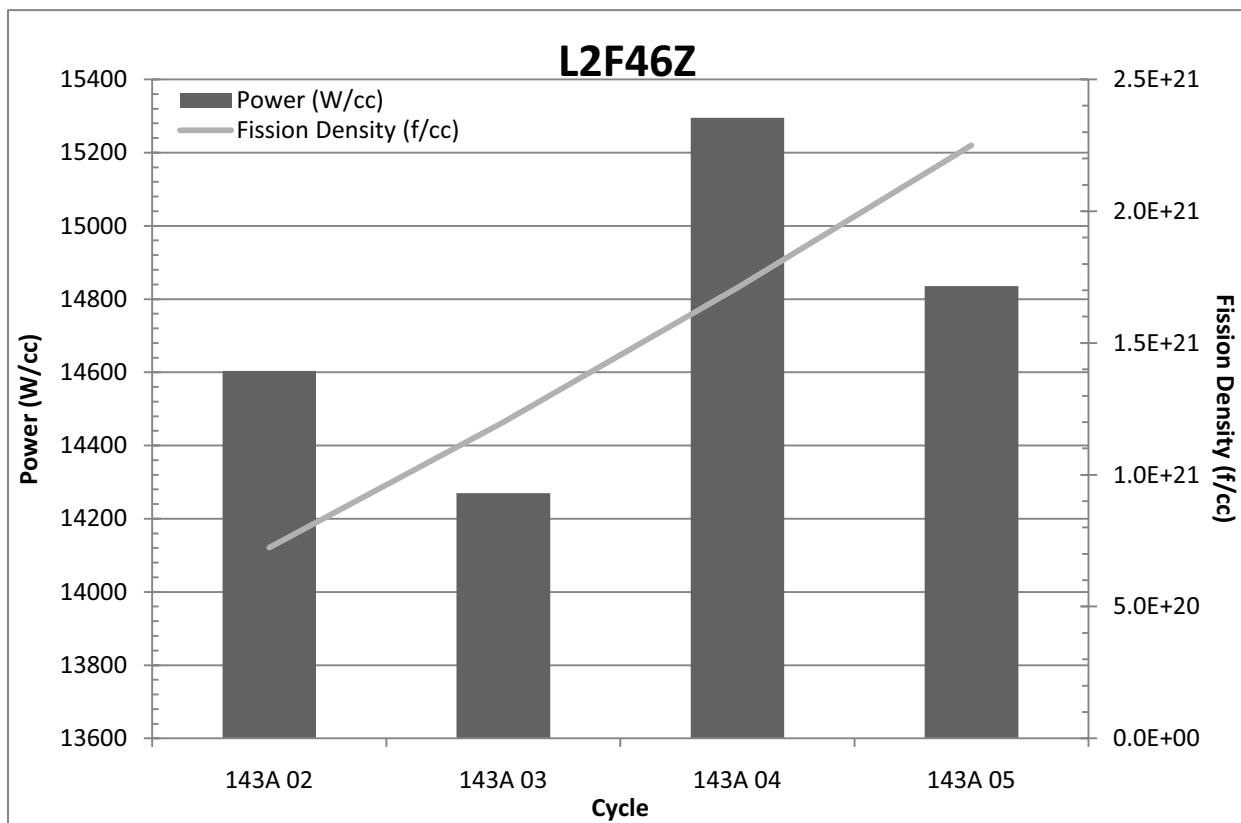
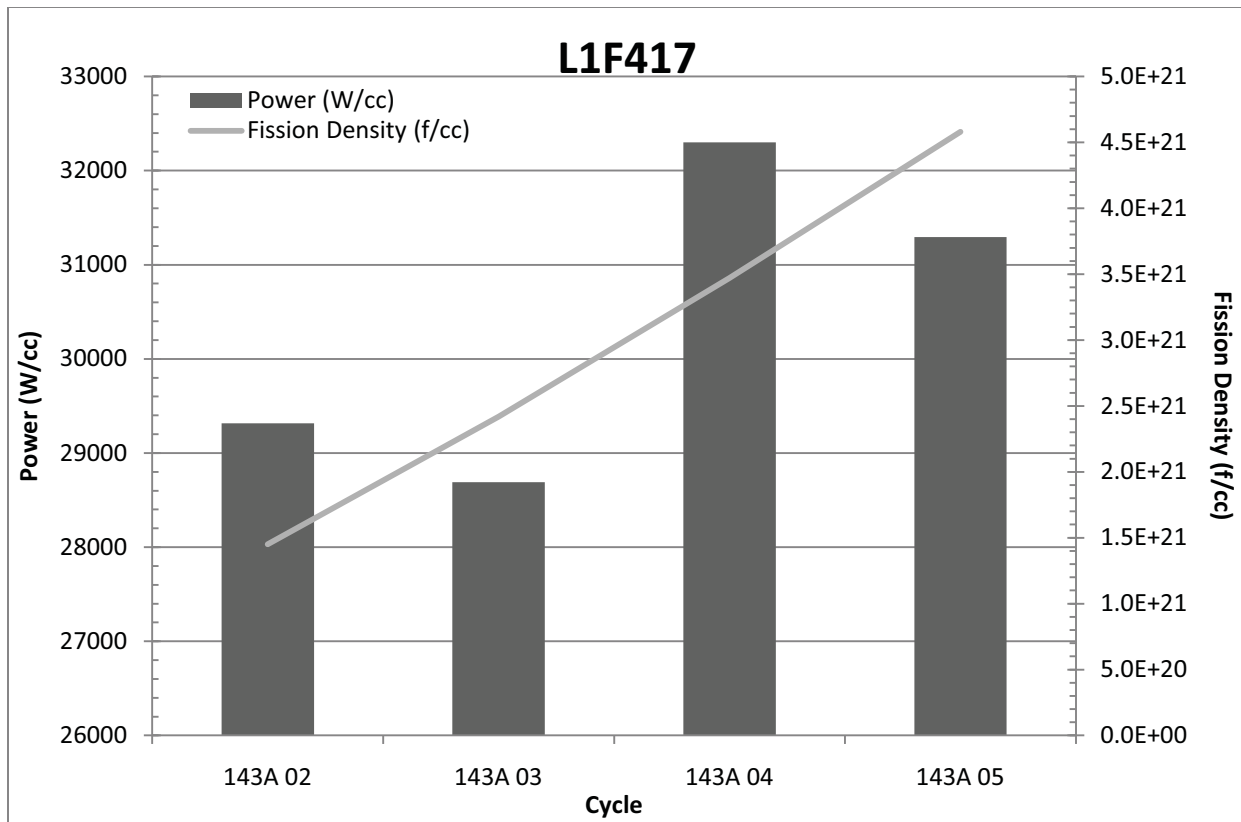


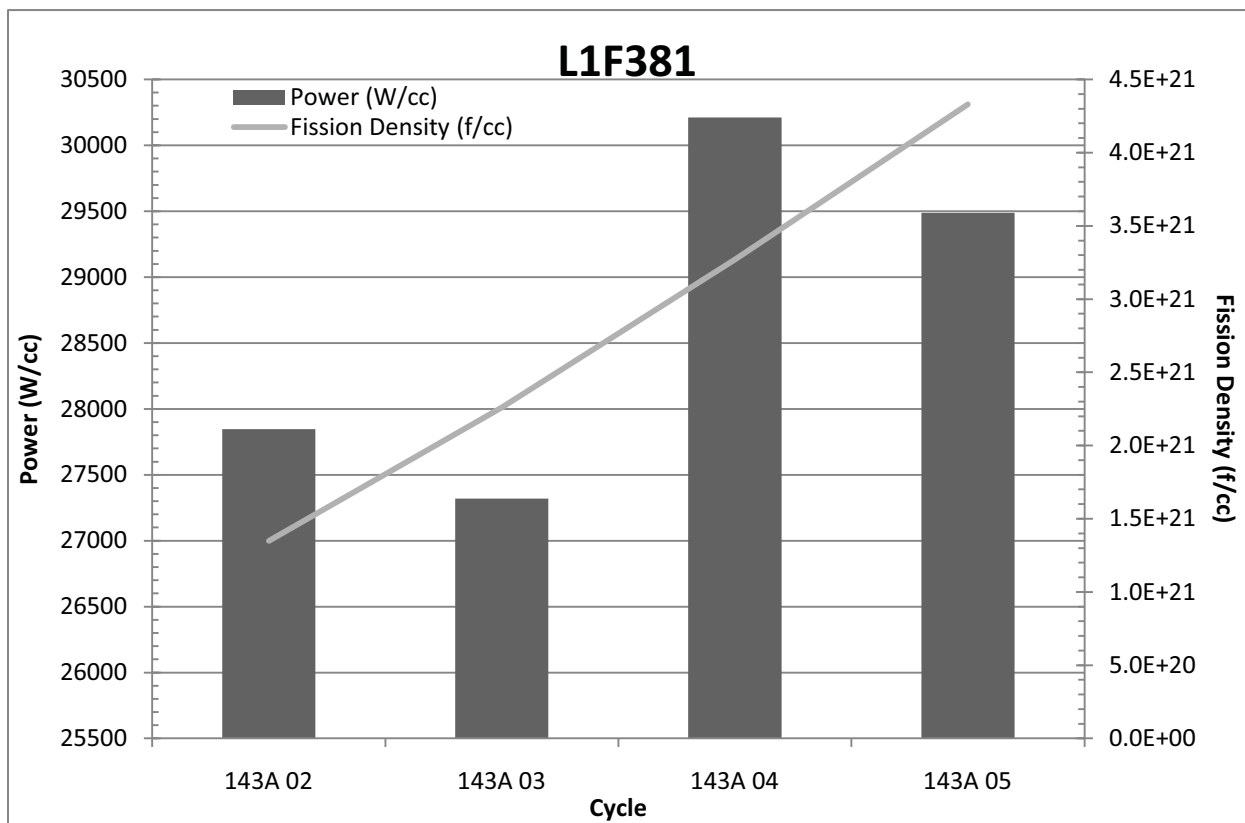
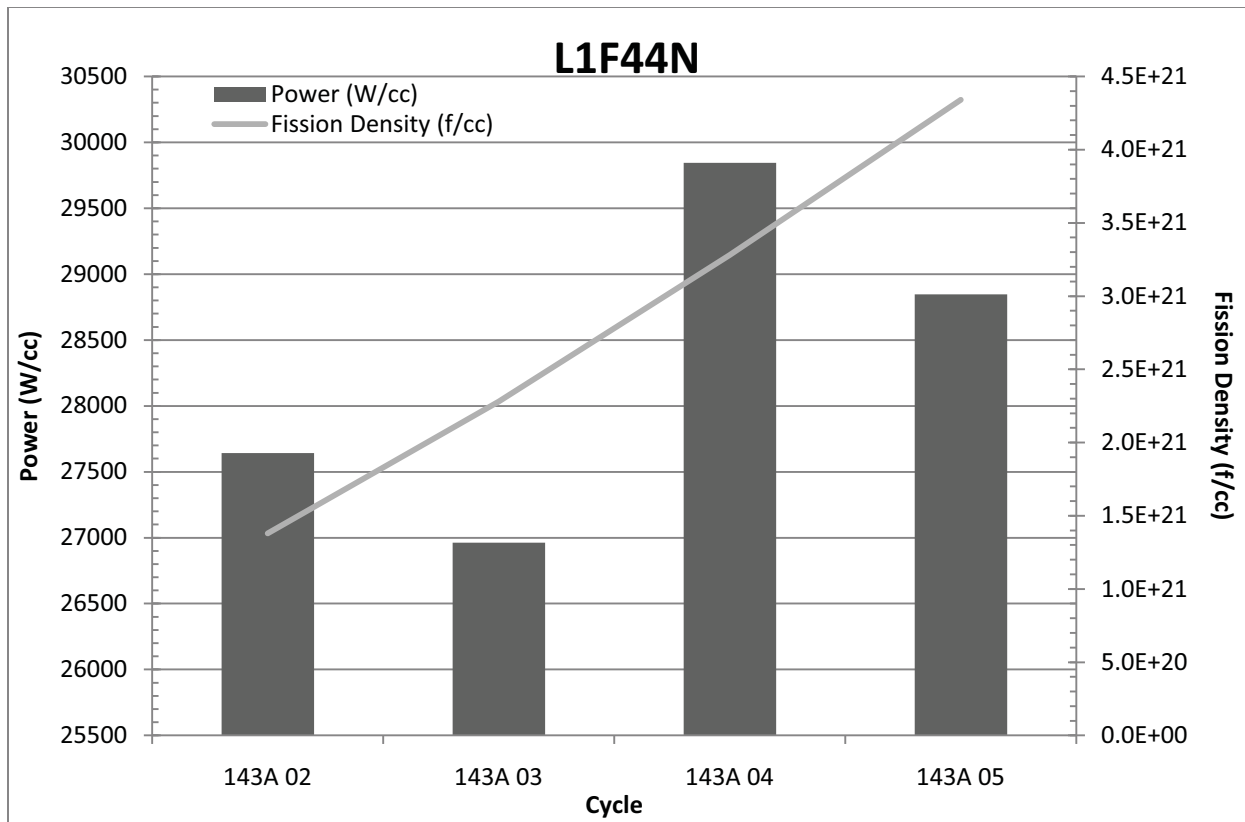


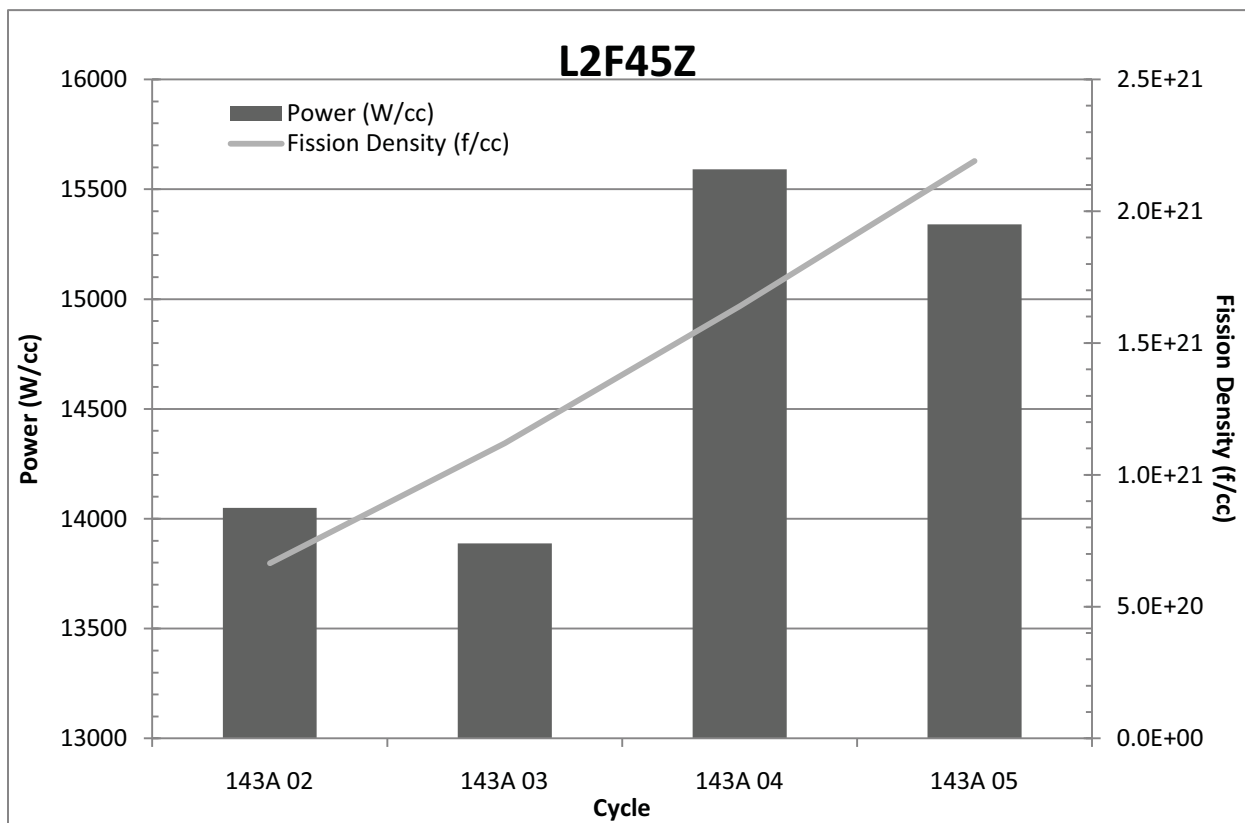
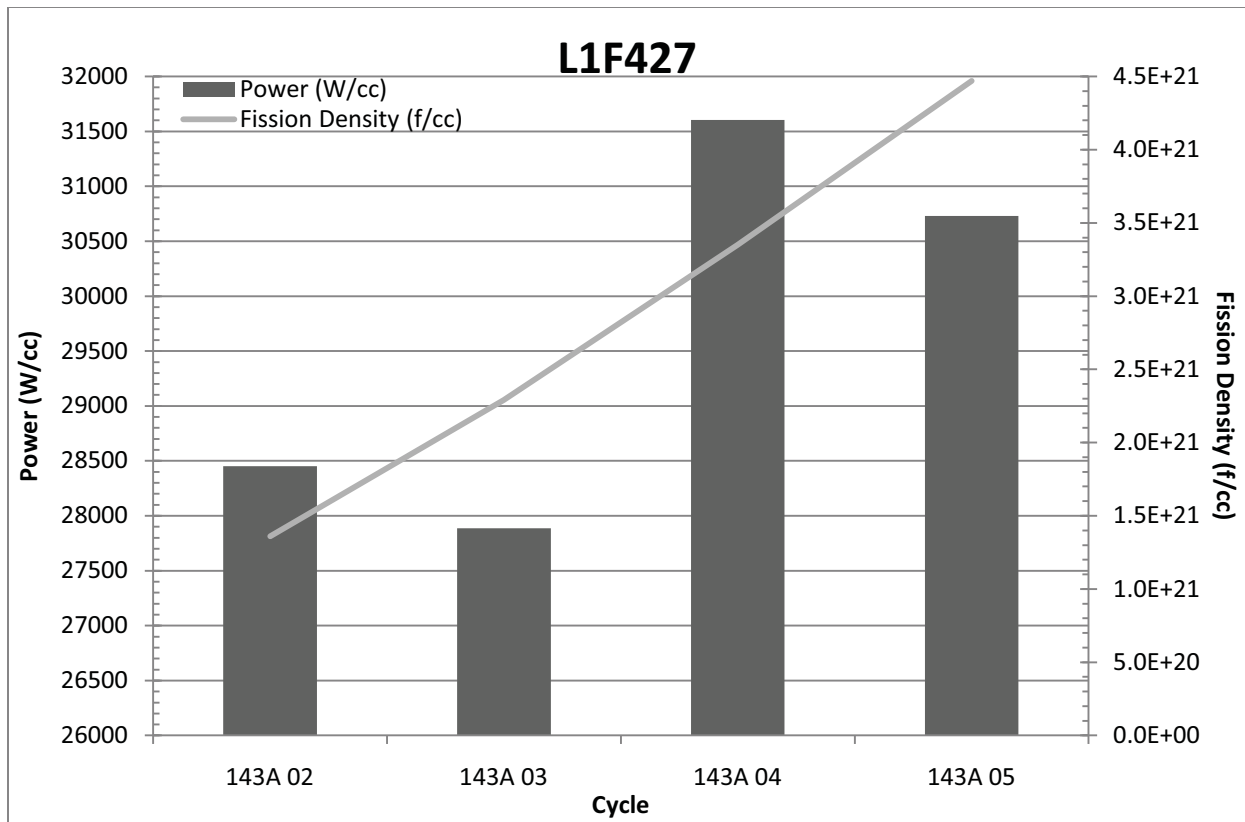
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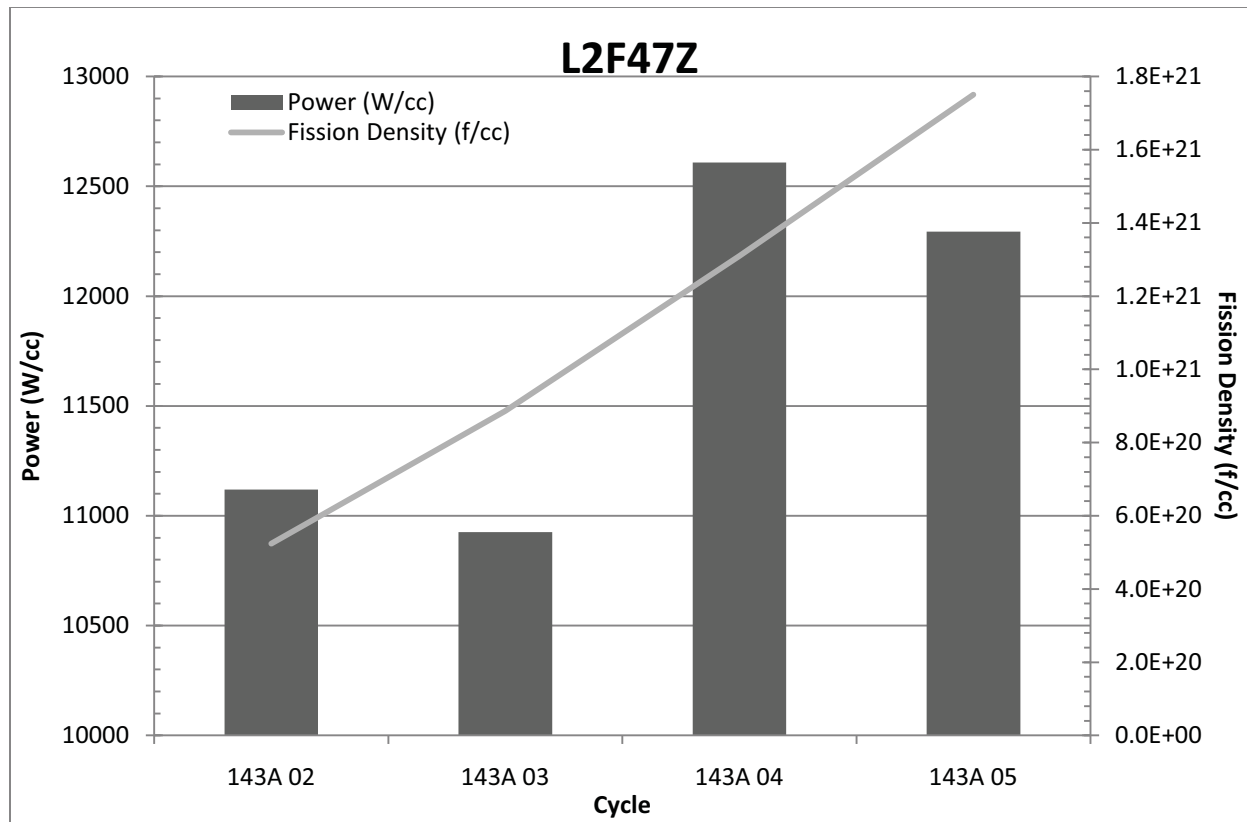












## **Appendix B**

### **References**

## Appendix B References



Glenn A.  
Roth/ROTHGA/CC01/INEEL/  
US

04/08/2010 08:06 AM

To: Danielle M Perez/PEREDM/CC01/INEEL/US@INEL  
cc: Bruce Nielson/RQN/CC01/INEEL/US@INEL, Daniel M  
Wachs/WACHDM/CC01/INEEL/US@INEL  
bcc:

Subject: RERTR-10 As-Run Data

Danielle,

Please find attached the summary data tables for the RERTR-10 As-run analysis.

The Maxima, Minima, and Average tables show the max, min, and average temps for each plate in each capsule for each stage of each cycle. They also show an overall capsule value (the max, min or average of a given capsule for a given stage) and an experiment overall (the max, min or average of the entire experiment for a particular stage).

The channel table shows the maximum and average temperature for each channel for each stage of each cycle. Following the table, there are plots of each of the channels for each stage of each cycle.

**BE ADVISED:** These results **HAVE NOT** been technically checked or reviewed. Consider them slightly better than coming to my office and asking "what do you think about...?" - since I have actually done some analysis. They have not been documented in any referenceable form. While I am confident that they are correct, they do not yet meet the company standard for analysis.

Thanks, let me know if you have any additional questions!

Glenn



Maximum\_Plate\_temps.pdf



Minimum\_Plate\_temps.pdf



Average\_Plate\_temps.pdf



Channel\_temps.pdf

Maxima		Cycle 142 B				Cycle 143 A				
		0 Day	16 Day	29.7 Day	52 Day	0 Day	15 Day	26 Day	37 Day	48 Day
Capsule A	Plate 1	182.1298	180.6166	178.8998	182.2812	200.224	197.398	196.58	128.396	128.396
	Plate 2	171.5048	170.8806	169.7782	172.9406	188.1538	186.4278	186.1142	127.8463	127.846
	Plate 3	171.4256	170.9406	169.6635	172.9179	188.7891	187.3304	186.9036	127.8473	127.847
	Plate 4	183.8572	182.9256	181.2234	185.332	205.8606	203.3462	202.3941	128.4036	128.4034
	Plate 5	198.55	196.3149	193.0976	197.6482	224.2854	220.1888	218.8015	130.4195	130.4105
	Plate 6	182.5624	180.092	178.4379	182.2788	202.8197	200.9996	200.4755	129.8597	129.8481
	Plate 7	184.2375	182.765	180.7965	184.8291	206.5679	203.9077	203.4271	129.8641	129.8521
	Plate 8	197.7725	195.1136	192.8075	197.4018	224.1447	219.5034	218.1357	130.4328	130.4232
	Capsule A Overall	198.55	196.3149	193.0976	197.6482	224.2854	220.1888	218.8015	130.4328	130.4232
Capsule B	Plate 1	134.9549	134.7668	134.5376	134.947	142.1248	141.3445	141.1596	134.3482	134.2128
	Plate 2	134.0941	133.9126	133.7015	134.1222	246.2073	236.7685	234.8292	235.3138	232.7917
	Plate 3	134.1471	133.9808	133.7808	134.2212	248.1087	238.3438	236.3829	240.5374	237.5346
	Plate 4	135.0716	134.8961	134.6928	135.1367	142.4468	141.6359	141.445	134.5402	134.3868
	Plate 5	136.7175	136.5022	136.2707	136.6866	145.9218	144.7676	144.5186	137.6123	137.3906
	Plate 6	135.929	135.7187	135.4975	135.9307	254.4955	242.7864	240.6173	240.8173	237.8867
	Plate 7	135.9703	135.7728	135.5591	136.0079	258.3628	245.9529	243.5834	246.8767	243.5051
	Plate 8	136.8113	136.6131	136.3998	136.8463	146.3646	145.1547	144.8923	137.9464	137.697
	Capsule B Overall	136.8113	136.6131	136.3998	136.8463	258.3628	245.9529	243.5834	246.8767	243.5051
Capsule C	Plate 1	213.0549	205.4212	202.0527	206.3685	246.1824	237.5866	235.6981	136.2208	136.0536
	Plate 2	196.0851	191.0455	188.4007	192.3361	232.2198	225.2812	224.3091	139.3259	138.9295
	Plate 3	194.4273	190.5965	188.0226	192.1141	231.0512	224.176	223.1784	139.3989	138.9963
	Plate 4	215.0093	208.8406	204.4709	209.8834	251.9214	243.5051	241.2953	136.4329	136.2481
	Plate 5	215.8986	209.2758	205.148	210.1518	249.6578	241.4731	239.5386	138.3179	138.1576
	Plate 6	198.9189	194.0969	191.0414	195.2681	235.8692	228.9346	227.9989	140.2047	139.9597
	Plate 7	199.7313	193.8526	191.9106	196.5898	237.0391	230.0528	229.1261	140.2668	140.0165
	Plate 8	216.5966	210.7375	207.0998	212.7448	253.7068	244.988	242.8581	138.5023	138.3274
	Capsule C Overall	216.5966	210.7375	207.0998	212.7448	253.7068	244.988	242.8581	140.2668	140.0165
Capsule D	Plate 1	145.0942	144.2092	143.6277	144.5073	161.3773	159.145	158.7012	142.4773	142.1905
	Plate 2	143.8308	142.9715	142.402	143.3217	257.2678	247.4263	245.5673	239.0989	236.7588
	Plate 3	143.9351	143.1267	142.5712	143.5491	258.0422	249.1101	247.1522	242.9342	240.1988
	Plate 4	145.3457	144.545	143.9705	144.9487	162.0436	159.7849	159.3025	142.8023	142.4869
	Plate 5	146.2847	145.4533	144.9052	145.7482	164.58	162.1873	161.7126	145.512	145.1975
	Plate 6	145.1898	144.3713	143.8283	144.7161	260.4045	252.1483	250.7797	246.3204	244.5151
	Plate 7	145.2704	144.4892	143.9559	144.8868	244.5595	237.3991	235.7698	231.1372	228.8648
	Plate 8	146.4795	145.7183	145.179	146.1035	164.6882	162.3058	161.7956	145.2538	144.9021
	Capsule D Overall	146.4795	145.7183	145.179	146.1035	260.4045	252.1483	250.7797	246.3204	244.5151
Over all Capsules		216.5966	210.7375	207.0998	212.7448	260.4045	252.1483	250.7797	246.8767	244.5151

Minima		Cycle 142 B				Cycle 143 A				
		0 Day	16 Day	29.7 Day	52 Day	0 Day	15 Day	26 Day	37 Day	48 Day
Capsule A	Plate 1	126.7197	126.6969	126.6612	126.7272	127.144	127.102	127.091	125.595	125.595
	Plate 2	126.6161	126.6014	126.576	126.6468	127.0912	127.0503	127.0422	125.5793	125.5793
	Plate 3	126.6155	126.6037	126.5751	126.648	127.1067	127.0711	127.0607	125.5793	125.5793
	Plate 4	126.739	126.7255	126.7004	126.7617	127.2122	127.1741	127.1606	125.595	125.595
	Plate 5	130.3368	130.2291	130.0989	130.3775	132.0548	131.8314	131.771	125.7758	125.7758
	Plate 6	129.8342	129.7727	129.661	129.954	131.518	131.3533	131.3159	125.6924	125.6924
	Plate 7	129.8404	129.7872	129.669	129.974	131.5819	131.4288	131.3861	125.6924	125.6924
	Plate 8	130.451	130.3794	130.2457	130.5716	132.4418	132.2387	132.1664	125.7779	125.7779
	Capsule A Overall	126.6155	126.6014	126.5751	126.6468	127.0912	127.0503	127.0422	125.5793	125.5793
Capsule B	Plate 1	132.6021	132.3932	132.1481	132.6106	135.6983	135.3198	135.2085	126.1556	126.1552
	Plate 2	132.0686	131.8912	131.6839	132.1384	136.9324	136.4615	136.349	129.0218	128.9587
	Plate 3	132.0844	131.9126	131.7085	132.1691	137.0703	136.5853	136.4702	129.1478	129.0729
	Plate 4	132.6975	132.5122	132.2878	132.7846	136.0472	135.654	135.5355	126.1627	126.1622
	Plate 5	132.9179	132.6964	132.438	132.9276	137.5624	137.0461	136.9006	127.724	127.7002
	Plate 6	132.3594	132.1708	131.9509	132.4335	142.6379	141.7302	141.5082	134.024	133.8396
	Plate 7	132.3731	132.189	131.9721	132.46	142.8859	141.9953	141.7681	134.2912	134.081
	Plate 8	133.0141	132.8177	132.5808	133.1051	138.0248	137.4753	137.3208	127.7989	127.77
	Capsule B Overall	132.0686	131.8912	131.6839	132.1384	135.6983	135.3198	135.2085	126.1556	126.1552
Capsule C	Plate 1	135.4337	135.0479	134.7214	135.2841	143.1645	142.2405	142.0225	130.8574	130.7508
	Plate 2	134.4712	134.1575	133.8715	134.4309	146.9402	145.5664	145.2827	134.9937	134.7588
	Plate 3	134.4623	134.1841	133.906	134.4793	147.1916	145.7855	145.4936	135.2411	134.9849
	Plate 4	135.5747	135.2413	134.9157	135.5353	143.7138	142.7498	142.5152	131.0824	130.9587
	Plate 5	140.0174	139.2366	138.7407	139.5307	150.1772	148.694	148.3626	131.3714	131.2634
	Plate 6	138.7799	138.1532	137.7062	138.4993	152.7086	150.9093	150.5551	135.2026	134.9572
	Plate 7	138.7536	138.1851	137.7362	138.5486	153.069	151.2382	150.8671	135.4694	135.2011
	Plate 8	140.1999	139.545	139.0087	139.8954	151.1257	149.5999	149.2299	131.603	131.478
	Capsule C Overall	134.4623	134.1575	133.8715	134.4309	143.1645	142.2405	142.0225	130.8574	130.7508
Capsule D	Plate 1	142.4173	141.4412	140.798	141.7941	155.0724	153.2015	152.7984	132.9568	132.8104
	Plate 2	141.4087	140.5341	139.9559	140.964	158.2171	156.2213	155.8256	138.6598	138.3563
	Plate 3	141.4374	140.5786	140.0057	141.0315	158.5941	156.5729	156.1612	138.9043	138.5787
	Plate 4	142.6084	141.7198	141.0972	142.1925	156.0554	154.1077	153.6664	133.2129	133.0474
	Plate 5	142.7844	141.7685	141.1025	142.1332	156.7913	154.7553	154.3153	134.3185	134.1537
	Plate 6	141.7719	140.8578	140.2585	141.3038	162.6697	160.2863	159.8121	142.882	142.5002
	Plate 7	141.797	140.8962	140.3012	141.3615	163.0755	160.7008	160.2086	142.8271	142.4282
	Plate 8	142.9735	142.0459	141.4032	142.5345	157.8981	155.7841	155.3	134.6069	134.4198
	Capsule D Overall	141.4087	140.5341	139.9559	140.964	155.0724	153.2015	152.7984	132.9568	132.8104
Over all Capsules		126.6155	126.6014	126.5751	126.6468	127.0912	127.0503	127.0422	125.5793	125.5793



Averages		Cycle 142 B				Cycle 143 A				
		0 Day	16 Day	29.7 Day	52 Day	0 Day	15 Day	26 Day	37 Day	48 Day
Capsule A	Plate 1	155.5315	154.7168	153.7754	155.6052	165.5172	163.9732	163.5243	126.2529	126.2528
	Plate 2	150.6175	150.2401	149.6255	151.3682	159.9628	159.0061	158.8265	126.1198	126.1198
	Plate 3	150.6074	150.3196	149.6097	151.4018	160.3544	159.5184	159.2816	126.1198	126.1198
	Plate 4	156.3722	155.842	154.9238	157.1245	168.384	166.9851	166.4658	126.2554	126.2552
	Plate 5	164.4787	163.2776	161.5817	164.0483	178.2951	176.1365	175.4174	126.7532	126.7528
	Plate 6	157.0072	155.702	154.7884	156.9306	168.5597	167.5098	167.2161	126.4472	126.4468
	Plate 7	157.8527	157.0526	155.9734	158.2181	170.4439	169.02	168.7454	126.4475	126.447
	Plate 8	164.1478	162.7633	161.519	164.0336	178.4344	176.0157	175.3009	126.7603	126.7599
	Capsule A Overall	157.0769	156.2392	155.2246	157.3413	168.7439	167.2706	166.8472	126.3945	126.3943
Capsule B	Plate 1	133.3737	133.157	132.8967	133.3694	137.9177	137.389	137.2458	128.8142	128.7721
	Plate 2	132.7262	132.5325	132.3079	132.7759	194.4942	189.1812	188.0855	185.1336	183.754
	Plate 3	132.7655	132.5849	132.3686	132.8518	195.6866	190.175	189.0613	188.0273	186.3771
	Plate 4	133.4914	133.2938	133.0612	133.5727	138.3186	137.7588	137.608	128.8939	128.845
	Plate 5	133.7796	133.5619	133.3014	133.7757	140.3119	139.5738	139.3922	131.0588	130.9637
	Plate 6	133.0326	132.8358	132.6079	133.081	199.5397	193.0217	191.7972	188.5017	186.8986
	Plate 7	133.0719	132.8877	132.6683	133.1566	201.733	194.819	193.4863	191.8454	189.9922
	Plate 8	133.8978	133.6991	133.4659	133.9781	140.7707	139.9893	139.7974	131.2526	131.1414
	Capsule B Overall	133.2673	133.0691	132.8347	133.3201	168.5966	165.2385	164.5592	159.191	158.343
Capsule C	Plate 1	175.2827	171.2575	169.3932	171.8478	197.1008	192.0823	190.984	133.0798	132.9351
	Plate 2	167.3034	164.4574	162.8978	165.2763	191.5187	187.2357	186.5927	136.9468	136.6613
	Plate 3	166.4668	164.2191	162.722	165.1881	191.1332	186.8656	186.2027	137.0992	136.8006
	Plate 4	176.2657	172.9809	170.6444	173.6617	200.2229	195.2499	193.9788	133.3226	133.1583
	Plate 5	177.9032	174.21	171.9335	174.7945	200.8215	195.8255	194.6773	133.6982	133.5488
	Plate 6	169.8596	167.0509	165.2514	167.845	195.3918	190.9355	190.276	137.1966	136.9118
	Plate 7	170.226	166.9228	165.6851	168.5125	196.2092	191.7038	191.0375	137.344	137.0466
	Plate 8	178.3151	175.0532	172.9915	176.2254	203.195	197.908	196.6432	133.9459	133.7771
	Capsule C Overall	172.7028	169.519	167.6899	170.4189	196.9492	192.2258	191.299	135.3291	135.1049
Capsule D	Plate 1	143.4208	142.4175	141.7609	142.7564	157.744	155.6249	155.1817	136.3079	136.1043
	Plate 2	142.2965	141.3751	140.769	141.78	209.6322	203.4262	202.2489	191.0701	189.72
	Plate 3	142.3705	141.4884	140.895	141.9508	209.9774	204.2509	203.0056	192.8621	191.2862
	Plate 4	143.6703	142.7633	142.1216	143.2279	158.6669	156.4854	156.0046	136.5879	136.361
	Plate 5	143.8145	142.8138	142.1593	143.1536	159.9477	157.6915	157.2264	138.5679	138.3298
	Plate 6	142.6164	141.6884	141.0786	142.0943	212.291	206.7716	205.8182	195.343	194.2396
	Plate 7	142.6914	141.8022	141.2045	142.2645	204.3722	199.4532	198.3554	187.6884	186.3292
	Plate 8	144.0605	143.1543	142.515	143.6178	160.6759	158.3815	157.8765	138.7051	138.4365
	Capsule D Overall	143.1176	142.1879	141.563	142.6057	184.1634	180.2607	179.4647	164.6415	163.8508
Over all Capsules		151.5412	150.2538	149.328	150.9215	179.6133	176.2489	175.5425	146.389	145.9233

Flow Channels		Cycle 142 B				Cycle 143 A				
		0 Day	16 Day	29.7 Day	52 Day	0 Day	15 Day	26 Day	37 Day	48 Day
Max Temp (°F)	Channel 1	144.69	143.44	142.65	143.76	157.88	155.72	155.26	135.29	135.11
	Channel 2	142.88	141.74	141.01	142.13	165.43	162.53	161.97	142.84	142.45
	Channel 3	141.78	140.8	140.16	141.29	174.46	170.81	170.12	152.69	152.01
	Channel 4	143.01	141.98	141.29	142.52	165.45	162.59	161.99	142.59	142.15
	Channel 5	145.21	144.12	143.32	144.61	158.85	156.63	156.12	135.48	135.26
Average Temp (°F)	Channel 1	136.39	135.82	135.39	136.05	142.7	141.67	141.43	128.61	128.55
	Channel 2	135.68	135.13	134.72	135.4	146.53	145.09	144.79	132.19	132.01
	Channel 3	134.66	134.22	133.88	134.54	149.2239	147.51	147.18	135.88	135.59
	Channel 4	135.48	135.01	134.63	135.35	146.34	144.92	144.61	132.13	131.94
	Channel 5	136.66	136.15	135.73	136.49	143.52	142.44	142.17	128.74	128.67