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RESUME OF KER LOOP IRRADIATION TESTS FOR 1957, 1958, AND 1959

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RESUME OF KER LOOP IRRADIATION TESTS
FOR 1957, 1958, AND 1959

by

W. K. Kratzer

March 28, 1960

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RESUME OF KER LOOP IRRADIATION TESTS
FOR 1957, 1958, AND 1959

In 1957 three of the four high temperature recirculating loops in KE Reactor were put into service and in 1958 the fourth loop was started up. The primary purpose of the loops has been high temperature irradiation testing of fuel elements in support of the NPR fuel element development program, although tests have been run to provide information for PRTR fuel development and high temperature aluminum corrosion programs. Coolant technology studies relating to activity build-up, crud formation, corrosion, failure detection, and decontamination are carried on in conjunction with the fuel element tests.

The purpose of this document is to provide a resume of all fuel element test irradiations in the KER Loops from the time they started up to the end of CY-1959. A description of each test, its operating conditions, a chronological history of each loop, and a bibliography of documents pertaining to the tests are included. Supplements to this report will be issued periodically to bring the information up to date.

Description of the Loops

The four loops consist of high pressure Zircaloy-2 process tubes running front-to-rear in the high flux region of KE Reactor. The loops contain facilities for controlling the flow, pressure, temperature, and composition of the coolant. Charging and discharging can only take place during reactor outages, and, in general, loop operation is subordinate to the operation of KE Reactor as a production reactor. Table I lists the main characteristics of the loops. The KER Operations Manual^{(1)*} and Process Standards, Reactor,⁽²⁾ contain a more complete description of the operating procedures and restrictions.

Production Test Design Limitations

Production test temperatures and operating conditions are limited by Process Standards, based on loop mechanical and hydraulic characteristics, and by the need for loop operating flexibility. Process Standards specify limiting values of pressure, temperature, and flow variation. Automatic trips are provided to shut the reactor down if these values are exceeded. Reliable loop operation requires an operating range in which any particular parameter can vary without accidentally exceeding the trip setting. The bottom of this range, therefore, is the maximum operating value available for normal testing. For example, the maximum coolant outlet temperature for loop 2 is specified as 303°C by the Process Standards. Loop operation requires a 15°C spread between the operating temperature and the trip temperature, giving a 288°C maximum outlet temperature available for normal operation.

Most of the fuel element production test irradiations in the loops are designed to provide the maximum fuel element temperature available within the limitations of the following design parameters:

- a. The outlet temperature of the process tube coolant shall not exceed a temperature 25°C less than the saturation temperature of the system.

*Superscript numbers refer to reports or documents listed in the bibliography.

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- b. The local channeled bulk coolant temperature in multi-channeled elements, such as the tubular and cluster elements, shall not exceed the saturation temperature of the system either during normal operation or at the limiting trip conditions - high outlet temperature trip, low system pressure trip, and low coolant flow trip.
- c. The fuel element surface temperature should not exceed the system saturation temperature during normal operation unless surface boiling is specifically desired.
- d. Subcooled burnout should not occur during the simultaneous approach to the high outlet temperature trip, low flow trip, and low pressure trip.
- e. Although not mandatory, it is desirable to maintain the tube power low enough to permit reduction of the outlet temperature to 100°C so that the loop can be switched from recirculation to single pass operation without shutting the reactor down in the event of a leak or some other occurrence that would prevent continued high pressure operation. Maximum tube powers at which this can be accomplished are about 675 KW for loop 1 and 800 KW in loops 2, 3, and 4.

Description of the Tables and Figures

Table I provides a list of the principal loop characteristics that most directly influence fuel element test conditions. Table 2 gives a description of the main fuel elements that have been tested. Table 3 provides the purpose, test conditions, duration of irradiation, exposure, and results of each test. In general, power, exposure, and surface temperature values apply only to the principal fuel elements in the test. Powers and temperatures are normal equilibrium values which best categorize the operating conditions. Average values will be lower because of non-equilibrium and low temperature operation. Periods of low temperature operation for more than 30% of the irradiation time have been noted. In cases of heterogeneous loadings, power values are at best approximate since there is no way of experimentally measuring the power of the different elements in the charge. No one number can categorize tubular element surface temperatures, since there are three flow channels with asymmetrical flow and heat distributions and four heat generating surfaces with different heat fluxes across each surface. The number given is the highest surface temperature predicted for the charge, and temperatures at other surfaces and other positions in the charge should be lower.

At best, the numbers given in Table 3 provide a means of assessing relative test severity. Interpretation of data must be based on a detailed analysis of each test, which is beyond the scope of this report.

Figure 1 gives a chronological listing of the tests run in each loop and a graphical representation of loop and reactor operating periods.

Reactor Fuels Unit
Process & Reactor Development Subsection
Research and Engineering Section
IRRADIATION PROCESSING DEPARTMENT

TABLE I

KER LOOP CHARACTERISTICS, DECEMBER, 1959

LOOP	PROCESS TUBE				OUT OF PILE LOOP MAT'L.	SYSTEM PRESSURE, PSIG		COOLANT FLOW, GPM		MAXIMUM OPERATING COOLANT OUTLET TEMPERATURE, °C	HEAT EXCHANGER CAPACITY, KW
	MAT'L.	OD IN.	ID IN.			OPERATING	MINIMUM	OPERATING	MINIMUM		
			HYDRAULIC	PLUG GAUGE							
1 2160 KE	Zr-2	2.40	2.089	2.079	Carbon Steel	1300	1250	50	40	270	1200
2 2864 KE	Zr-2	2.40	2.030	2.023	Stainless Steel	1600	1500	60	48	288	1200
3 3565 KE	Zr-2	2.40	2.030	2.018	Stainless Steel	1600	1500	60	48	288	1200
4 4268 KE	Zr-2	2.40	2.030	2.023	Stainless Steel	1600	1500	60	48	288	1200
CHARACTERISTICS PRIOR TO PROCESS TUBE REPLACEMENT IN LOOPS 2 AND 3 ON MARCH 24, 1959, AND LOOP 4 ON JULY 11, 1959											
1	Zr-2	2.40	2.089	2.079	Carbon Steel	1300	1250	50	40	270	1200
2	Zr-2	2.40	2.10	-----	Stainless Steel	835	785	60	48	245	1200
3	Zr-2	2.40	2.10	-----	Stainless Steel	835	785	60	48	245	1200
4	Zr-2	2.40	2.10	-----	Stainless Steel	835	785	60	48	245	1200

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FUEL ELEMENT DESCRIPTION

DESIGNATION	GEOMETRY	SIZE INCHES			JACKET MATERIAL	ENRICHMENT	NOTES	PURPOSE	TESTS	REFERENCES
		OD	LENGTH	JACKET THICKNESS						
T&T, En.	Two concentric tubes	1.82 1.05	1.45 36 0.50 36	.020 .020	Zr-2	1.47		Obtain high power, high exposure behavior tube-and-tube elements.	250, Supp. B.	64, 69, 70, 71, 72, 73
T&T, Nat.	"	"	"	"	"	Nat.		Determine jacket, bond and uranium behavior at low and high exposure	250, Supp. A	64, 65, 66, 78
T&T, Nat. A	"	"	"	"	"	Nat.	Uran. alloyed with 2 w/o Zn	"	246, Supp. A, 250 Supp. A	60, 61, 62, 64, 65, 66, 78
R&T, Nat.	Outer tube and concentric inner rod	1.785 1.000	1.375 36 36	.030 .020	"	Nat.		Evaluate tubular material	205	41, 42, 43, 44
R&T, Nat. A	"	1.82 0.89	1.45 33 33	.020 .020	"	Nat.	Uran. alloyed with 2 w/o Zn	"	246, Supp. A	60, 61, 62
TRC, .020, En.	Seven rods uniformly spaced in cluster	0.593	13	.020	"	1.6		Evaluate uranium, jacket and bond behavior	226, 226 Supp. A, 226 Supp. B	52, 58, 59, 67, 77
TRC, .030, En.	"	"	"	.030	"	1.6		"	214, 226, 226 Supp. A, 226 Supp. B, 246	45, 46, 47, 48, 52, 58, 59, 60, 61, 62, 67, 77
TRC, .020, Nat.	"	"	"	.020	"	Nat.		"	246	60, 61, 62, 63, 76
TRC, .030, Nat.	"	0.593	13	.030	Zr-2	Nat.		Flow channel temperature measurements	221	49, 51

TABLE II (Cont'd)

DESIGNATION	GEOMETRY	SIZE INCHES				JACKET MATERIAL	ENRICHMENT	NOTES	PURPOSE	TESTS	REFERENCES
		OD	ID	LENGTH	JACKET THICKNESS						
7RC, .030-.630 Nat.	Seven Rods uniformly spaced in cluster	0.630	----	13	.030	Zr-2	Nat.		Initial seven-rod cluster evaluation	146	25, 26, 27
7RC, .020, Nat., HH	"	0.593	"	"	.020	"	"	Hot-headed closure on rods	Evaluate hot-headed cluster	288	74, 75
4RC, .030, En.	Four Rods uniformly spaced in cluster	0.630	"	9.4	.030	Zr-2	1.6		Initial test of enriched Zr-2 jacketed rod for dimensional characteristics	172	21, 22, 23, 24
4RC, SS, Nat.	"	"	"	"	"	Stainless Steel	Nat.		Initial trial of clusters	74, 144	6, 7, 8, 9, 12, 13
3RC, 3ft., En.	Three rods uniformly spaced in cluster	.593	----	38	.030	Zr-2	1.6		Determine behavior of long rods at high exposure.	214	45, 46, 47, 48
3RC, 3ft., Nat.	"	.630	"	"	"	"	Nat.		Determine maximum unsupported length of cluster rods	186	28
3RC, 2ft., Nat.	"	"	"	26	"	"	"		" " "	186	28
Al Jacketed Cored	Cylindrical, cored, externally cooled	1.44	.515	8.9	.040	X-8001 Al	Nat.		Check of loop operation; aluminum corrosion.	61	3
Al Jacketed I&E Massive	Cylindrical, internally & externally cooled	1.80	.576	8.9	.050	X-8001 Al	"		Fuel distortion; Al corrosion	75, 90	4, 5

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TABLE II (Cont'd)

DESIGNATION	GEOMETRY	SIZE INCHES				JACKET MATERIAL	ENRICHMENT	NOTES	PURPOSE	TESTS	REFERENCES
		OD	ID	LENGTH	JACKET THICKNESS						
Al Jacketed I&E Wafered, Nat.	Cylindrical, internally & externally cooled	1.80	.576	8.9	.050	X-8001 Al	Nat.	Element made up of 43 U wafers 3/16" thick dip canned	Determine stability of wafered element; local jacket straining	114	10, 11
Al Jacketed I&E Wafered, En.	"	"	"	"	"	A2 Al	1.6	Elements made up of 43 Ni plated U wafers 3/16" thick hot press canned	Evaluate jacket straining, wafer distortion and jacket corrosion	134	14, 15, 16, 17, 18, 19, 20
Doe	Cylindrical	1.44	----	6.6	.045	X-8001-C810 Al	Doe	}	Used for Al corrosion studies to avoid hazard of U-water reaction in case of failure.	172, 190, 229	21, 22, 23, 24, 32, 33, 34, 35, 36, 37, 38, 53 54, 56
Thermocouple Doe	"	"	"	"	.125	"	"				
MINT	Cylindrical	1.44	----	4.6	0.45	X-8001 Al	---		Absorb neutrons and determine MINT behavior in high temperature water	172	21, 22
UO ₂ , 18" 4RC,, SS	Four rods uniformly spaced in cluster	.625	----	18	.035	Stainless Steel	Nat.	Rods contain swaged compacted UO ₂	PRTR Evaluation	146	25, 26
UO ₂ , 12" 4RC, Zr-2	"	.625	----	12	.030	Zr-2	1.6 & Nat.	"	" "	186	28, 29
Pu-Al, 10" 4RC, Zr-3	Four rods uniformly spaced in cluster	.565	----	10	.030	Zr-3	8 w/o Pu		" "	186	28, 30, 31

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DESIGNATION	GEOMETRY	SIZE INCHES				JACKET MATERIAL	ENRICHMENT	NOTES	PURPOSE	TESTS	REFERENCES
		OD	ID	LENGTH	JACKET THICKNESS						
8ft., UO ₂ Cluster	Seven rods uniformly spaced in cluster	.560	----	96	.030	Stainless Steel	Nat.	Rod spacing and support supplied by wire wrap. Element contained swaged UO ₂	Determine difficulties in handling 8' element. PRTR Evaluation	213	39, 40
UO ₂ , 18" TRC, Zr-2	"	.560	----	18	.030	Zr-2	Nat.	"	PRTR Evaluation	205, 214	41, 42, 43 46, 47, 48
Al Jacketed Solid Depleted	Cylindrical	1.44	----	8	.045	Al	.14	Dip canned	Evaluate dip canned Al-Si bond stability at high temperature	229	53, 54, 55, 57
Pu-Al, 28" TRC, Zr-2	Seven rods uniformly spaced in cluster	.570	----	28	.030	Zr-2	1.8 w/o Pu	Rod spacing and support supplied by wire wrap	PRTR Evaluation	226 Supp. B	67, 68

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TABLE III
PRODUCTION TESTS IRRADIATED IN THE KER LOOPS

PRODUCTION TEST	CHARGE & DISCHARGE DATE	LOOP	ORDINAL NUMBER OF LOADING IN LOOP	ELEMENTS (a)	POWER KW/FT/ELEMENT	HEAT FLUX B/HR.-FT ²	TEMPERATURE, °C		COOLANT	EXPOSURE, MWD/T		PURPOSE AND RESULTS	REFERENCES (b)
							OUTLET	SURFACE		GOAL	DISCHARGE		
61A (1)	23 May 57 21 June 57	4	1	38 Al jacketed cored	60	.54 x 10 ⁶	147	184	pH 4.5, H ₃ PO ₄	250	250	Check loop operation, determine effect of H ₃ PO ₄ on Al corrosion. H ₃ PO ₄ shown to reduce corrosion	3
(2)	21 June 57 25 July 57	2	1	38 Al jacketed cored	60	.54 x 10 ⁶	177	212	pH 4.5, H ₃ PO ₄	250	250		
(3)	8 July 57 13 Aug 57	3	1	38 Al jacketed cored	60	.54 x 10 ⁶	169	195	Deionized water, pH ⁶	250	250		
75A	25 July 57 13 Dec 57	2	2	10 Al jacketed I&E massive	75	.55 x 10 ⁶	180	230	pH 4.5, H ₃ PO ₄	Variable	800	Evaluate jacket corrosion and core distortion. Both distortion and corrosion were negligible	4
90A	19 Aug 57 13 Nov 57	4	2	"	35	.26 x 10 ⁶	200	210	"	"	650		
74A	19 Sept 57 28 June 58	3	2	20 4RC, SS, Nat.	38	.20 x 10 ⁶	235	250	Deionized water, pH ⁶	2000	2300	Evaluate fuel distortion. External distortion was negligible extensive internal flow into void spaces	6, 7, 8, 9
119A (1)	13 Dec 57 30 Jan 58	2	3	10 Al jacketed I&E wafered, Nat.	70	.51 x 10 ⁶	225	260	pH 4.5, H ₃ PO ₄	700	350	Measure wafer distortion and jacket strain. Neither observed. Tests discharged prematurely because of dump valve failure	10, 11
(2)	9 Jan 58 23 Jan 58	4	3	"	80	.59 x 10 ⁶	230	270	pH 4.5, H ₃ PO ₄	700	100		
(a) Fuel element designations are explained in Table II													
(b) Numbers designate references in the bibliography													

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TABLE III (Cont'd)

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PRODUCTION TEST	CHARGE & DISCHARGE DATE	LOOP	ORDINAL NUMBER OF LOADING IN LOOP	ELEMENTS	POWER KW/FT/ELEMENT	HEAT FLUX B/HR.-FT ²	TEMPERATURE, °C		COOLANT	EXPOSURE, MWD/T		PURPOSE AND RESULTS	REFERENCES
							OUTLET	SURFACE		GOAL	DISCHARGE		
144A	12 Feb 58 15 May 58	1	1	19 4RC, SS, Nat.	36	.19 x 10 ⁶	260	280	pH8, L10H	1000	580	Check initial loop operation. Test was discharged when this was accomplished	12, 13
134A (1)	12 March 58 28 June 58	4	4	10 Al jacketed I&E wafered, En.	72	.52 x 10 ⁶	240	250	pH 4.5, H ₃ PO ₄	Based on corrosion	725	Evaluate jacket strain wafer distortion, bond retention, and jacket corrosion. Jacket, wafer and bond unaffected. Jacket corrosion less than anticipated.	14, 15, 16, 17, 18, 19, 20
(2)	17 April 58 15 May 58	2	4	"	150	1.1 x 10 ⁶	198	250	pH 4.5, H ₃ PO ₄	"	400		
172A	28 June 58 9 Nov 58	2	5	4 4RC, .030 En; 26 Doe; 1 thermocouple Doe; 8 MINT	90	.47 x 10 ⁶	200	250	pH 4.5, H ₃ PO ₄	2000	2200	Determine irradiation behavior of coextruded Zr-2 jacketed rod. Rods increased 3% in volume and had macro-cracks in uranium. No gross distortion, no bond deterioration. Negligible corrosion of Does; failure observed on one MINT piece.	21, 22, 23, 24
146A	4 Aug 58 14 Jan 59	1	2	2 7RC, .030-.630, Nat; 6 UO ₂ 18" 4RC, SS	70	.21 x 10 ⁶	265	270	pH10, L10H	1000	1250	Evaluate seven-rod cluster geometry. Elements showed no distortion, no bond deterioration, no cracking. UO ₂ elements charged to provide PRTR information.	25, 26, 27

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TABLE III (Cont'd)

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PRODUCTION TEST	CHARGE & DIS-CHARGE DATE	LOOP	ORDINAL NUMBER OF LOADING IN LOOP	ELEMENTS	POWER KW/FT/ELEMENT	HEAT FLUX B/HR.-FT ²	TEMPERATURE, °C		COOLANT	EXPOSURE, MWD/T		PURPOSE AND RESULTS	REFERENCES
							OUTLET	SURFACE		COAL	DISCHARGE		
186A	4 Aug 58 27 Dec 58	3	3	1 3RC, 3ft., Nat; 1 3RC, 2ft. Nat; 4 UO ₂ 12" 4RC, Zr-2; 1 PuAl, 10" 4RC, Zr-2	25	.17 x 10 ⁶	185	210	Deionized water, pH6	1200	1100	Determine deformation of long unsupported rods under maximum creep conditions. No deformation was observed. UO ₂ and PuAl elements irradiated for PRTR information.	28, 29, 30, 31
190A (1)	4 Aug 58 17 Nov 58	4	5	14 Doe; 1 ther- mocouple Doe	40	.37 x 10 ⁶	205	235	pH 4.5, H ₃ PO ₄	55 days	53 days	Test to measure Al corrosion. Corrosion observed was too small to be measured. Ther- mocouple slug measured a significant tempera- ture drop across corro- sion and crud films.	32, 33, 34, 34, 36, 37, 38
(2)	23 May 59 28 June 59	3	6	20 Doe	38	.35 x 10 ⁶	230	260	pH 4.5, H ₃ PO ₄	----	----	Conditioning charge to insure correct water quality in decontaminated loop. Elements discharged because of crud bursts.	
(3)	28 June 59 11 July 59	3	7	20 Doe, 1 ther- mocouple Doe	38	.35 x 10 ⁶	245	275	pH 4.5, H ₃ PO ₄	----	10 days	Conditioning test terminated by fuel element failure because of poor element design	
(4)	11 July 59 26 July 59	3	8	20 Doe	38	.35 x 10 ⁶	100	130	pH 4.5, H ₃ PO ₄	4 Mo.	13 days	Elements irradiated at low temperature while cause of previous failure was determined. Elements discharged when faulty design appeared responsible.	

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PRODUCTION TEST	CHARGE & DIS-CHARGE DATE	LOOP	ORDINAL NUMBER OF LOADING IN LOOP	ELEMENTS	POWER KW/FT/ELEMENT	HEAT FLUX B/Hr.-FT ²	TEMPERATURE, °C		COOLANT	EXPOSURE, MWD/T		PURPOSE AND RESULTS	REFERENCES
							OUTLET	SURFACE		GOAL	DISCHARGE		
213A	9 Nov 58 8 Dec 58	2	6	1 8 ft. UO ₂ cluster	60	.20 x 10 ⁶	185	260	pH 10, LiOH	60 days	31 days	Determine difficulty in charging or irradiating long wire-wrapped cluster. PRTR application. No difficulty was observed.	39, 40
205A	17 Nov 58 11 July 59	4	6	2 R&T, Nat; 1 UO ₂ , 18", 7RC, Zr-2	73	-----	220 70% of time	260	pH 4.5, H ₃ PO ₄	2500	1900	Observe tubular element behavior. Jacket corrosion observed as result of crud film on surface. One rod showed 3% volume increase; one tube was internally cracked and distorted.	41, 42, 43, 44
214A	9 Dec 58 24 March 59	2	7	4 7RC, .030, En; 1 3RC, 3 ft., En; 2 UO ₂ , 18", 7RC, Zr-2	140	.44 x 10 ⁶	203	260	pH 10, LiOH	3500	1600	Test was to determine high power, high exposure behavior of material. Elements discharged with failure attributed to faulty Zr-2 jacket.	45, 46, 47, 48
221A	27 Dec 58 4 Feb 59	3	4	8 7RC, .030, Nat.	72	.23 x 10 ⁶	200	250	Deionized water, pH 6	1 Mo Operation	290	Measure flow channel temperature. Ratios obtained for this fuel and tube size.	49, 50, 51
226 A	14 Jan 59 29 March 59	1	3	4 7RC, .020, En; 3 7RC, .030, En.	130	.41 x 10 ⁶	225 30% of time	290	pH 10, LiOH	4500	1200	Test was to compare .020 and .030 inch jacketed elements at high power and exposure. Test was discharged when loop operating difficulties prevented continued operation.	52

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PRODUCTION TEST	CHARGE & DISCHARGE DATE	LOOP	ORDINAL NUMBER OF LOADING IN LOOP	ELEMENTS	POWER KW/FT/ELEMENT	HEAT FLUX B/HR.-FT ²	TEMPERATURE, °F		COOLANT	EXPOSURE, MIN/T		PURPOSE AND RESULTS	REFERENCES
							INLET SURFACE	OUTLET SURFACE		GOAL	DISCHARGE		
229A	4 Feb 59 24 March 59	3	5	25 Al jacketed solid, depleted; 1 thermocouple Doe	25	.23 x 10 ⁶	232	240	pH 4.5, H ₃ PO ₄	500	105	Evaluate Al-Si bond stability at high temperature. Test discharged at low exposure because of failure indications later attributed to heavy crud film slough off. Thermocouple element results agreed with 190-A (1).	53, 54, 55, 56, 57
226A Supp A	18 May 59 15 Oct 59	2	8	6 TRC, .020, En. 1 TRC, .030, En.	122	.38 x 10 ⁶	250	310	pH 10, LiOH	5000	2240	Obtain high exposure, high temperature behavior of Zr-2 clad rod. Test was terminated by failure of one of the .020 inch wall elements. Cause undetermined.	59, 58, 77
246A	18 May 59 28 June 59	1	4	1 TRC, .030, En; 1 TRC, .020, Nat 1 R&T, Nat., A; 1 T&T, Nat., A	---	-----	263 40% of time	---	pH 10, LiOH	500	500	Determine low exposure behavior of each type of fuel element as basis for evaluating high exposure behavior. No abnormalities observed except excessive deformation of non-beta heat treated, randomly oriented tube.	60, 61, 62, 63, 76

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PRODUCTION TEST	CHARGE & DIS-CHARGE DATE	LOOP	ORDINAL NUMBER OF LOADING IN LOOP	ELEMENTS	POWER KW/FT/ELEMENT	HEAT FLUX B/HR.-FT ²		TEMPERATURE, °C		COOLANT	EXPOSURE, MWD/T		PURPOSE AND RESULTS	REFERENCES
								OUTLET	SURFACE		GOAL	DISCHARGE		
250A Supp A	28 June 59 31 July 59	1	5	2 T&T, Nat; 2 T&T, Nat, A	60	.14-.23 x 10 ⁶		270	270-290	pH 10, LiOH	2500	250	Determine jacket, bond, and uranium behavior of tubular fuel elements at high exposure. Test discharged with failure. Location, nature, and cause of failure not determined. Bumping observed on vacuum beta heat treated slow cooled tubes. Radial cracks observed on one tube examined metallographically.	64, 65, 66, 78
226A Supp B	24 Aug 59 -----	1	6	4 7RC, .020, En; 2 7RC, .030, En; 1 PuAl, 28", 7RC, Zr-2	128	.40 x 10 ⁶		230	310	pH 10, LiOH	4500	2900 -----	Compare 20 and 30 mil. jackets, determine bond and uranium behavior at high exposure. Test was still running at end of CY-59 and had attained an exposure of 1770 MWD/T.	67, 68

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TABLE III (Con'd)

PRODUCTION TEST	CHARGE & DIS-CHARGE DATE	LOOP	ORDINAL NUMBER OF LOADING IN LOOP	ELEMENTS	POWER KW/FT/ELEMENT	HEAT FLUX B/HR/-FT ²	TEMPERATURE, °C		COOLANT	EXPOSURE, MWD/T		PURPOSE AND RESULTS	REFERENCES
							OUTLET	SURFACE		GOAL	DISCHARGE		
250 A Supp B	7 Sept 59 30 Sept 59	3	9	3 T&T, En.	92	.24-.41 x 10 ⁶	252 70% of time 283 30% of time	280- 310	pH 4.5, H ₃ PO ₄	5000	310	Obtain high power, high exposure behavior of tube and tube elements. Test terminated by failure. Failure attributed to high jacket temperatures induced by heavy crud film build-up causing severe pitting corrosion of jackets.	64, 69, 70, 71, 72, 73
288A	30 Oct 59 -----	3	10	7 TRC, .020 Mat., HH	91	.29 x 10 ⁶	270	310	Ph 10, LiOH	2000	---	Evaluate hot-headed closure on rods. Test was still running at end of Cy-59 and had attained an exposure of 885 MWD/T.	74, 75

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FIGURE 1

Loop Testing Chronology
First 6 Mo. CY 1957

ALCOA RICHMOND WASH

FIGURE 1 (Continued)

Loop Testing Chronology
Last 6 Mo. CY 1957

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FIGURE 1 (Continued)

Loop Testing Chronology
First 6 Mo. CY 1958

FIGURE 1 (Continued)

Loop Testing Chronology
Last 6 Mo. CY 1958

FIGURE 1 (Continued)

Loop Testing Chronology
First 6 Mo. CY 1959

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FIGURE 1 (Continued)

Loop Testing Chronology

Last 6 Mo. CY 1959

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