

Table E-7.1. Time dependent energy characteristics of fuel rod # RT7

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	0.00E+00	0.000	0.000	0.000	0.000	0.000	0.000
0.001	3.77E-03	0.045	25.09	0.046	0.194	0.671	0.004
0.002	1.65E-02	0.248	109.7	0.255	1.067	0.671	0.013
0.003	7.63E-02	1.153	508.5	1.187	4.968	0.671	0.031
0.004	3.14E-01	5.134	2090	5.268	22.06	0.671	0.130
0.005	8.37E-01	18.27	5577	18.73	78.42	0.844	0.542
0.006	9.39E-01	40.46	6260	41.56	174.0	2.954	2.713
0.007	5.20E-01	57.56	3462	59.10	247.4	11.084	10.941
0.008	2.34E-01	65.86	1560	67.63	283.1	30.369	30.902
0.009	1.19E-01	69.64	796.4	71.61	299.8	51.815	53.058
0.010	7.54E-02	71.86	502.5	73.84	309.2	64.176	65.721
0.012	5.38E-02	74.73	358.3	76.74	321.3	72.209	73.965
0.014	5.62E-02	77.15	374.7	79.31	332.1	74.823	76.698
0.016	6.56E-02	79.97	437.0	82.20	344.1	76.831	78.858
0.018	7.47E-02	83.30	497.7	85.56	358.2	79.111	81.308
0.020	7.60E-02	86.80	506.6	89.18	373.4	81.899	84.282
0.022	6.89E-02	90.20	459.1	92.67	388.0	85.046	87.624
0.024	5.89E-02	93.23	393.0	95.72	400.8	88.160	90.927
0.026	4.85E-02	95.64	323.6	98.28	411.5	90.906	93.838
0.028	3.99E-02	97.71	266.2	100.4	420.4	93.182	96.258
0.030	3.41E-02	99.42	227.6	102.1	427.5	94.995	98.186
0.050	2.83E-02	113.0	189.0	116.0	485.8	106.142	110.175
0.070	2.46E-02	125.1	163.7	128.4	537.7	116.336	120.734
0.090	1.83E-02	134.5	121.9	138.5	579.7	124.433	129.209
0.110	9.39E-03	141.3	62.72	145.1	607.3	129.425	134.525
0.130	3.68E-03	143.7	24.68	147.9	619.4	131.404	136.246
0.150	1.69E-03	145.3	11.46	149.1	624.3	131.628	136.222
0.200	4.93E-04	146.3	3.441	150.3	629.1	130.640	134.603
1.000	7.30E-05	148.5	0.594	152.9	640.2	115.626	116.979
10.00	8.50E-06	153.4	0.079	159.5	667.8	46.313	33.119
100.0	1.72E-07	155.7	0.003	163.7	685.4	7.031	5.041
1000	6.74E-13	155.7	1.43E-04	165.2	691.7	0.000	0.000

¹⁾ Average values determined in accordance with results of RRC KI and VNIIEF calculations²⁾ Maximum power value is 6663 kW (t=0.00555 s)³⁾ Average radial value

RT7

Table E-7.2. Radial energy characteristics of fuel rod # RT7*

Parameters	Coordinates of fuel radial layers (mm)			
	1 layer (0.825-2.777)	2 layer (2.777-3.454)	3 layer (3.454-3.747)	4 layer (3.747-3.840)
Number of fissions $\times 10^{-14}$ (fiss)	6.673	4.455	2.879	1.590
Fission density $\times 10^{-13}$ (fiss/g fuel)	1.999	2.224	2.873	4.745
Power ** (kW)	2847	1903	1231	681.5
Energy deposition (cal/g fuel)	141.2	157.3	203.4	336.6
Energy deposition (J/g fuel)	591.2	658.5	851.8	1409
Energy deposition *** (per-unit)	0.420	0.467	0.604	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 0.00555 s

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

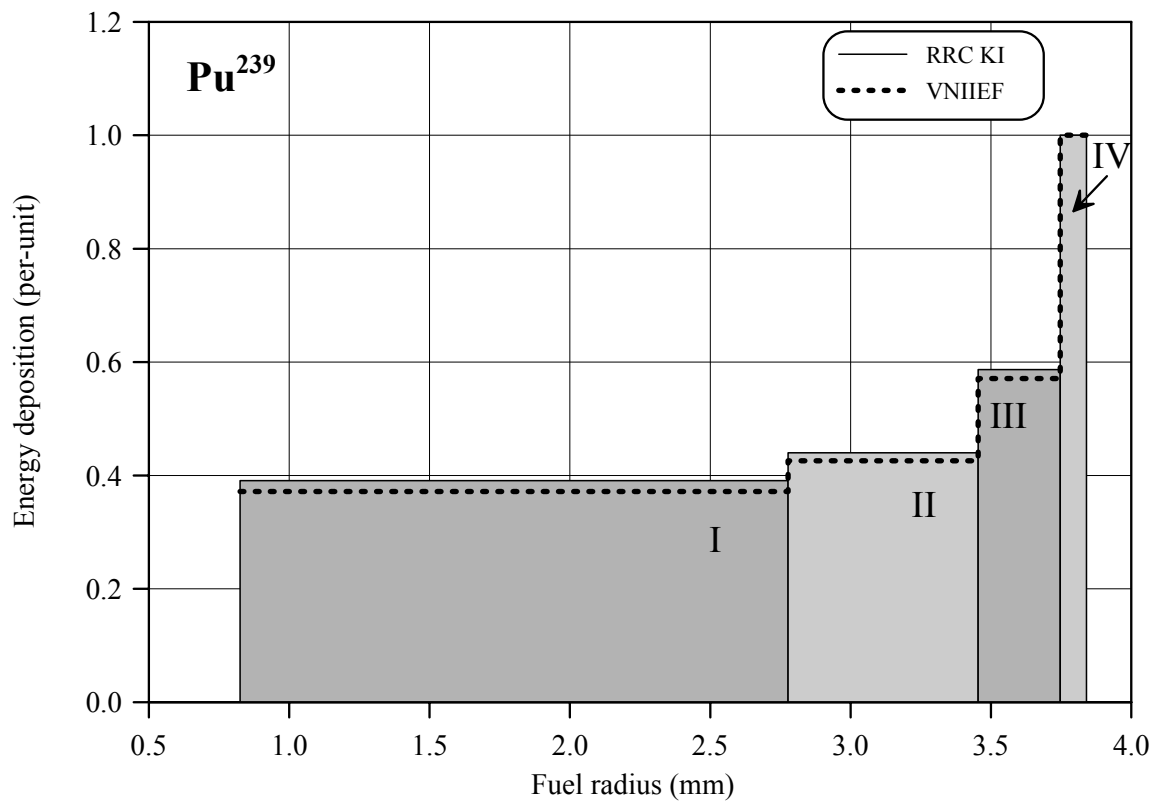
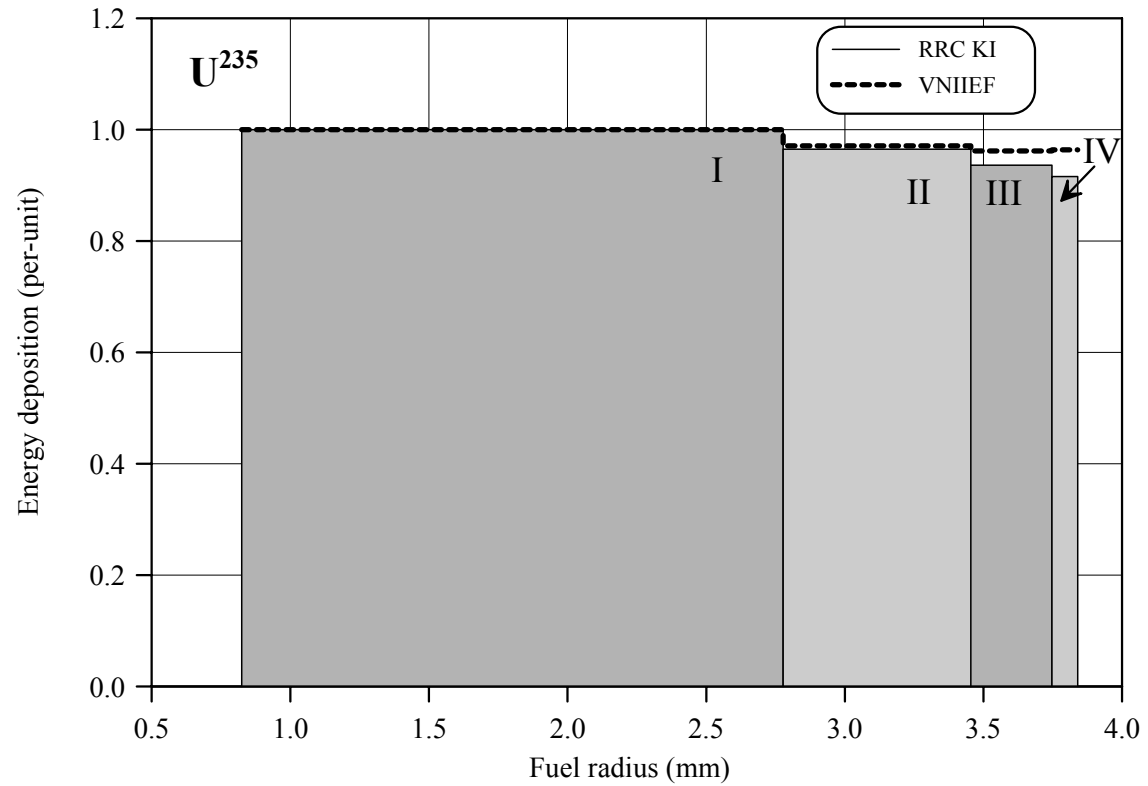


Fig.E-7.4. U^{235} and Pu^{239} radial distribution of energy deposition for fuel rod # RT7

RT7

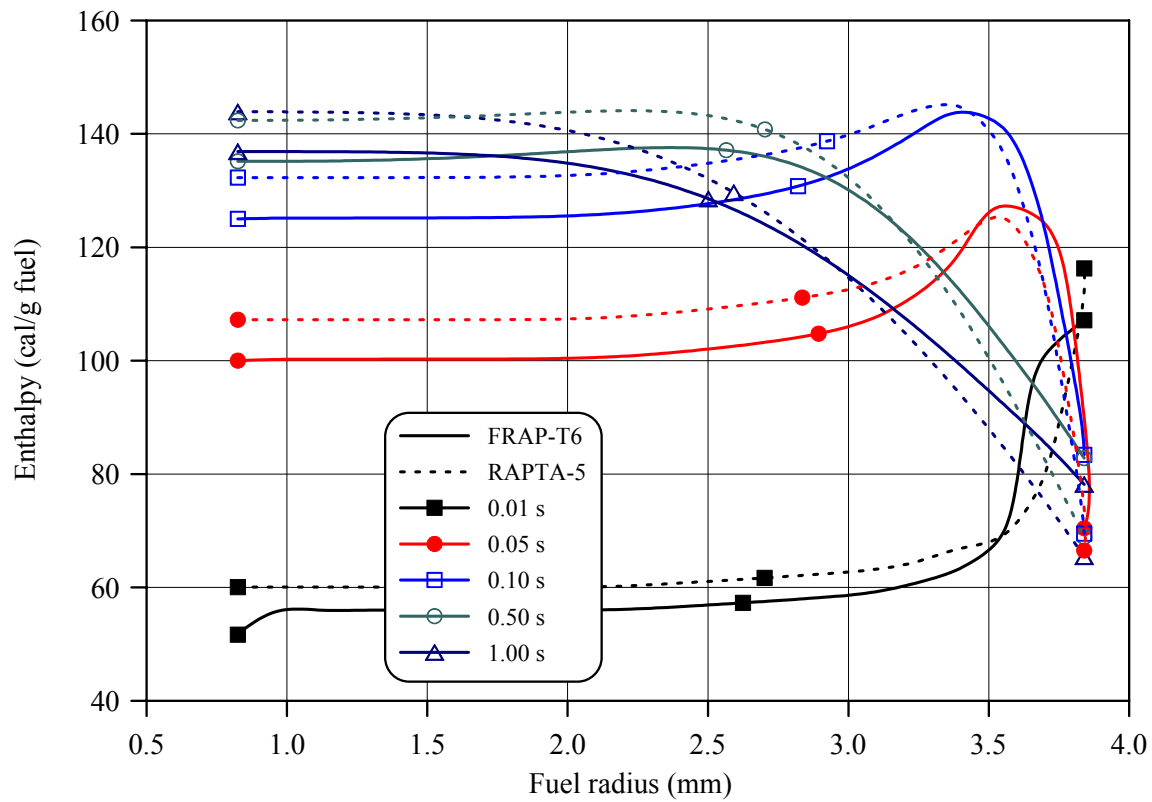
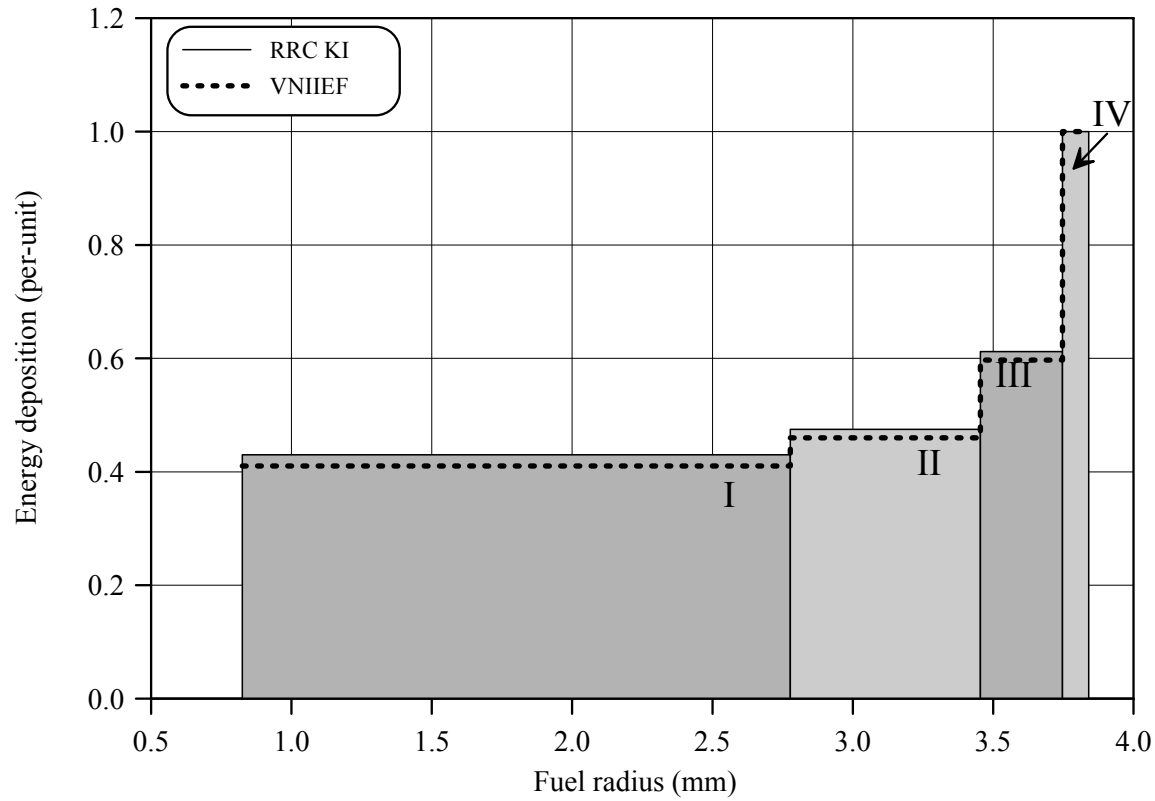


Fig.E-7.5. Radial distribution of energy deposition and fuel enthalpy for fuel rod # RT7

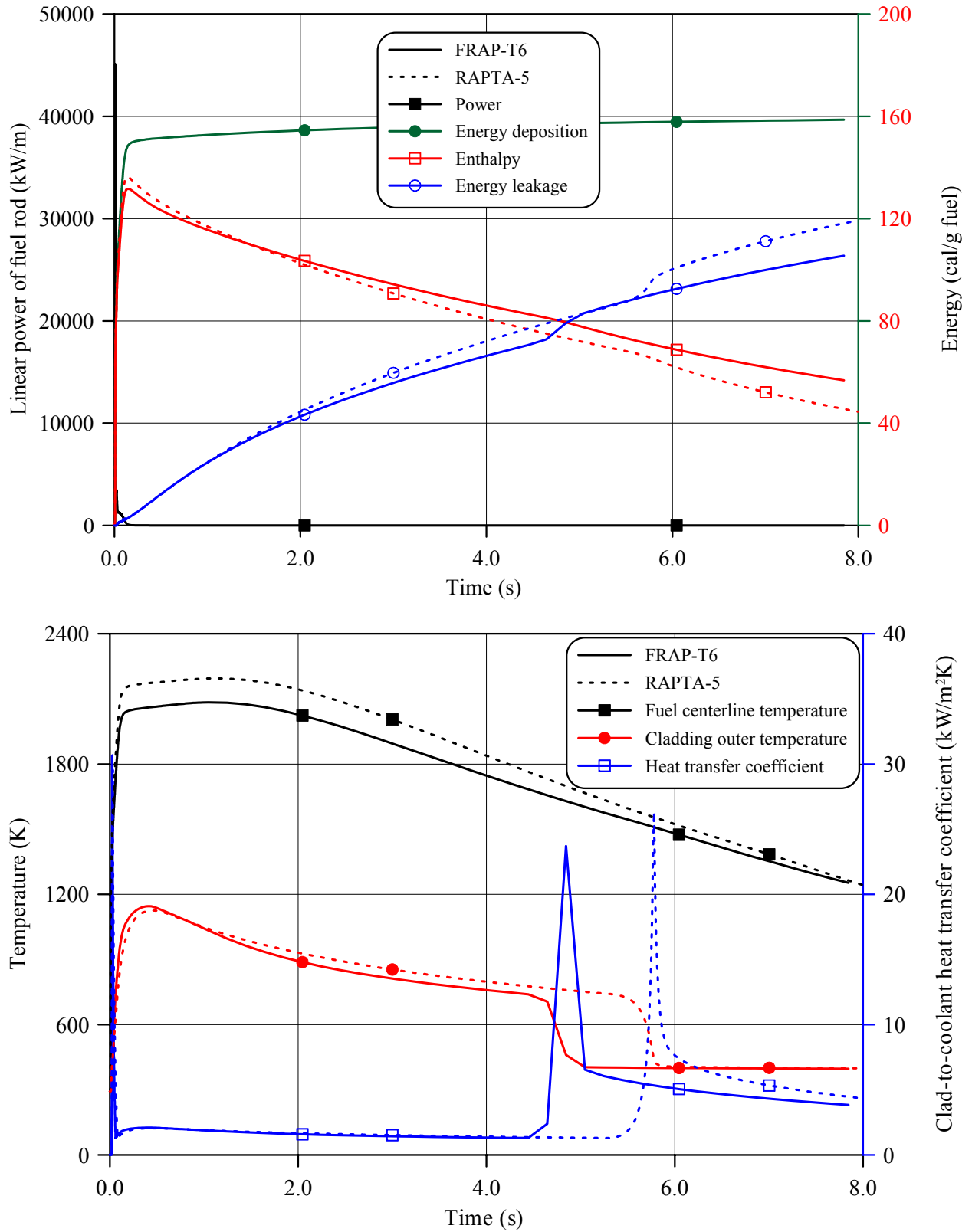


Fig.E-7.6. Thermal history of fuel rod # RT7 during the BIGH test in accordance with FRAP-T6/VVER and RAPTA-5 calculations

RT7

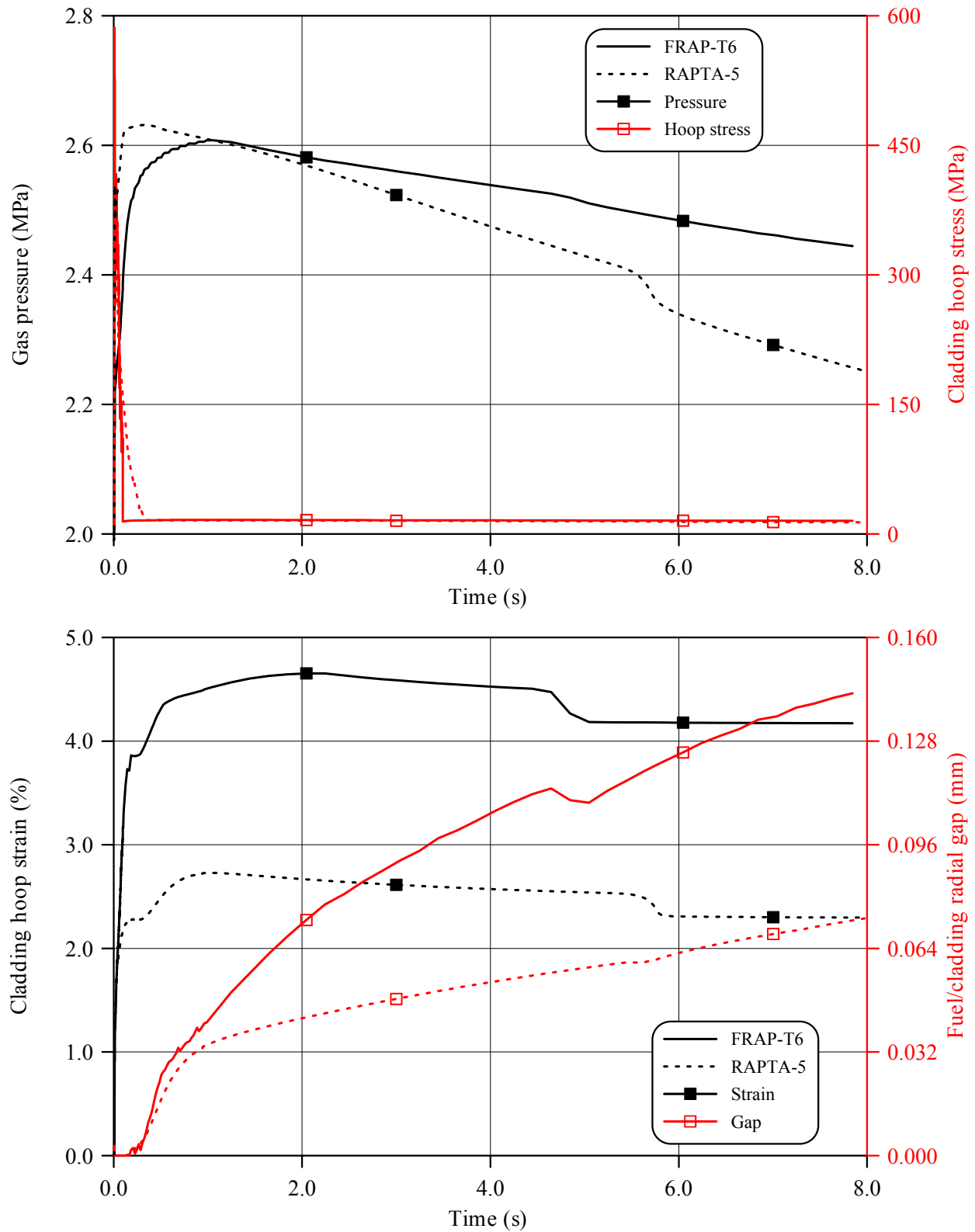


Fig.E-7.7. Mechanical behavior of fuel rod # RT7 during the BIGH test in accordance with FRAP-T6/VVER and RAPTA-5 calculations

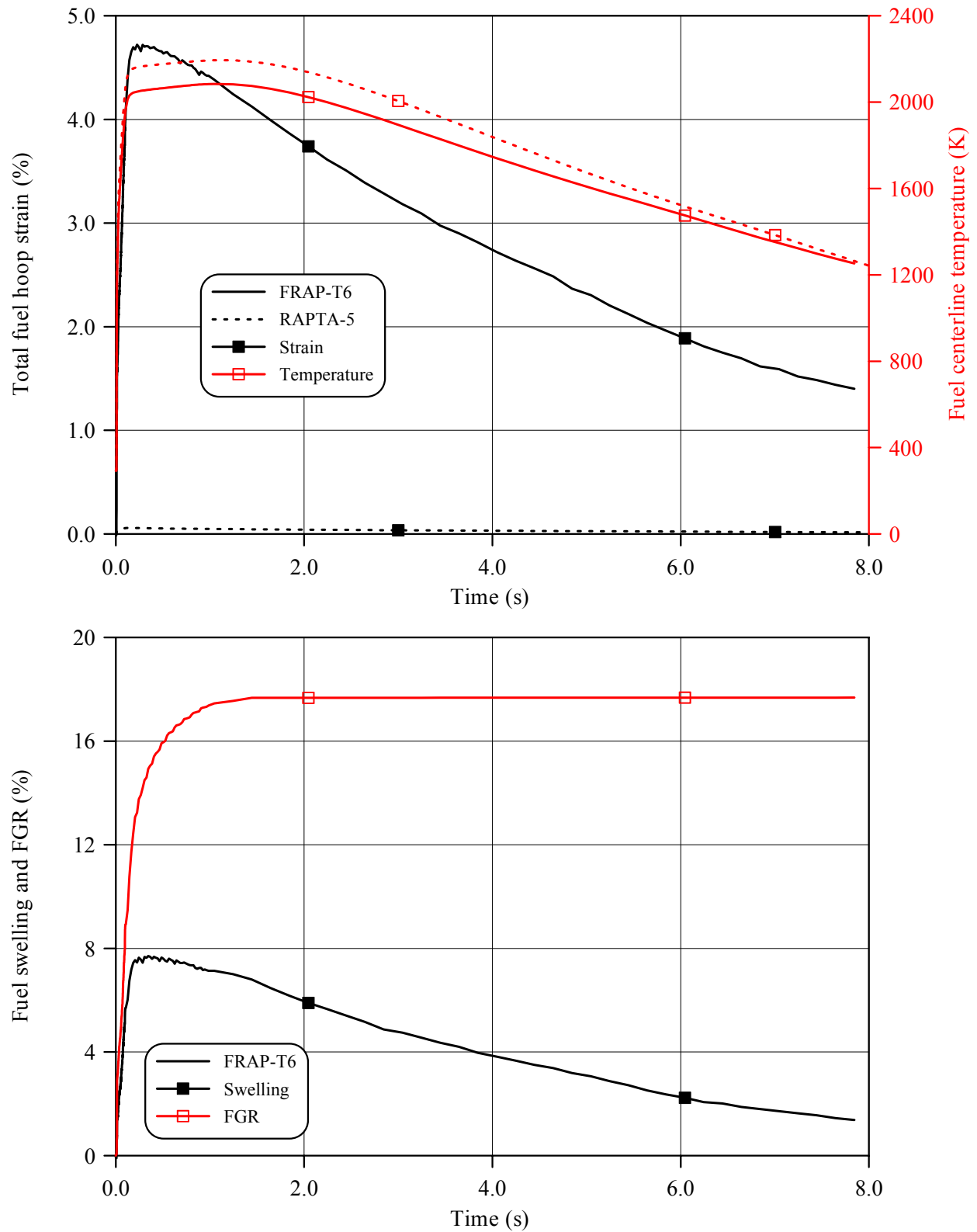


Fig.E-7.8. Fuel behavior during the BIGH test of fuel rod # RT7 in accordance with FRAP-T6/VVER and RAPTA-5 calculations

RT7

Table E-7.3. Axial distribution of cladding average outer diameter in fuel rod # RT7*

Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)
26	9.180	64	9.250	102	9.330	140	9.130
28	9.150	66	9.320	104	9.270	142	9.180
30	9.160	68	9.370	106	9.230	144	9.220
32	9.220	70	9.330	108	9.270	146	9.240
34	9.260	72	9.280	110	9.310	148	9.210
36	9.280	74	9.300	112	9.310	150	9.160
38	9.250	76	9.350	114	9.310	152	9.180
40	9.220	78	9.380	116	9.230	154	9.250
42	9.260	80	9.370	118	9.230	156	9.290
44	9.290	82	9.310	120	9.240	158	9.310
46	9.270	84	9.260	122	9.270	160	9.290
48	9.260	86	9.290	124	9.270	162	9.270
50	9.180	88	9.320	126	9.200	164	9.290
52	9.210	90	9.350	128	9.140	166	9.310
54	9.280	92	9.310	130	9.160	168	9.310
56	9.340	94	9.240	132	9.190	170	9.290
58	9.310	96	9.240	134	9.230	172	9.190
60	9.270	98	9.300	136	9.220	174	9.100
62	9.220	100	9.340	138	9.170	176	9.100

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

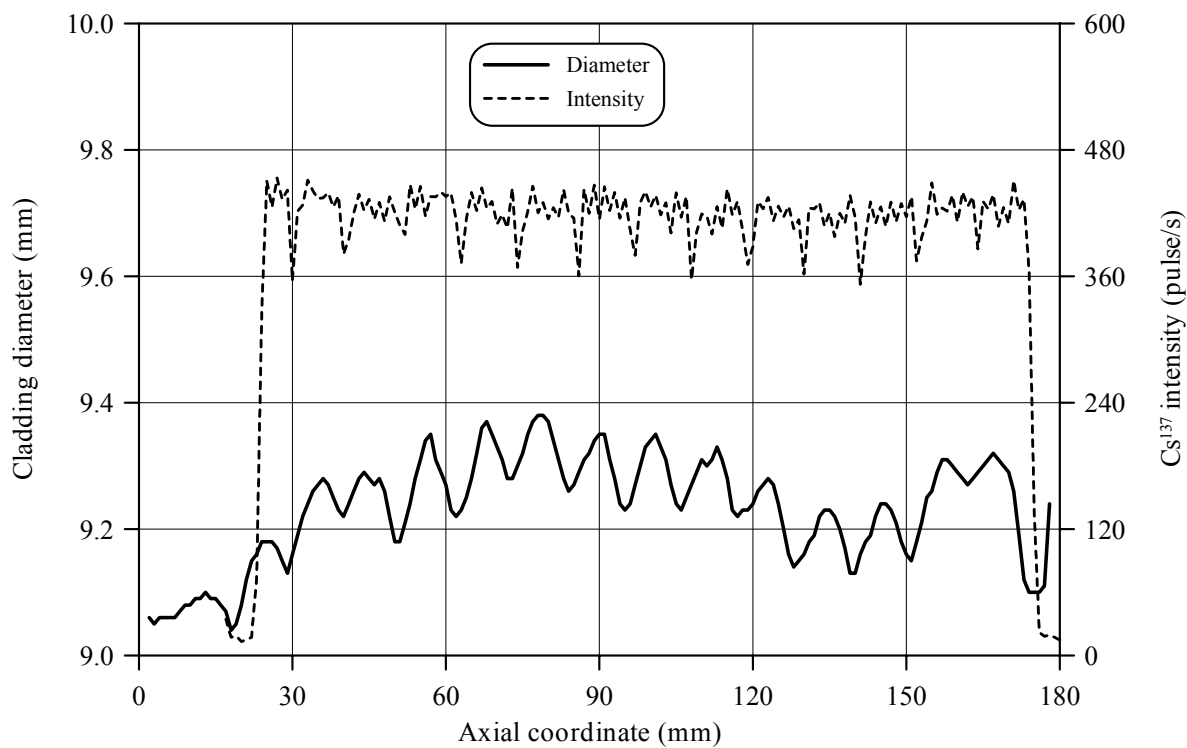


Fig.E-7.9. Cladding measured average diameter and γ -scanning results for fuel rod # RT7

Table E-7.4. The PIE results for fuel rod # RT7

Parameter		Value
1.	Cladding outer diameter (mm):	
1.1.	Maximum diameter of the bidimensional data sample in "fuel rod length - azimuthal angle" coordinates (mm)	9.38
1.2.	Averaged azimuthal diameter and maximum diameter along the length selected from the sample of averaged azimuthal diameter (mm)	9.38
1.3.	Averaged diameter of the bidimensional data sample in "fuel rod length - azimuthal angle" coordinates (mm)	9.25
2.	Cladding maximum residual hoop strain (%)	3.50
3.	Fuel pellet conditional diameter (mm) in cross-section*: at 107 mm elevation	7.74
4.	ZrO ₂ outer thickness (μm) in cross-section: at 107 mm elevation	3-5
5.	ZrO ₂ inner thickness (μm) in cross-section: at 107 mm elevation	9
6.	Parameters characterizing FGR:	
6.1.	Gas composition (% by volume):	
	He	76.83
	N ₂	1.92
	O ₂	0.05
	Ar	0.014
	CO ₂	0.080
	Kr	1.82
	Xe	19.29
6.2.	Free gas volume (cm ³)	5.9
6.3.	Gas volume under normal conditions (cm ³)	158.9
6.4.	Gas pressure under normal conditions (MPa)	2.7
6.5.	FGR (%)	26.8

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

RT7

Table E-7.5. Organized BGR test results for fuel rod # RT7

	Parameter	Unit	Value		
			Measured	Calculated	
				FRAP-T6	RAPTA-5
1.	Fuel burnup	MW d/kg U	60.3	60.3	60.3
2.	Initial gas pressure	MPa	2.0	2.0	2.0
3.	Energy deposition	cal/g fuel	165.2	165.2	165.2
4.	Peak fuel enthalpy*	cal/g fuel	-	131.7	136.4
5.	Fuel maximum temperature	K	-	2183	2251
6.	Maximum temperature of cladding outer surface	K	-	1146	1126
7.	Cladding burst	Failed, Unfailed	Unfailed	Unfailed	Unfailed
8.	Cladding residual hoop strain				
	- average**	%	2.07	3.68	2.73
	- maximum	%	3.50	3.68	2.73
9.	Kr volume content in gas composition after the BGR test	%	1.82	2.99	-
10.	Xe volume content in gas composition after the BGR test	%	19.29	17.93	-

* Average value of peak fuel enthalpy 134.0 cal/g fuel

** Average value along the fuel stack length

Appendix E–8
Individual Characteristics of Fuel Rod # RT8
after the BGR Test

RT8

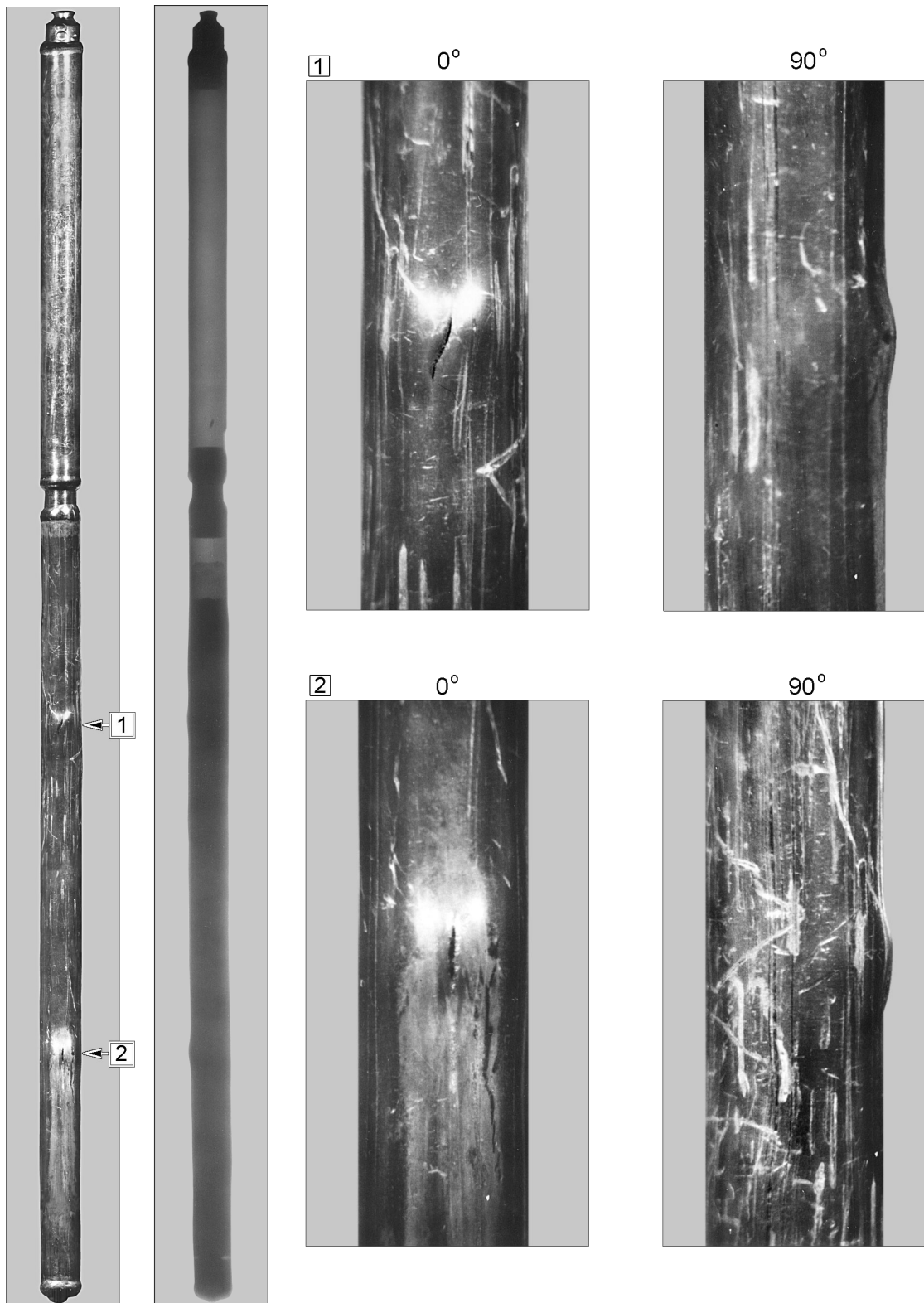


Fig.E-8.1. Appearance of failed fuel rod # RT8 after the BGR test (photographs and X-ray photograph)

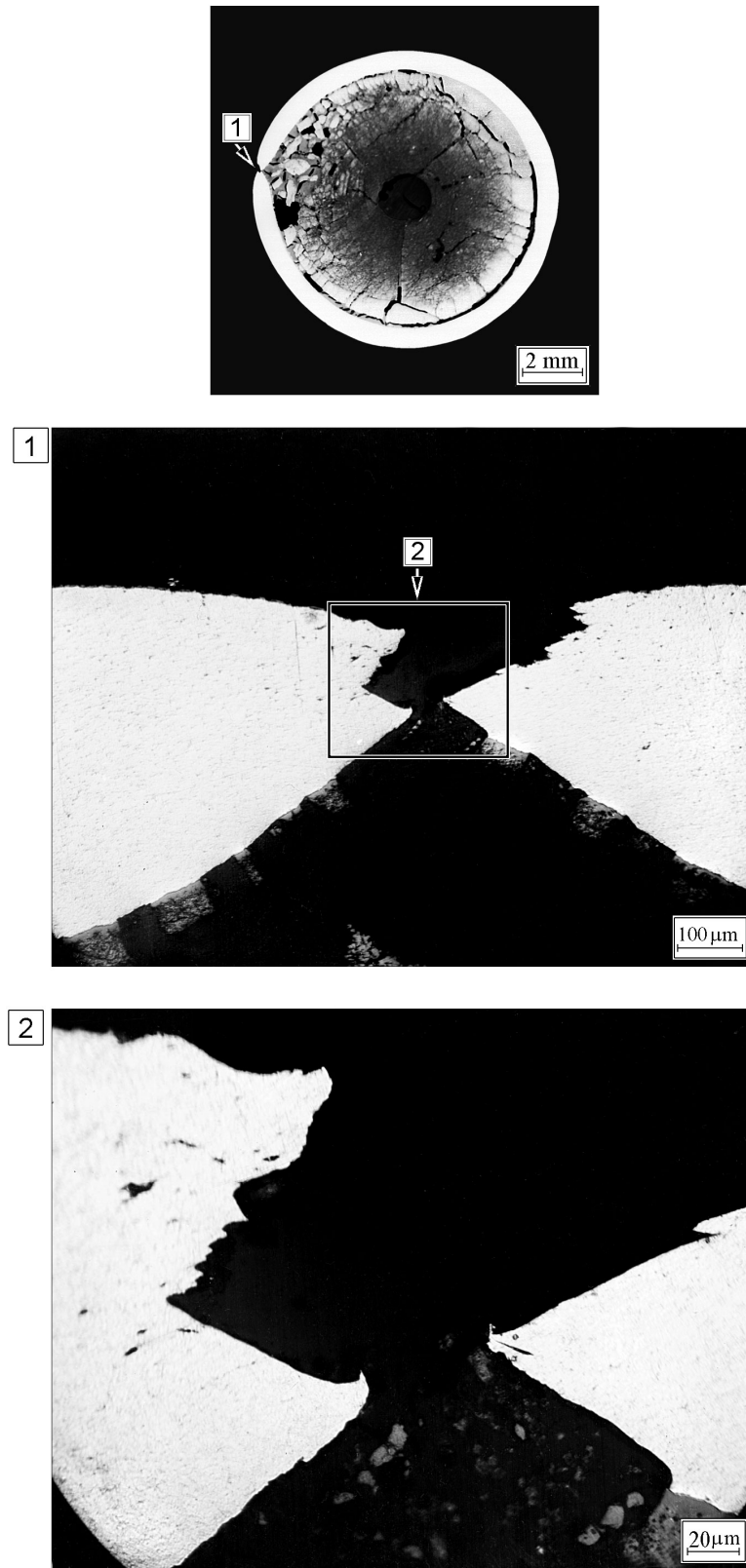


Fig.E-8.2. Cross-section and cladding microstructure in the burst area of fuel rod # RT8 at 53 mm elevation (from low cap)

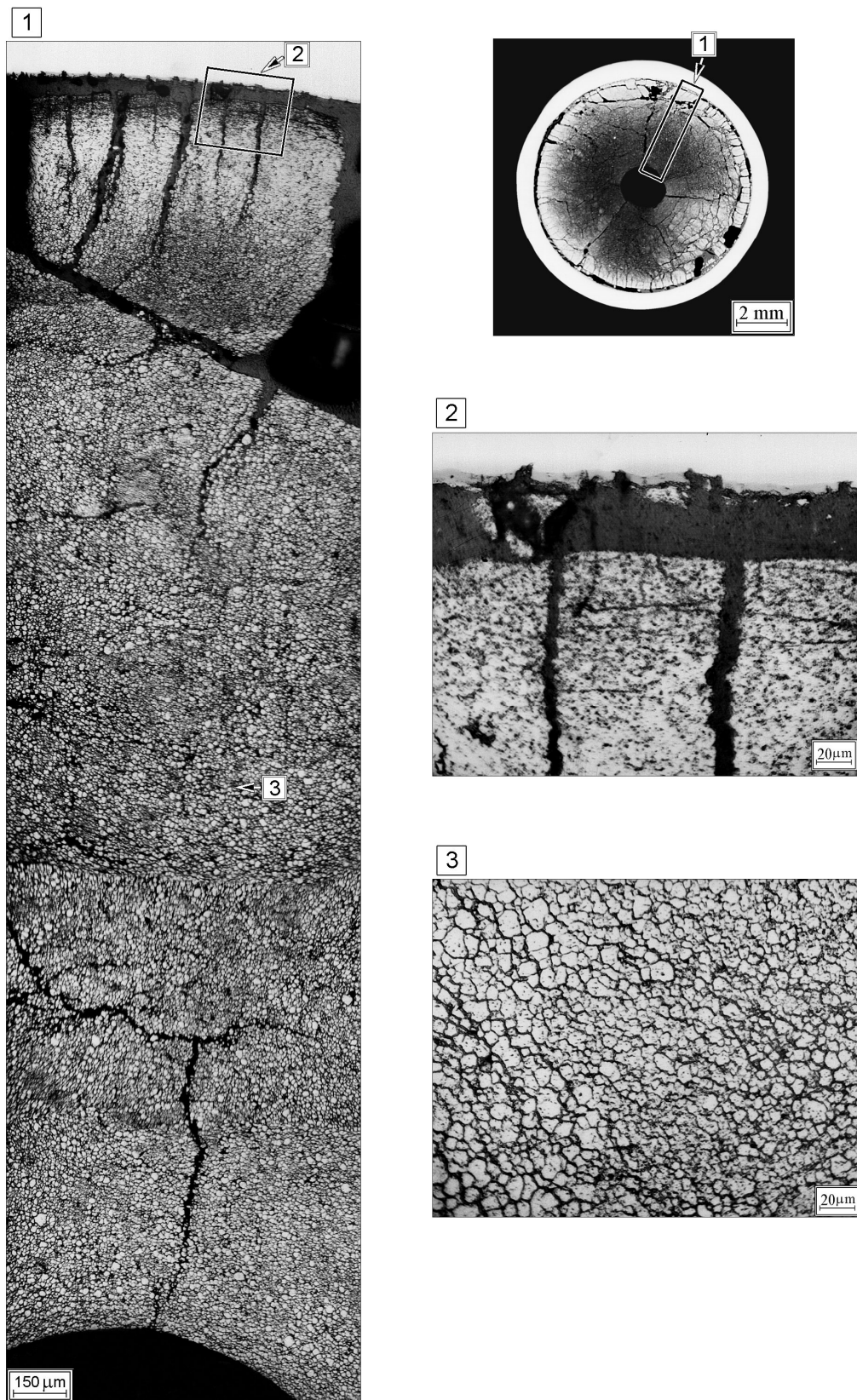


Fig.E-8.3. Cross-section and fuel microstructure of fuel rod # RT8 at 97 mm elevation (from low cap)

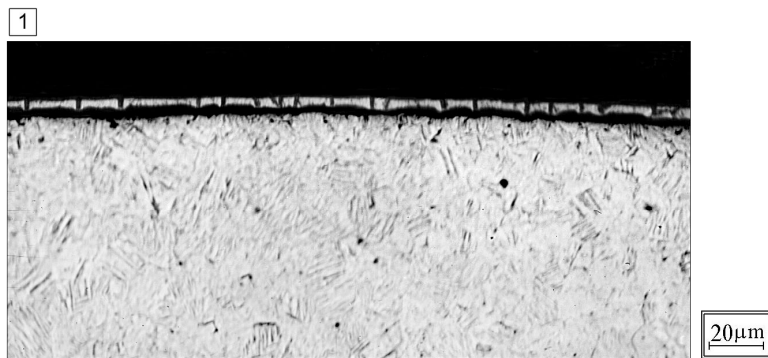
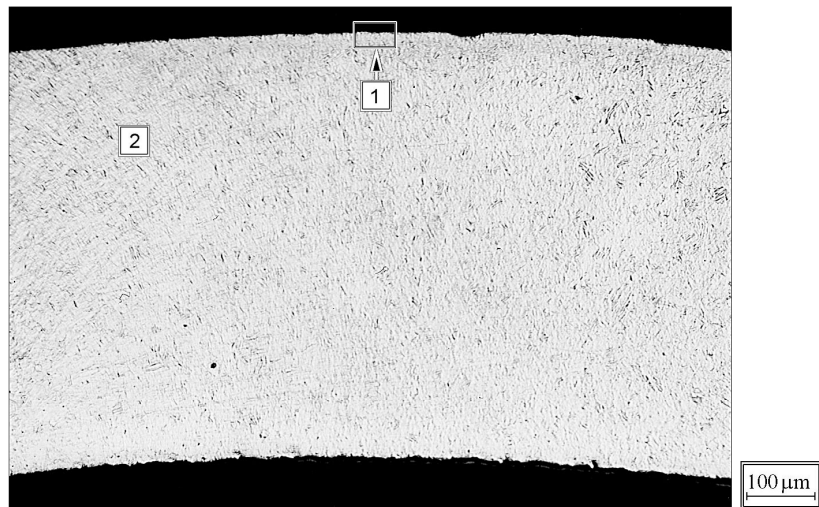


Fig.E-8.4. Cladding microstructure of fuel rod # RT8 at 97 mm elevation (from low cap)

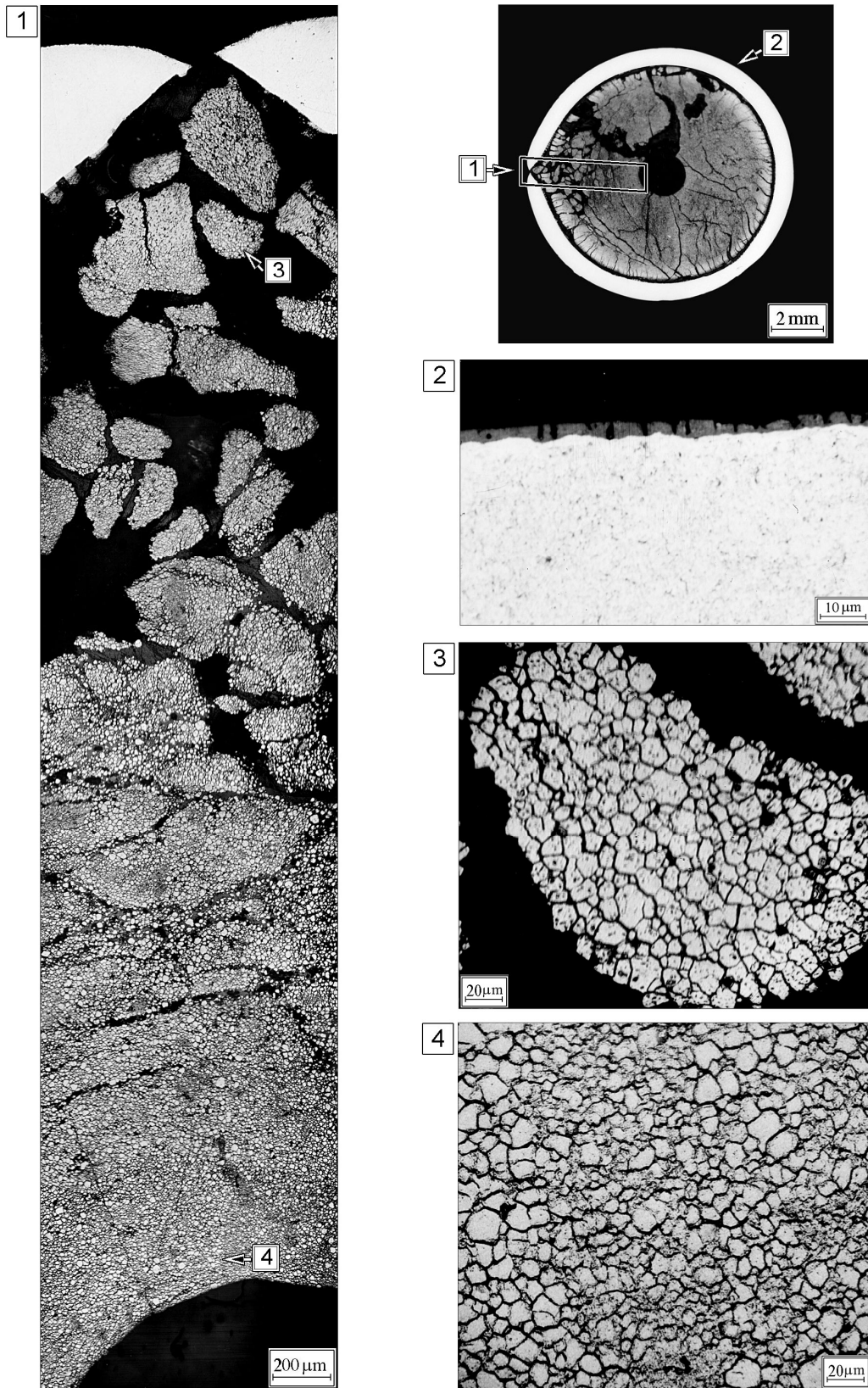


Fig.E-8.5. Cross-section and cladding microstructure of fuel rod # RT8 at 133 mm elevation (from low cap)

Table E-8.1. Time dependent energy characteristics of fuel rod # RT8

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	0.00E+00	0.000	0.000	0.000	0.000	0.000	0.000
0.001	2.74E-03	0.037	21.08	0.038	0.161	0.671	0.039
0.002	1.20E-02	0.206	92.68	0.213	0.890	0.671	0.204
0.003	5.50E-02	0.970	423.4	1.001	4.191	1.276	1.074
0.004	2.39E-01	4.391	1836	4.530	18.97	4.939	4.676
0.005	7.06E-01	16.47	5432	17.01	71.21	17.598	17.715
0.006	9.90E-01	40.90	7613	42.26	176.9	42.949	43.901
0.007	6.19E-01	63.22	4758	65.26	273.2	65.896	67.516
0.008	2.82E-01	74.86	2171	77.26	323.5	77.575	79.466
0.009	1.36E-01	80.15	1046	82.74	346.4	82.629	84.594
0.010	8.10E-02	82.97	623.4	85.62	358.5	85.108	87.175
0.012	5.36E-02	86.35	412.1	89.11	373.1	87.862	90.099
0.014	5.43E-02	89.18	417.8	92.05	385.4	90.164	92.594
0.016	6.39E-02	92.32	492.1	95.30	399.0	92.864	95.506
0.018	7.43E-02	96.12	572.0	99.15	415.1	96.196	99.043
0.020	7.80E-02	100.2	600.6	103.4	432.9	99.972	103.046
0.022	7.36E-02	104.3	566.3	107.7	450.8	103.748	107.029
0.024	6.17E-02	108.2	474.9	111.4	466.4	107.027	110.502
0.026	4.96E-02	111.2	381.7	114.5	479.3	109.629	113.275
0.028	4.02E-02	113.3	309.2	117.0	489.6	111.646	115.445
0.030	3.42E-02	115.4	263.2	119.1	498.4	113.264	117.197
0.050	2.72E-02	130.6	209.4	134.9	564.7	125.680	130.399
0.070	2.44E-02	144.6	187.7	149.1	624.3	137.020	142.329
0.090	2.06E-02	156.1	158.5	161.3	675.4	147.055	152.391
0.110	1.57E-02	166.2	120.7	171.8	719.1	155.898	160.736
0.130	7.95E-03	173.0	61.39	178.4	746.9	160.853	165.400
0.150	3.05E-03	175.7	23.65	181.2	758.8	162.225	166.440
0.200	6.92E-04	177.3	5.511	183.3	767.3	161.502	164.962
1.000	7.64E-05	180.3	0.717	186.7	781.8	151.533	147.195
10.00	8.86E-06	186.3	0.095	194.7	815.4	76.383	55.533
100.0	1.79E-07	189.4	0.004	199.9	836.7	8.643	5.231
1000	7.01E-13	189.5	1.70E-04	201.7	844.3	0.000	0.000

¹⁾ Average values determined in accordance with results of RRC KI and VNIIEF calculations²⁾ Maximum power value is 7693 kW (t=0.00588 s)³⁾ Average radial value

RT8

Table E-8.2. Radial energy characteristics of fuel rod # RT8*

Parameters	Coordinates of fuel radial layers (mm)			
	1 layer (0.825-2.777)	2 layer (2.777-3.454)	3 layer (3.454-3.747)	4 layer (3.747-3.840)
Number of fissions $\times 10^{-14}$ (fiss)	8.381	5.429	3.366	1.780
Fission density $\times 10^{-13}$ (fiss/g fuel)	2.533	2.734	3.389	5.360
Power ** (kW)	3396	2202	1369	726.3
Energy deposition (cal/g fuel)	178.1	192.5	239.1	379.1
Energy deposition (J/g fuel)	745.6	805.8	1000.9	1587
Energy deposition *** (per-unit)	0.470	0.508	0.631	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 0.00588 s

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

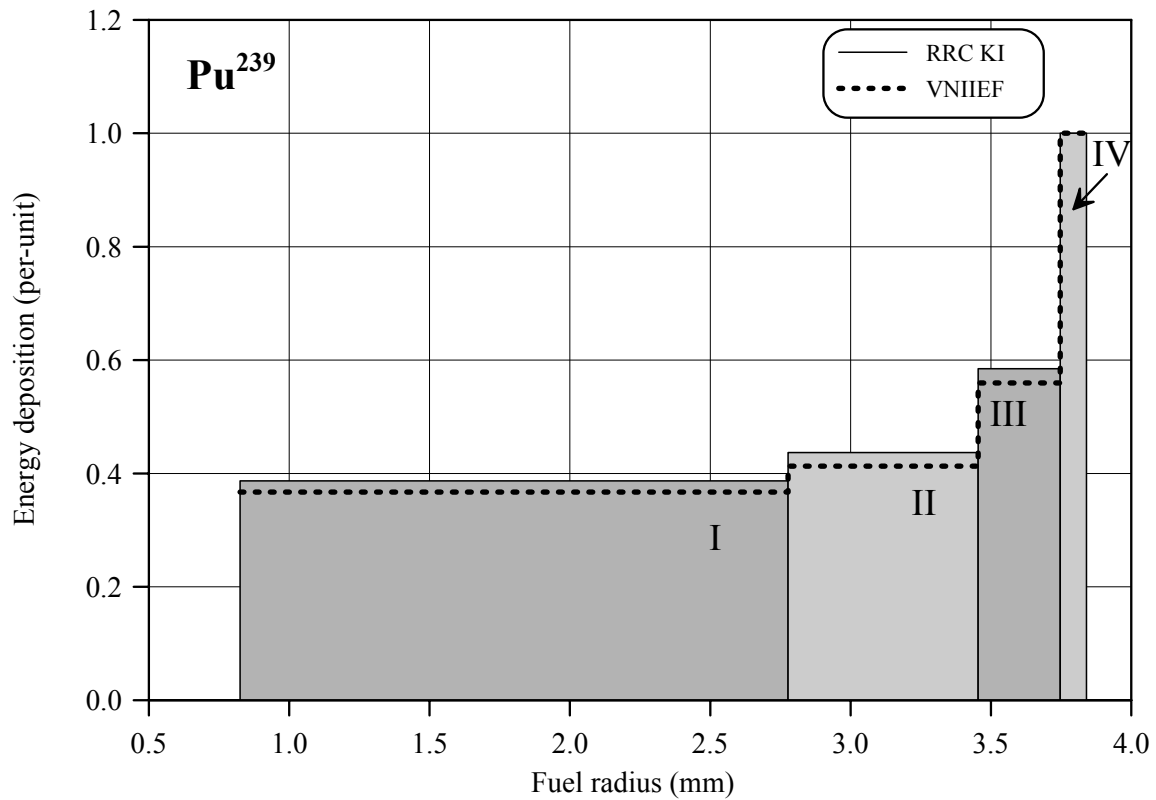
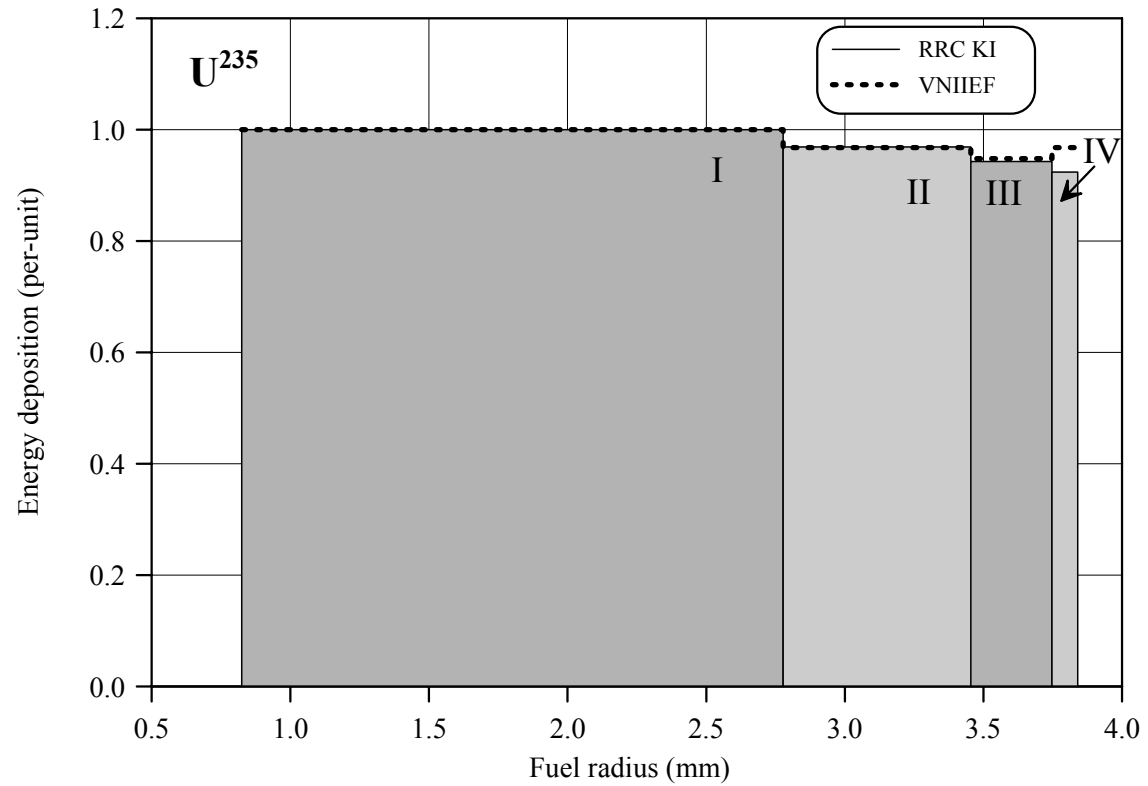


Fig.E-8.6. U^{235} and Pu^{239} radial distribution of energy deposition for fuel rod # RT8

RT8

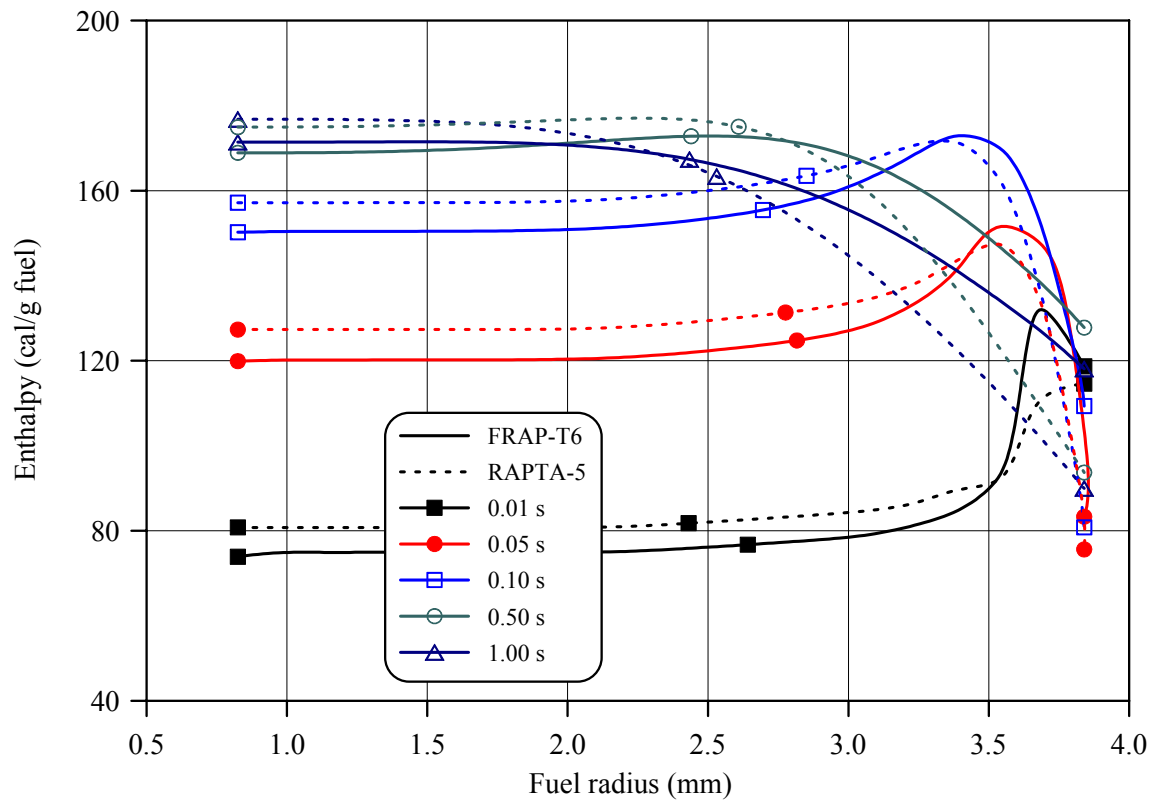
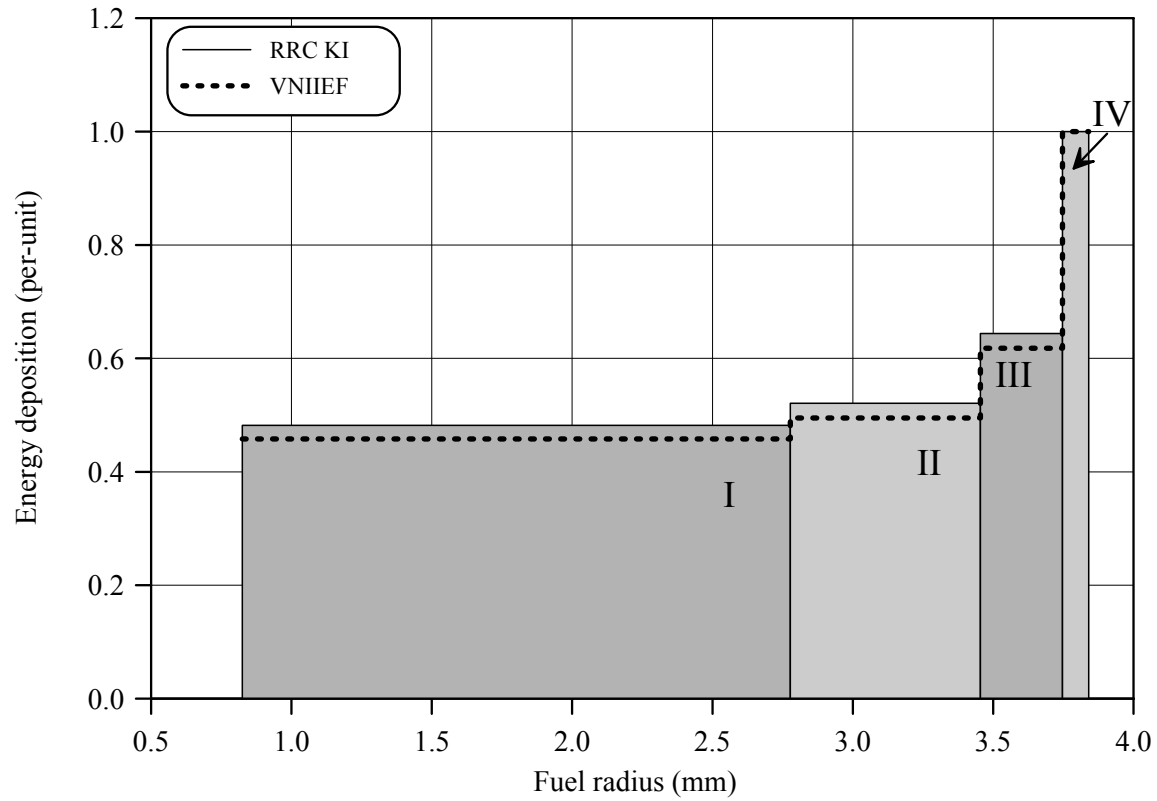


Fig.E-8.7. Radial distribution of energy deposition and fuel enthalpy for fuel rod # RT8

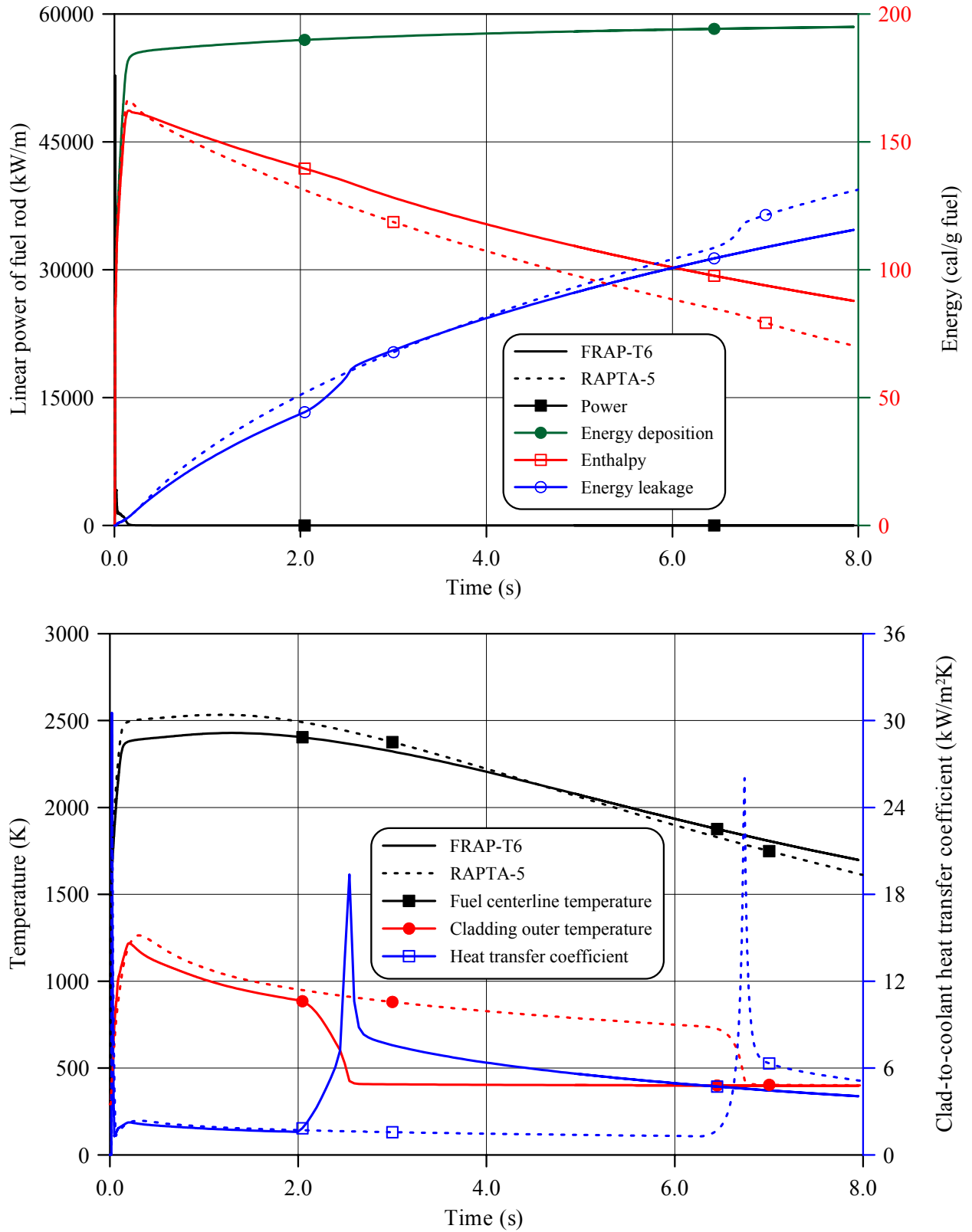


Fig.E-8.8. Thermal history of fuel rod # RT8 during the BIGH test in accordance with FRAP-T6/VVER and RAPTA-5 calculations

RT8

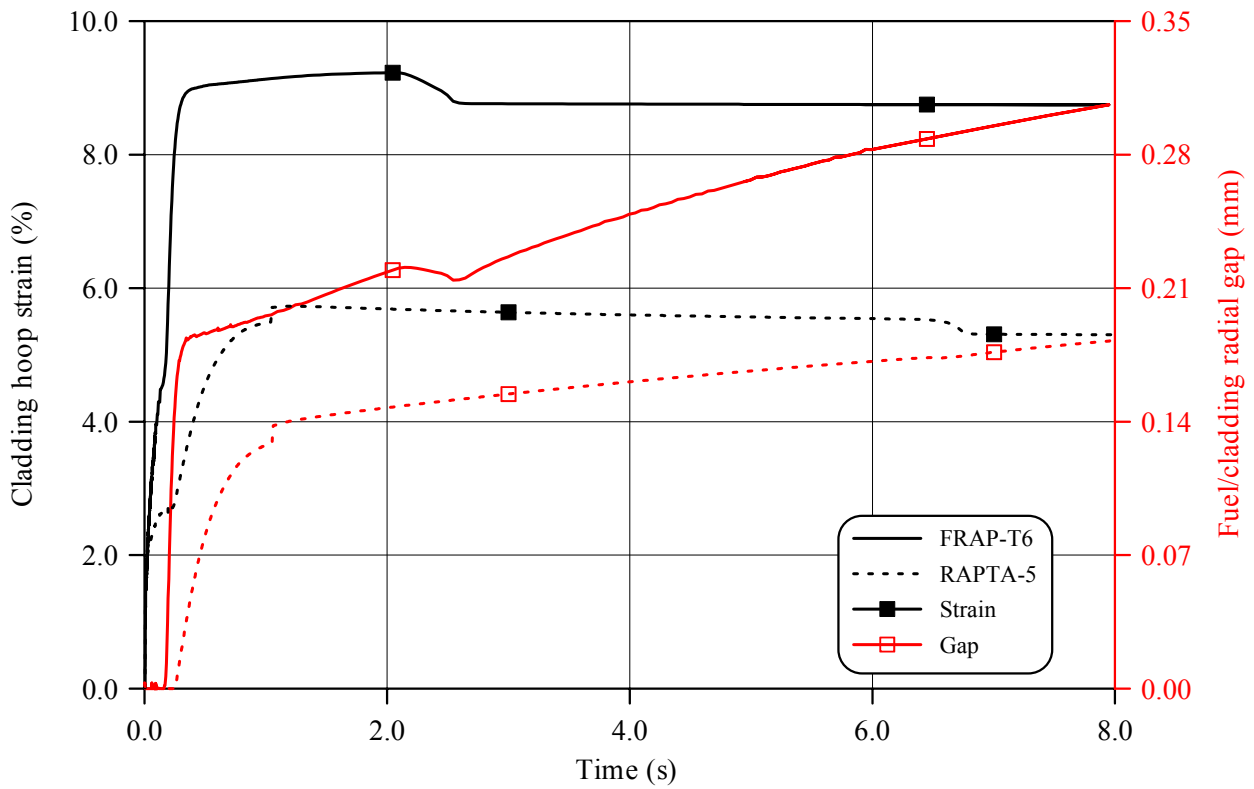
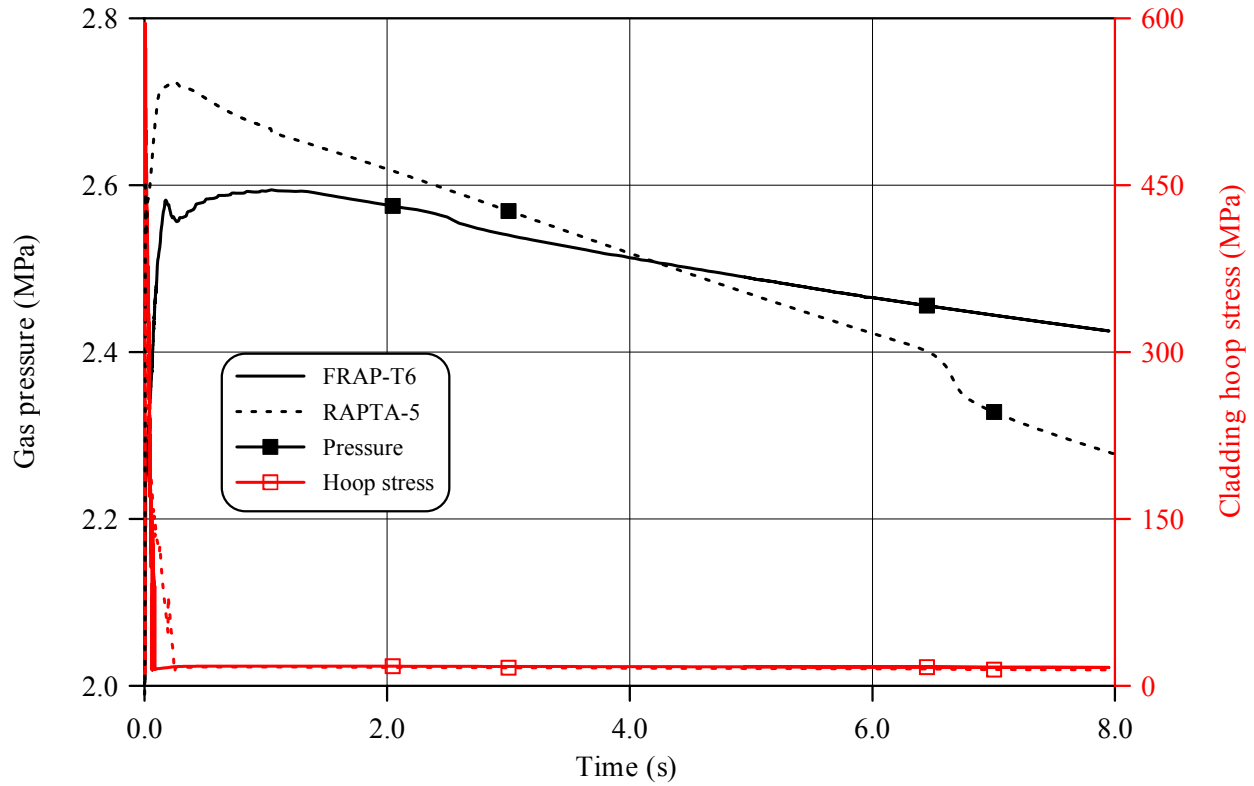


Fig.E-8.9. Mechanical behavior of fuel rod # RT8 during the BIGH test in accordance with FRAP-T6/VVER and RAPTA-5 calculations

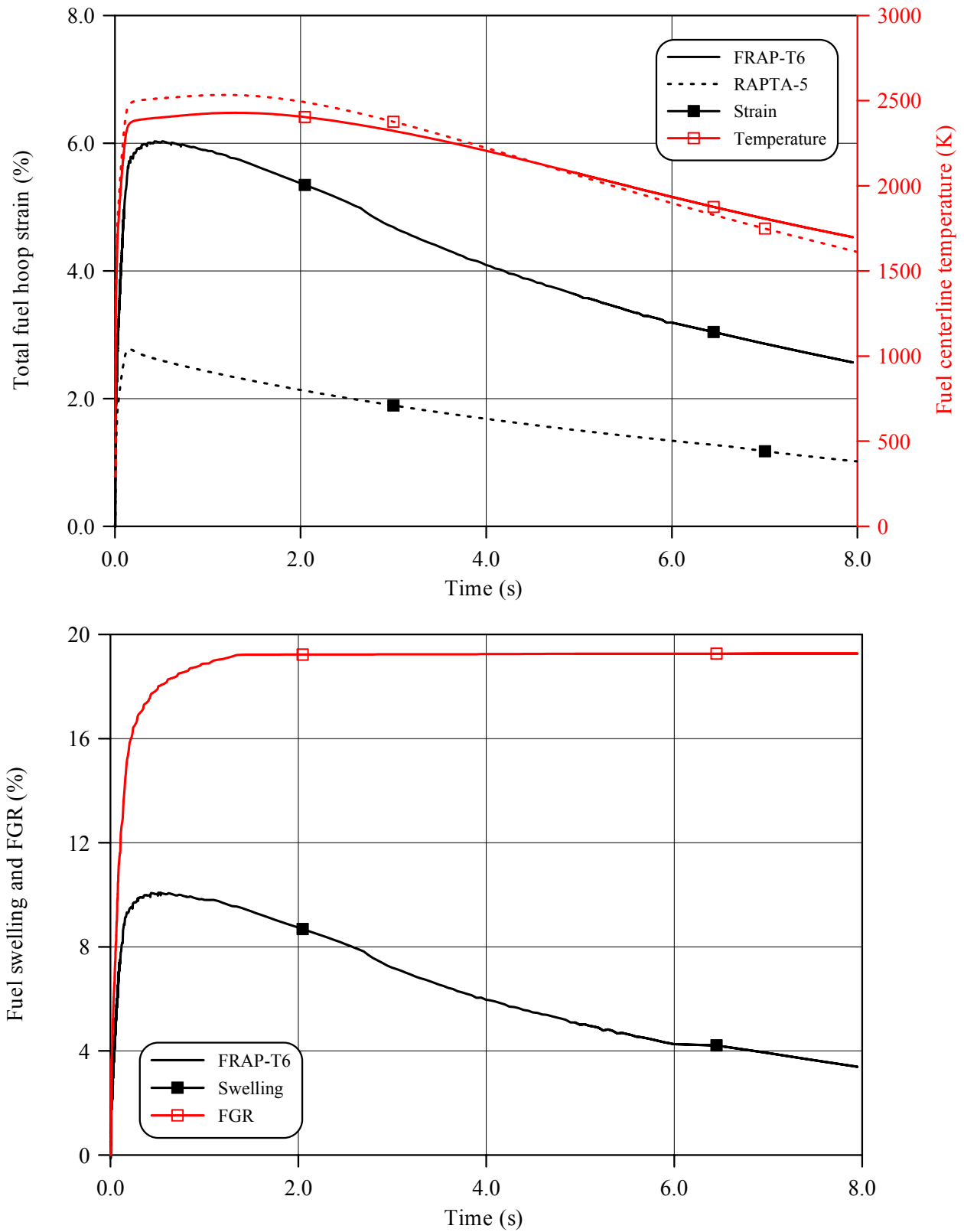


Fig.E-8.10. Fuel behavior during the BGR test of fuel rod # RT8 in accordance with FRAP-T6/VVER and RAPTA-5 calculations

RT8

Table E-8.3. Axial distribution of cladding average outer diameter in fuel rod # RT8*

Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)
7	9.128	45	9.663	83	9.695	121	9.703
9	9.223	47	9.694	85	9.713	123	9.655
11	9.290	49	9.783	87	9.714	125	9.626
13	9.326	51	9.914	89	9.723	127	9.649
15	9.296	53	10.058	91	9.702	129	9.734
17	9.257	55	10.085	93	9.701	131	9.824
19	9.247	57	9.938	95	9.733	133	9.801
21	9.277	59	9.795	97	9.731	135	9.680
23	9.343	61	9.745	99	9.688	137	9.670
25	9.409	63	9.716	101	9.620	139	9.694
27	9.496	65	9.701	103	9.642	141	9.715
29	9.584	67	9.680	105	9.733	143	9.703
31	9.626	69	9.664	107	9.783	145	9.650
33	9.645	71	9.681	109	9.751	147	9.613
35	9.634	73	9.733	111	9.663	149	9.602
37	9.619	75	9.745	113	9.608	151	9.567
39	9.651	77	9.728	115	9.615	153	9.521
41	9.676	79	9.681	117	9.670	155	9.442
43	9.673	81	9.659	119	9.705	157	9.261

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

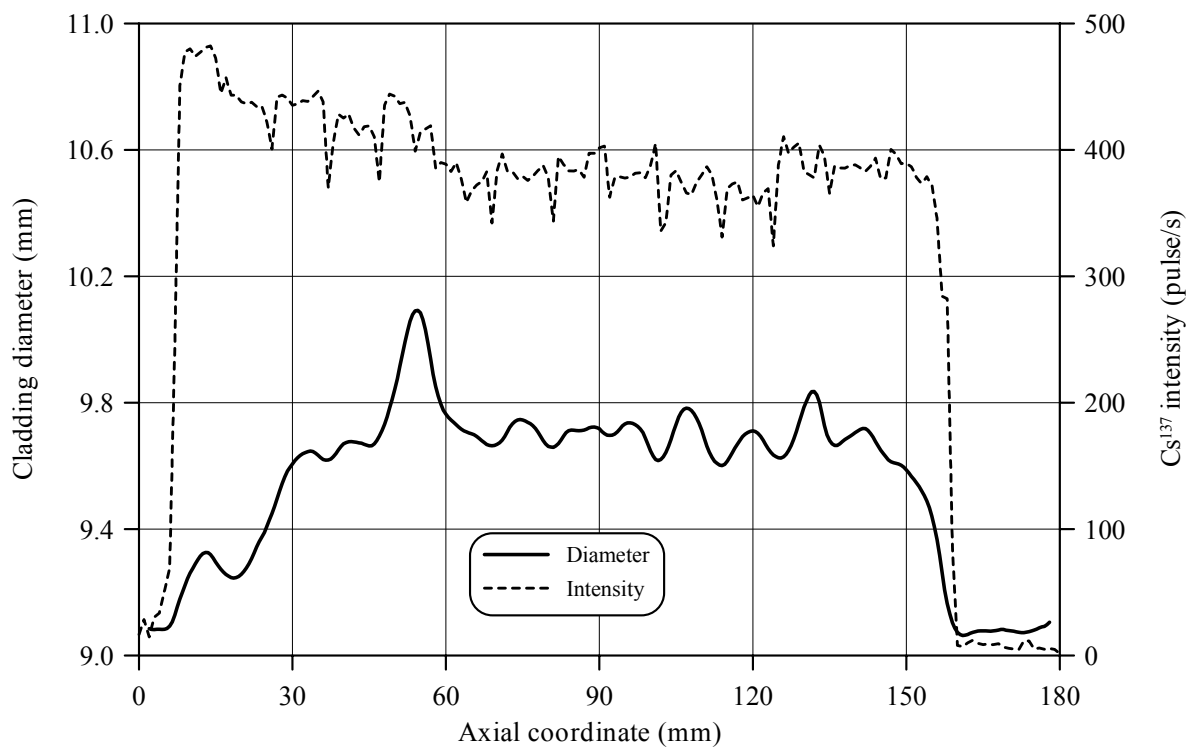


Fig.E-8.11. Cladding measured average diameter and γ -scanning results for fuel rod # RT8

Table E-8.4. The PIE results for fuel rod # RT8

Parameter		Value
1.	Cladding outer diameter (mm):	
1.1.	Maximum diameter of the bidimensional data sample in "fuel rod length - azimuthal angle" coordinates (mm)	10.35
1.2.	Averaged azimuthal diameter and maximum diameter along the length selected from the sample of averaged azimuthal diameter (mm)	10.09
1.3.	Averaged diameter of the bidimensional data sample in "fuel rod length - azimuthal angle" coordinates (mm)	9.60
2.	Cladding residual hoop strain (%):	
2.1.	Maximum hoop strain	11.10
2.2.	Hoop strain at rupture	11.1, 8.3
3.	Fuel pellet conditional diameter (mm) in cross-section*:	
	at 53 mm elevation	8.33
	at 97 mm elevation	8.28
	at 133 mm elevation	8.22
4.	ZrO ₂ outer thickness (μm) in cross-section:	
	at 53, 97, 133 mm elevations	5-7
5.	ZrO ₂ inner thickness (μm) in cross-section:	
	at 97 mm elevation	4
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

RT8

Table E-8.5. Organized BGR test results for fuel rod # RT8

Parameter	Unit	Value			
		Measured	Calculated		
			FRAP-T6	RAPTA-5	
1. Fuel burnup	MW d/kg U	60.2	60.2	60.2	
2. Initial gas pressure	MPa	2.0	2.0	2.0	
3. Energy deposition	cal/g fuel	201.7	201.7	201.7	
4. Peak fuel enthalpy*	cal/g fuel	-	162.3	166.4	
5. Fuel maximum temperature	K	-	2514	2580	
6. Maximum temperature of cladding outer surface	K	-	1219	1264	
7. Cladding burst	Failed, Unfailed	Failed	-**	-**	
8. Cladding residual hoop strain					
- average***	%	6.08	8.64	5.73	
- maximum	%	11.10	8.64	5.73	

* Average value of peak fuel enthalpy 164.3 cal/g fuel

** This parameter was not calculated

*** Average value along the fuel stack length

Appendix E–9
Individual Characteristics of Fuel Rod # RT9
after the BGR Test

RT9

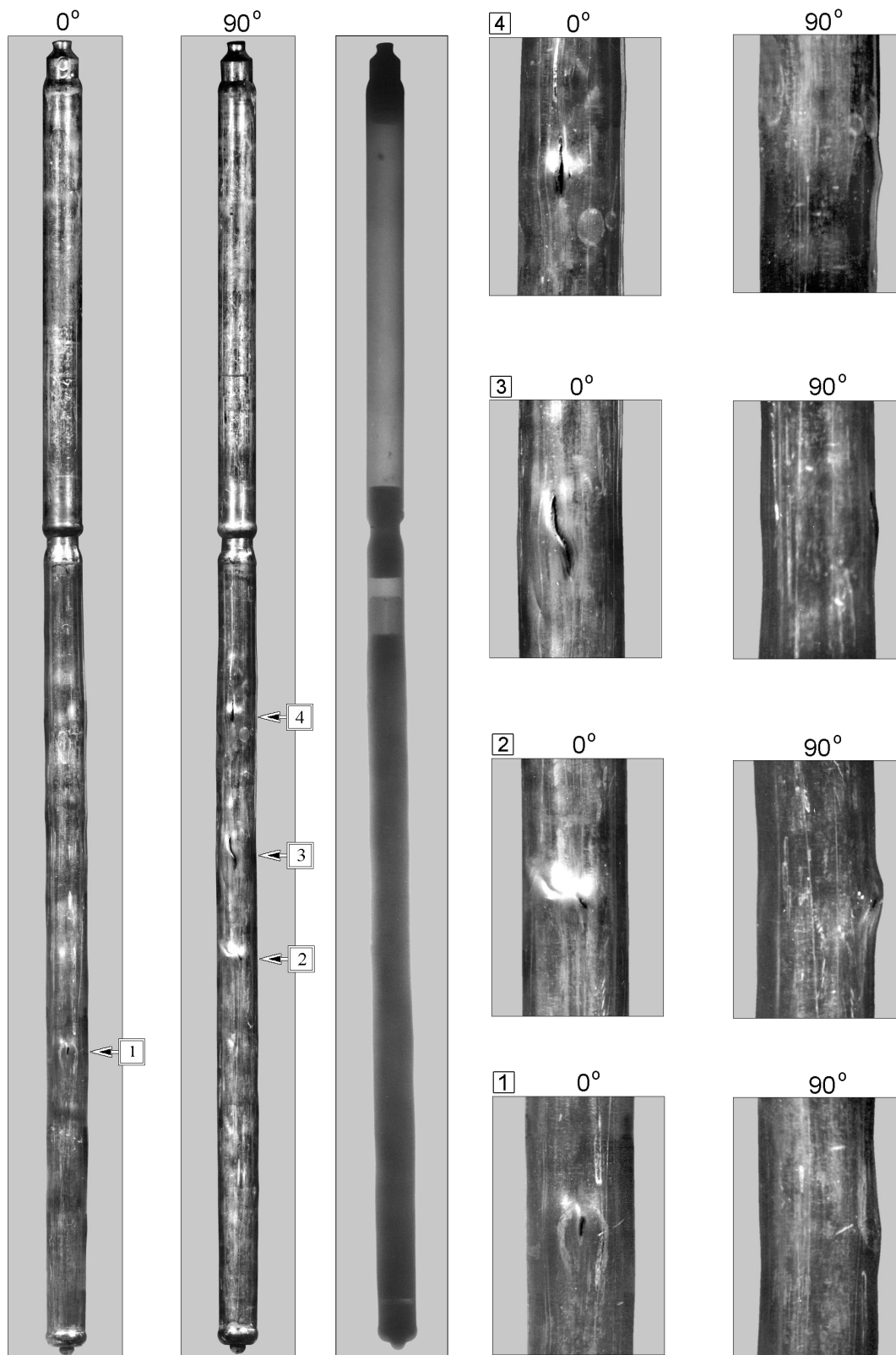


Fig.E-9.1. Appearance of failed fuel rod # RT9 after the BGR test (photographs and X-ray photograph)

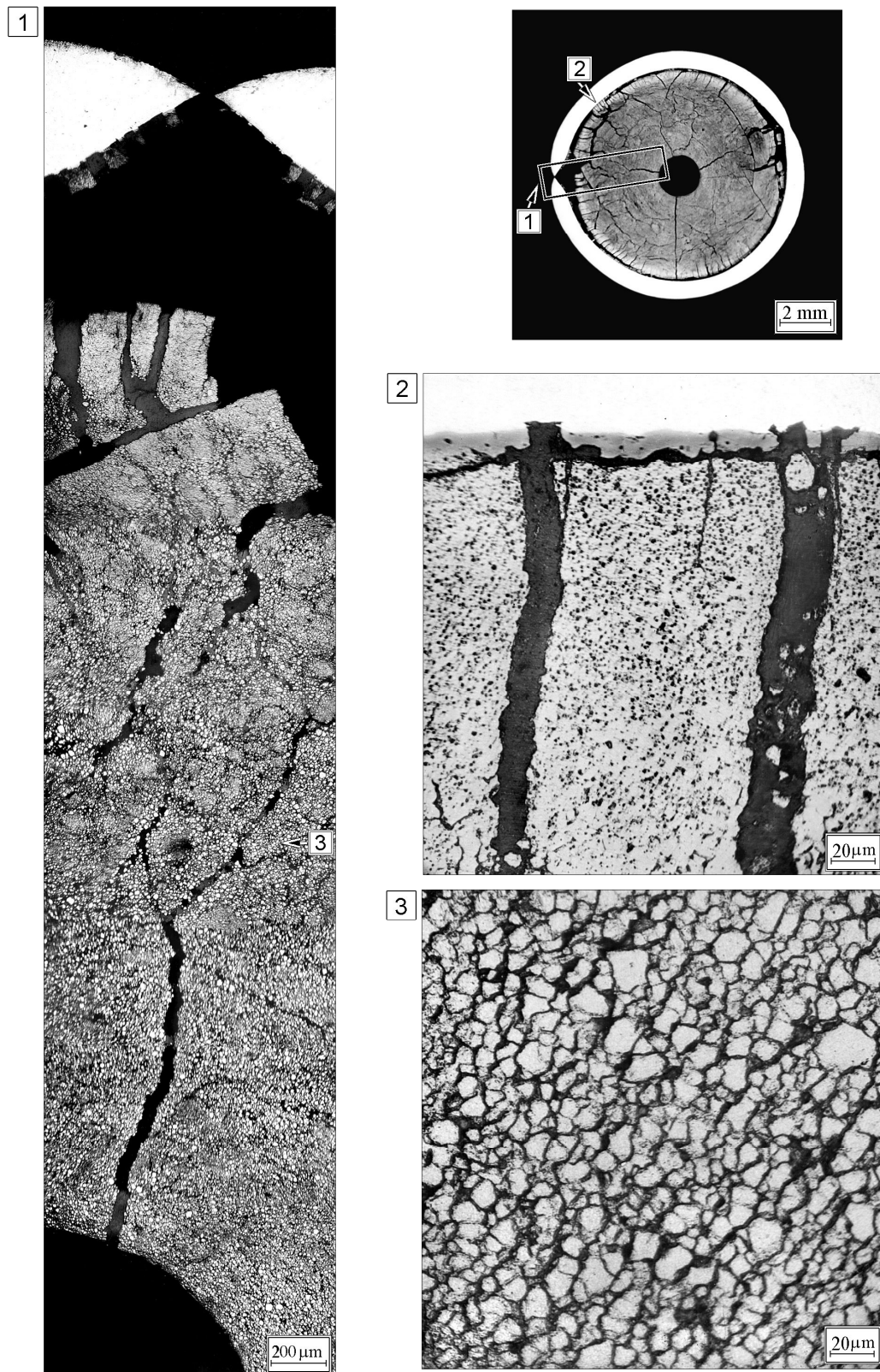


Fig.E-9.2. Cross-section and microstructure of fuel and cladding of fuel rod # RT9 at 69 mm elevation (from low cap)

RT9

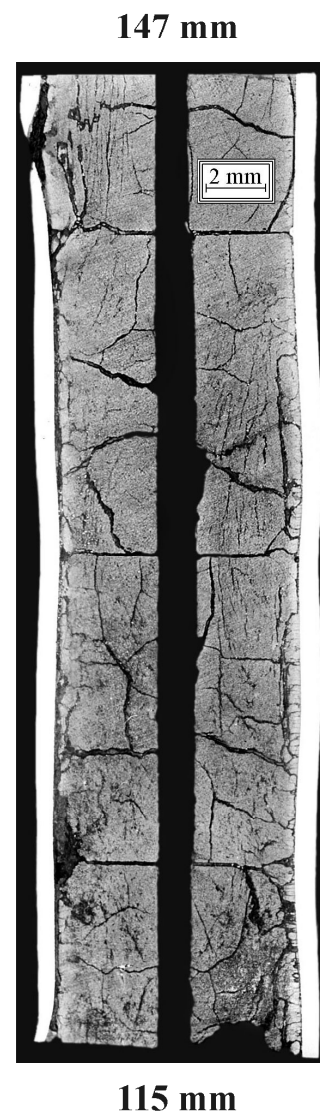
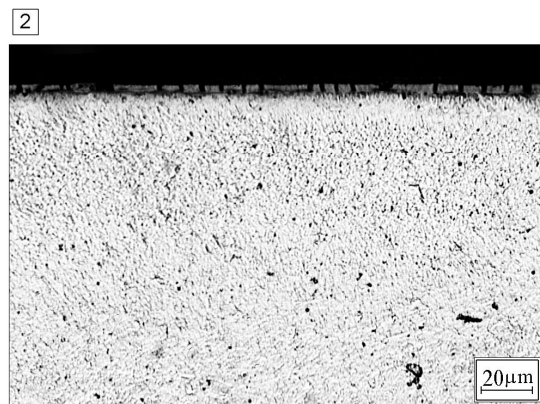
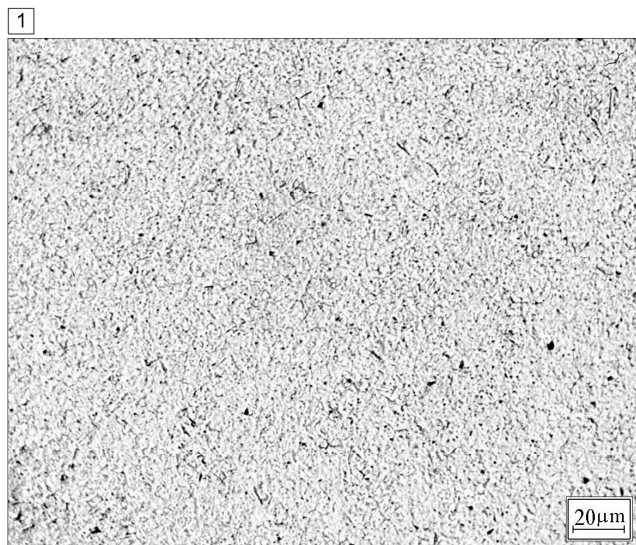
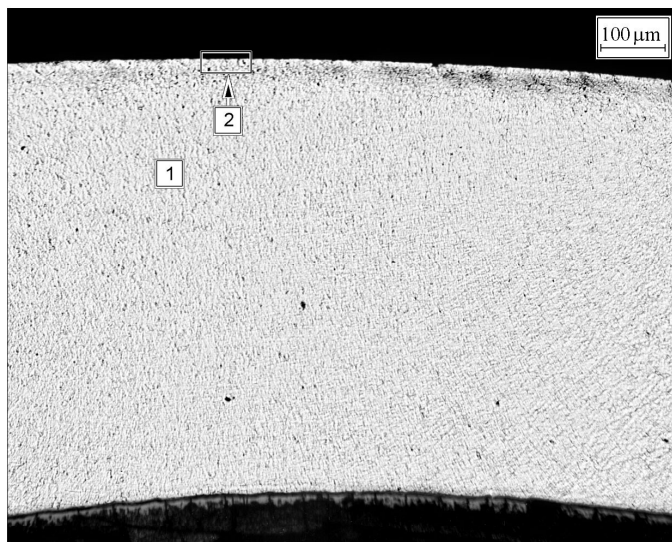


Fig.E-9.3. Cladding microstructure at 69 mm elevation (from low cap) and longitudinal metallographic specimen image of fuel rod # RT9

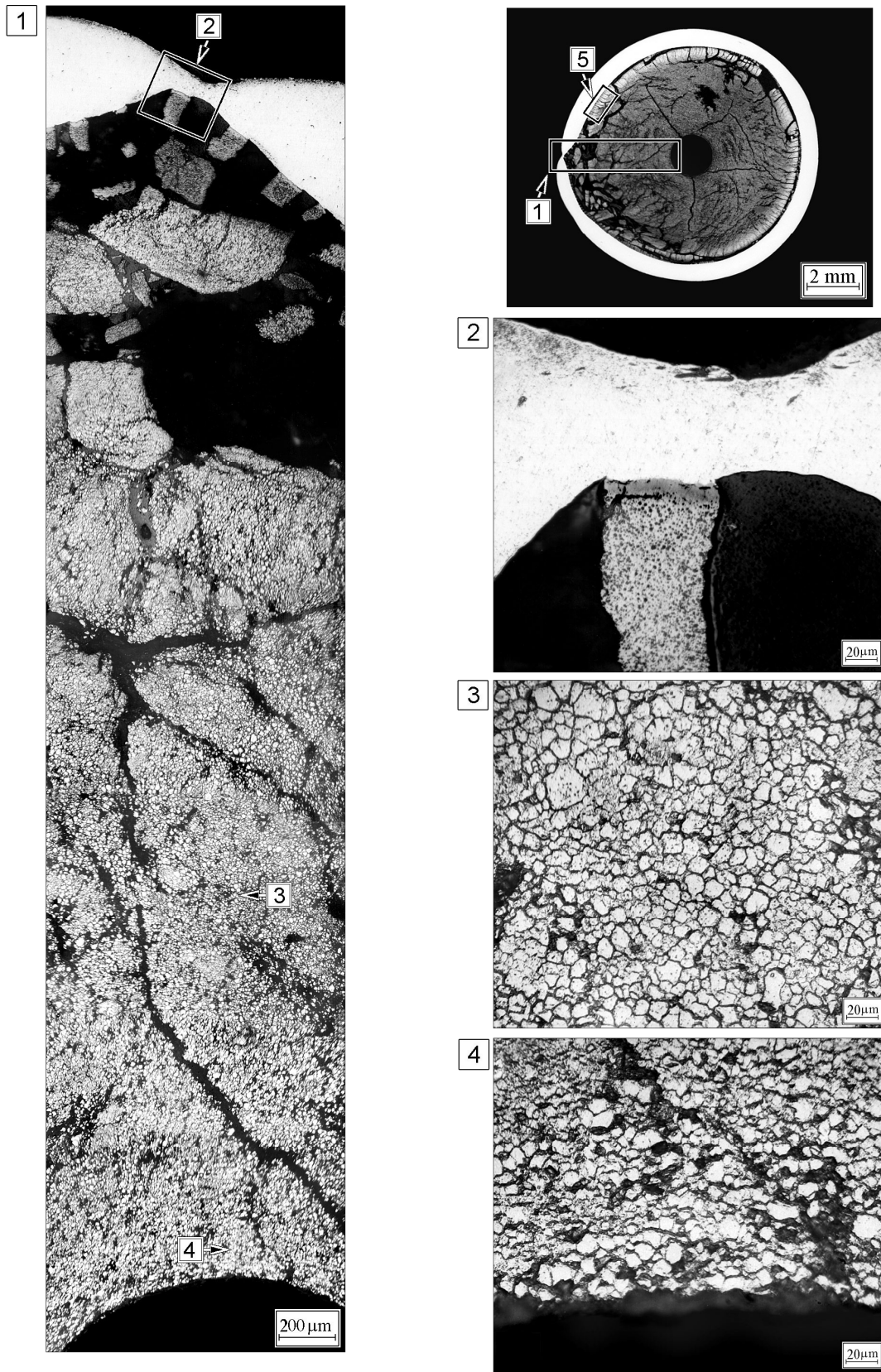


Fig.E-9.4. Cross-section and microstructure of fuel and cladding of fuel rod # RT9 at 88 mm elevation (from low cap)

RT9

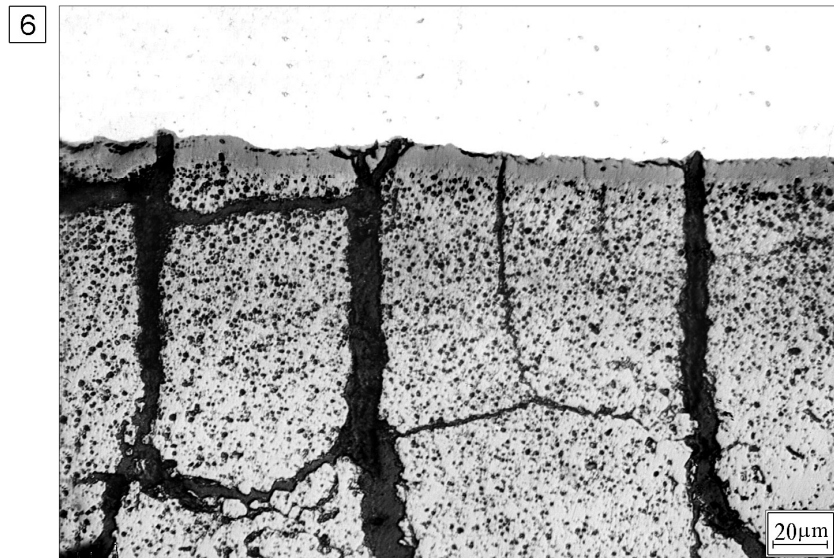
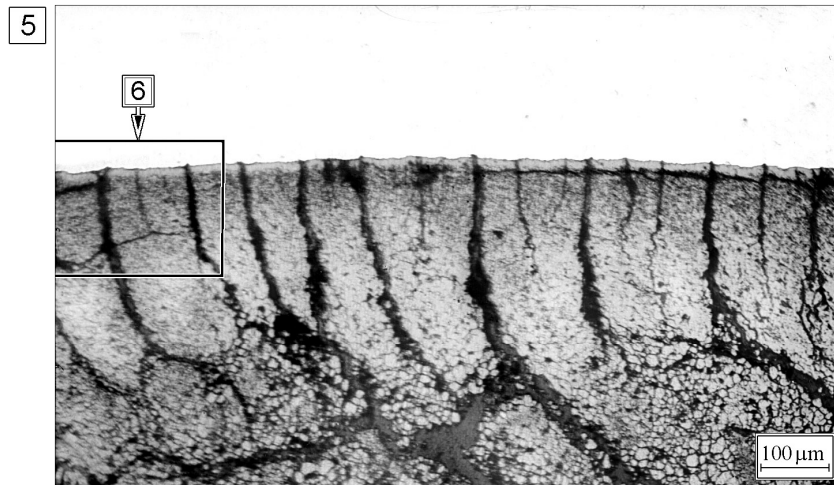
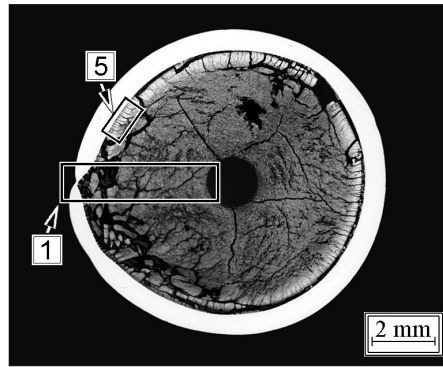


Fig.E-9.5. Microstructure of fuel and cladding in their interaction area for fuel rod # RT9 at 88 mm elevation (from low cap)

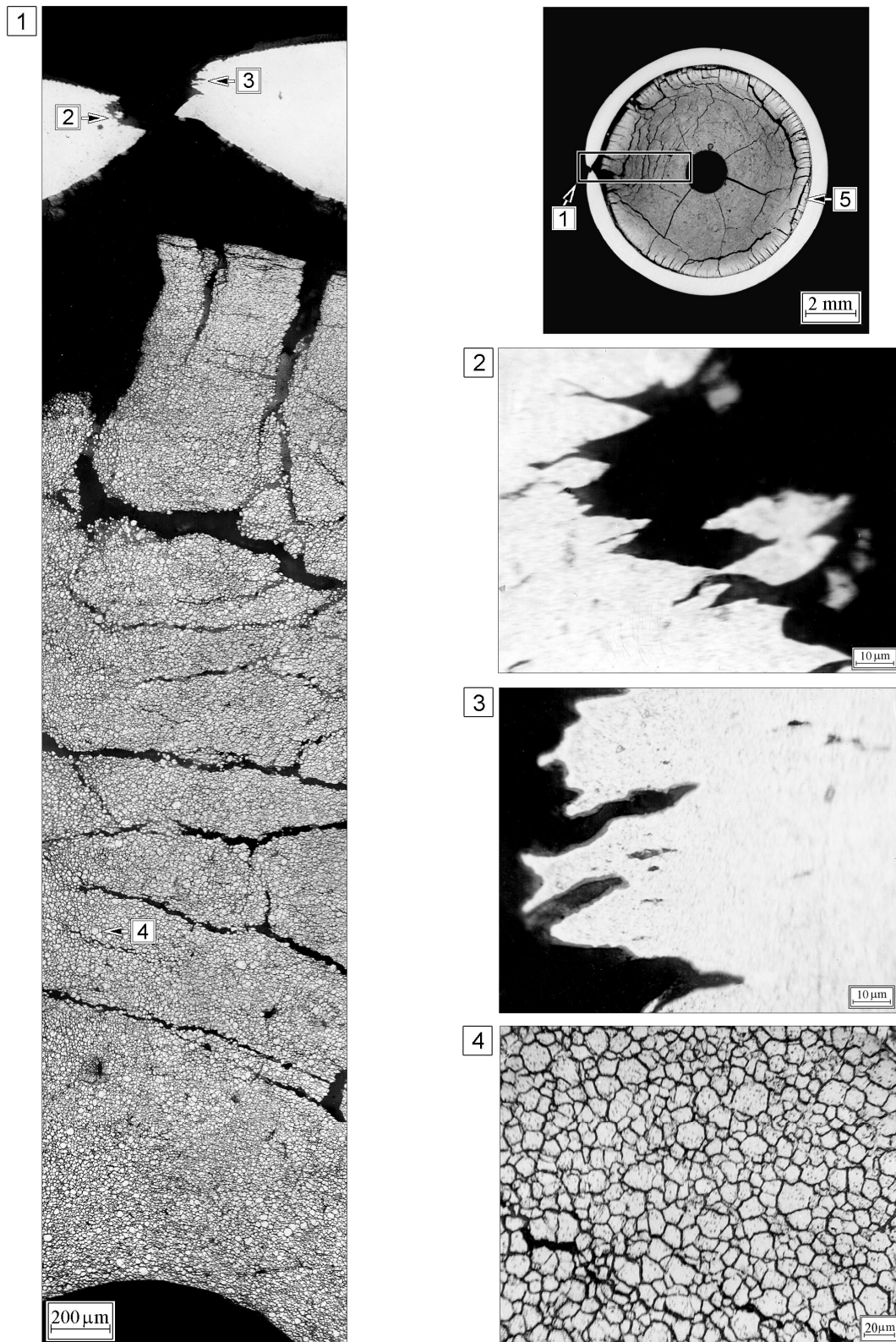


Fig.E-9.6. Cross-section and microstructure of fuel and cladding of fuel rod # RT9 at 110 mm elevation (from low cap)

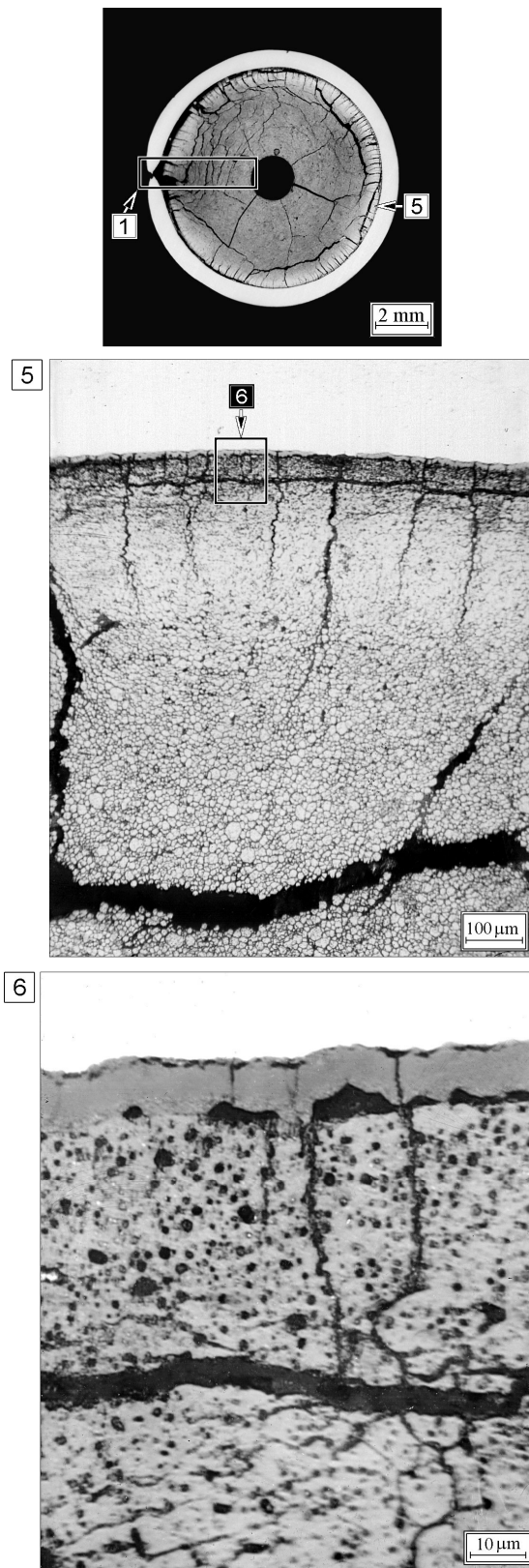


Fig.E-9.7. Microstructure of fuel and cladding in their interaction area for fuel rod # RT9 at 110 mm elevation (from low cap)

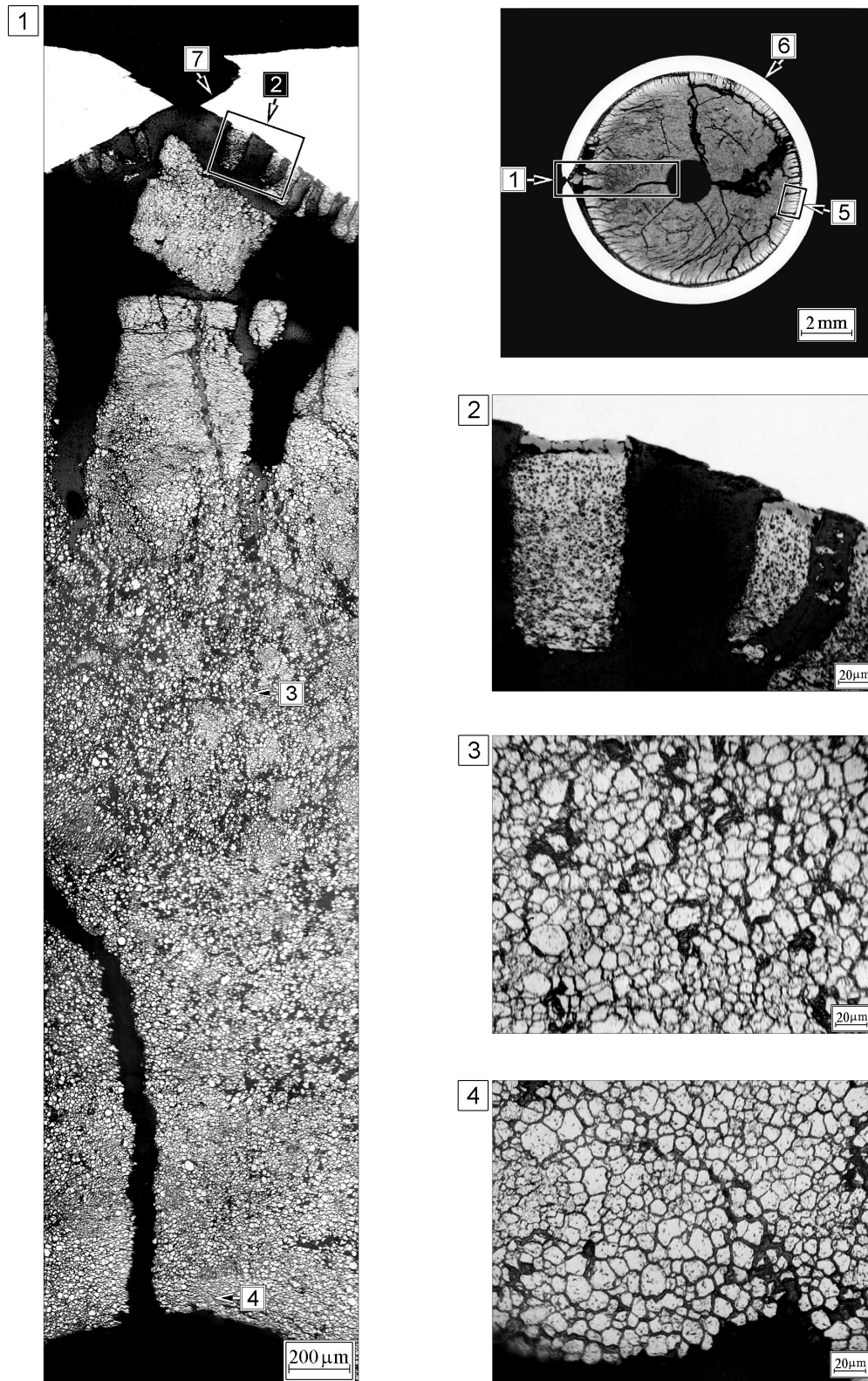


Fig.E-9.8. Cross-section and microstructure of fuel and cladding of fuel rod # RT9 at 144 mm elevation (from low cap)

RT9

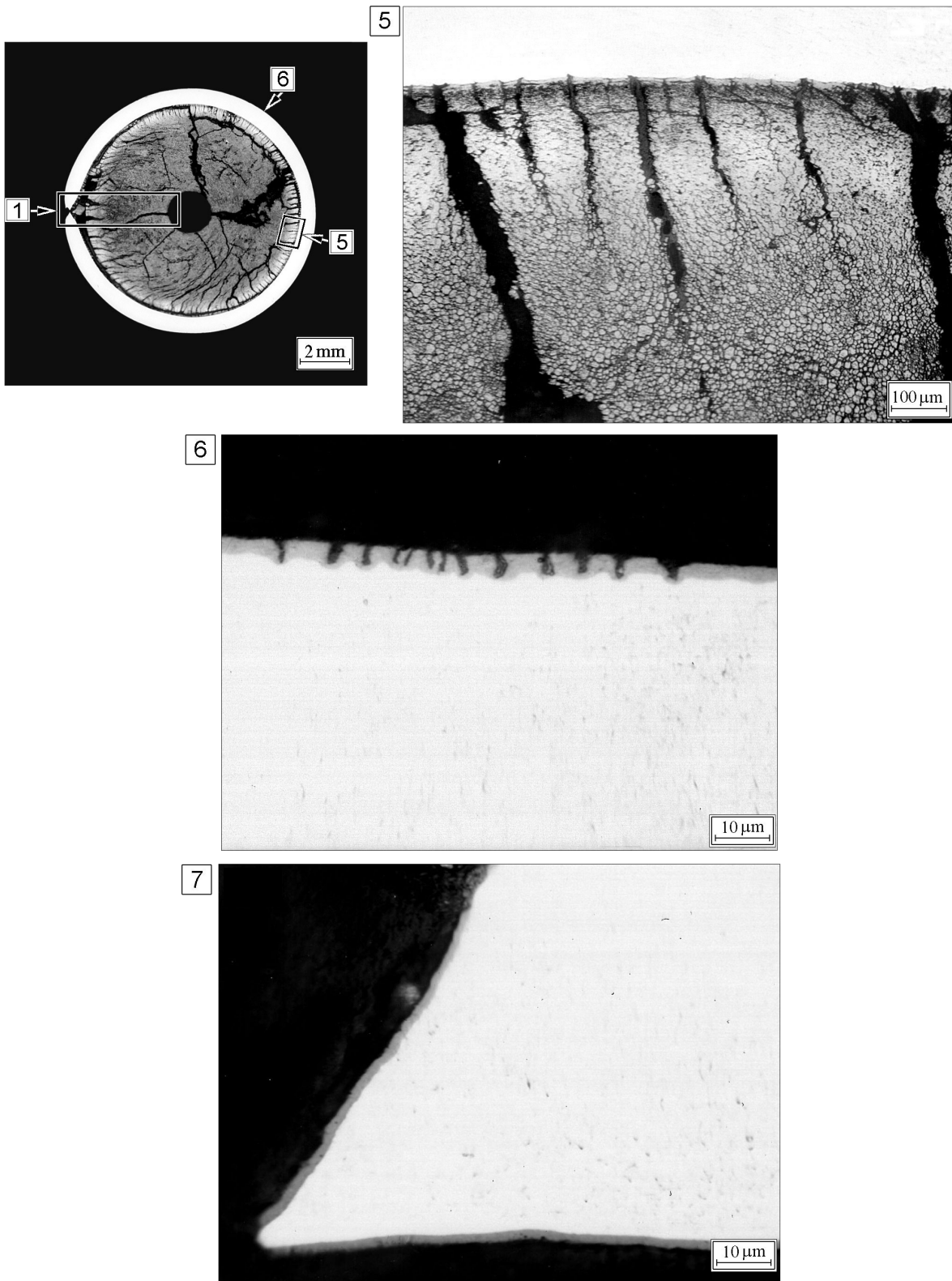


Fig.E-9.9. Fuel and cladding microstructures in their interaction area, cladding microstructure in the burst area at 144 mm elevation (from low cap) for fuel rod # RT9

Table E-9.1. Time dependent energy characteristics of fuel rod # RT9

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	0.00E+00	0.000	0.000	0.000	0.000	0.000	0.000
0.001	3.10E-03	0.040	22.09	0.041	0.173	0.671	0.044
0.002	1.31E-02	0.211	93.19	0.218	0.911	0.671	0.213
0.003	5.73E-02	0.961	408.0	0.990	4.143	1.257	1.037
0.004	2.40E-01	4.153	1705	4.283	17.93	4.653	4.408
0.005	6.88E-01	15.16	4895	15.62	65.38	16.101	16.216
0.006	9.98E-01	37.52	7104	38.64	161.8	39.125	40.065
0.007	6.70E-01	59.06	4767	60.82	254.7	61.314	62.915
0.008	3.19E-01	70.98	2269	73.10	306.0	73.501	75.284
0.009	1.55E-01	76.58	1103	78.87	330.2	79.094	80.938
0.010	9.19E-02	79.51	654.8	81.91	342.9	81.940	83.814
0.012	5.93E-02	82.98	422.2	85.52	358.1	85.168	86.986
0.014	6.09E-02	85.98	433.6	88.56	370.8	87.826	89.659
0.016	7.20E-02	89.32	513.0	91.96	385.0	90.861	92.773
0.018	8.32E-02	93.20	592.4	95.97	401.8	94.503	96.536
0.020	8.64E-02	97.43	615.1	100.4	420.1	98.522	100.700
0.022	8.11E-02	101.7	577.3	104.7	438.2	102.487	104.809
0.024	7.01E-02	105.6	499.5	108.6	454.7	106.028	108.464
0.026	5.82E-02	108.7	414.5	111.9	468.4	108.974	111.515
0.028	4.75E-02	111.1	338.1	114.6	479.7	111.362	113.964
0.030	3.86E-02	113.6	275.4	116.8	489.0	113.405	115.907
0.050	3.01E-02	129.2	214.8	133.3	558.2	127.090	129.994
0.070	2.74E-02	143.4	195.0	147.8	618.7	135.847	142.414
0.090	2.31E-02	156.1	164.4	160.6	672.3	145.515	153.144
0.110	1.78E-02	166.3	127.1	171.3	717.2	154.950	161.897
0.130	8.36E-03	173.1	59.70	178.1	745.7	160.310	166.618
0.150	3.09E-03	175.2	22.14	180.7	756.5	161.988	167.474
0.200	7.25E-04	177.3	5.351	182.8	765.1	162.116	165.632
1.000	8.18E-05	180.2	0.712	186.1	779.1	145.296	142.784
10.00	9.48E-06	186.5	0.094	194.1	812.4	77.015	42.662
100.0	1.91E-07	189.1	0.004	199.1	833.6	8.681	4.998
1000	7.50E-13	189.2	1.70E-04	200.9	841.1	0.000	0.000

¹⁾ Average values determined in accordance with results of RRC KI and VNIIEF calculations²⁾ Maximum power value is 7120.5 kW (t=0.00594 s)³⁾ Average radial value

RT9

Table E-9.2. Radial energy characteristics of fuel rod # RT9*

Parameters	Coordinates of fuel radial layers (mm)			
	1 layer (0.825-2.777)	2 layer (2.777-3.454)	3 layer (3.454-3.747)	4 layer (3.747-3.840)
Number of fissions $\times 10^{-14}$ (fiss)	8.494	5.371	3.326	1.737
Fission density $\times 10^{-13}$ (fiss/g fuel)	2.567	2.705	3.349	5.230
Power ** (kW)	3190	2020	1254	657.0
Energy deposition (cal/g fuel)	180.1	190.0	235.8	369.2
Energy deposition (J/g fuel)	754.0	795.6	987.1	1546
Energy deposition *** (per-unit)	0.488	0.515	0.639	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 0.00594 s

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

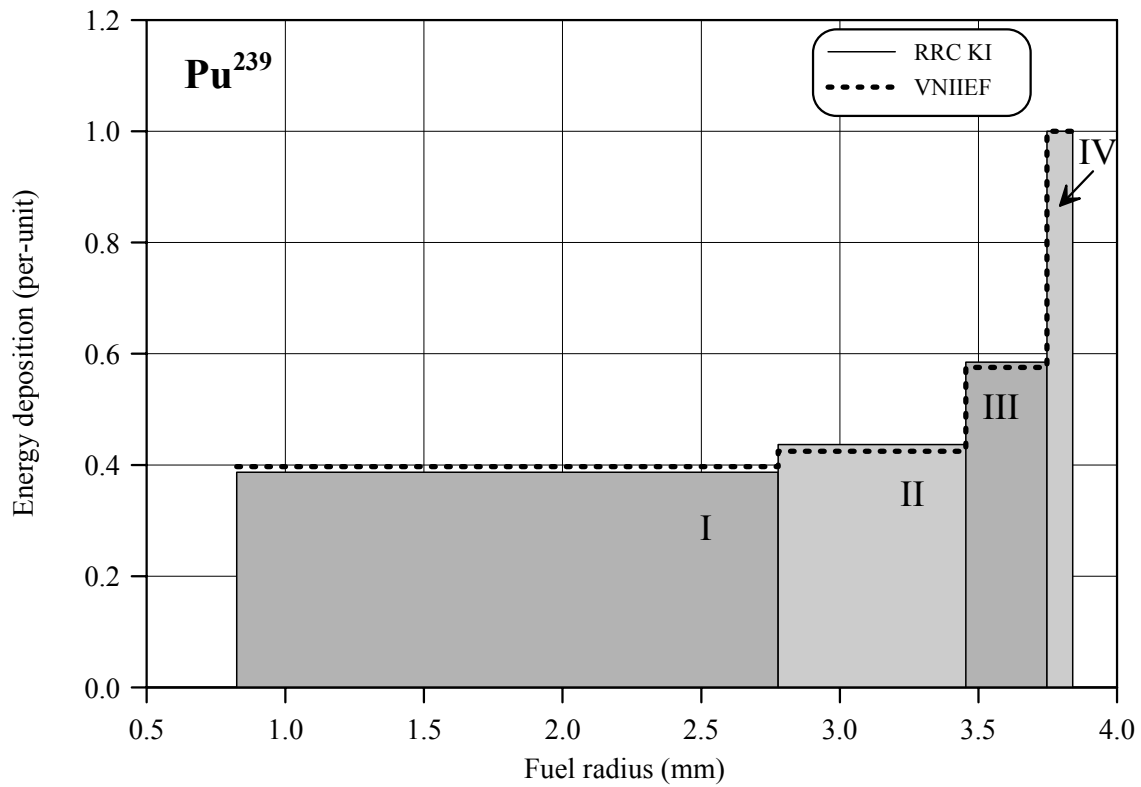
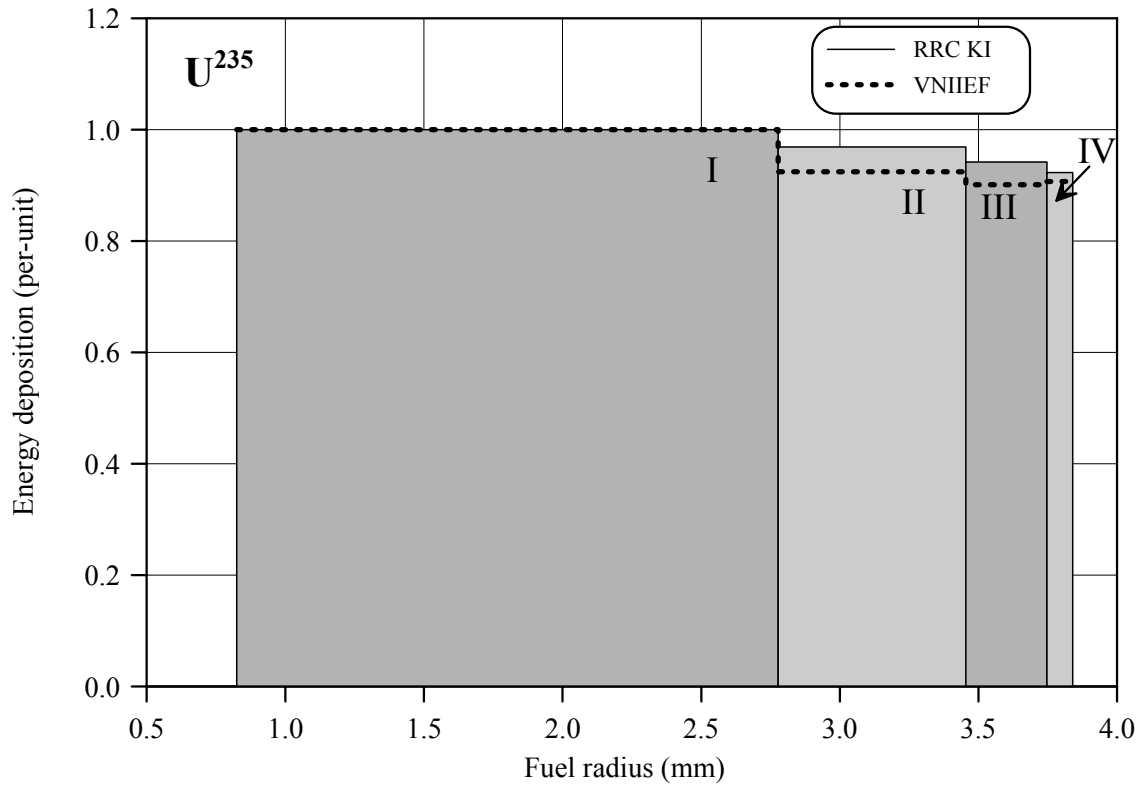


Fig.E-9.10. U^{235} and Pu^{239} radial distribution of energy deposition for fuel rod # RT9

RT9

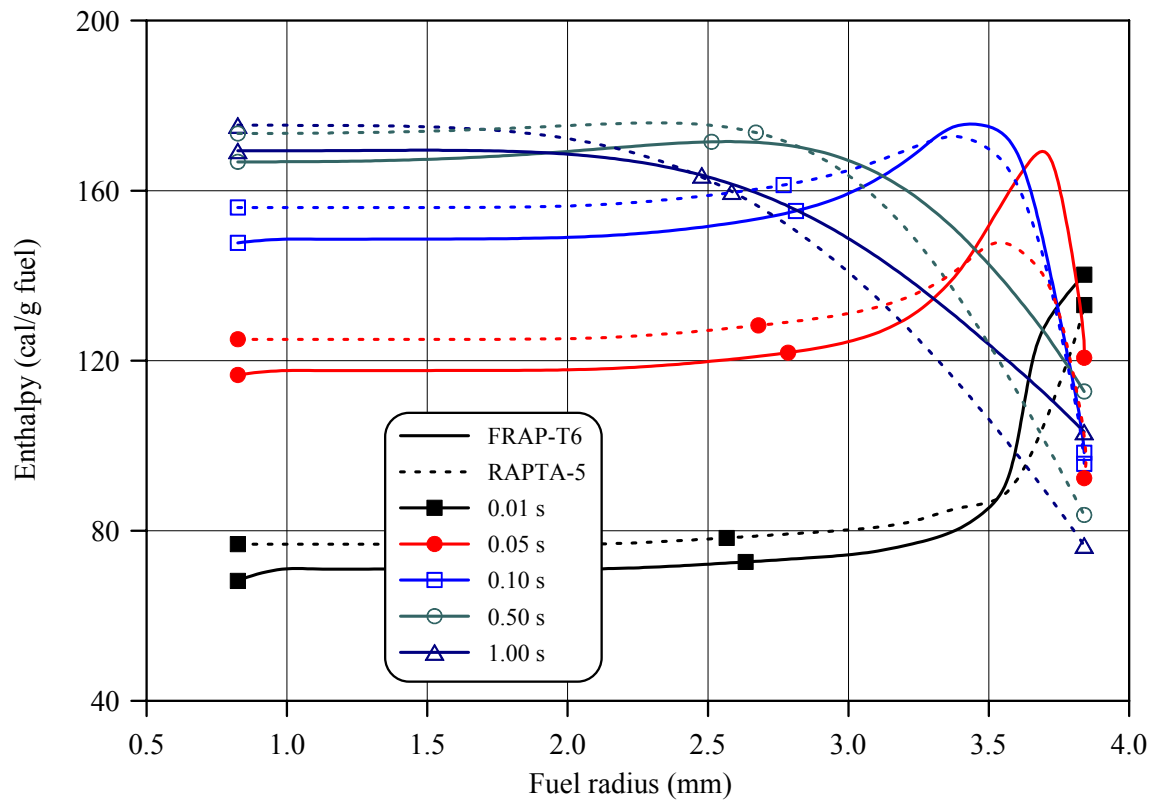
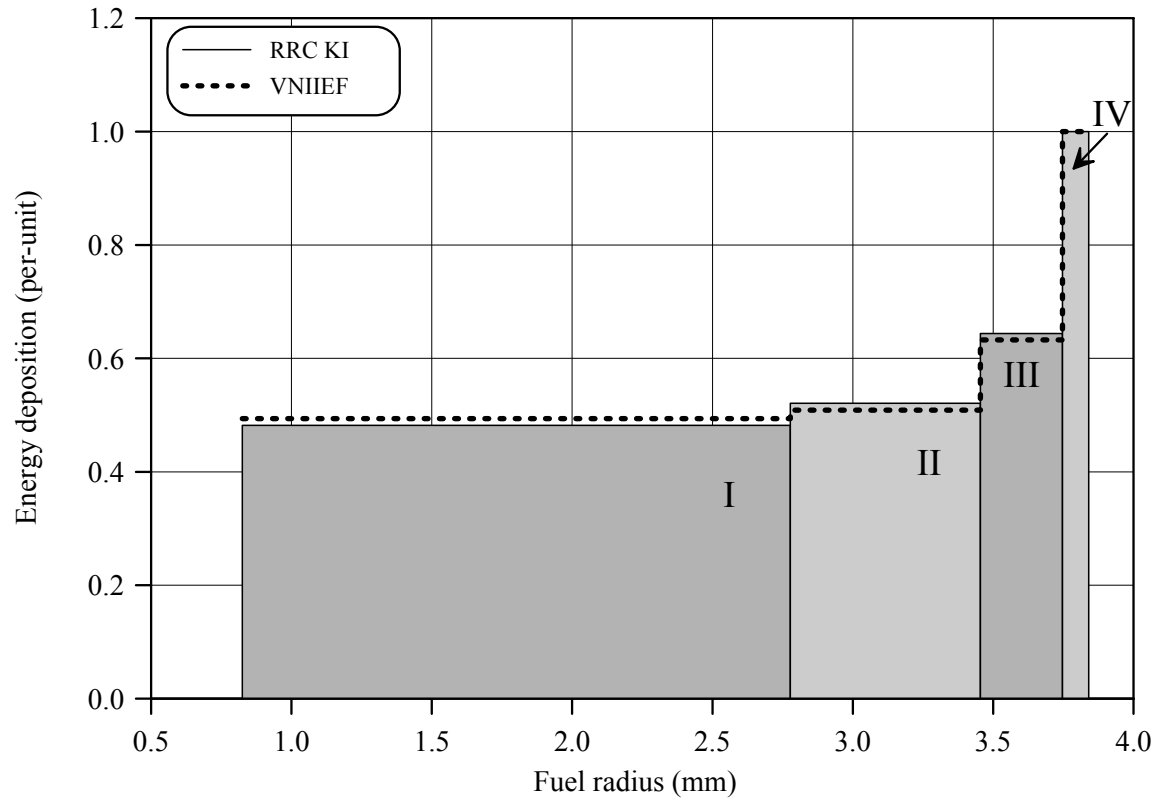


Fig.E-9.11. Radial distribution of energy deposition and fuel enthalpy for fuel rod # RT9

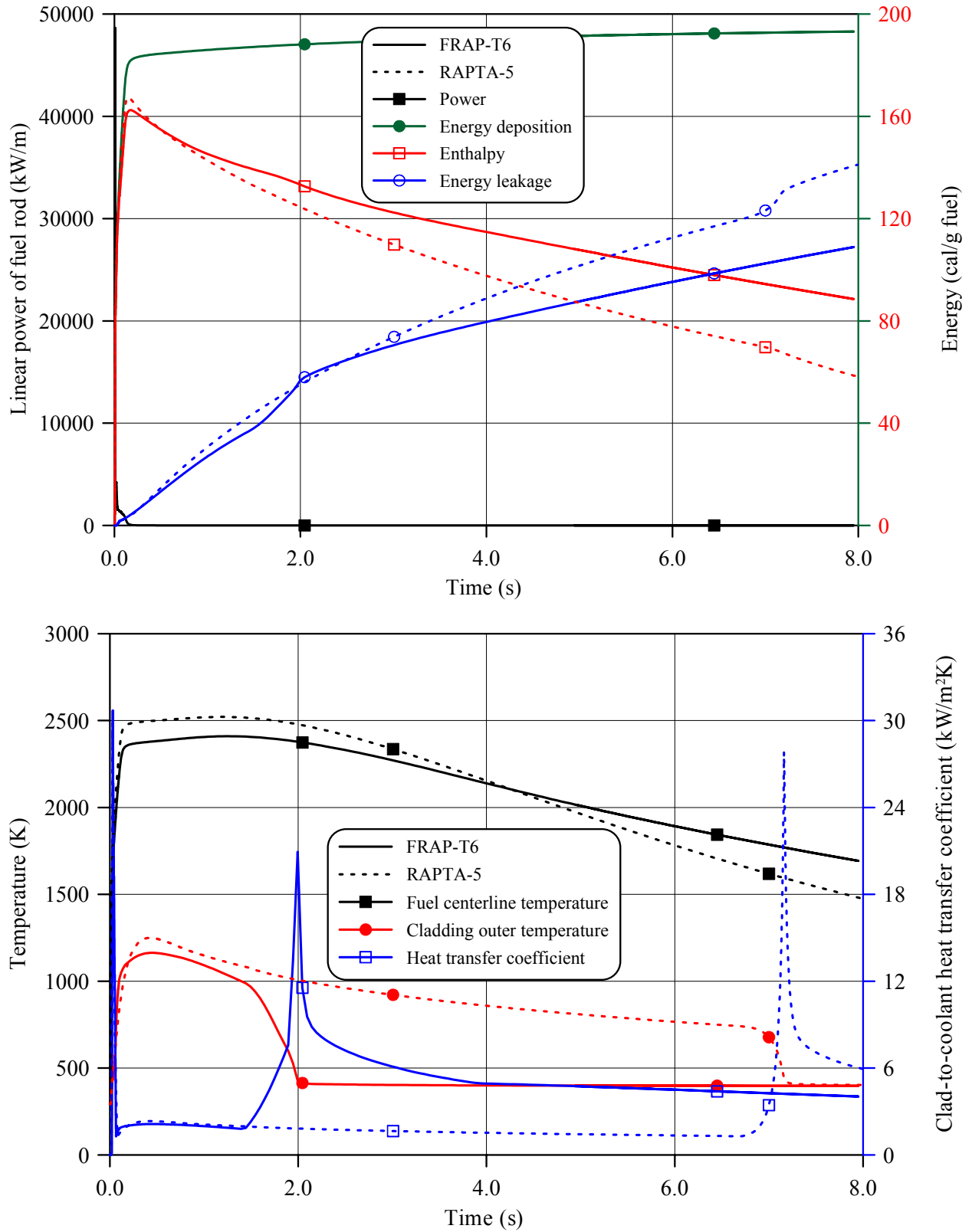


Fig.E-9.12. Thermal history of fuel rod # RT9 during the BGR test in accordance with FRAP-T6/VVER and RAPTA-5 calculations

RT9

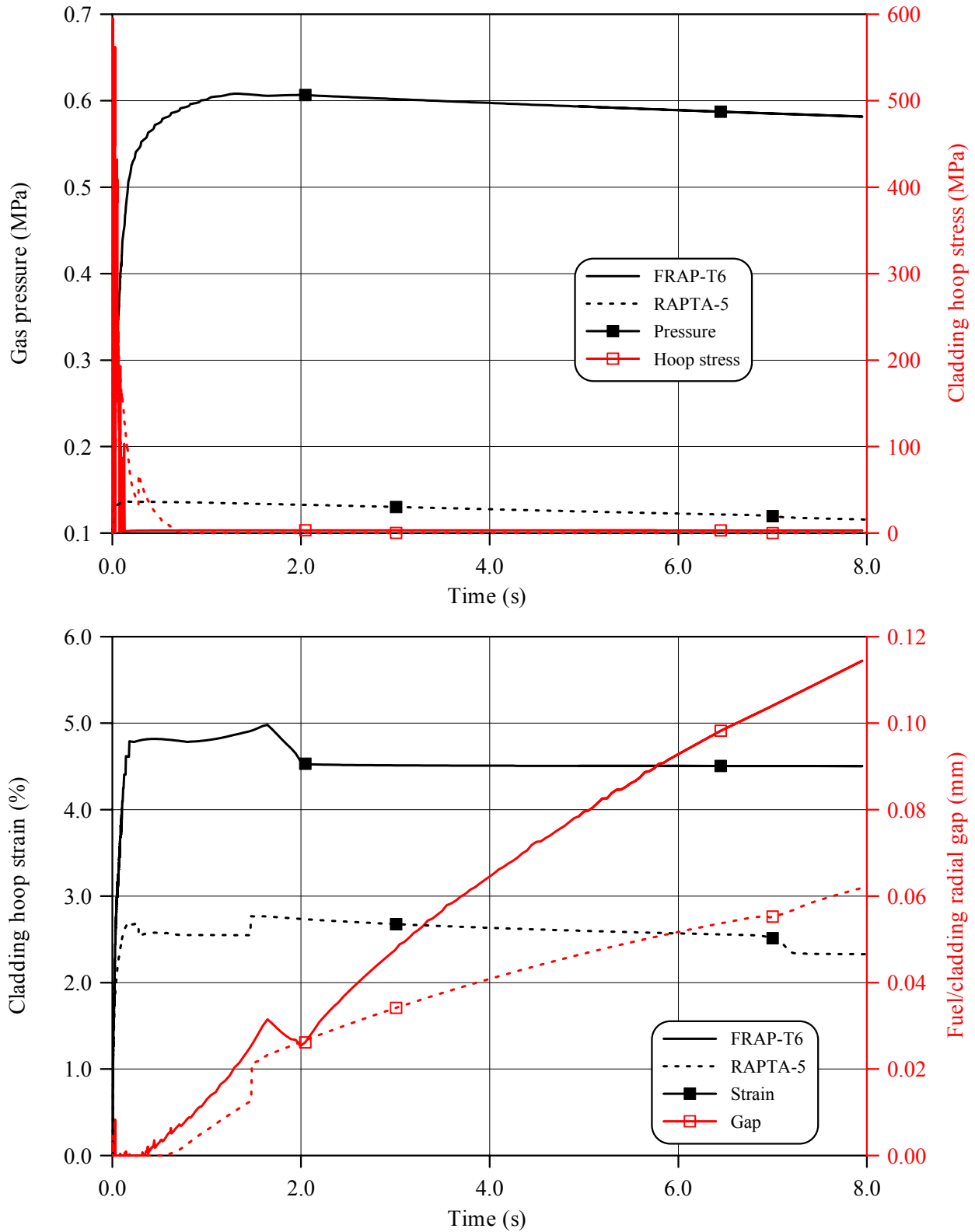


Fig.E-9.13. Mechanical behavior of fuel rod # RT9 during the BGR test in accordance with FRAP-T6/VVER and RAPTA-5 calculations

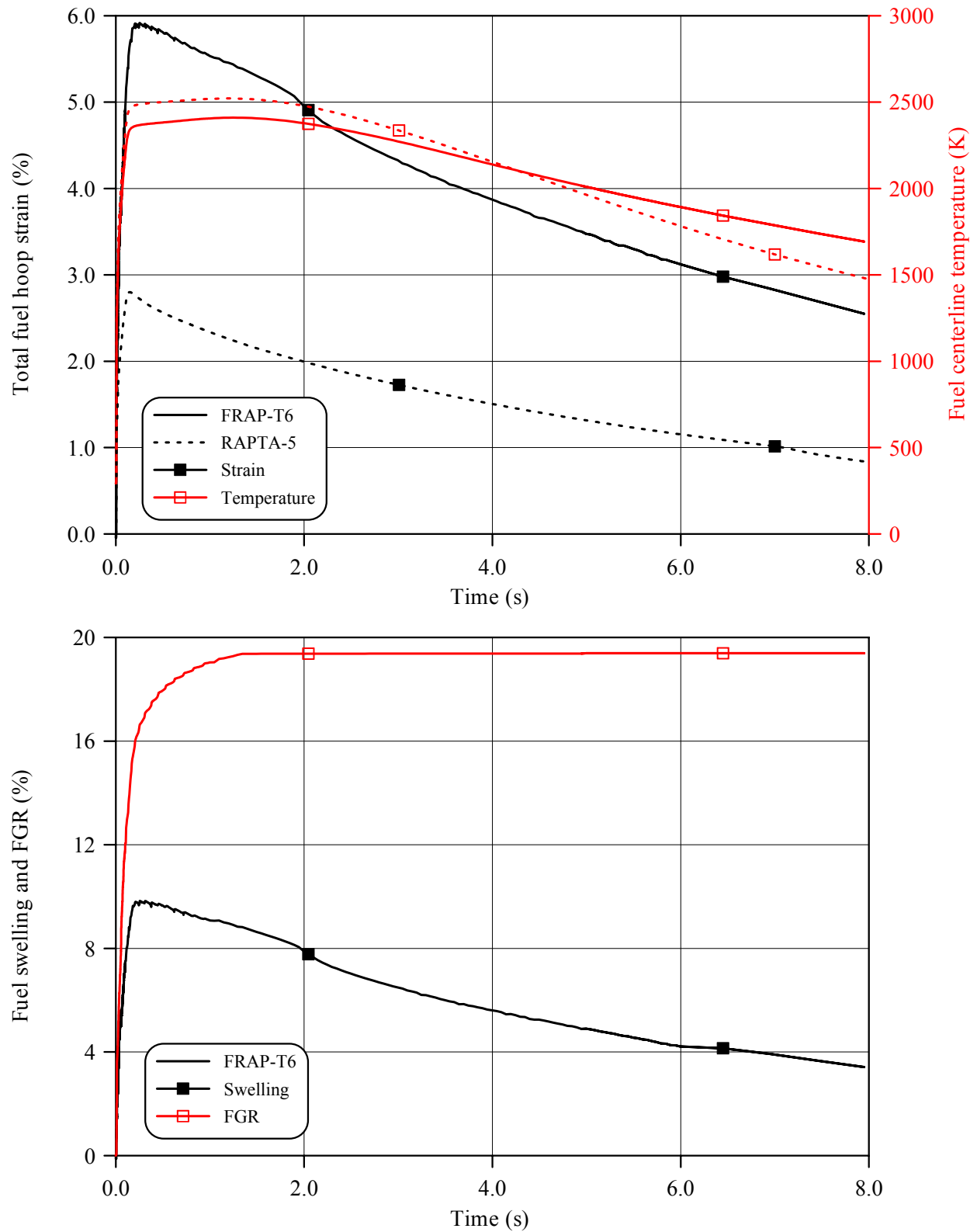


Fig.E-9.14. Fuel behavior during the BGR test of fuel rod # RT9 in accordance with FRAP-T6/VVER and RAPTA-5 calculations

RT9

Table E-9.3. Axial distribution of cladding average outer diameter in fuel rod # RT9*

Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)	Axial coordinate (mm)	Cladding diameter (mm)
8	9.185	46	9.804	84	9.695	122	9.710
10	9.265	48	9.741	86	9.859	124	9.648
12	9.321	50	9.726	88	9.944	126	9.553
14	9.334	52	9.770	90	9.734	128	9.577
16	9.330	54	9.753	92	9.569	130	9.673
18	9.350	56	9.687	94	9.580	132	9.694
20	9.404	58	9.639	96	9.633	134	9.643
22	9.480	60	9.668	98	9.623	136	9.592
24	9.551	62	9.733	100	9.559	138	9.600
26	9.549	64	9.823	102	9.517	140	9.679
28	9.537	66	9.897	104	9.556	142	9.780
30	9.578	68	9.836	106	9.651	144	9.856
32	9.642	70	9.694	108	9.729	146	9.742
34	9.678	72	9.680	110	9.790	148	9.642
36	9.634	74	9.727	112	9.802	150	9.638
38	9.625	76	9.734	114	9.680	152	9.624
40	9.677	78	9.688	116	9.569	154	9.520
42	9.763	80	9.645	118	9.555	156	9.399
44	9.801	82	9.646	120	9.636	158	9.248

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

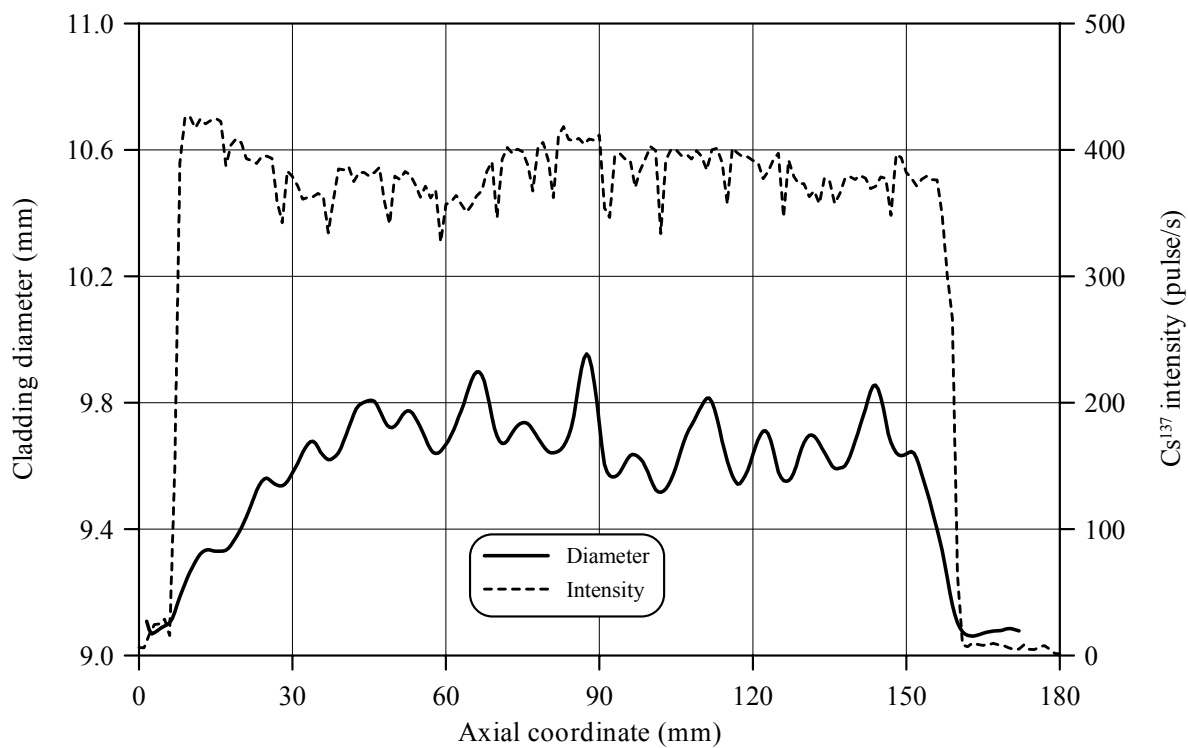


Fig.E-9.15. Cladding measured average diameter and γ -scanning results for fuel rod # RT9

Table E-9.4. The PIE results for fuel rod # RT9

Parameter		Value
1.	Cladding outer diameter (mm):	
1.1.	Maximum diameter of the bidimensional data sample in "fuel rod length - azimuthal angle" coordinates (mm)	10.37
1.2.	Averaged azimuthal diameter and maximum diameter along the length selected from the sample of averaged azimuthal diameter (mm)	9.95
1.3.	Averaged diameter of the bidimensional data sample in "fuel rod length - azimuthal angle" coordinates (mm)	9.62
2.	Cladding residual hoop strain (%):	
2.1.	Maximum hoop strain	9.60
2.2.	Hoop strain at rupture	9.1; 9.6; 8.2; 8.6
3.	Fuel pellet conditional diameter (mm) in cross-section*:	
	at 69 mm elevation	8.21
	at 88 mm elevation	8.19
	at 110 mm elevation	8.24
	at 144 mm elevation	8.20
4.	ZrO ₂ outer thickness (μm) in cross-section:	
	at 69, 88, 110, 144 mm elevations	5
5.	ZrO ₂ inner thickness (μm) in cross-section:	
	at 69 mm elevation	8
	at 110 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

RT9

Table E-9.5. Organized BGR test results for fuel rod # RT9

	Parameter	Unit	Value		
			Measured	Calculated	
				FRAP-T6	RAPTA-5
1.	Fuel burnup	MW d/kg U	59.9	59.9	59.9
2.	Initial gas pressure	MPa	0.1	0.1	0.1
3.	Energy deposition	cal/g fuel	200.9	200.9	200.9
4.	Peak fuel enthalpy*	cal/g fuel	-	162.4	167.5
5.	Fuel maximum temperature	K	-	2524	2584
6.	Maximum temperature of cladding outer surface	K	-	1164	1249
7.	Cladding burst	Failed, Unfailed	Failed	-**	-**
8.	Cladding residual hoop strain				
	- average***	%	6.27	4.41	2.77
	- maximum	%	9.60	4.98	2.77

* Average value of peak fuel enthalpy 164.9 cal/g fuel

** This parameter was not calculated

*** Average value along the fuel stack length

Appendix E-10
Individual Characteristics of Fuel Rod # RT10
after the BGR Test

RT10

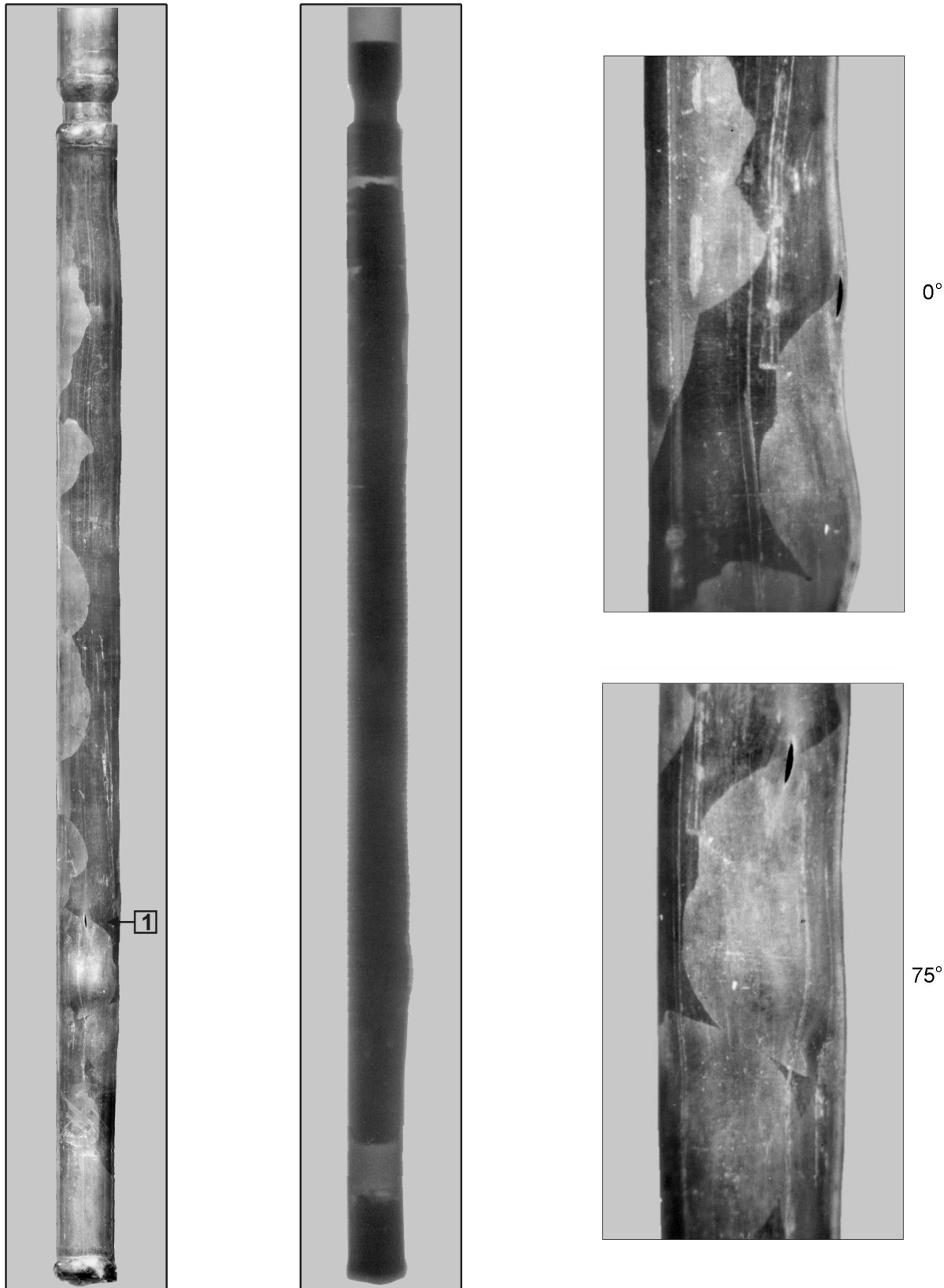


Fig.E-10.1. Appearance of failed fuel rod # RT10 after the BGR test (photographs and X-ray photograph)

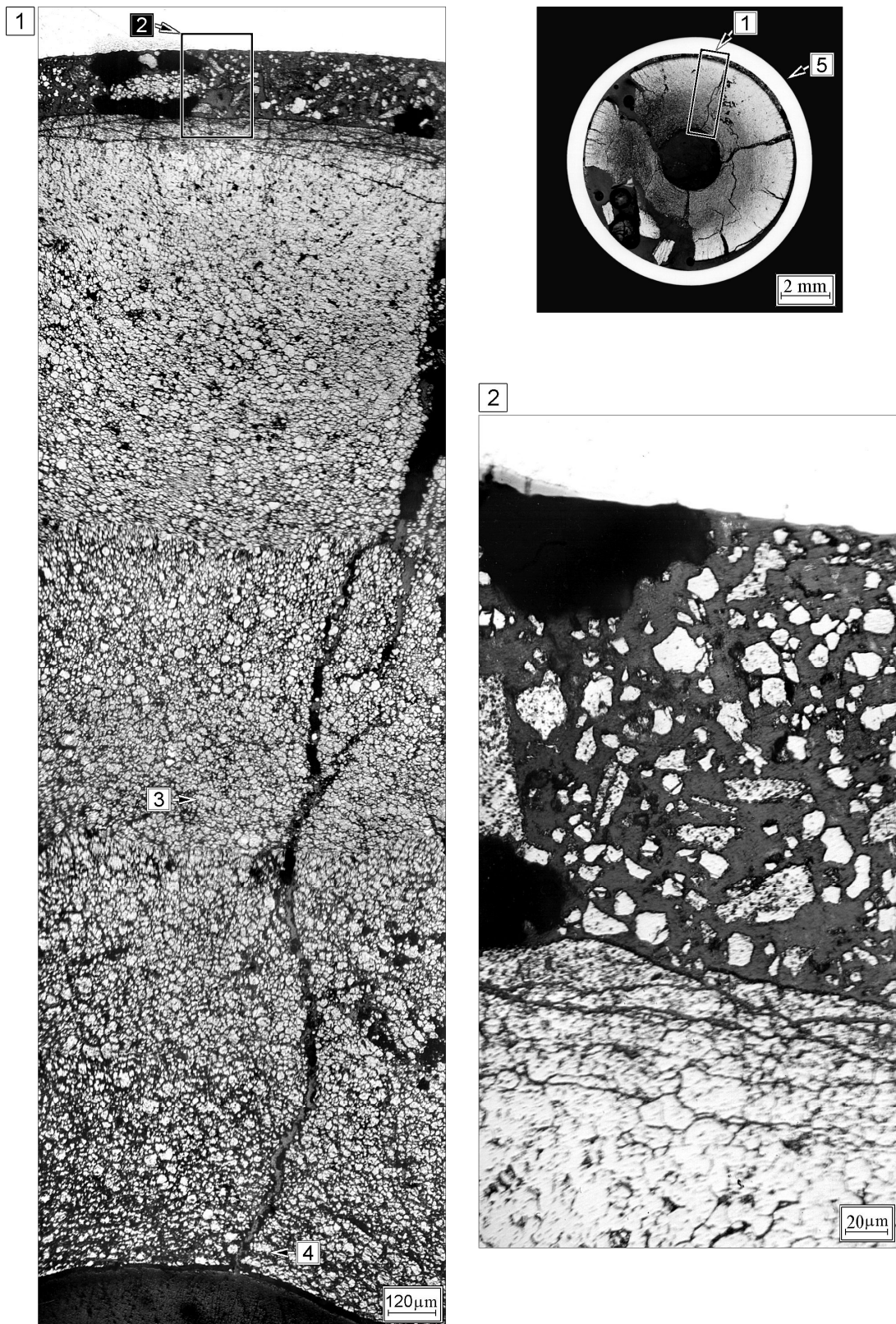


Fig.E-10.2. Cross-section and fuel microstructure of fuel rod # RT10 at 33 mm elevation (from low cap)

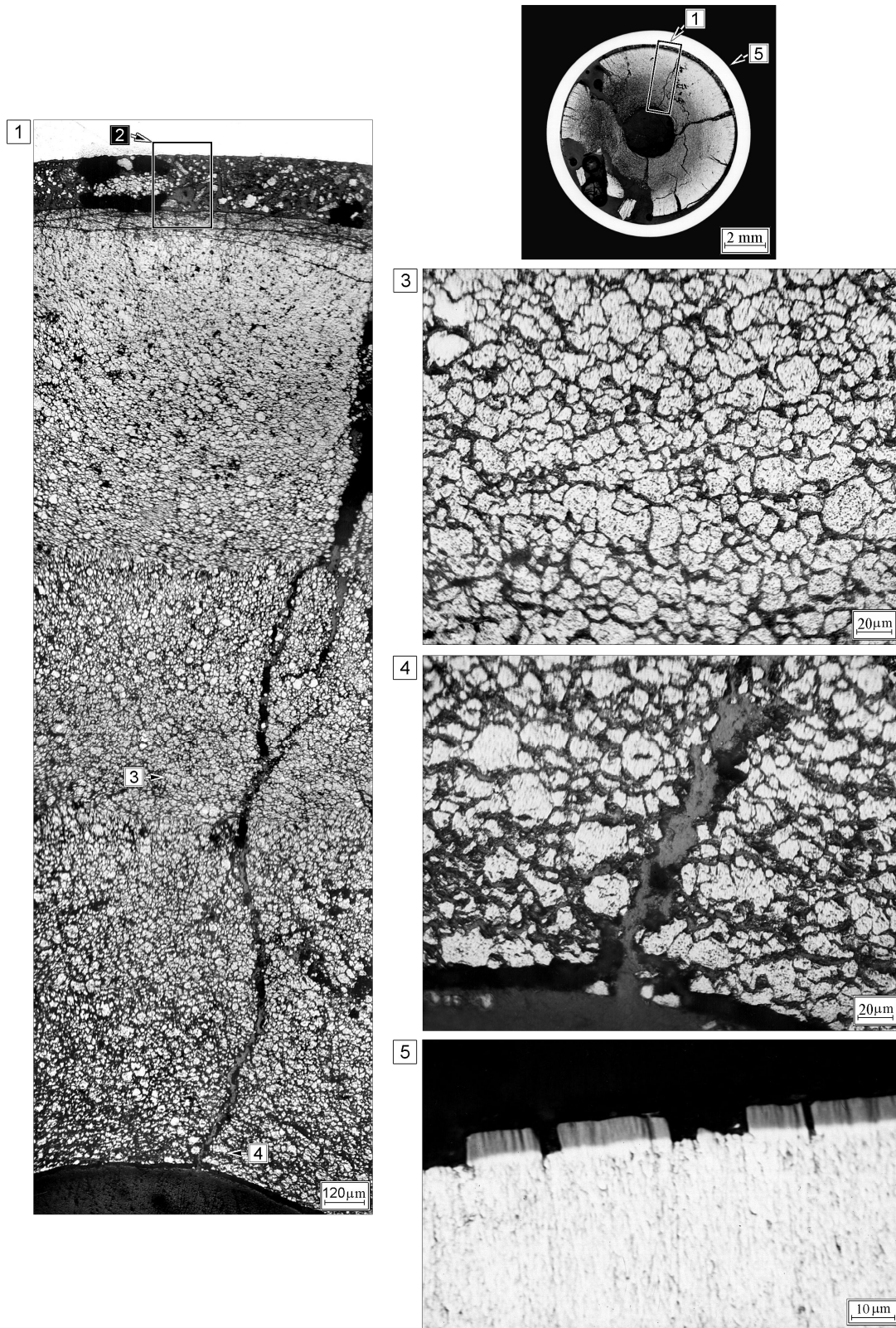


Fig.E-10.3. Cross-section and microstructure of fuel and cladding of fuel rod # RT10 at 33 mm elevation (from low cap)