

Fig.E-4.2. Cross-section and cladding microstructure of fuel rod # RT4 at 108 mm elevation (from low cap)

RT4

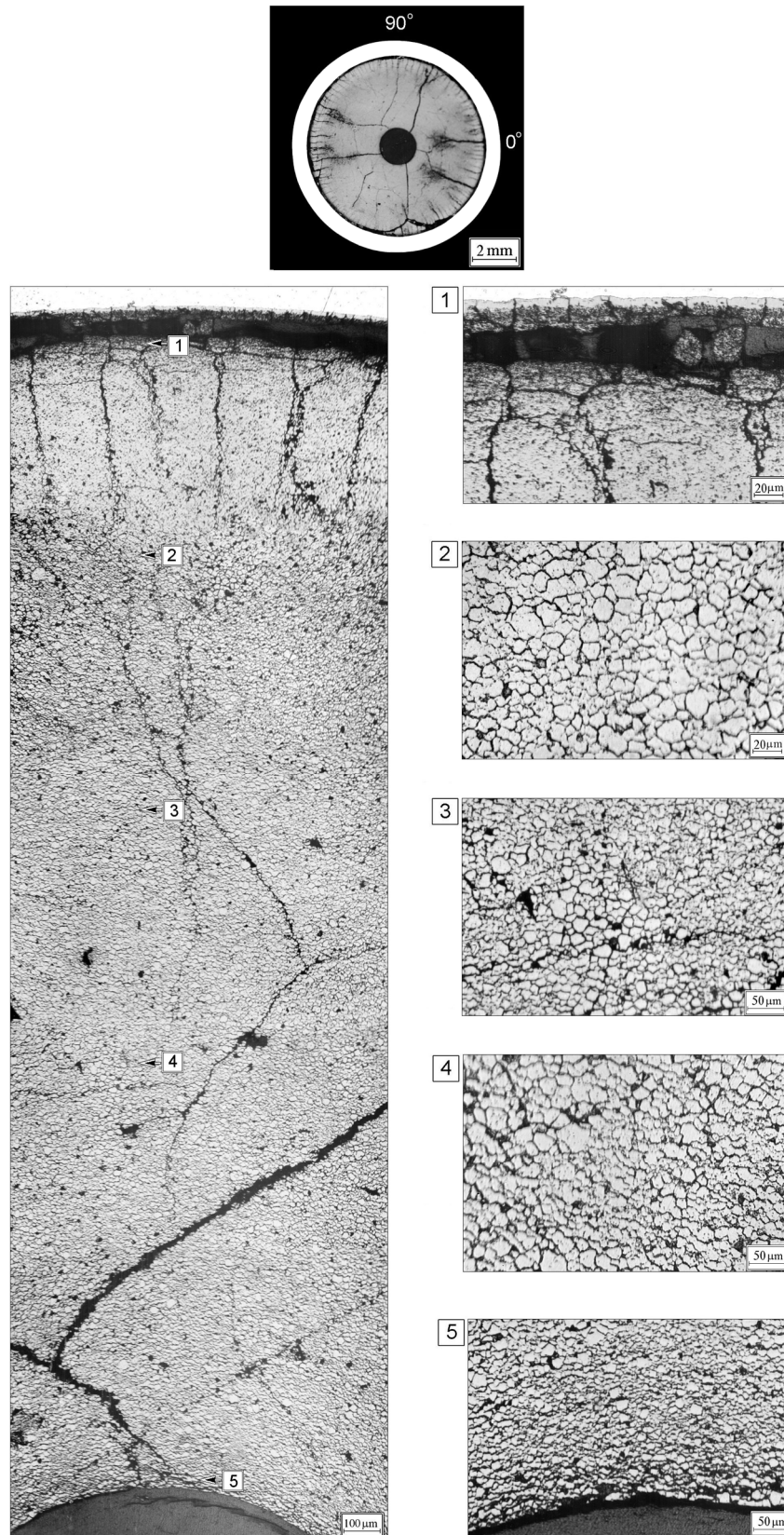


Fig.E-4.3. Cross-section and fuel microstructure of fuel rod # RT4 at 108 mm elevation (from low cap)

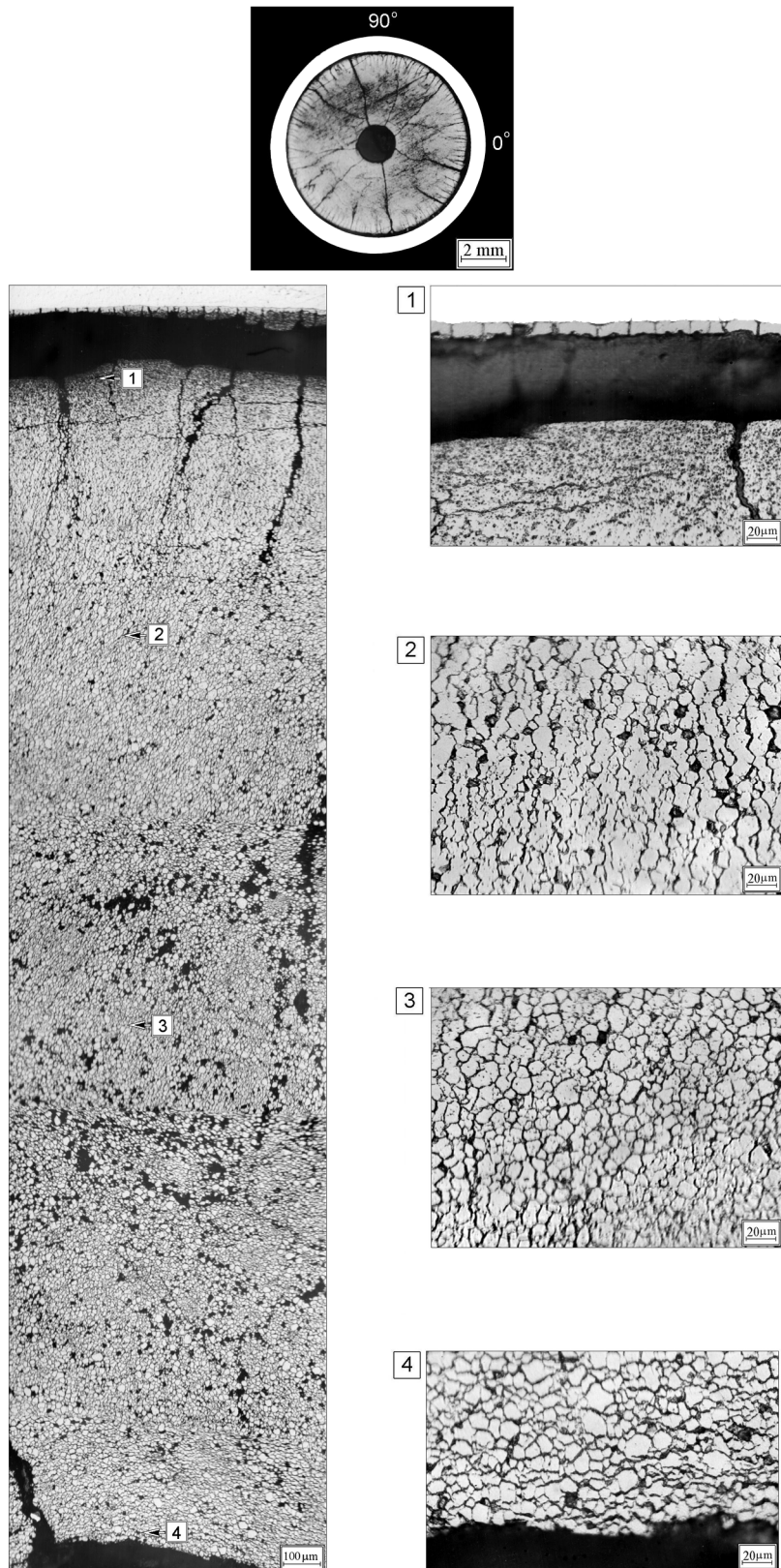


Fig.E-4.4. Cross-section and fuel microstructure of fuel rod # RT4 after the BGR test at 117 mm elevation (from low cap)

RT4

Table E-4.1. Time dependent energy characteristics of fuel rod # RT4

Time (s)	Relative reactor power (current/ maximum value) (per-unit)	Cumulative number of fissions in fuel rod (fiss) x10 ⁻¹⁴	Power of fuel rod ¹⁾²⁾ (kW)	Energy deposition		Fuel enthalpy ³⁾	
				(cal/g fuel)	(J/g fuel)	FRAP-T6	RAPTA-5
0.000	1.88E-02	0.000	0.000	0.000	0.000	0.000	0.000
0.001	1.91E-01	0.257	1297	2.477	10.37	3.138	2.366
0.002	6.03E-01	1.247	4085	12.07	50.51	13.615	11.950
0.003	1.00E+00	3.438	6778	33.38	139.8	35.372	33.202
0.004	6.48E-01	5.663	4393	54.98	230.2	56.687	54.522
0.005	2.66E-01	6.805	1804	66.06	276.6	67.189	65.110
0.006	1.42E-01	7.321	961.5	71.06	297.5	71.731	69.656
0.007	7.58E-02	7.575	513.9	73.49	307.7	73.952	71.890
0.008	5.27E-02	7.756	357.1	75.28	315.2	75.188	73.149
0.009	4.50E-02	7.878	304.8	76.50	320.3	76.058	74.091
0.010	4.44E-02	8.001	300.7	77.61	324.9	76.919	74.963
0.012	5.31E-02	8.252	359.8	80.07	335.2	78.844	76.956
0.014	6.69E-02	8.567	453.3	83.11	348.0	81.379	79.559
0.016	7.50E-02	8.938	508.6	86.75	363.2	84.510	82.711
0.018	7.34E-02	9.332	497.6	90.55	379.1	87.719	86.298
0.020	6.46E-02	9.694	438.0	94.09	393.9	90.803	89.384
0.022	5.92E-02	10.02	401.4	97.21	407.0	93.371	92.225
0.024	5.21E-02	10.31	353.2	100.0	418.9	95.776	94.529
0.026	4.18E-02	10.56	283.4	102.4	428.8	97.670	96.723
0.028	3.21E-02	10.75	217.4	104.3	436.6	99.134	98.213
0.030	2.57E-02	10.90	174.0	105.7	442.7	100.164	99.336
0.050	1.89E-02	12.02	128.4	116.6	488.0	108.491	107.080
0.070	1.71E-02	12.98	116.4	126.0	527.3	114.982	114.030
0.090	1.27E-02	13.76	86.32	133.5	558.9	120.271	119.230
0.110	8.10E-03	14.32	55.07	138.9	581.7	124.073	122.830
0.130	3.02E-03	14.59	20.66	141.6	592.8	125.177	123.870
0.150	1.15E-03	14.69	7.992	142.6	596.9	125.119	123.500
0.200	3.10E-04	14.77	2.316	143.4	600.3	123.882	121.670
1.000	2.83E-05	14.88	0.295	144.9	606.6	104.923	104.430
10.00	3.21E-06	15.09	0.042	148.4	621.2	32.490	25.516
100.0	6.25E-08	15.20	0.006	151.0	632.2	5.621	4.506
1000	2.45E-13	15.20	1.49E-04	152.3	637.5	0.000	0.000

¹⁾ Average values determined in accordance with results of RRC KI and VNIIEF calculations

²⁾ Maximum power value is 6778 κВт (t=0.003 c)

³⁾ Average radial value

Table E-4.2. Radial energy characteristics of fuel rod # RT4*

Parameters	Coordinates of fuel radial layers (mm)			
	1 layer (0.825-2.77)	2 layer (2.77-3.45)	3 layer (3.45-3.75)	4 layer (3.75-3.84)
Number of fissions $\times 10^{-14}$ (fiss)	6.702	4.402	2.759	1.333
Fission density $\times 10^{-13}$ (fiss/g fuel)	1.960	2.134	2.629	4.165
Power** (kW)	2990	1948	1238	600.5
Energy deposition (cal/g fuel)	146.0	155.1	191.7	288.5
Energy deposition (J/g fuel)	611.4	649.3	802.5	1208
Energy deposition*** (per-unit)	0.506	0.538	0.664	1.000

* Average values were determined in accordance with results of RRC KI and VNIIEF calculations

** The power for the entire length of each layer at time 0.003 s

*** Energy deposition in current layer/energy deposition in 4th layer

RT4

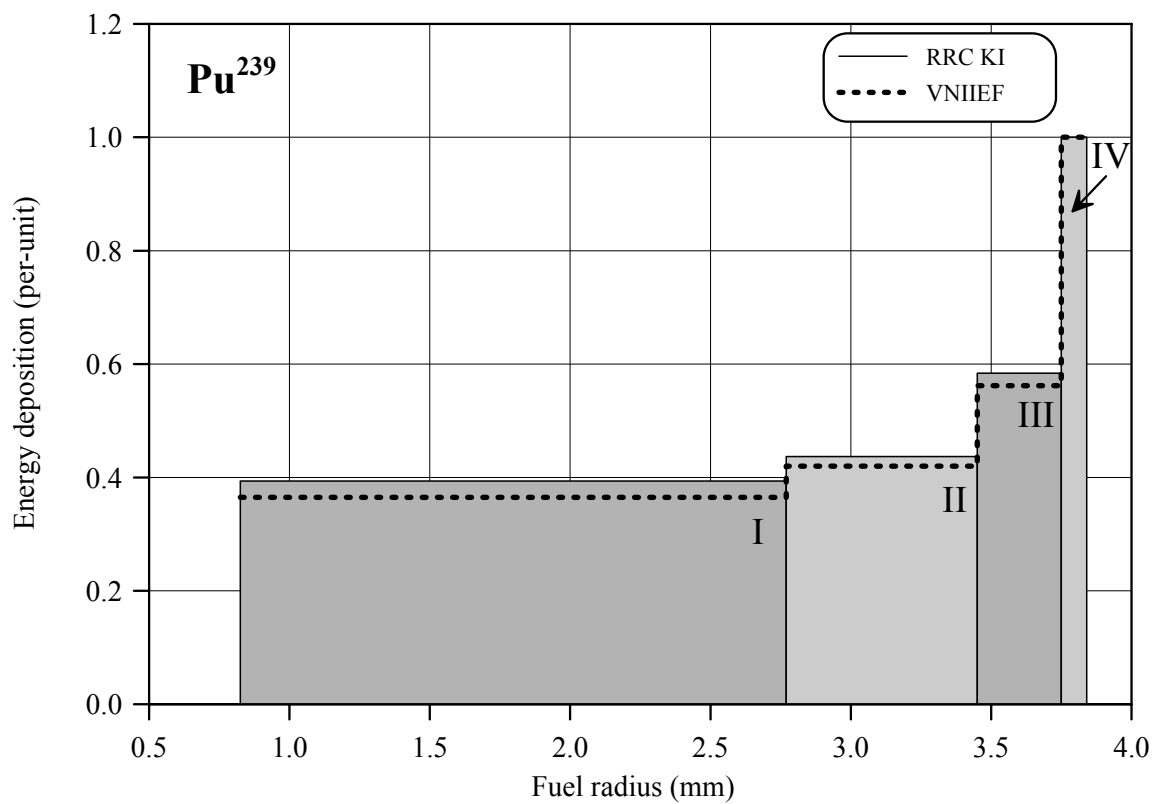
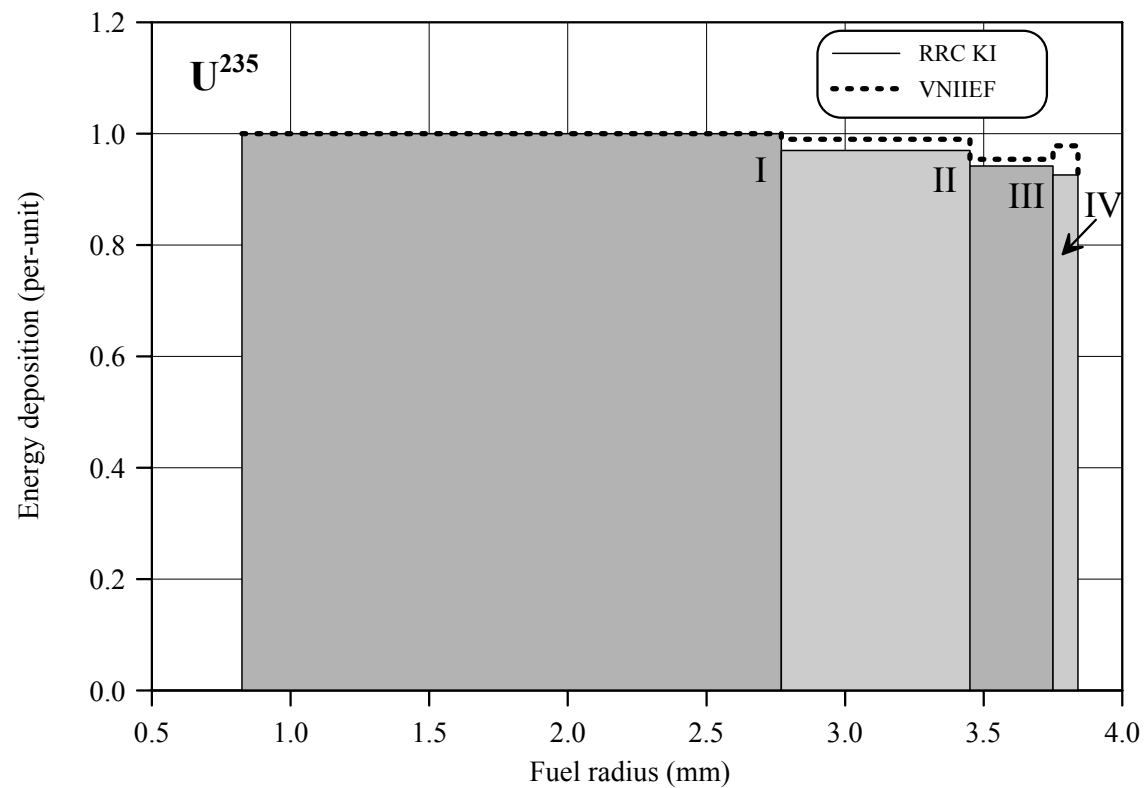


Fig.E-4.5. U^{235} and Pu^{239} radial distribution of energy deposition for fuel rod # RT4

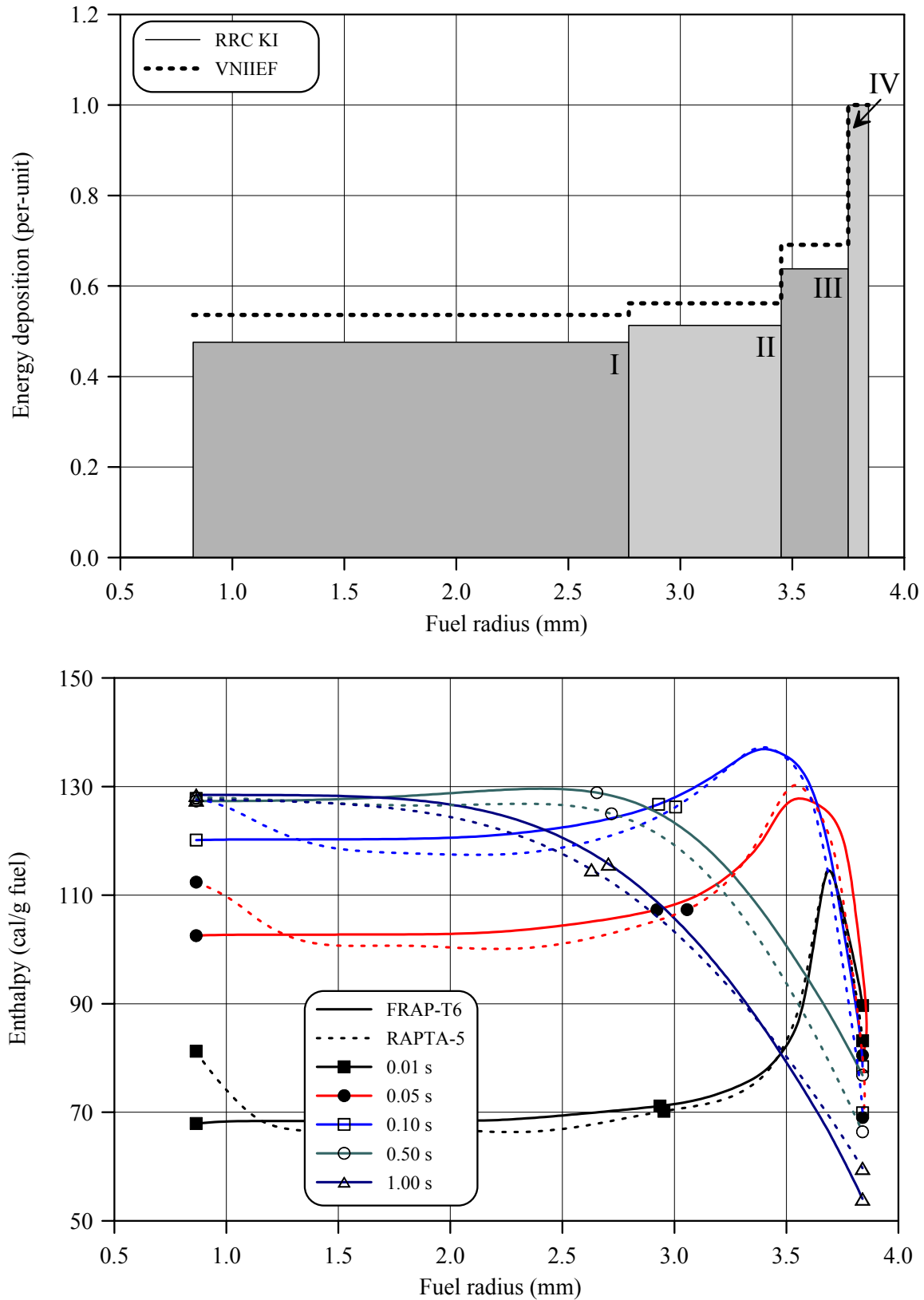


Fig.E-4.6. Radial distribution of energy deposition and fuel enthalpy for fuel rod # RT4

RT4

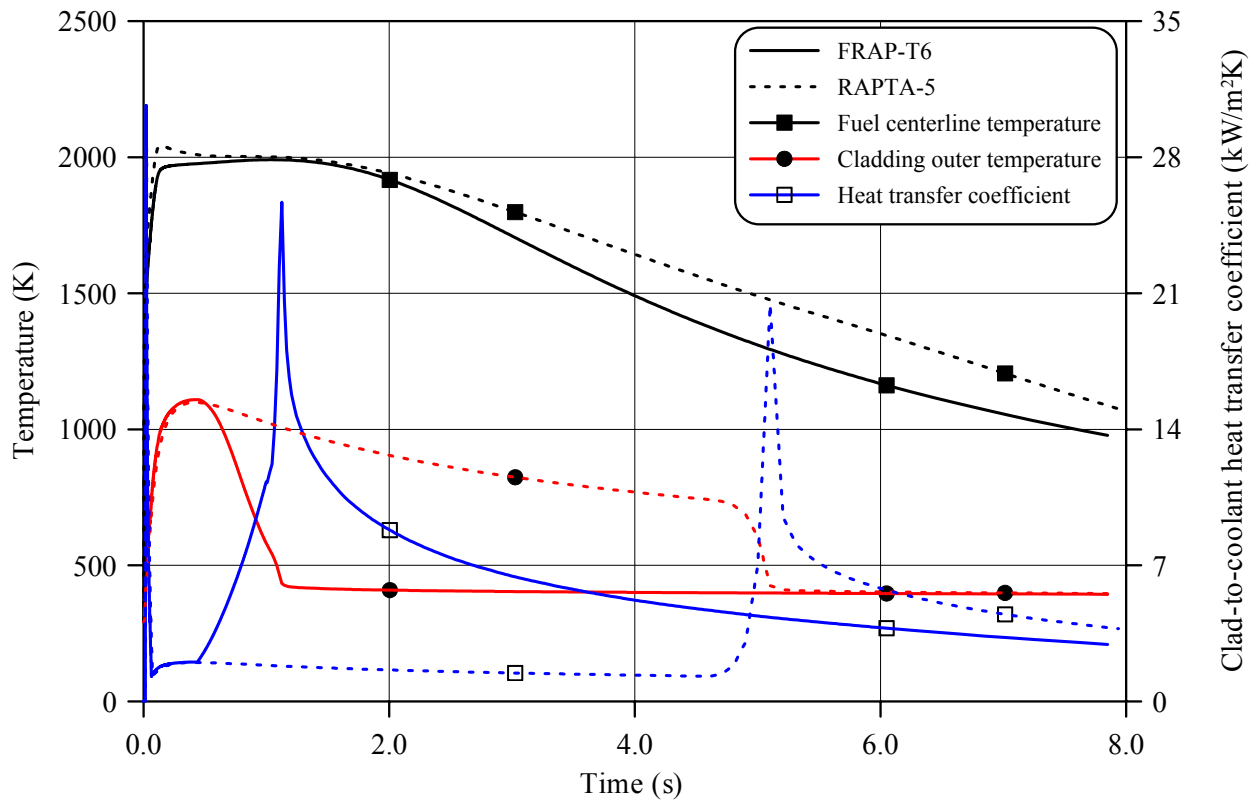
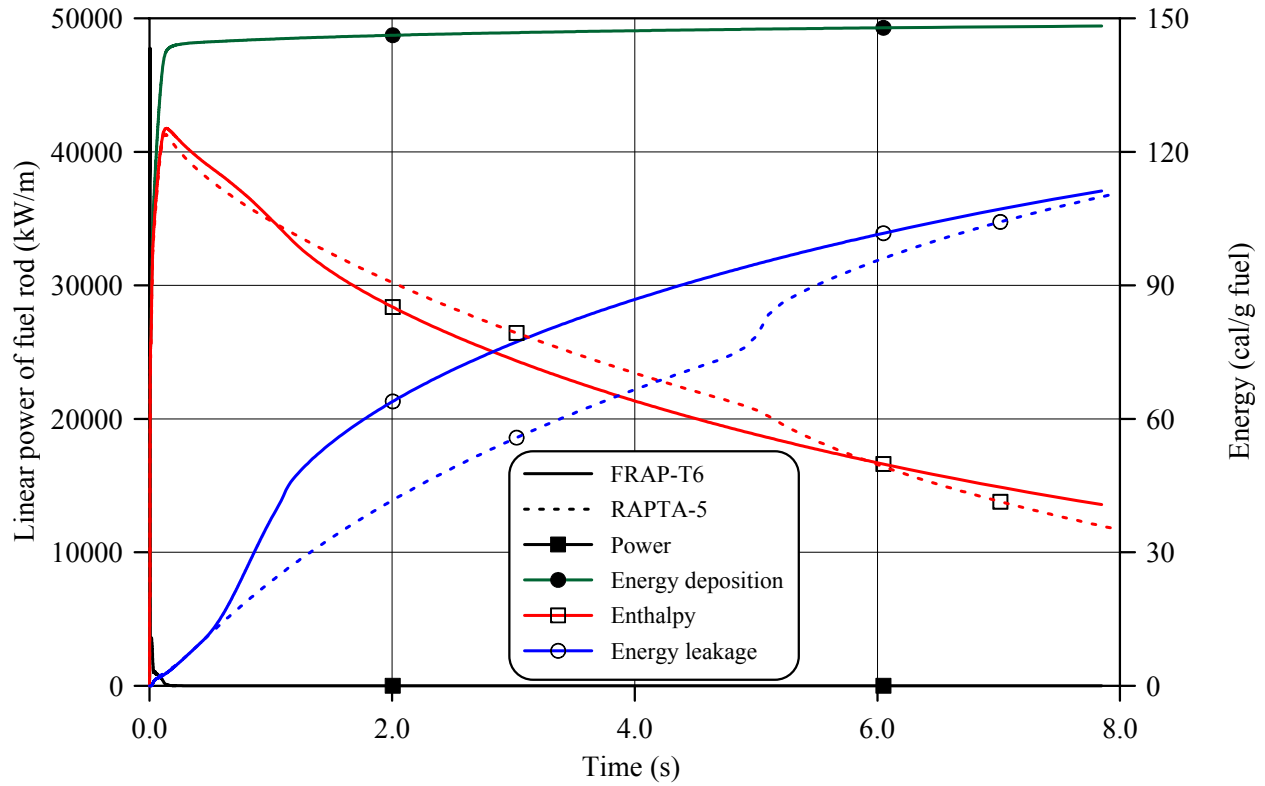


Fig.E-4.7. Thermal history of fuel rod # RT4 during the BGR test in accordance with FRAP-T6/VVER and RAPTA-5 calculations

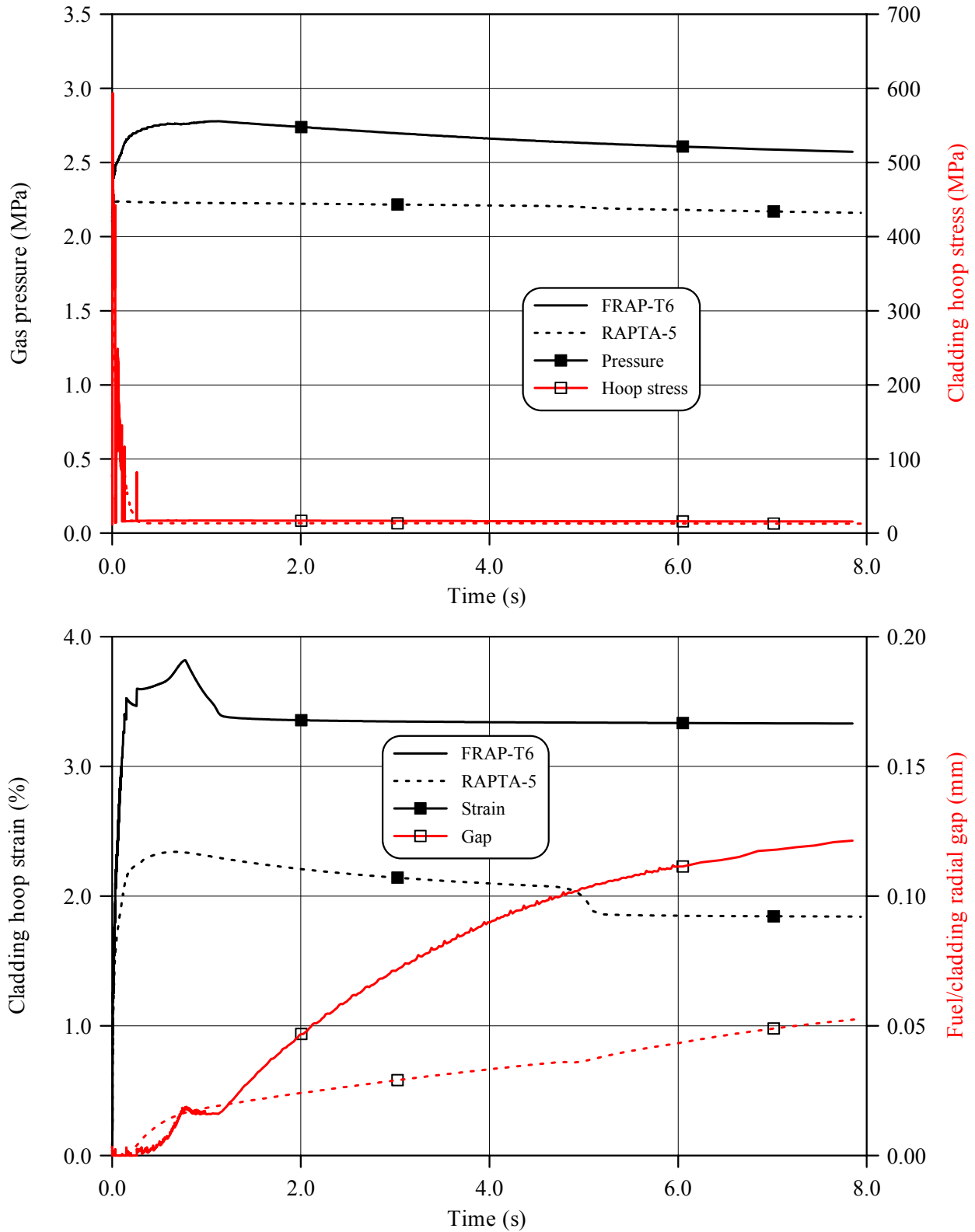


Fig.E-4.8. Mechanical behavior of fuel rod # RT4 during the BGR test in accordance with FRAP-T6/VVER and RAPTA-5 calculations

RT4

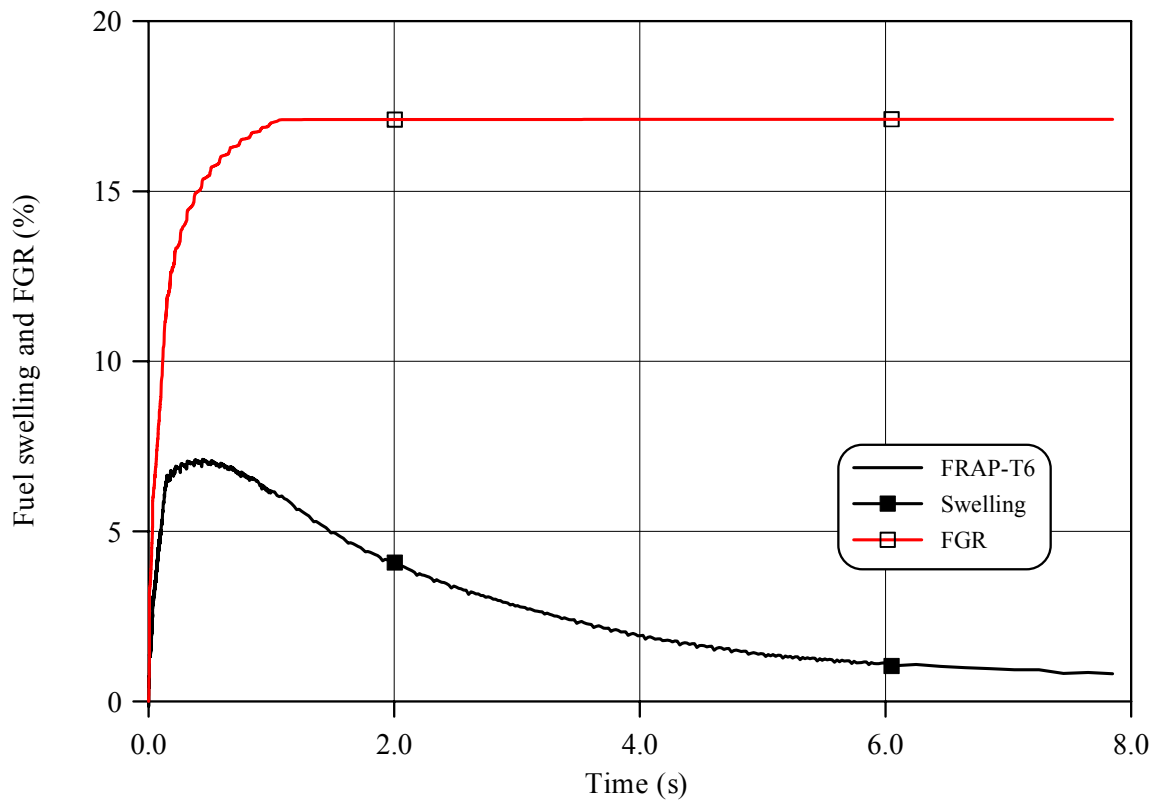
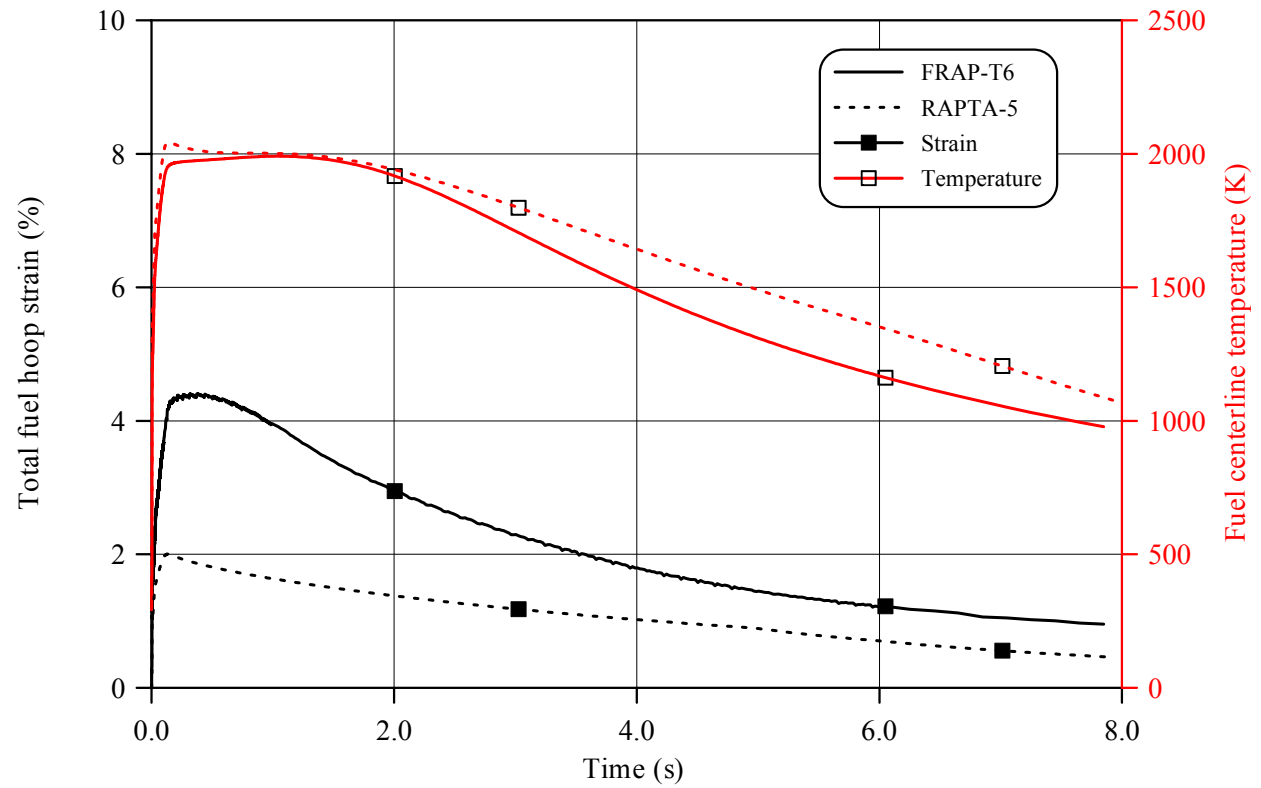
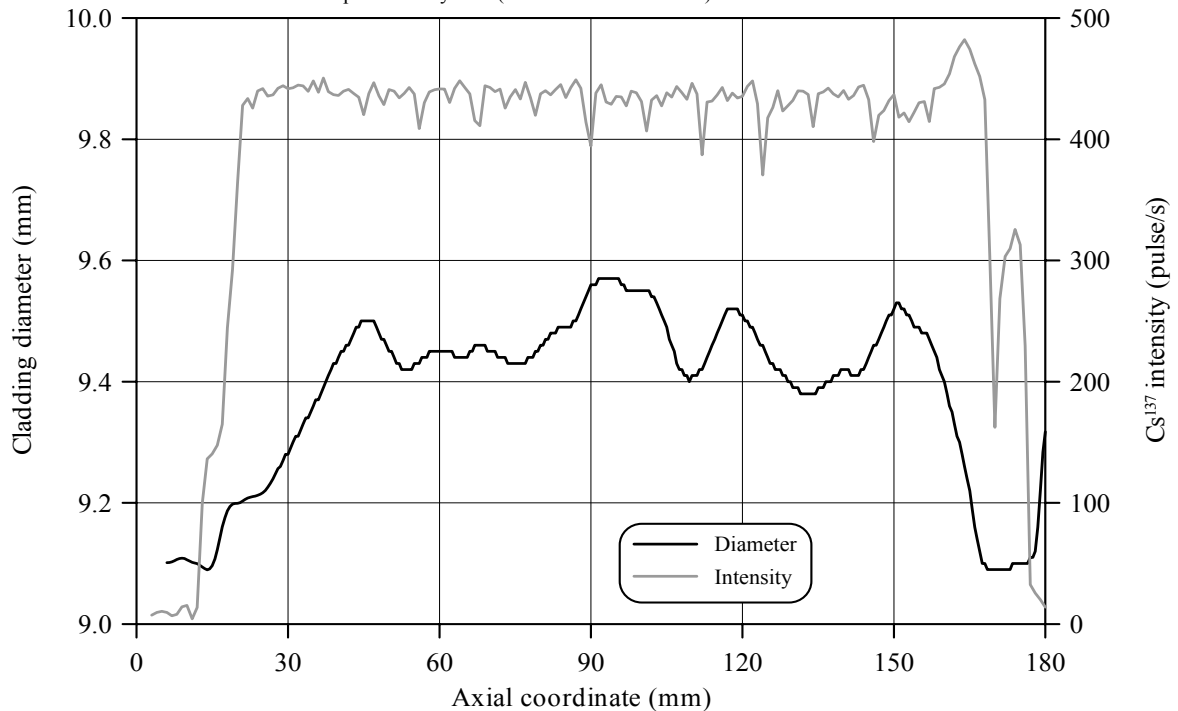


Fig.E-4.9. Fuel behavior during the B1GR test of fuel rod # RT4 in accordance with FRAP-T6/VVER and RAPTA-5 calculations

Table E-4.3. Axial distribution of cladding average outer diameter in fuel rod # RT4*

Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)
6	9.101	50	9.452	94	9.573	138	9.408
8	9.107	52	9.428	96	9.562	140	9.417
10	9.106	54	9.423	98	9.546	142	9.412
12	9.100	56	9.435	100	9.550	144	9.422
14	9.090	58	9.446	102	9.542	146	9.455
16	9.123	60	9.448	104	9.510	148	9.488
18	9.187	62	9.447	106	9.459	150	9.521
20	9.199	64	9.438	108	9.416	152	9.521
22	9.208	66	9.446	110	9.406	154	9.493
24	9.212	68	9.459	112	9.424	156	9.481
26	9.226	70	9.452	114	9.460	158	9.450
28	9.257	72	9.441	116	9.502	160	9.395
30	9.284	74	9.432	118	9.523	162	9.332
32	9.314	76	9.427	120	9.510	164	9.259
34	9.344	78	9.440	122	9.486	166	9.163
36	9.374	80	9.456	124	9.456	168	9.098
38	9.409	82	9.477	126	9.429	170	9.091
40	9.440	84	9.489	128	9.412	172	9.088
42	9.465	86	9.494	130	9.394	174	9.098
44	9.494	88	9.521	132	9.382	176	9.100
46	9.503	90	9.556	134	9.381	178	9.121
48	9.482	92	9.568	136	9.392	180	9.317

* Measured value determined on the basis of profilometry data (16 azimuthal directions)

**Fig.E-4.10. Cladding measured average diameter and γ -scanning results for fuel rod # RT4**

RT4

Table E-4.4. The PIE results for fuel rod # RT4

Parameter		Value
1.	Cladding outer diameter (mm):	
1.1.	Maximum diameter of the bidimensional data sample in "fuel rod length - azimuthal angle" coordinates (mm)	9.65
1.2.	Averaged azimuthal diameter and maximum diameter along the length selected from the sample of averaged azimuthal diameter (mm)	9.58
1.3.	Averaged diameter of the bidimensional data sample in "fuel rod length - azimuthal angle" coordinates (mm)	9.41
2.	Cladding maximum residual hoop strain (%)	5.50
3.	Fuel pellet conditional diameter (mm) in cross-section*:	
	at 108 mm elevation	7.98
	at 117 mm elevation	7.88
4.	ZrO ₂ outer thickness (μm) in cross-section:	
	at 108 mm elevation	3-5
	at 117 mm elevation	3-5
5.	ZrO ₂ inner thickness (μm) in cross-section:	
	at 108 mm elevation	6
	at 117 mm elevation	8
6.	Parameters characterizing FGR:	
6.1.	Gas composition (% by volume):	
	He	-
	N ₂	-
	O ₂	-
	Ar	-
	CO ₂	-
	Kr	-
	Xe	-
6.2.	Free gas volume (cm ³)	-
6.3.	Gas volume under normal conditions (cm ³)	-
6.4.	Gas pressure under normal conditions (MPa)	-

* Reference value determined by the processing of fuel cross-section photographs

Table E-4.5. Organized BGR test results for fuel rod # RT4

Parameter		Unit	Value		
			Measured	Calculated	
				FRAP-T6	RAPTA-5
1.	Fuel burnup	MW d/kg U	60.1	60.1	60.1
2.	Initial gas pressure	MPa	2.1	2.1	2.1
3.	Energy deposition	cal/g fuel	152.3	152.3	152.3
4.	Peak fuel enthalpy*	cal/g fuel	-	125.3	123.9
5.	Fuel maximum temperature	K	-	2099	2126
6.	Maximum temperature of cladding outer surface	K	-	1110	1099
7.	Cladding burst	Failed, Unfailed	Unfailed	Unfailed	Unfailed
8.	Cladding residual hoop strain**	%	3.70	3.23	1.77
9.	Kr volume content in gas composition after the BGR test	%	-	2.81	-
10.	Xe volume content in gas composition after the BGR test	%	-	16.82	-

* Average value of peak fuel enthalpy is 124.6 cal/g fuel

** Average value along the fuel stack length

Appendix E–5
Individual Characteristics of Fuel Rod # RT5
after the BGR Test

RT5

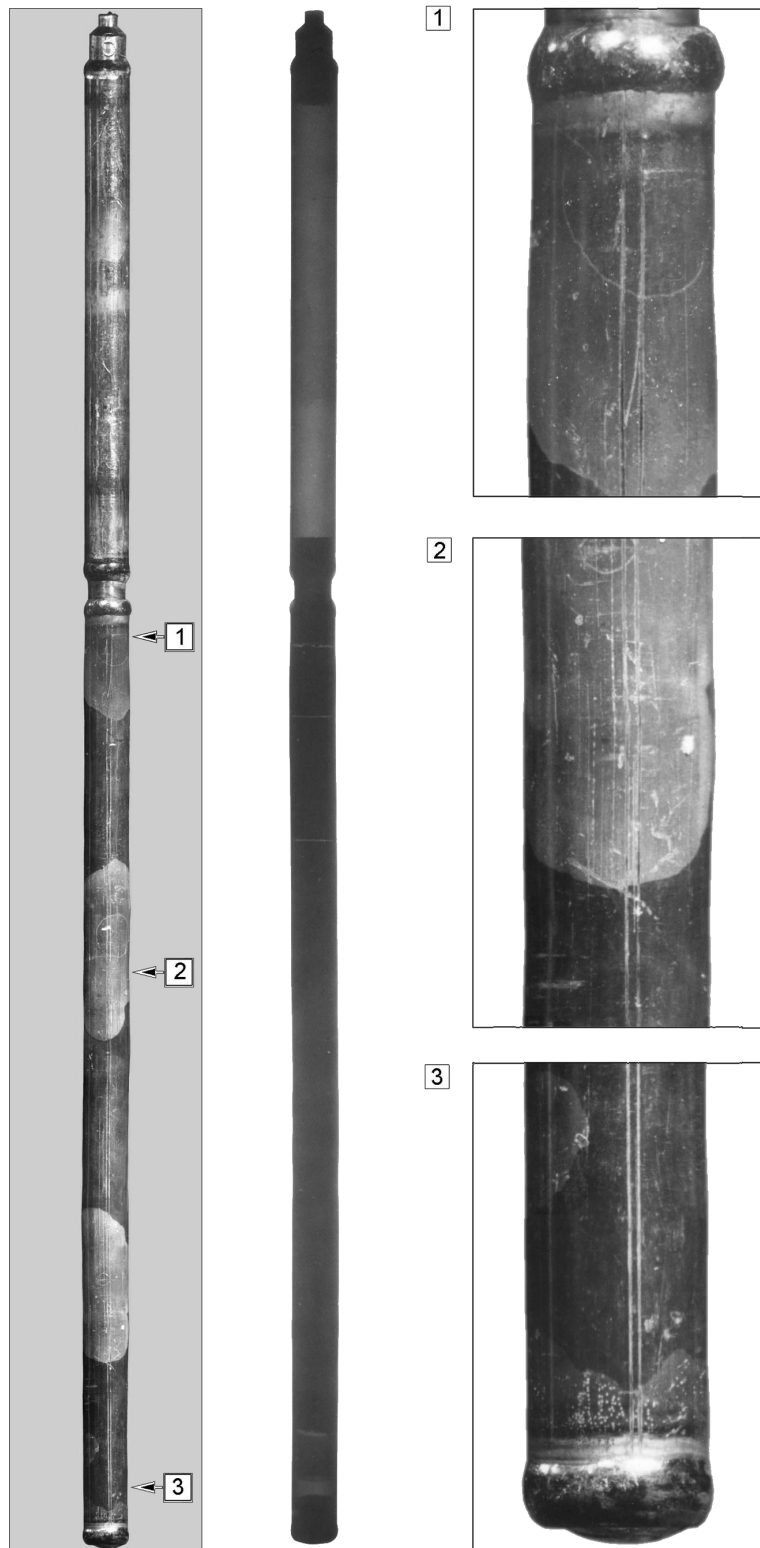


Fig.E-5.1. Appearance of unfailed fuel rod # RT5 after the BGR test (photographs and X-ray photograph)

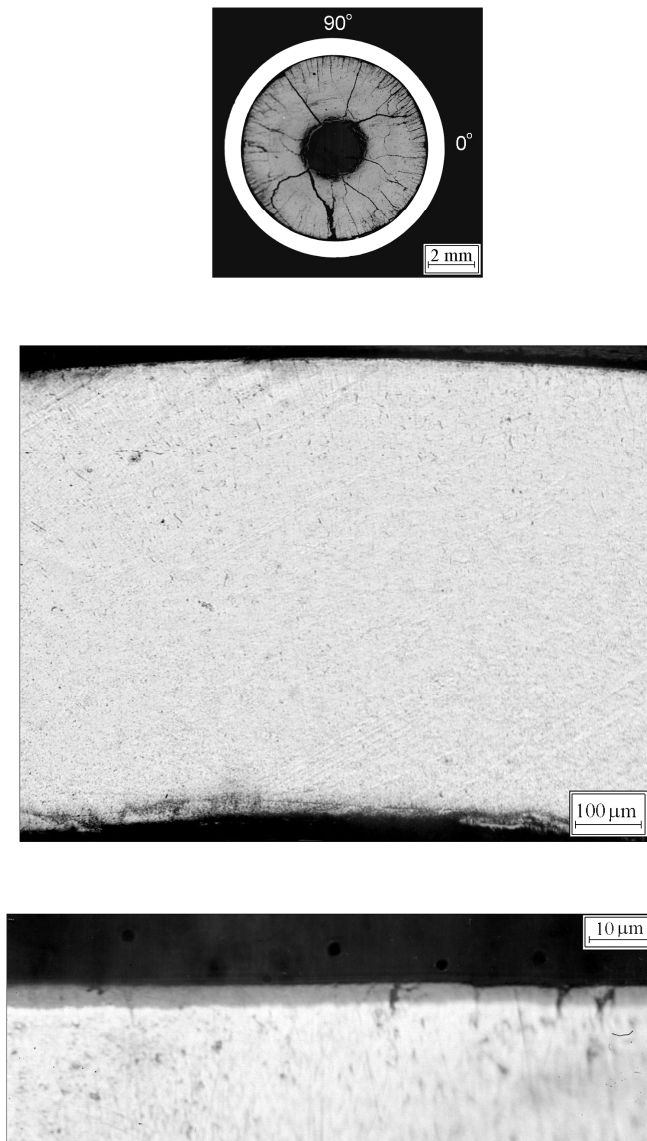


Fig.E-5.2. Cross-section and cladding microstructure of fuel rod # RT5 at 105 mm elevation (from low cap)

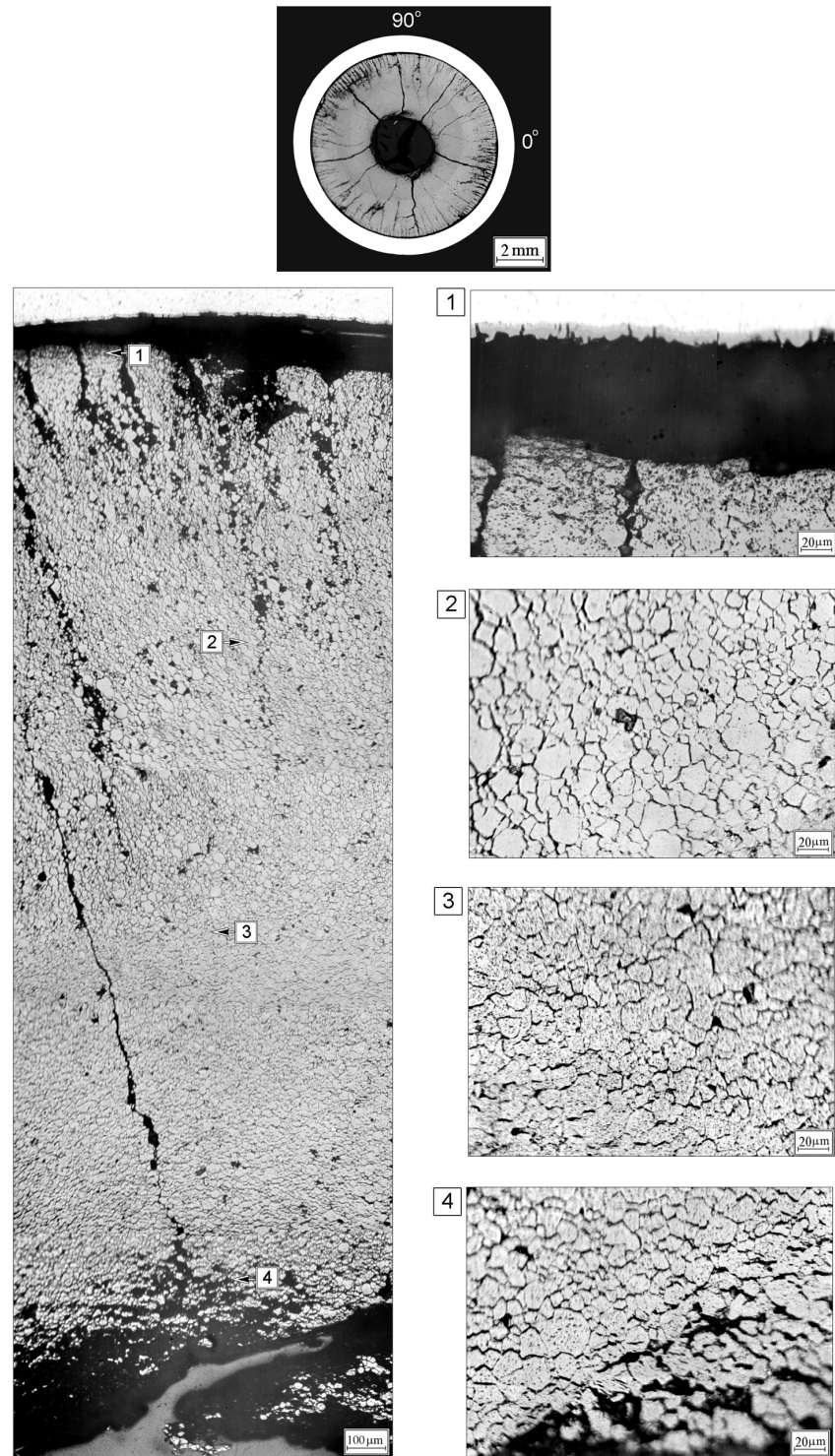


Fig.E-5.3. Cross-section and fuel microstructure of fuel rod # RT5 at 105 mm elevation (from low cap)

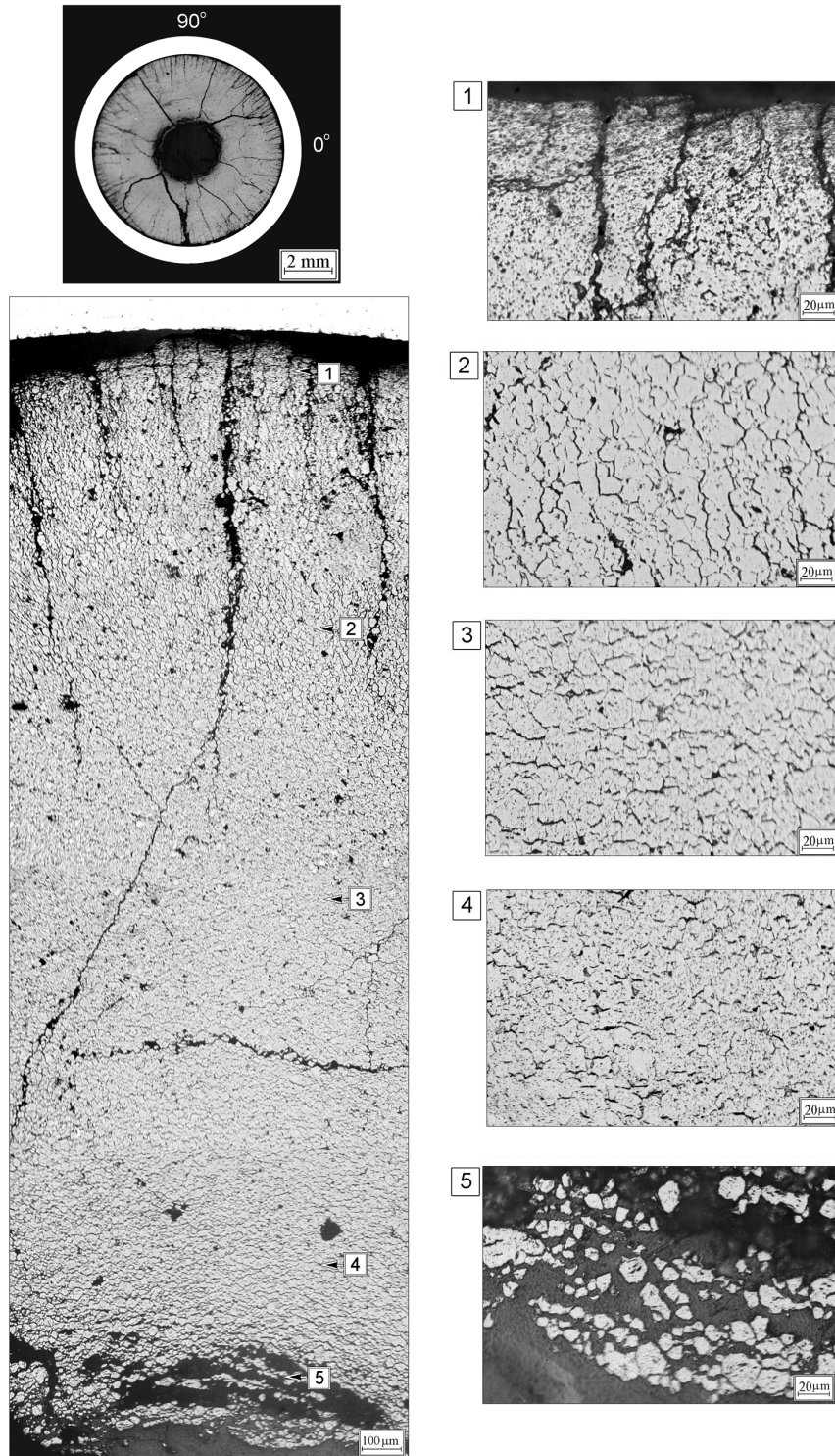


Fig.E-5.4. Cross-section and fuel microstructure of fuel rod # RT5 after the BGR test at 122 mm elevation (from low cap)

RT5

Table E-5.1. Time dependent energy characteristics of fuel rod # RT5

Time (s)	Relative reactor power (current/ maximum value) (per-unit)	Cumulative number of fissions in fuel rod (fiss) x 10 ⁻¹⁴	Power of fuel rod ¹⁾²⁾ (kW)	Energy deposition		Fuel enthalpy ³⁾	
				(cal/g fuel)	(J/g fuel)	FRAP-T6	RAPTA-5
0.000	1.74E-02	0.000	0.000	0.000	0.000	0.000	0.000
0.001	1.90E-01	0.287	1455	3.009	12.60	3.560	2.884
0.002	5.90E-01	1.377	4520	14.46	60.52	15.511	14.376
0.003	1.00E+00	3.803	7661	39.97	167.3	41.007	39.902
0.004	6.53E-01	6.297	5005	66.17	277.0	66.919	65.870
0.005	2.69E-01	7.583	2061	79.70	333.7	80.280	78.956
0.006	1.46E-01	8.172	1121	85.91	359.7	86.224	84.688
0.007	7.73E-02	8.482	591.8	89.17	373.3	89.159	87.538
0.008	5.38E-02	8.673	411.8	91.14	381.6	90.806	89.143
0.009	4.52E-02	8.816	346.1	92.64	387.9	92.001	90.323
0.010	4.49E-02	8.948	344.0	94.03	393.7	93.086	91.409
0.012	5.30E-02	9.231	406.1	97.02	406.2	95.520	93.875
0.014	6.55E-02	9.583	501.5	100.7	421.5	98.613	96.972
0.016	7.41E-02	9.995	567.8	105.0	439.6	102.367	100.780
0.018	7.28E-02	10.42	557.8	109.5	458.6	106.351	104.820
0.020	6.12E-02	10.82	468.9	113.8	476.3	109.976	108.800
0.022	4.91E-02	11.15	376.0	117.2	490.5	112.797	111.730
0.024	3.90E-02	11.40	298.9	119.9	501.8	115.005	113.980
0.026	2.98E-02	11.60	228.6	122.0	510.7	116.645	115.540
0.028	2.41E-02	11.76	185.0	123.6	517.5	117.847	116.750
0.030	2.22E-02	11.90	170.4	125.0	523.4	118.850	117.940
0.050	1.85E-02	13.14	142.0	138.1	578.3	128.238	127.630
0.070	1.62E-02	14.18	124.2	149.1	624.2	135.808	135.660
0.090	1.15E-02	14.99	88.35	157.6	660.0	141.600	141.310
0.110	6.98E-03	15.54	53.63	163.5	684.4	145.075	144.810
0.130	2.60E-03	15.81	20.14	166.2	695.9	146.269	145.590
0.150	9.92E-04	15.91	7.801	167.2	700.2	146.280	144.940
0.200	2.67E-04	15.98	2.270	168.1	703.9	144.671	142.520
1.000	2.44E-05	16.09	0.294	169.7	710.5	123.856	121.150
10.00	2.76E-06	16.29	0.043	173.6	726.8	31.755	28.725
100.0	5.38E-08	16.39	0.007	176.5	739.0	5.054	4.463
1000	2.11E-13	16.39	1.52E-04	178.0	745.3	0.000	0.000

¹⁾ Average values determined in accordance with results of RRC KI and VNIIEF calculations

²⁾ Maximum power value is 7660.5 kW (t=0.003 s)

³⁾ Average radial value

Table E-5.2. Radial energy characteristics of fuel rod # RT5*

Parameters	Coordinates of fuel radial layers (mm)			
	1 layer (1.25-2.84)	2 layer (2.84-3.47)	3 layer (3.47-3.74)	4 layer (3.74-3.808)
Number of fissions $\times 10^{-14}$ (fiss)	7.363	4.783	2.872	1.381
Fission density $\times 10^{-13}$ (fiss/g fuel)	2.341	2.493	3.068	4.513
Power** (kW)	3414	2238	1346	662.4
Energy deposition (cal/g fuel)	156.4	166.0	203.8	299.2
Energy deposition (J/g fuel)	654.8	695.0	853.2	1253
Energy deposition*** (per-unit)	0.523	0.555	0.681	1.000

* Average values were determined in accordance with results of RRC KI and VNIIEF calculations

** The power for the entire length of each layer at time 0.003 s

*** Energy deposition in current layer/energy deposition in 4th layer

RT5

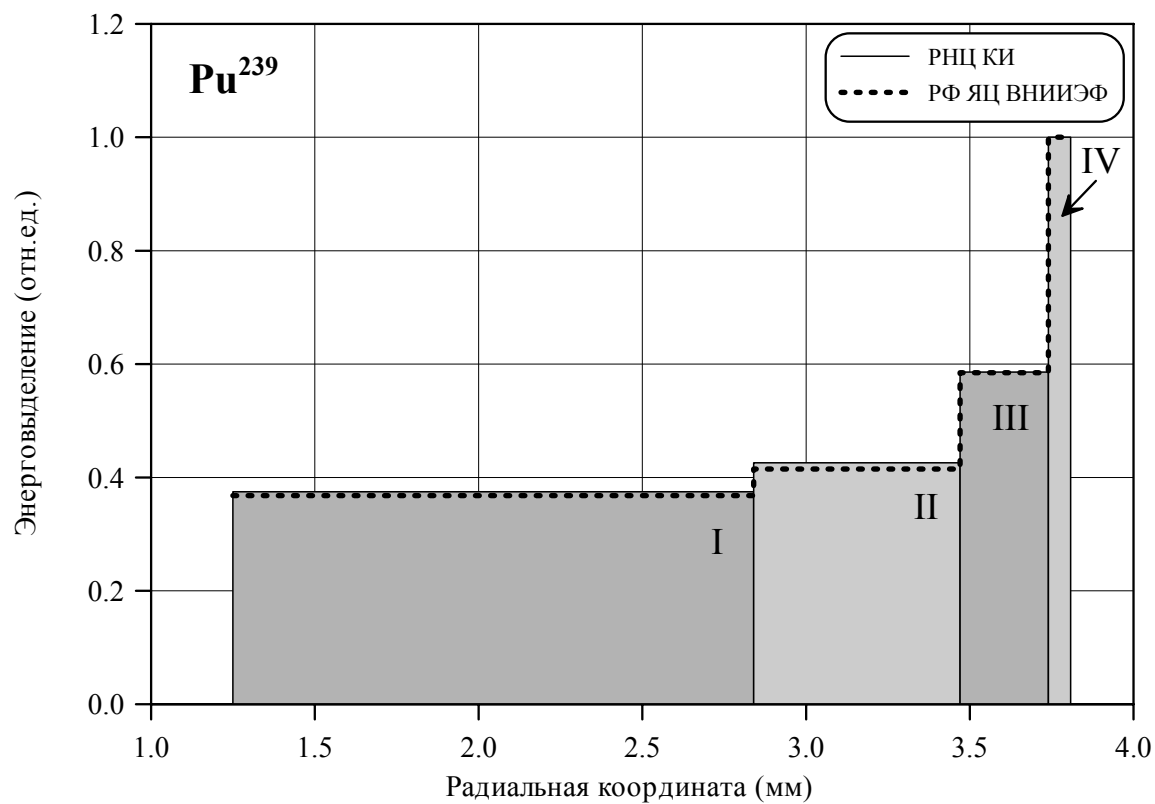
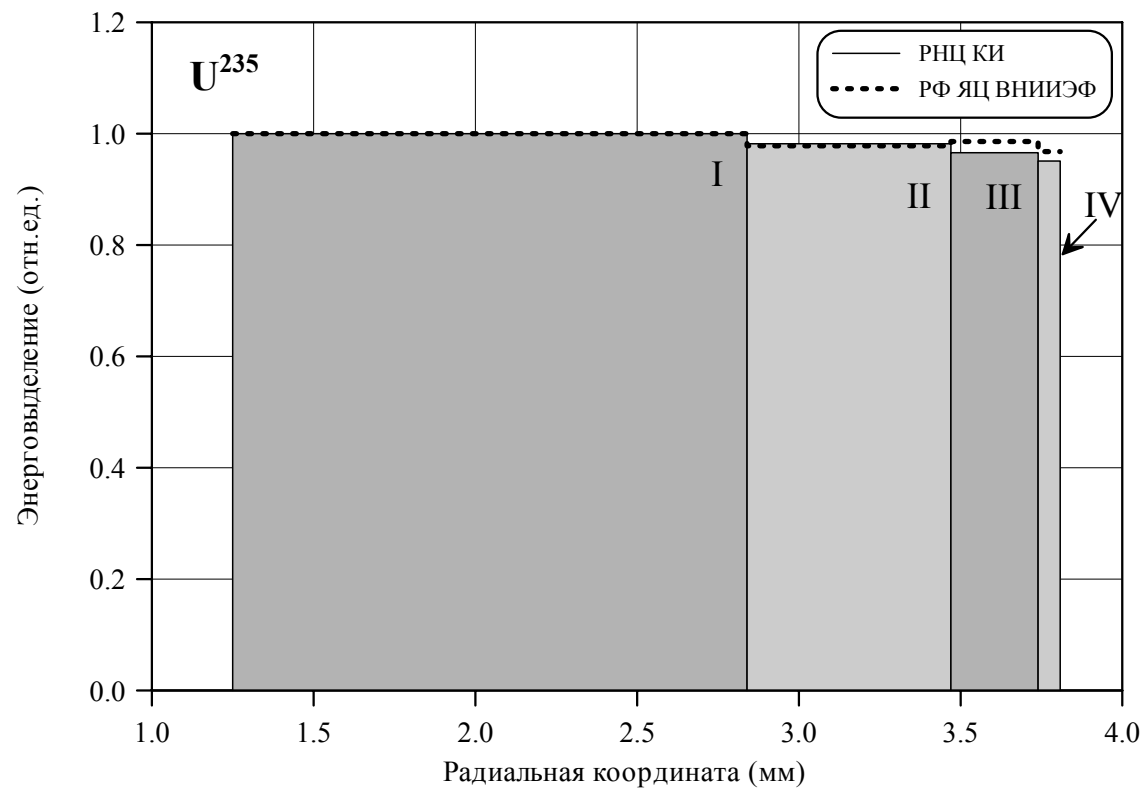


Fig.E-5.5. U^{235} and Pu^{239} radial distribution of energy deposition for fuel rod # RT5

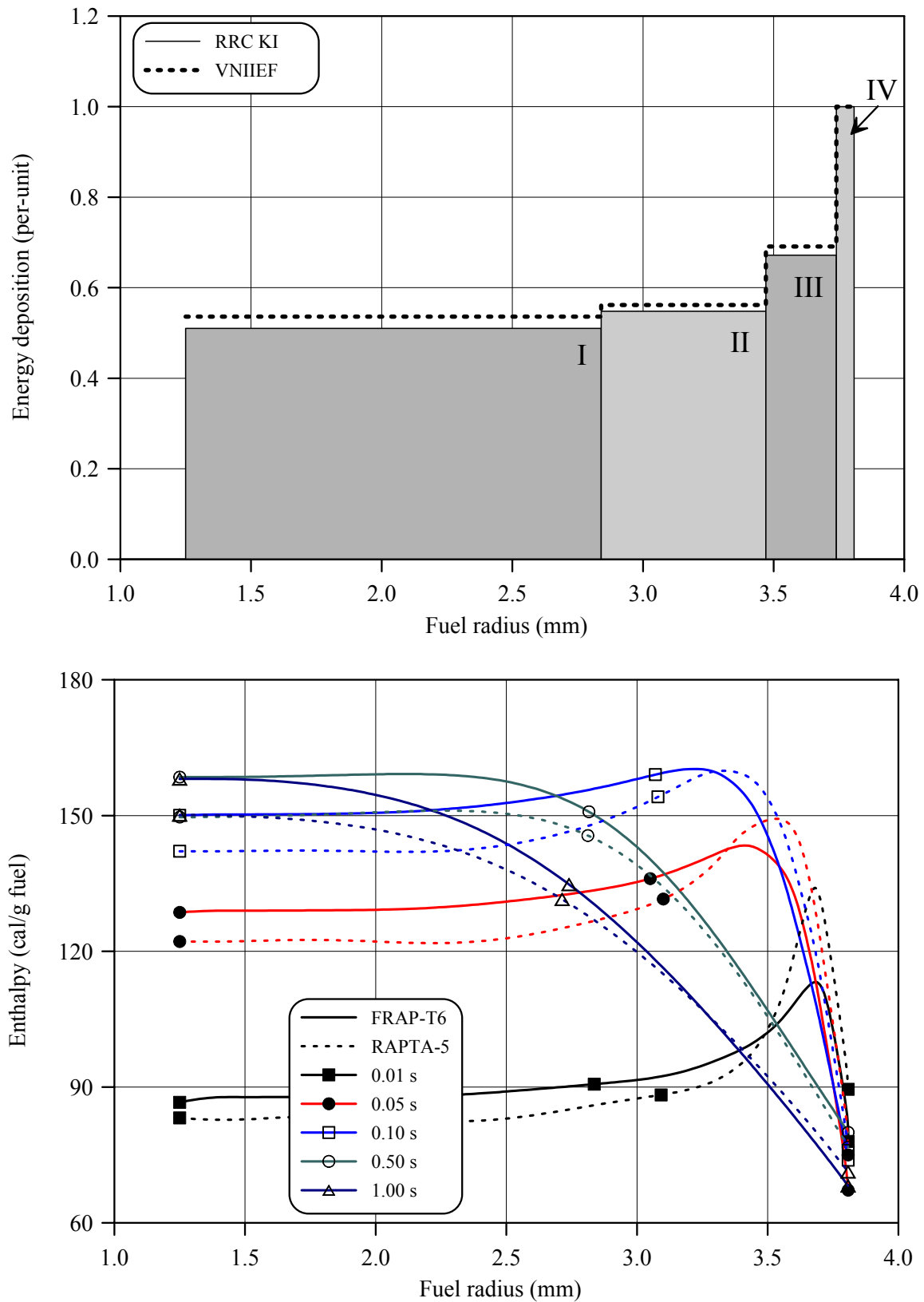


Fig.E-5.6. Radial distribution of energy deposition and fuel enthalpy for fuel rod # RT5

RT5

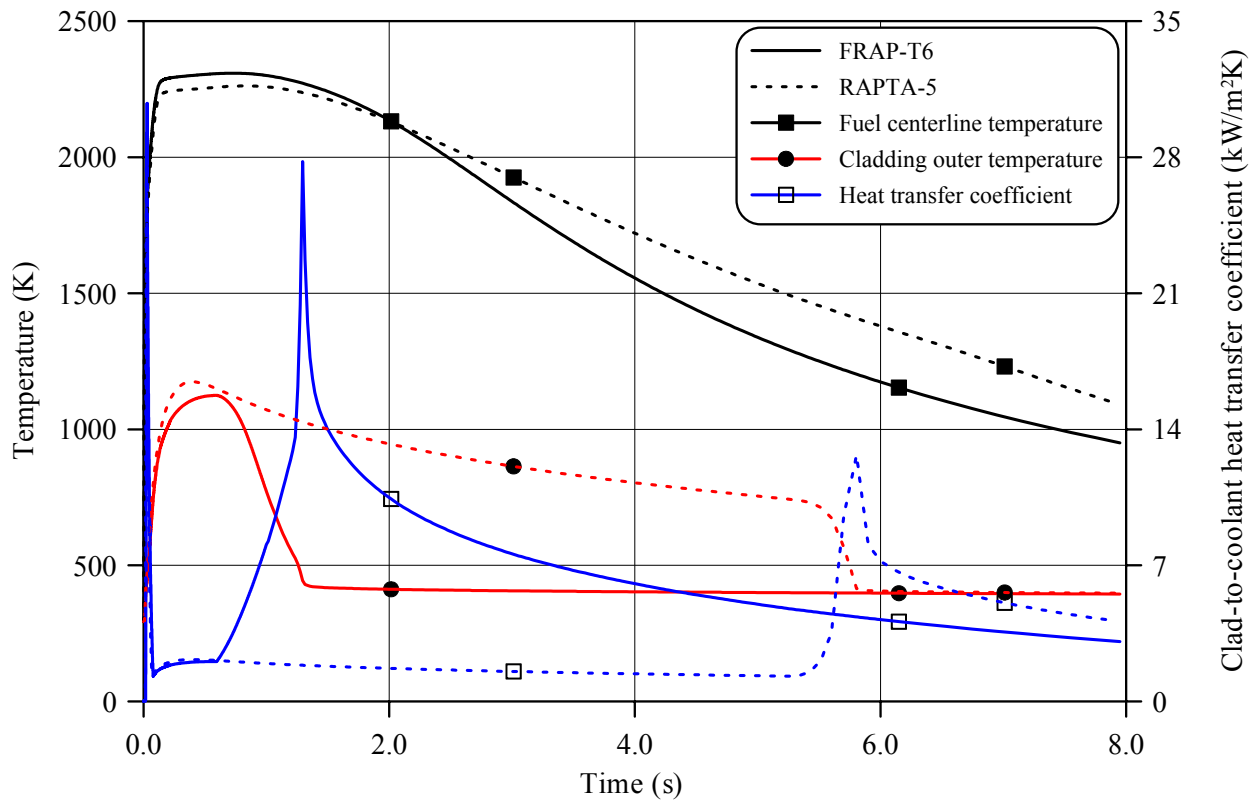
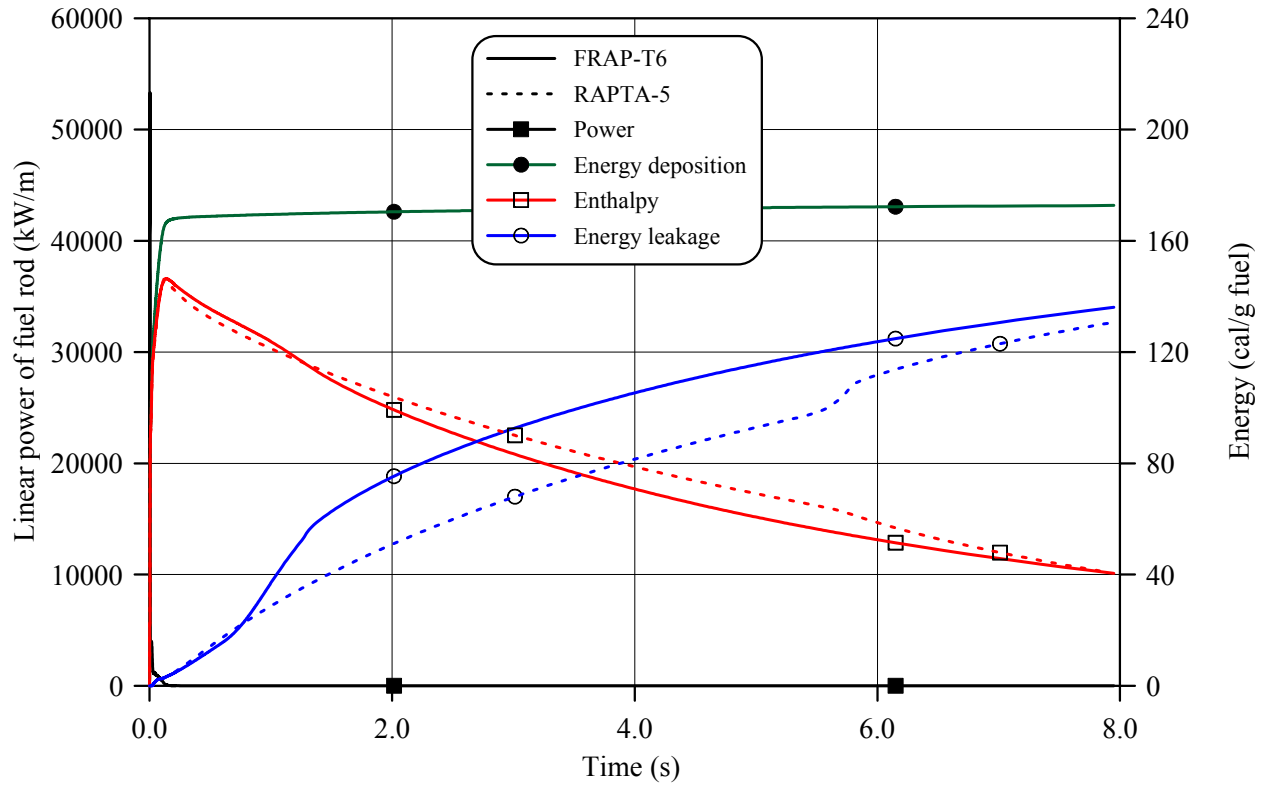


Fig.E-5.7. Thermal history of fuel rod # RT5 during the BIGR test in accordance with FRAP-T6/VVER and RAPTA-5 calculations

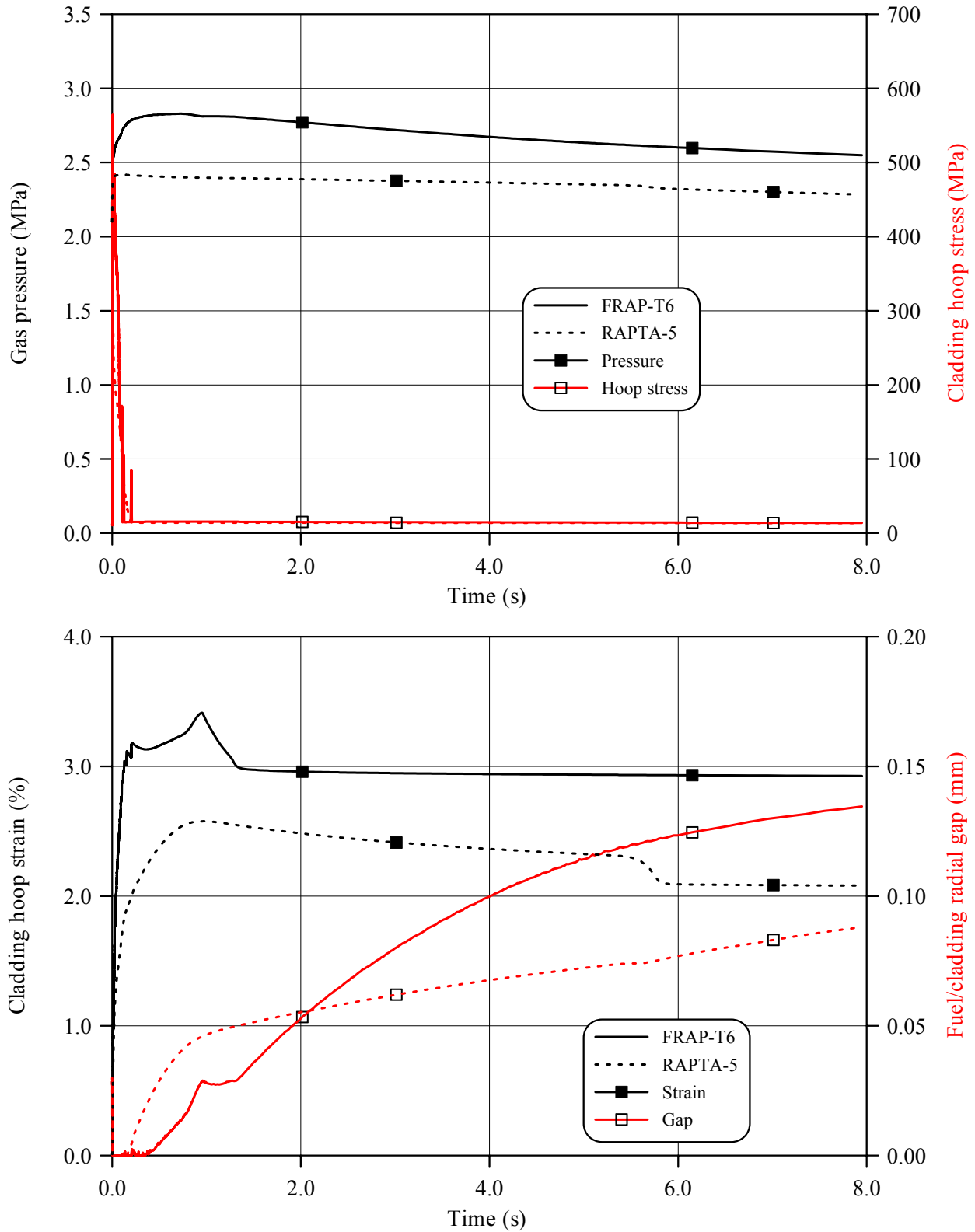


Fig.E-5.8. Mechanical behavior of fuel rod # RT5 during the BIGH test in accordance with FRAP-T6/VVER and RAPTA-5 calculations

RT5

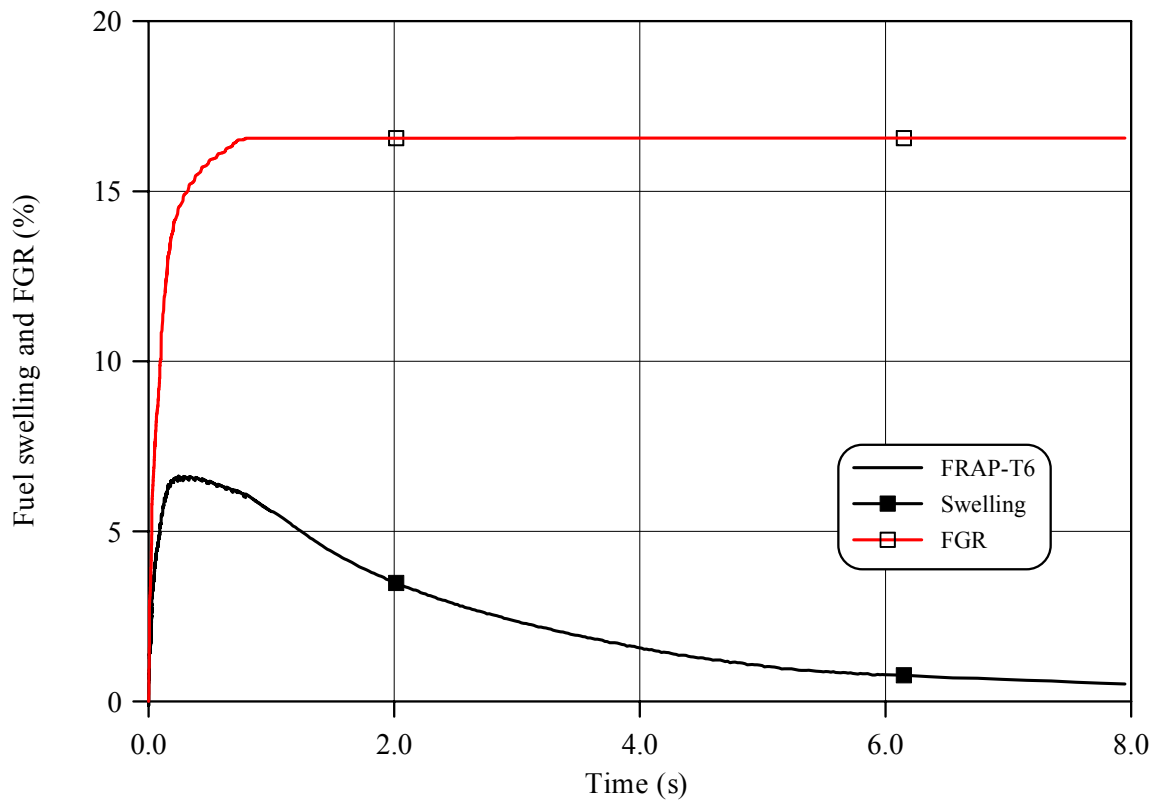
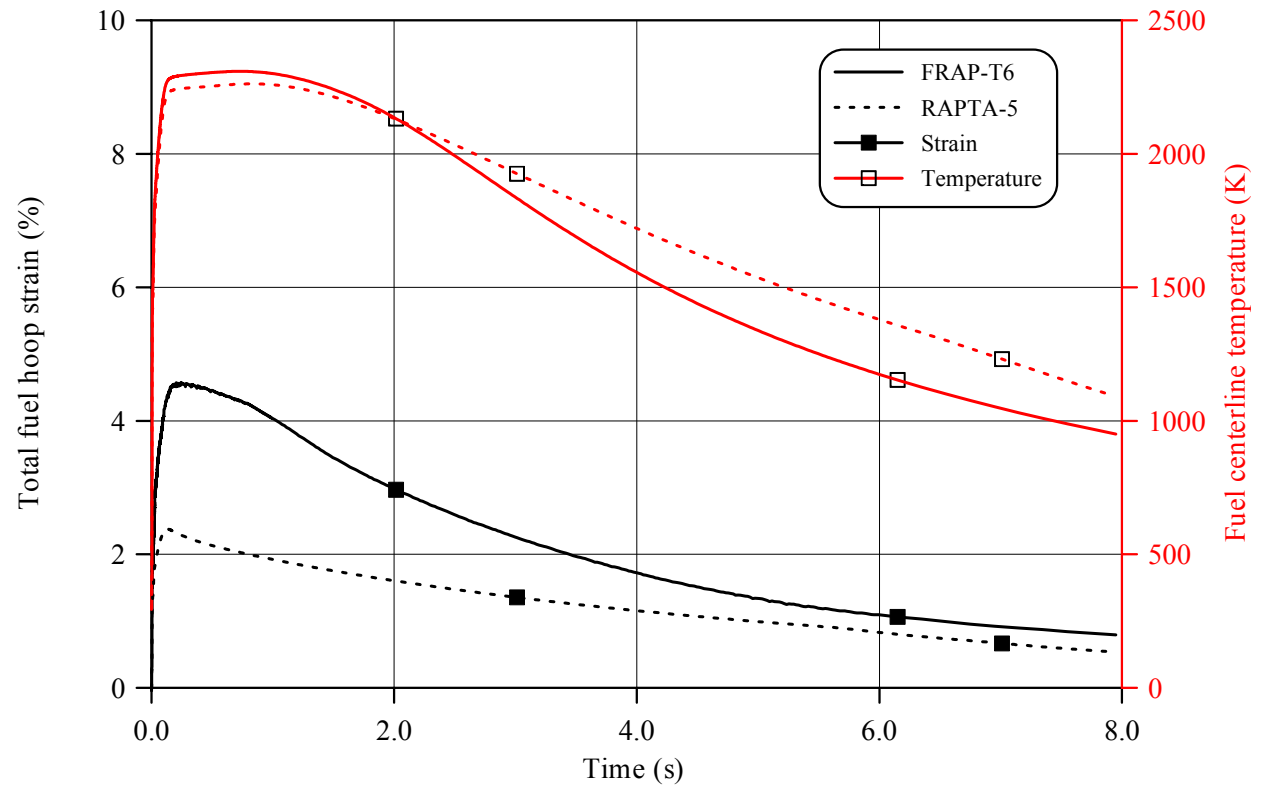
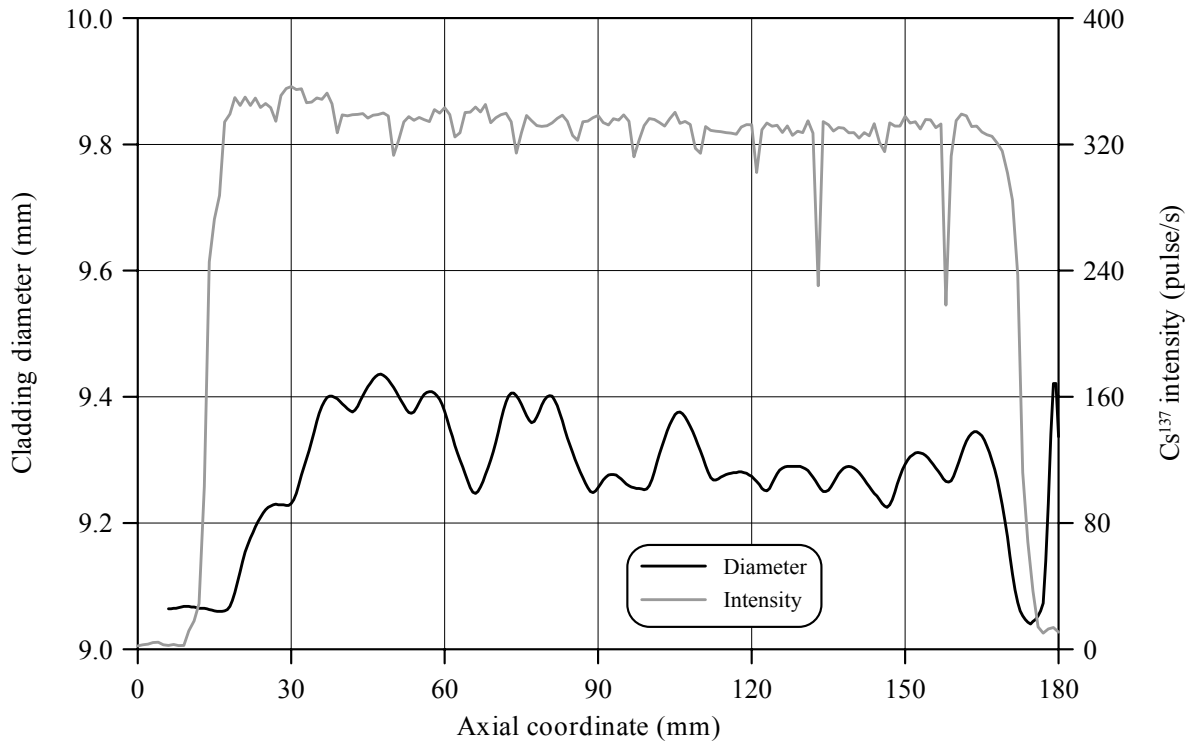


Fig.E-5.9. Fuel behavior during the BGR test of fuel rod # RT5 in accordance with FRAP-T6/VVER and RAPTA-5 calculations

Table E-5.3. Axial distribution of cladding average outer diameter in fuel rod # RT5*

Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)
6	9.064	50	9.415	94	9.273	138	9.287
8	9.066	52	9.387	96	9.259	140	9.287
10	9.068	54	9.376	98	9.255	142	9.269
12	9.065	56	9.404	100	9.259	144	9.247
14	9.063	58	9.406	102	9.310	146	9.227
16	9.060	60	9.377	104	9.356	148	9.249
18	9.068	62	9.323	106	9.376	150	9.293
20	9.123	64	9.278	108	9.353	152	9.311
22	9.176	66	9.247	110	9.314	154	9.307
24	9.209	68	9.277	112	9.272	156	9.287
26	9.227	70	9.328	114	9.273	158	9.266
28	9.229	72	9.392	116	9.279	160	9.285
30	9.231	74	9.402	118	9.281	162	9.330
32	9.276	76	9.370	120	9.274	164	9.345
34	9.330	78	9.368	122	9.255	166	9.322
36	9.385	80	9.400	124	9.263	168	9.269
38	9.401	82	9.386	126	9.287	170	9.178
40	9.389	84	9.335	128	9.290	172	9.074
42	9.376	86	9.291	130	9.288	174	9.043
44	9.402	88	9.256	132	9.273	176	9.053
46	9.428	90	9.256	134	9.250	178	9.231
48	9.434	92	9.276	136	9.264	180	9.337

* Measured value determined on the basis of profilometry data (16 azimuthal directions)

**Fig.E-5.10. Cladding measured average diameter and γ -scanning results for fuel rod # RT5**

RT5

Table E-5.4. The PIE results for fuel rod # RT5

Parameter		Value
1.	Cladding outer diameter (mm):	
1.1.	Maximum diameter of the bidimensional data sample in "fuel rod length - azimuthal angle" coordinates (mm)	9.49
1.2.	Averaged azimuthal diameter and maximum diameter along the length selected from the sample of averaged azimuthal diameter (mm)	9.44
1.3.	Averaged diameter of the bidimensional data sample in "fuel rod length - azimuthal angle" coordinates (mm)	9.30
2.	Cladding maximum residual hoop strain (%)	4.20
3.	Fuel pellet conditional diameter (mm) in cross-section*:	
	at 105 mm elevation	7.72
	at 122 mm elevation	7.76
4.	ZrO ₂ outer thickness (μm) in cross-section:	
	at 105 mm elevation	3-5
	at 122 mm elevation	3-5
5.	ZrO ₂ inner thickness (μm) in cross-section:	
	at 105 mm elevation	7
6.	Parameters characterizing FGR:	
6.1.	Gas composition (% by volume):	
	He	81.16
	N ₂	0.52
	O ₂	0.033
	Ar	0.017
	CO ₂	0.01
	Kr	1.52
	Xe	16.75
6.2.	Free gas volume (cm ³)	6.2
6.3.	Gas volume under normal conditions (cm ³)	138.7
6.4.	Gas pressure under normal conditions (MPa)	2.24
6.5.	FGR (%)	26.00

* Reference value determined by the processing of fuel cross-section photographs

Table E-5.5. Organized BGR test results for fuel rod # RT5

Parameter	Unit	Value			
		Measured	Calculated		
			FRAP-T6	RAPTA-5	
1. Fuel burnup	MW d/kg U	48.6	48.6	48.6	
2. Initial gas pressure	MPa	2.1	2.1	2.1	
3. Energy deposition	cal/g fuel	178.0	178.0	178.0	
4. Peak fuel enthalpy*	cal/g fuel	-	146.4	145.6	
5. Fuel maximum temperature	K	-	2353	2379	
6. Maximum temperature of cladding outer surface	K	-	1125	1175	
7. Cladding burst	Failed, Unfailed	Unfailed	Unfailed	Unfailed	
8. Cladding residual hoop strain**	%	2.70	2.83	2.01	
9. Kr volume content in gas composition after the BGR test	%	1.52	1.87	-	
10. Xe volume content in gas composition after the BGR test	%	16.75	11.18	-	

* Average value of peak fuel enthalpy is 146.0 cal/g fuel

** Average value along the fuel stack length

Appendix E–6
Individual Characteristics of Fuel Rod # RT6
after the BGR Test

RT6

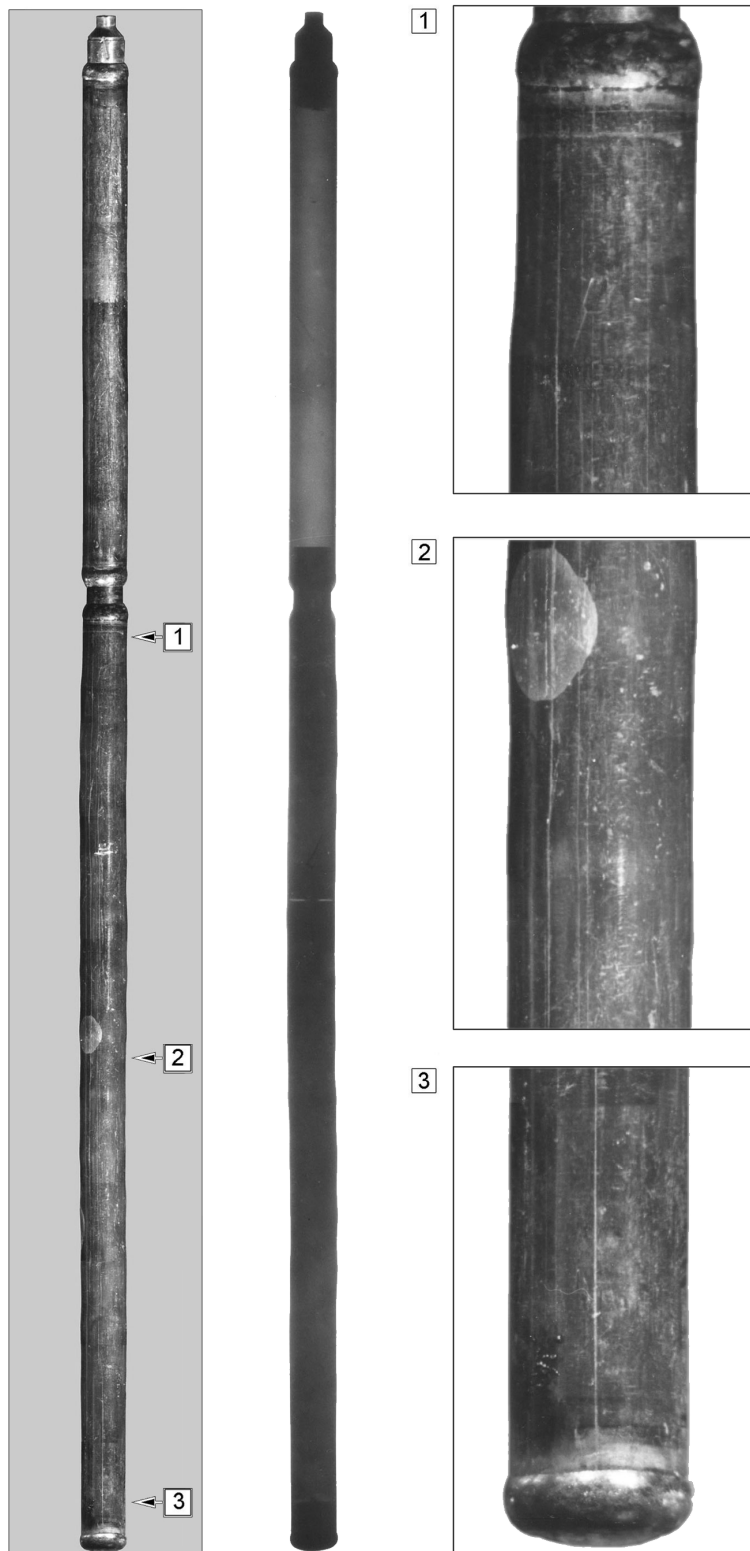


Fig.E-6.1. Appearance of unfailed fuel rod # RT6 after the BGR test (photographs and X-ray photograph)

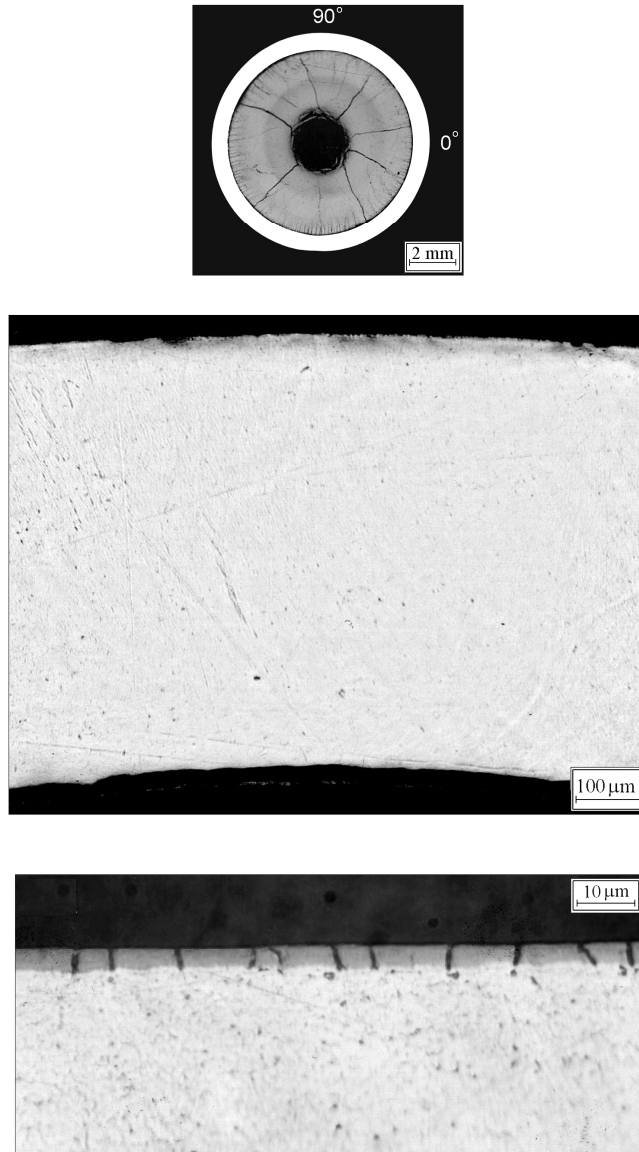


Fig.E-6.2. Cross-section and cladding microstructure of fuel rod # RT6 at 114 mm elevation (from low cap)

RT6

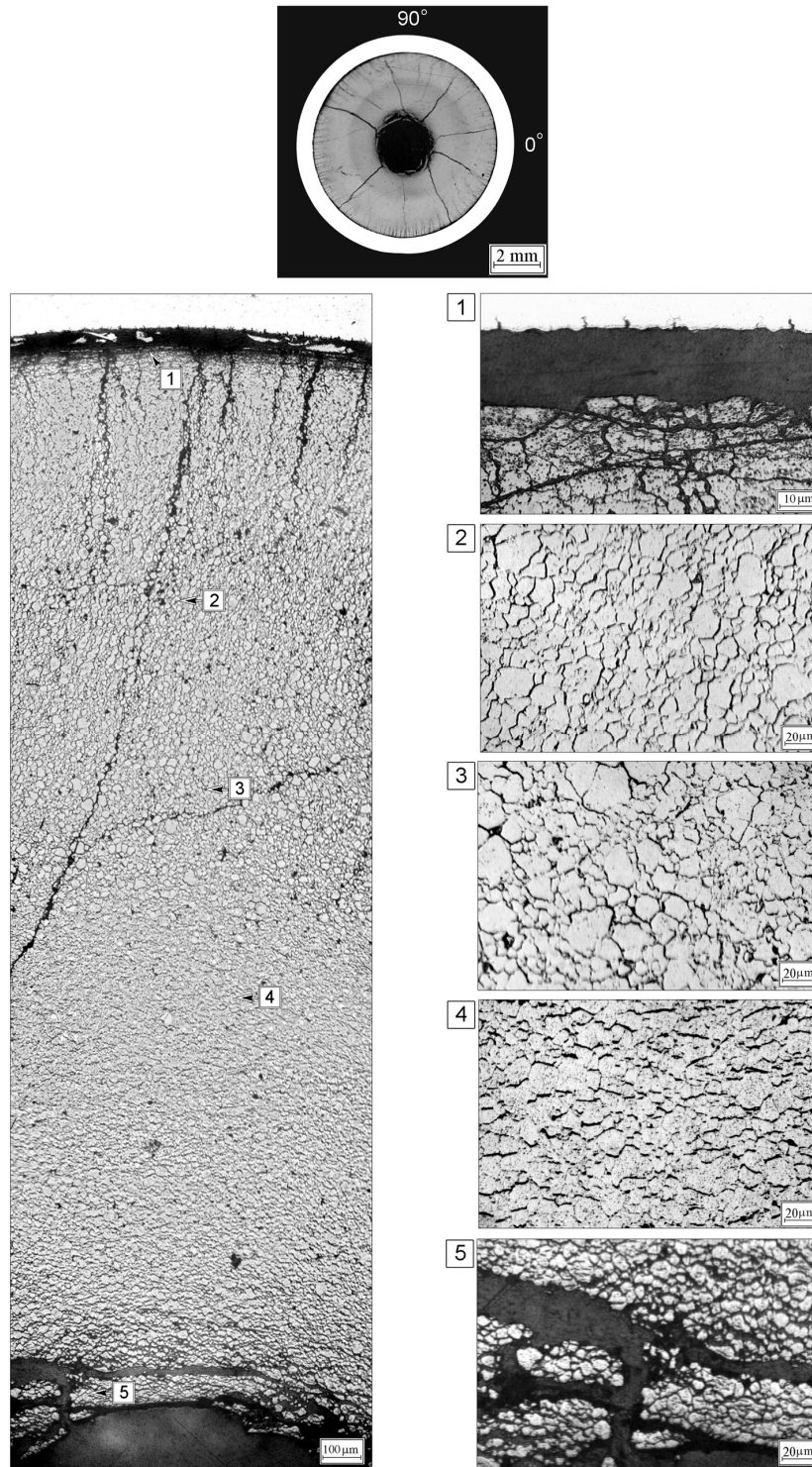


Fig.E-6.3. Cross-section and fuel microstructure of fuel rod # RT6 at 114 mm elevation (from low cap)

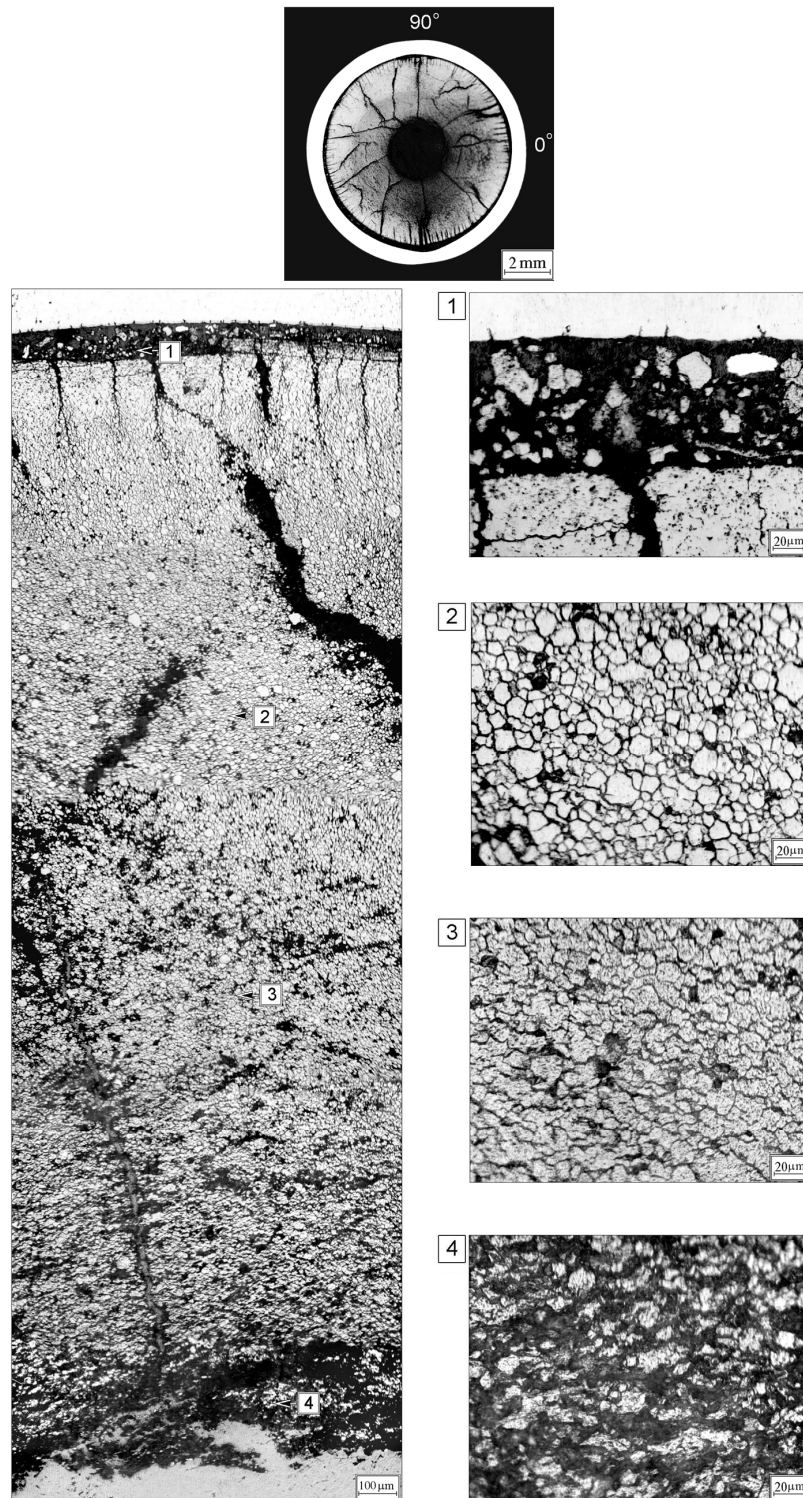


Fig.E-6.4. Cross-section and fuel microstructure of fuel rod # RT6 after the BIGH test at 132 mm elevation (from low cap)

RT6

Table E-6.1. Time dependent energy characteristics of fuel rod # RT6

Time (s)	Relative reactor power (current/maximum value) (per-unit)	Cumulative number of fissions in fuel rod (fiss) x 10 ⁻¹⁴	Power of fuel rod ¹⁾²⁾ (kW)	Energy deposition		Fuel enthalpy ³⁾	
				(cal/g fuel)	(J/g fuel)	FRAP-T6	RAPTA-5
0.000	5.55E-03	0.000	0.000	0.000	0.000	0.000	0.000
0.001	1.75E-01	0.192	1286	2.184	9.142	3.244	2.139
0.002	6.31E-01	1.266	4633	14.20	59.45	13.059	14.203
0.003	1.00E+00	3.620	7340	40.77	170.7	44.285	40.783
0.004	6.78E-01	6.040	4979	68.03	284.8	66.083	67.795
0.005	2.82E-01	7.294	2069	82.17	344.0	83.034	81.459
0.006	1.52E-01	7.878	1118	88.69	371.3	88.089	87.484
0.007	8.32E-02	8.183	610.4	92.17	385.9	91.939	90.526
0.008	5.79E-02	8.372	425.3	94.30	394.8	93.381	92.280
0.009	4.84E-02	8.519	355.1	95.92	401.6	94.956	93.567
0.010	4.74E-02	8.644	347.7	97.37	407.7	95.869	94.721
0.012	5.49E-02	8.923	403.3	100.5	420.8	98.352	97.226
0.014	6.67E-02	9.262	489.5	104.3	436.6	101.475	100.620
0.016	7.50E-02	9.661	550.3	108.8	455.6	105.267	104.490
0.018	7.30E-02	10.08	535.8	113.4	474.9	109.262	108.870
0.020	6.10E-02	10.44	447.7	117.7	492.7	112.878	112.560
0.022	4.89E-02	10.75	358.8	121.1	506.9	115.719	115.520
0.024	3.86E-02	10.99	283.7	123.8	518.2	117.902	117.770
0.026	3.11E-02	11.18	228.0	125.9	527.2	119.573	119.360
0.028	2.62E-02	11.33	192.7	127.7	534.5	120.880	120.620
0.030	2.35E-02	11.47	172.5	129.2	540.8	121.980	121.860
0.050	2.02E-02	12.73	148.7	143.4	600.5	132.238	132.490
0.070	1.76E-02	13.80	129.4	155.5	650.9	140.860	141.510
0.090	1.24E-02	14.62	91.47	164.7	689.6	147.338	147.820
0.110	7.71E-03	15.19	56.77	171.1	716.5	151.832	151.750
0.130	2.88E-03	15.46	21.30	174.2	729.2	152.508	152.670
0.150	1.10E-03	15.56	8.248	175.3	734.0	152.417	152.040
0.200	2.93E-04	15.64	2.397	176.3	738.1	151.207	149.570
1.000	2.63E-05	15.75	0.302	178.0	745.3	131.264	127.660
10.00	3.06E-06	15.96	0.044	182.3	763.0	38.467	32.063
100.0	5.95E-08	16.06	0.007	185.4	776.1	5.210	4.530
1000	2.32E-13	16.07	1.57E-04	186.9	782.7	0.000	0.000

¹⁾ Average values determined in accordance with results of RRC KI and VNIIEF calculations

²⁾ Maximum power value is 7340 kW (t=0.003 s)

³⁾ Average radial value

Table E-6.2. Radial energy characteristics of fuel rod # RT6*

Parameters**	Coordinates of fuel radial layers (mm)			
	1 layer (1.25-2.82)	2 layer (2.82-3.44)	3 layer (3.44-3.71)	4 layer (3.71-3.795)
Number of fissions $\times 10^{-14}$ (fiss)	7.469	4.829	2.876	1.404
Fission density $\times 10^{-13}$ (fiss/g fuel)	2.469	2.618	3.195	4.766
Power*** (kW)	3281	2145	1285	629.6
Energy deposition (cal/g fuel)	163.6	173.5	212.5	311.5
Energy deposition (J/g fuel)	684.9	726.4	889.6	1304
Energy deposition**** (per-unit)	0.526	0.557	0.683	1.000

* Average values were determined in accordance with results of RRC KI and VNIIEF calculations

** All parameters were determined for the undamaged section of a fuel stack (see Table C.2)

*** The power for the entire length of each layer at time 0.003 s

**** Energy deposition in current layer/energy deposition in 4th layer

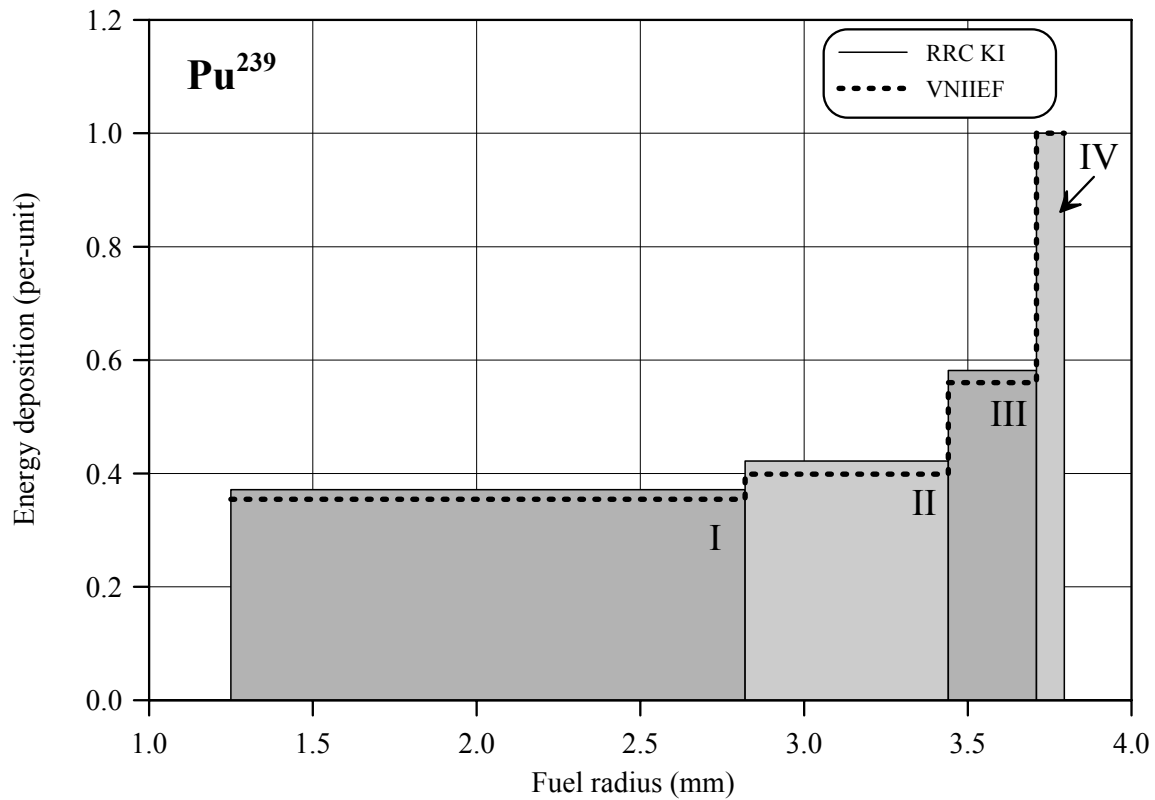
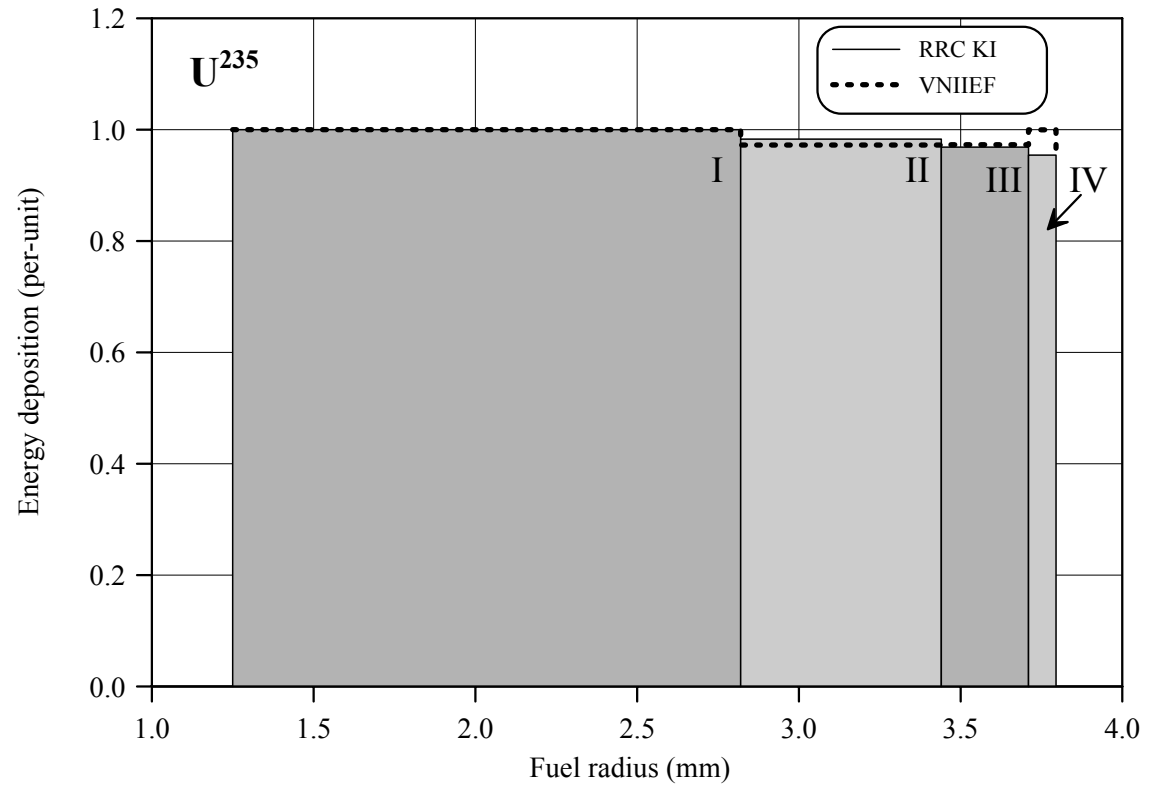


Fig.E-6.5. U^{235} and Pu^{239} radial distribution of energy deposition for fuel rod # RT6

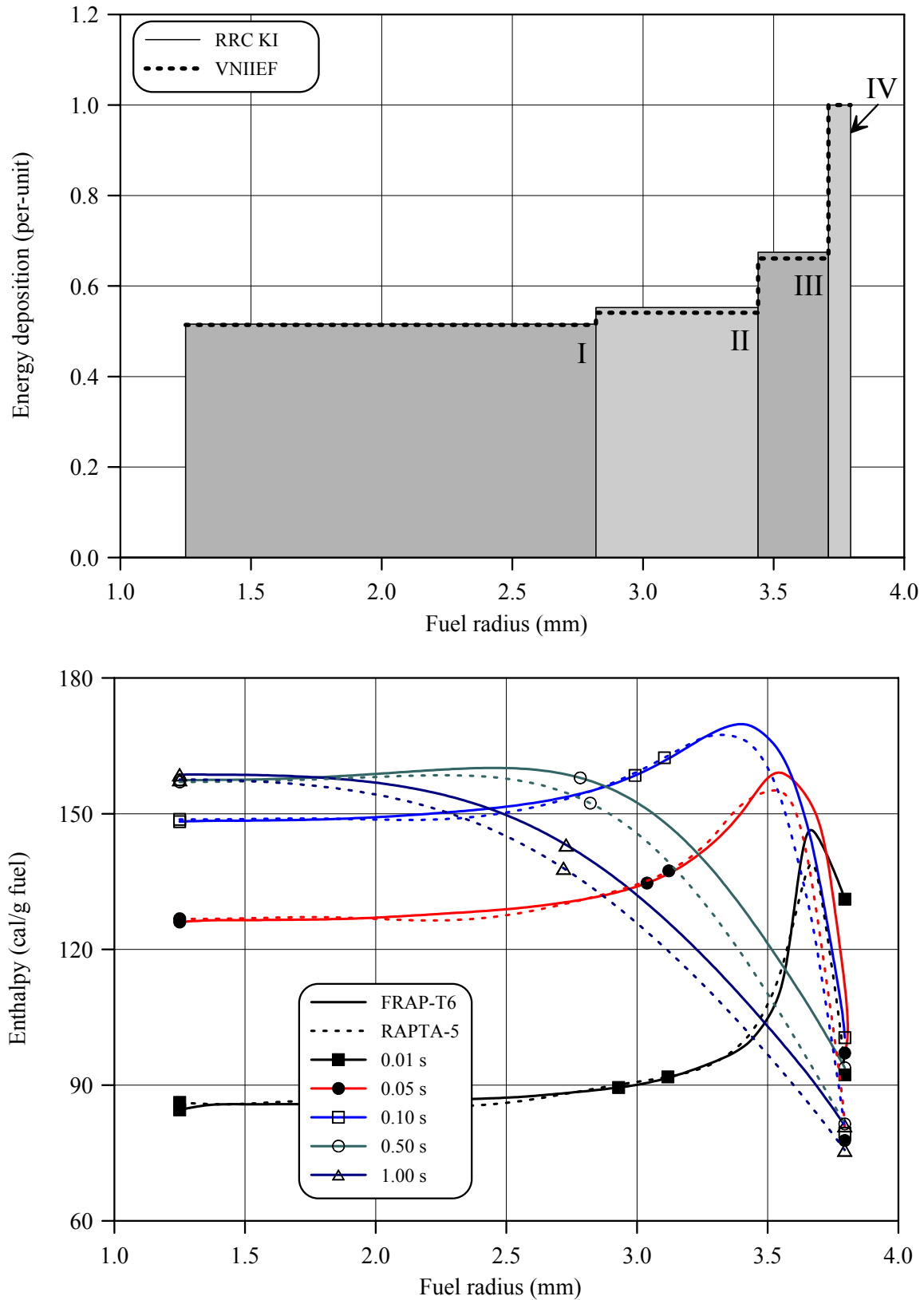


Fig.E-6.6. Radial distribution of energy deposition and fuel enthalpy for fuel rod # RT6

RT6

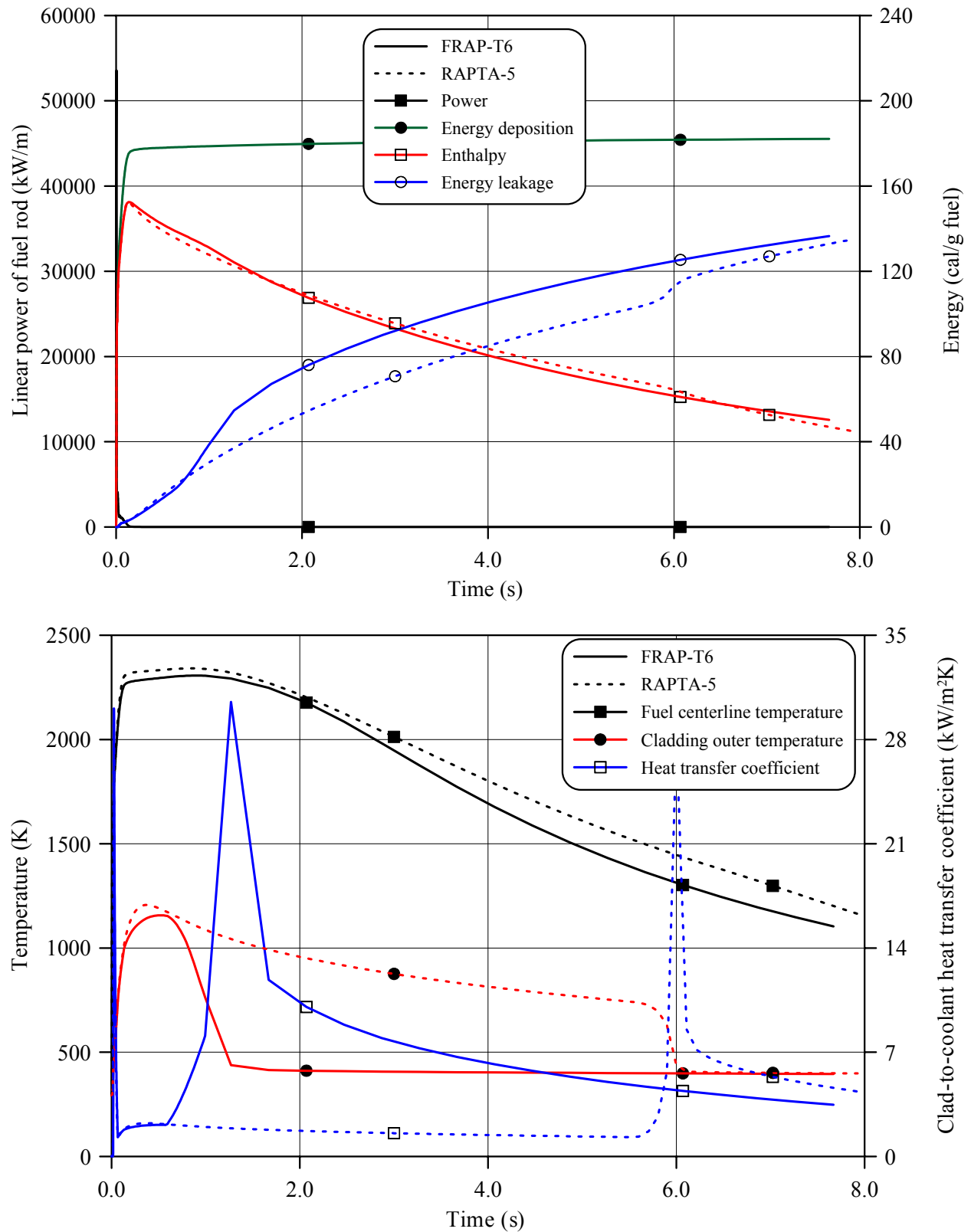


Fig.E-6.7. Thermal history of fuel rod # RT6 during the BGR test in accordance with FRAP-T6/VVER and RAPTA-5 calculations

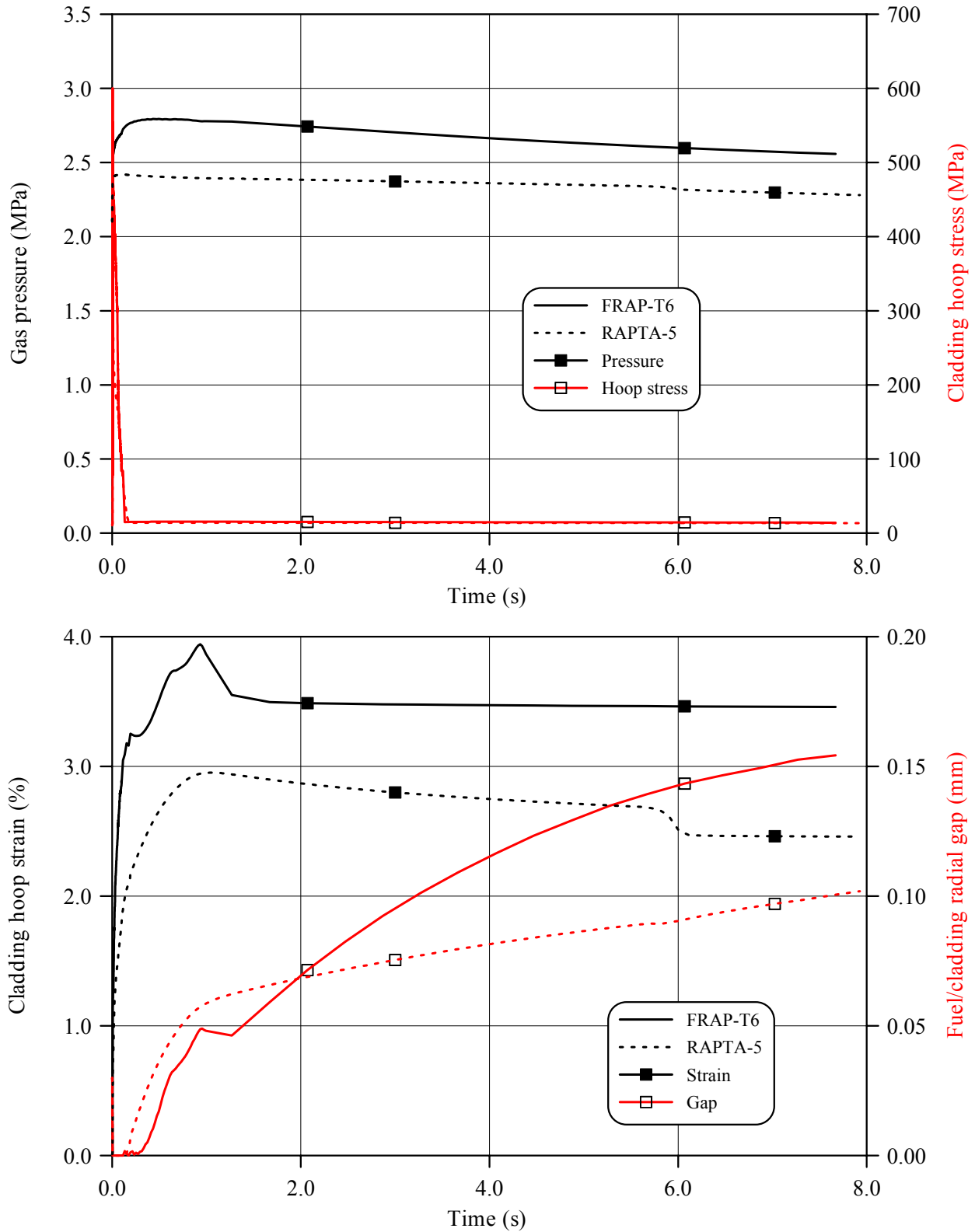


Fig.E-6.8. Mechanical behavior of fuel rod # RT6 during the BIGH test in accordance with FRAP-T6/VVER and RAPTA-5 calculations

RT6

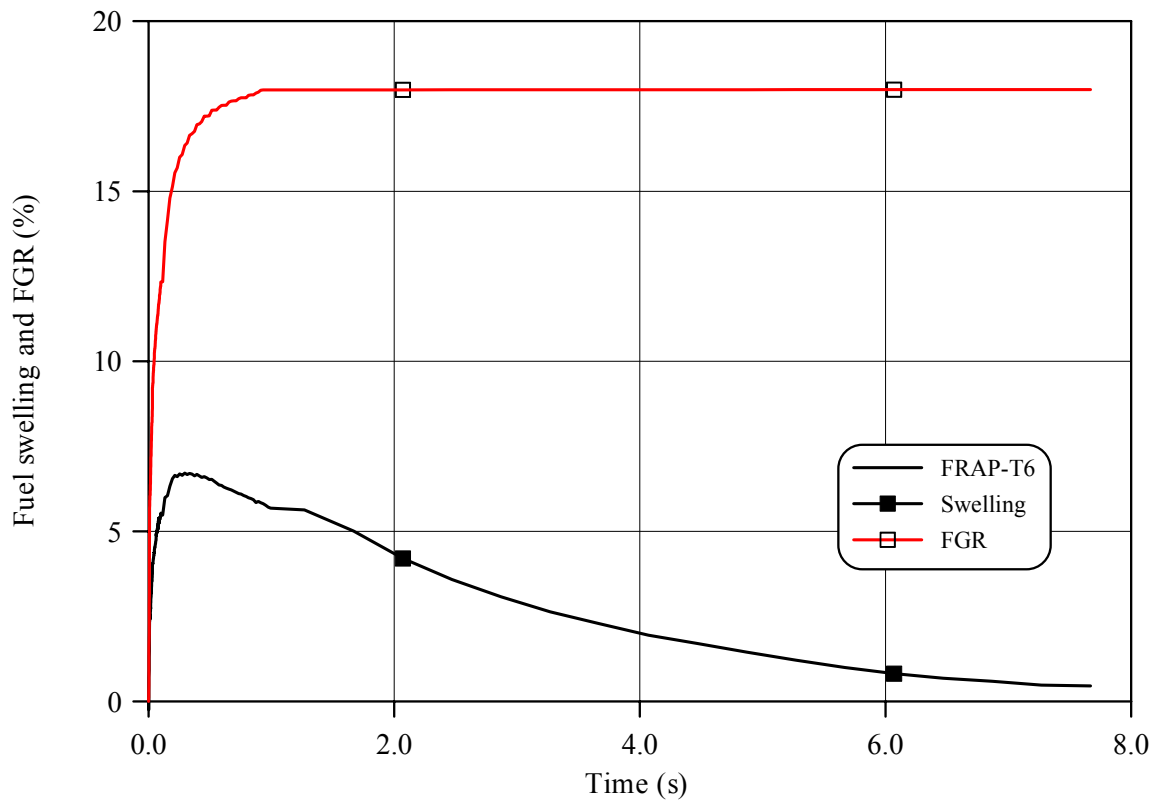
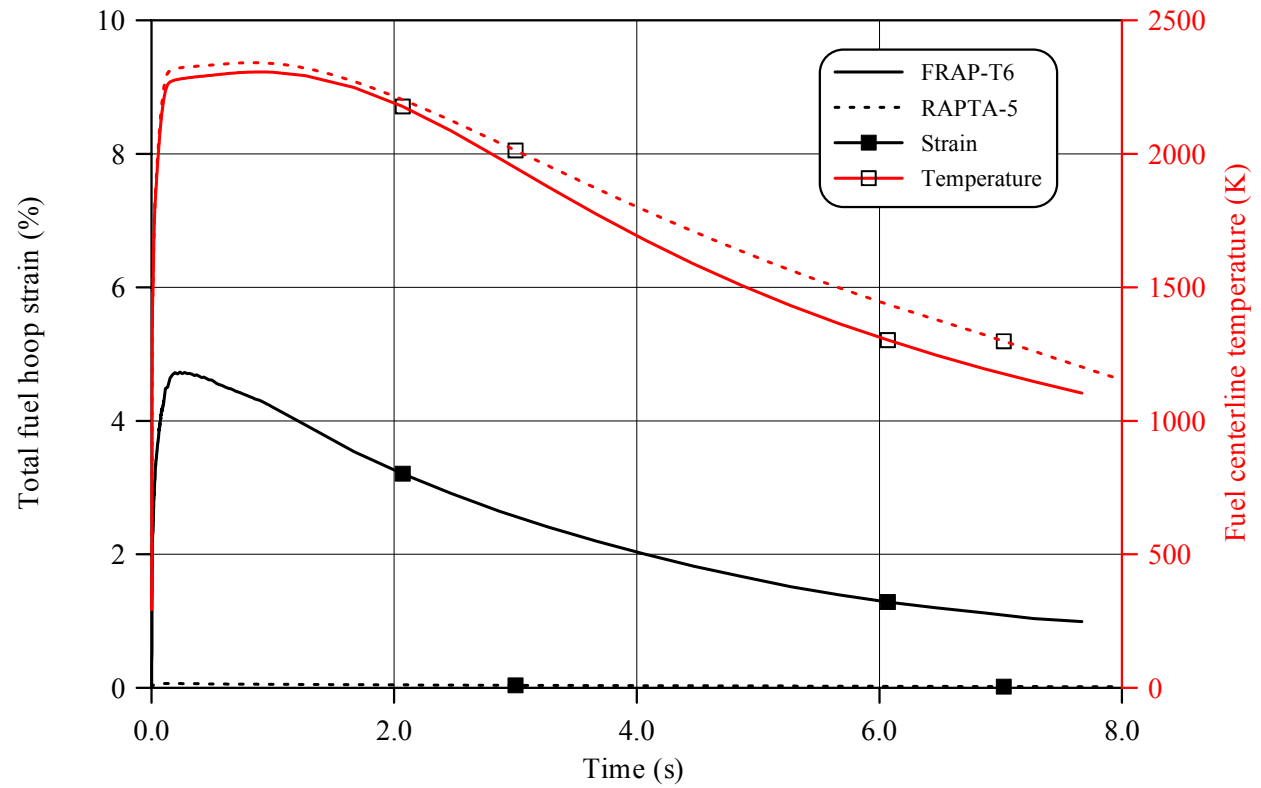
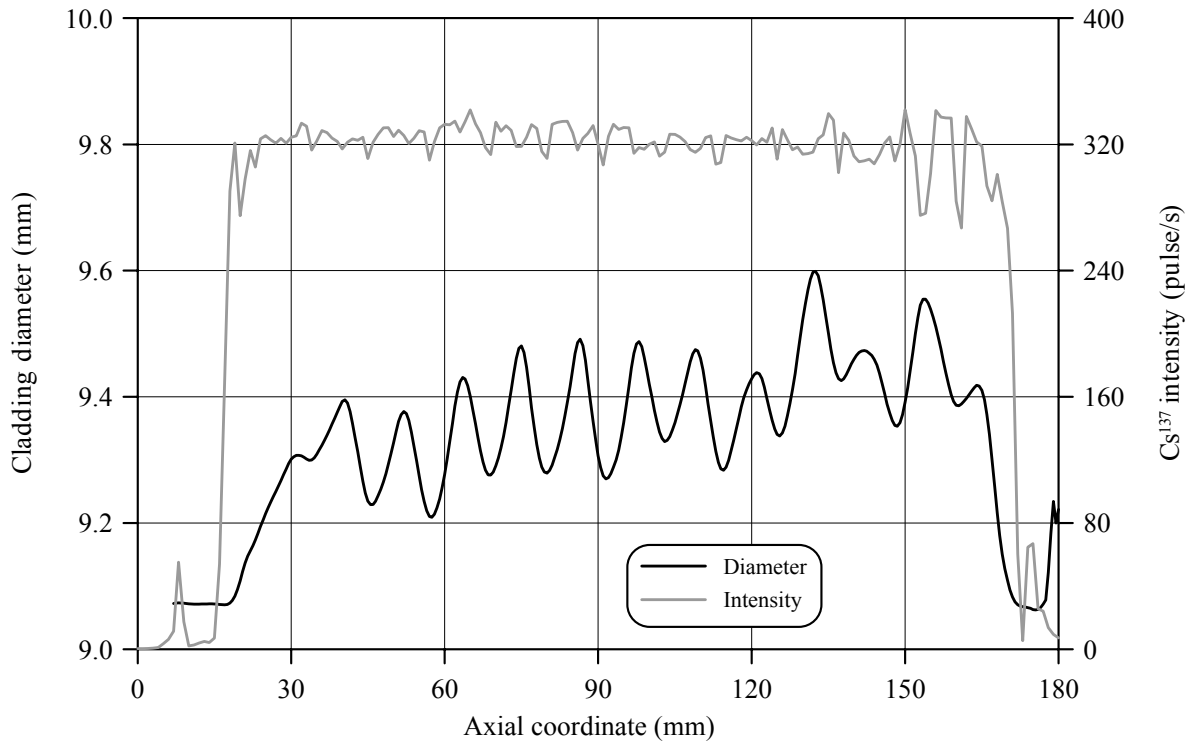


Fig.E-6.9. Fuel behavior during the B1GR test of fuel rod # RT6 in accordance with FRAP-T6/VVER and RAPTA-5 calculations

Table E-6.3. Axial distribution of cladding average outer diameter in fuel rod # RT6*

Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)
6	9.073	50	9.327	94	9.316	138	9.428
8	9.074	52	9.377	96	9.417	140	9.460
10	9.072	54	9.322	98	9.488	142	9.473
12	9.071	56	9.234	100	9.420	144	9.459
14	9.072	58	9.214	102	9.344	146	9.405
16	9.071	60	9.277	104	9.337	148	9.355
18	9.073	62	9.385	106	9.388	150	9.392
20	9.108	64	9.428	108	9.456	152	9.500
22	9.156	66	9.357	110	9.461	154	9.555
24	9.195	68	9.284	112	9.362	156	9.511
26	9.233	70	9.291	114	9.286	158	9.437
28	9.267	72	9.360	116	9.314	160	9.387
30	9.301	74	9.461	118	9.384	162	9.397
32	9.307	76	9.447	120	9.429	164	9.418
34	9.300	78	9.324	122	9.429	166	9.372
36	9.323	80	9.279	124	9.363	168	9.216
38	9.357	82	9.317	126	9.343	170	9.109
40	9.393	84	9.391	128	9.411	172	9.070
42	9.358	86	9.486	130	9.522	174	9.066
44	9.266	88	9.427	132	9.597	176	9.063
46	9.229	90	9.306	134	9.554	178	9.122
48	9.265	92	9.272	136	9.454	180	9.222

* Measured value determined on the basis of profilometry data (16 azimuthal directions)

**Fig.E-6.10. Cladding measured average diameter and γ -scanning results for fuel rod # RT6**

RT6

Table E-6.4. The PIE results for fuel rod # RT6

Parameter		Value
1.	Cladding outer diameter (mm):	
1.1.	Maximum diameter of the bidimensional data sample in "fuel rod length - azimuthal angle" coordinates (mm)	9.76
1.2.	Averaged azimuthal diameter and maximum diameter along the length selected from the sample of averaged azimuthal diameter (mm)	9.61
1.3.	Averaged diameter of the bidimensional data sample in "fuel rod length - azimuthal angle" coordinates (mm)	9.36
2.	Cladding maximum residual hoop strain (%)	6.00
3.	Fuel pellet conditional diameter (mm) in cross-section*:	
	at 114 mm elevation	7.84
	at 132 mm elevation	7.92
4.	ZrO ₂ outer thickness (μm) in cross-section:	
	at 114 mm elevation	3-5
	at 132 mm elevation	3-5
5.	ZrO ₂ inner thickness (μm) in cross-section:	
	at 114 mm elevation	0
	at 132 mm elevation	0
6.	Parameters characterizing FGR:	
6.1.	Gas composition (% by volume):	
	He	81.53
	N ₂	1.11
	O ₂	0.09
	Ar	0.021
	CO ₂	0.015
	Kr	1.53
	Xe	15.69
6.2.	Free gas volume (cm ³)	6.2
6.3.	Gas volume under normal conditions (cm ³)	141.8
6.4.	Gas pressure under normal conditions (MPa)	2.29
6.5.	FGR (%)	26.50

* Reference value determined by the processing of fuel cross-section photographs

Table E-6.5. Organized BGR test results for fuel rod # RT6

Parameter	Unit	Value		
		Measured	Calculated	
			FRAP-T6	RAPTA-5
1. Fuel burnup	MW d/kg U	47.84	47.84	47.84
2. Initial gas pressure	MPa	2.1	2.1	2.1
3. Energy deposition	cal/g fuel	186.9	186.9	186.9
4. Peak fuel enthalpy*	cal/g fuel	-	152.5	152.7
5. Fuel maximum temperature	K	-	2421	2459
6. Maximum temperature of cladding outer surface	K	-	1157	1207
7. Cladding burst	Failed, Unfailed	Unfailed	Unfailed	Unfailed
8. Cladding residual hoop strain**	%	3.20	3.36	2.39
9. Kr volume content in gas composition after the BGR test	%	1.53	1.89	-
10. Xe volume content in gas composition after the BGR test	%	15.69	11.30	-

* Average value of peak fuel enthalpy is 152.6 cal/g fuel

** Average value along the fuel stack length

Appendix E–7
Individual Characteristics of Fuel Rod # RT7
after the BGR Test

RT7

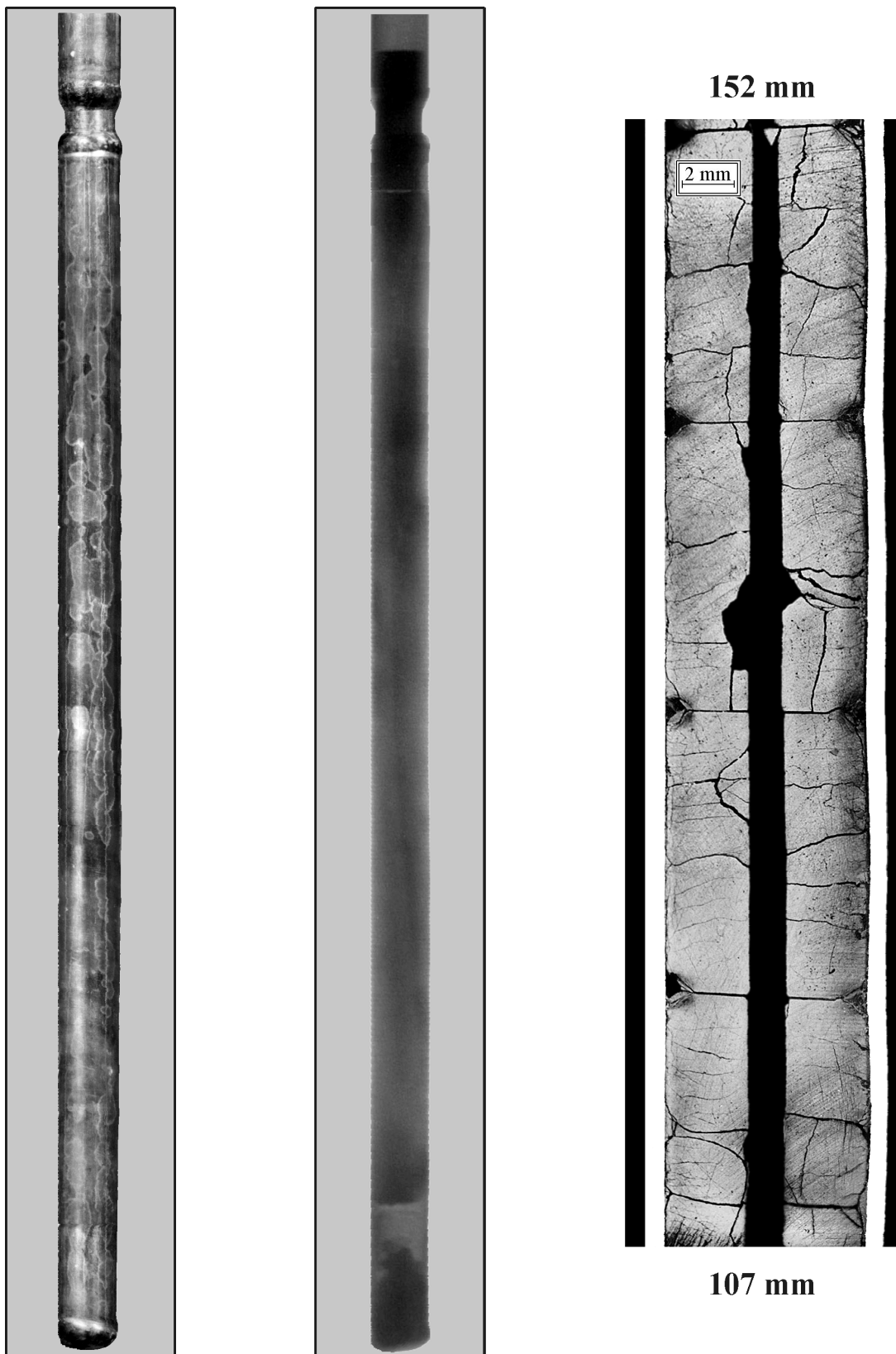


Fig.E-7.1. Appearance of unfailed fuel rod # RT7 after the BGR test (photographs and X-ray photograph) and longitudinal metallographic specimen image

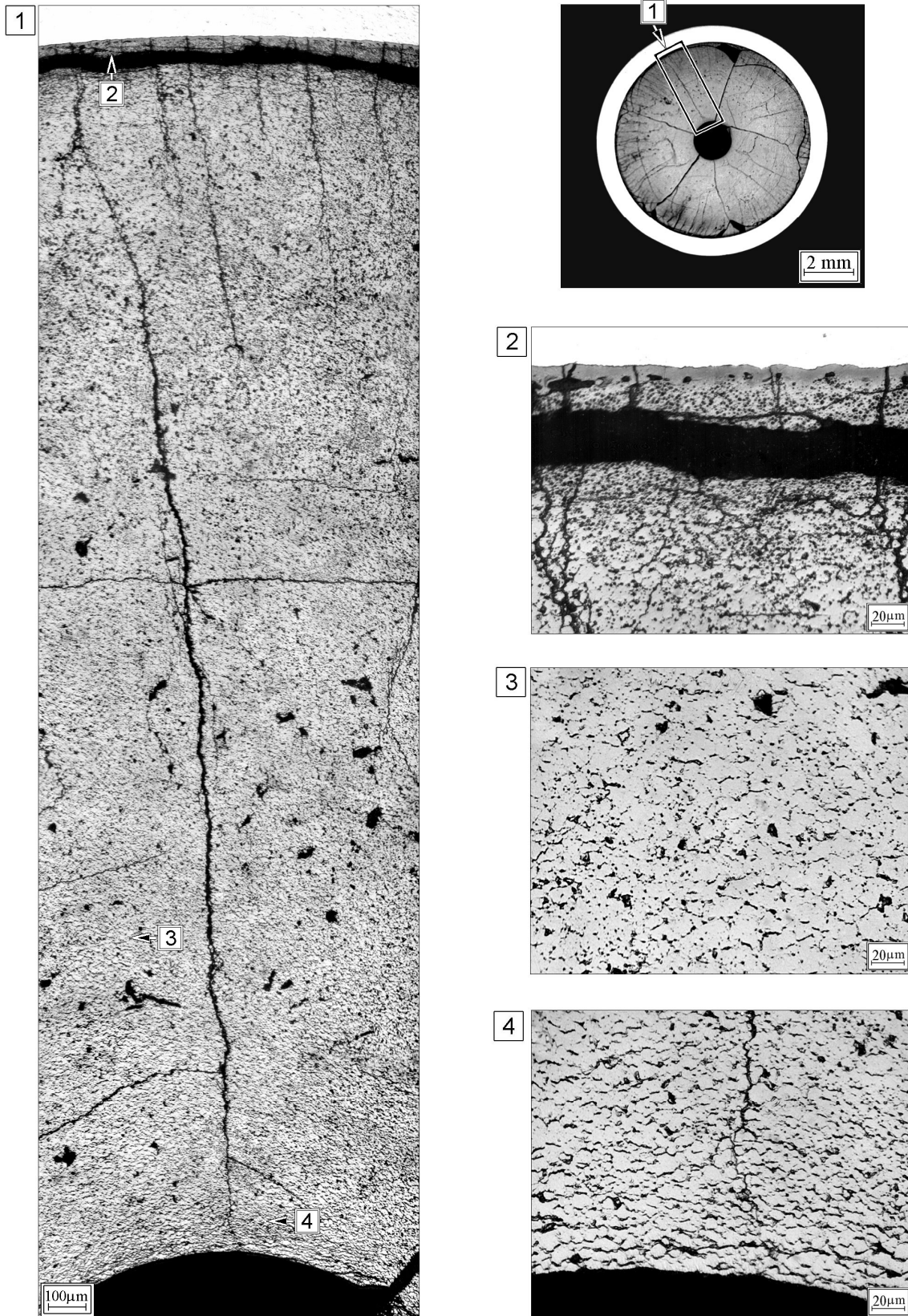


Fig.E-7.2. Cross-section and cladding microstructure of fuel rod # RT7 at 107 mm elevation (from low cap)

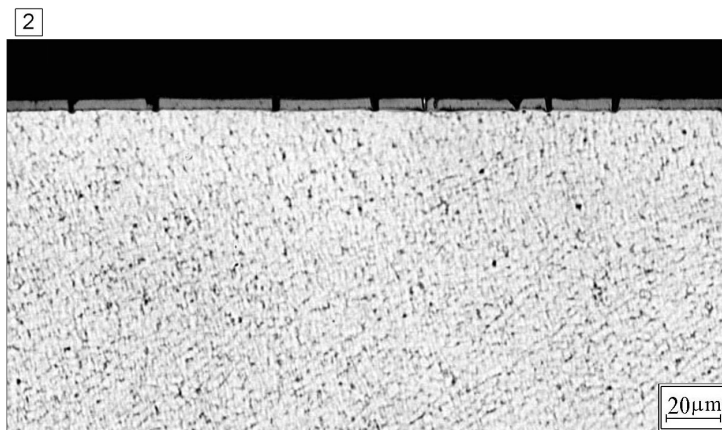
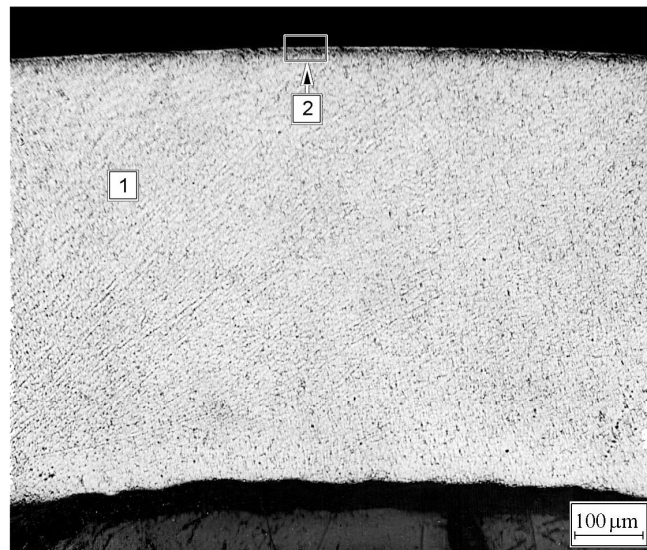


Fig.E-7.3. Cladding microstructure of fuel rod # RT7 at 107 mm elevation (from low cap)