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SCRAM RECOVERY DATA
PRECEDING "C" OVERBORE
FUEL FAILURES

Introduction

Considerable interest has been generated concerning the recent series of overbore fuel failures at C Reactor. It therefore seems appropriate to thoroughly document the operating conditions which existed prior to the failures. This report presents a chronological description of events leading up to the failures, and graphs and tables of various pertinent parameters.

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May 15, 1962

Discussion

On April 5, 1962, a Panellit scram occurred on spline tube 2891, the cause for which was not determined. A hot startup was then made, with first indication at 1:18 a.m. During the period from just after startup until 4:15 p.m. on the 5th, a series of heat cycles occurred, the latter stages of which involved tubes in the overbore block. Table II lists the overbore tube outlet temperatures, flow factors, and pile power level during the above period of time. Figure I presents a graph of the outlet temperatures of overbore tubes 3062, 3069, and 2853. Tube 3062 contained a 19 piece charge which eventually sustained three split ruptures and three incipient ruptures. Tube 3069, on the same row as the rupture tube, did not experience the degree of heat cycling as did 3062, and in which no ruptures were found. Tube 2853, containing a 32 piece fringe overbore charge, reached a slightly higher tube power than did 3062, but did not rupture. Figure 2 gives position versus time for HCR's No. 5 and No. 6, which control the flux in the overbore block.

At 2:45 p.m. on April 5, the gamma monitor indicated a rupture had occurred on row 29, and so a normal shutdown was made. Tubes 2955 and 2969 both gave high rear pigtail radiation readings, and were discharged as rupture suspects. Two side hot spot ruptures were found in the regular size enriched charge from 2955. No ruptures were found in the 19 piece overbore charge from tube 2969. Overbore tube 2853 was also discharged because of the high tube power experienced during the heat cycle, but no ruptures were found among the slugs from this tube.

A normal startup was made at 3:44 p.m. on April 7. The reactor was shut down at 9:10 a.m. on April 12 due to excessive water collection, and was started back up at 5:45 p.m. on April 14. On April 16, it was decided to try a quickie in order to repair a leaking rear connector on overbore tube 3366. During the shutdown procedure, the reactor was accidentally scrammed from about 300 MW below full power. At 11:29 a.m., a hot startup was made. During the startup no temperature maps were run, but temperatures were being monitored on the Brown recorders. The maximum tube outlet temperature observed was 112°. At 11:53 a.m. the reactor was scrammed by a Panellit high trip on overbore tube 3062. The gamma monitor trace for row 30 went full scale at the same time.

Inspection of the metal from 3062 revealed three split ruptures and three incipient ruptures. It was then decided to discharge the remainder of the tubes in the overbore block with the exception of the conversion ratio tubes, which were to be discharged as a group upon reaching goal exposure. The discharged metal was then visually examined to determine the condition of the metal. The final results of the observed failures is given in Table I below.

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May 15, 1962

Table I

Tube Number	Number and Type of Failure	Piece Number	Series Number	Type Material	Exposure at Discharge	Scheduled Goal Exposure
2863	4 incipient	9, 10, 11, 13	63Z	dingot	714	800
2865	1 incipient	12	73Z	ingot	670	800
2962	4 incipient	9, 10, 13, 14	80A	dingot	712	800
3062	3 split	12, 14, 15	75Z	ingot	676	800
	3 incipient	10, 11, 13	84A			800
3162	1 incipient	10		dingot	769	800
3163	1 incipient	8	78A	dingot	660	800
3169	1 incipient	12	74Z	ingot	708	800
3367	1 incipient	17	7A	dingot	522	800
3262	1 incipient	19	10A	dingot	578	800

The incipient rupture listed for tube 3163 was not completely confirmed by the visual examination, and so must be considered a possible failure. All the rest were confirmed. The piece numbers in Table I identify the position of the slug in the charge column, with piece number one being the most downstream slug and the rest of the numbers running consecutively in the upstream direction. This charge sequence is shown in Figure 3, along with the charge location with respect to the graphite stack and the HCR configuration. Also given is the weasel data for overbore tubes 3062 and 3163, taken ten days after discharge.

The incipient or "worm-track" ruptures all exhibited longitudinal splits in the uranium, with one track per element. Most splits extended the full length of the element. In all cases, the uranium splits were noted by observing the linear depressions in the aluminum can wall. With the exception of the three slugs from tube 3062, none of the uranium separations was observed to have caused a split in the can wall.

There is undoubtedly a great deal which can be learned from these overbore failures, specifically with regards to expected future fuel performance. It is hoped that the data in this report will prove useful in evaluating this performance.

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TABLE II

Overbore Outlet Temperatures, Flow Factors,
& Pile Power Level Versus Time On April 5, 1962

Tube Numbers	Time							
	0210	0220	0240	0300	0320	0345	0415	0445
0954	84	85	86	78	74	70	69	67
1453	89	87	88	78	76	72	71	69
59	90	91	94	85	83	78	78	76
64	109	113	120	117	112	104	106	104
94	42	42	42	41	41	41	41	41
2853	87	86	81	79	80	82	87	89
63	103	103	98	97	99	104	109	109
64	102	102	99	97	99	104	109	109
65	101	101	98	97	100	103	108	107
66	103	103	100	100	102	107	111	110
67	103	103	99	99	101	106	110	109
68	111	109	108	106	108	113	119	115
94	38	38	37	36	35	35	34	33
2962	98	98	92	91	95	99	106	106
63	95	95	91	90	94	97	99	100
64	89	89	86	85	88	93	98	98
66	91	90	88	86	90	94	100	100
67	98	92	90	90	93	98	103	102
68	101	97	93	92	96	100	106	105
69	109	107	102	102	104	109	114	113
3062	89	89	86	83	87	90	99	101
63	88	87	85	84	87	90	98	99
64	85	84	83	82	85	88	95	96
65	87	86	84	83	86	90	97	98
66	88	86	84	83	86	90	97	98
67	91	88	86	84	88	92	99	109
68	95	90	87	86	89	94	100	101
69	104	101	95	93	98	102	108	108
3162	94	93	91	90	94	99	106	109
63	91	90	88	87	91	95	102	104
64	87	86	85	83	88	91	98	100
65	89	87	86	84	89	92	100	101
66	91	89	87	86	90	95	102	103
67	93	90	89	87	92	96	104	104
68	95	91	89	88	92	97	103	104
69	108	105	101	109	103	108	115	116
3262	90	89	88	85	90	95	103	106
63	86	85	84	83	87	91	98	101
64	84	83	83	82	86	89	97	99
65	89	87	86	84	89	94	103	105
66	89	87	86	85	90	95	102	103
67	94	91	90	89	95	99	107	108
68	95	92	90	89	94	99	106	107
69	102	100	99	95	101	105	113	114
3353	71	70	68	66	69	72	78	82
63	84	83	82	80	85	89	99	102
64	85	85	84	83	87	92	100	104
65	87	86	83	83	88	94	100	104
66	87	86	84	83	89	94	101	104
67	90	89	88	86	92	97	105	107
68	94	92	91	90	96	100	109	110
94	37	36	35	33	33	32	31	30
4466	64	65	64	63	65	68	75	78
69	62	63	62	62	64	66	72	75
72	60	61	60	60	61	63	68	71
75	53	54	53	53	54	55	59	61
78	49	51	49	48	49	49	52	53
81	46	47	46	45	45	45	46	46
84	43	43	41	40	40	40	40	40
87	36	35	34	33	33	32	32	32
File Power Level, MW	1600	1600	1600	1600	1600	1640	1700	1700

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TABLE II (continued)

Overbore Outlet Temperatures, Flow Factors,
& Pile Power Level Versus Time On April 5, 1962

Tube Numbers	Flow Factor	Time											
		0510	0540	0605	0620	0640	0700	0740	0820	0835	0900	0940	
0954	14.1	65	65	64	62	61	61	58	54	52	48	48	
1453	14.6	67	65	66	63	62	64	61	58	55	51	51	
59	15.2	74	73	73	71	70	70	66	63	61	56	55	
64	14.3	102	101	101	98	94	92	85	81	77	70	66	
94	14.7	41	42	45	47	49	51	56	65	72	88	93	
2853	14.7	88	83	72	69	67	66	63	59	56	53	54	
63	15.0	110	110	99	90	86	84	80	75	73	68	72	
64	14.9	110	109	101	92	89	88	82	78	78	72	74	
65	15.4	108	108	102	96	93	90	86	81	80	75	75	
66	15.1	110	110	105	100	97	94	91	86	85	79	79	
67	15.3	109	109	105	101	98	96	93	89	88	81	81	
68	14.8	115	111	114	109	107	105	104	100	100	92	89	
94	14.8	33	33	34	34	35	36	39	43	48	57	61	
2962	15.0	109	108	93	83	80	78	74	69	67	64	69	
63	15.0	101	101	95	85	81	79	77	70	69	65	71	
64	15.7	100	99	92	84	81	78	76	70	69	65	70	
65	15.6	99	99	92	85	82	80	78	72	71	66	71	
66	15.4	101	101	96	90	88	85	82	78	77	72	75	
67	14.9	103	103	100	95	92	89	88	84	83	79	78	
68	15.4	105	106	103	99	97	95	93	90	90	84	82	
69	15.0	113	114	113	109	108	106	105	102	104	96	92	
3062	15.6	103	101	88	81	78	76	72	67	65	62	69	
63	15.0	101	100	89	79	77	76	72	67	66	62	70	
64	15.3	97	97	89	81	78	76	73	68	67	63	70	
65	14.9	99	99	92	85	83	81	73	73	72	68	72	
66	15.4	99	99	93	88	85	83	80	76	76	71	74	
67	15.3	100	101	97	92	90	88	86	81	81	76	78	
68	15.5	101	102	99	95	93	91	90	86	86	81	81	
69	15.4	109	110	108	105	103	102	101	97	98	92	90	
3162	15.3	111	111	98	89	86	84	80	75	73	70	77	
63	14.9	105	105	97	89	86	84	80	75	74	70	77	
64	15.8	102	102	95	88	86	83	80	75	74	70	76	
65	15.4	103	103	97	90	89	85	83	78	78	73	78	
66	15.2	104	105	101	96	93	91	88	83	83	78	81	
67	15.4	105	106	102	98	96	94	92	87	87	82	84	
68	15.8	105	106	104	100	99	97	96	91	91	86	87	
69	15.0	116	117	115	114	114	112	111	107	109	103	103	
3262	15.3	109	108	97	89	87	85	82	76	75	72	79	
63	15.7	103	103	96	89	87	84	82	77	76	72	78	
64	16.0	101	101	96	89	87	84	82	77	76	72	78	
65	14.9	107	107	103	97	95	92	89	84	84	79	82	
66	15.3	105	106	102	97	95	92	90	85	85	81	84	
67	15.0	109	110	108	104	102	100	98	93	95	88	90	
68	15.3	109	110	109	106	105	103	102	98	99	91	95	
69	15.4	115	116	117	112	112	111	110	107	109	102	103	
3353	15.4	83	76	65	64	65	64	61	57	56	53	56	
63	15.3	104	104	97	90	89	86	83	78	78	73	79	
64	15.4	108	108	101	96	94	91	88	82	82	78	83	
65	15.7	106	107	103	99	97	95	92	87	86	82	87	
66	15.4	106	107	104	99	98	96	93	88	88	83	87	
67	15.2	109	110	108	104	103	102	99	95	96	90	93	
68	15.4	111	113	112	109	109	107	105	101	103	97	99	
94	14.7	29	29	30	30	31	31	34	37	41	48	52	
4466	16.3	82	83	83	83	83	83	83	81	82	80	83	
69	16.0	79	80	80	81	81	82	82	81	83	83	85	
72	15.6	73	74	74	76	77	78	79	79	82	82	86	
75	16.6	62	63	63	65	66	67	69	70	73	75	73	
78	16.5	54	54	54	57	58	58	61	63	66	69	73	
81	15.9	47	47	47	49	50	50	53	55	59	63	66	
84	14.7	40	40	40	41	42	43	45	47	51	56	60	
87	15.5	31	32	31	32	33	33	35	37	40	44	47	
Pile Power Level, MW		1710	1715	1720	1725	1725	1725	1725	1725		1770	1780	

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TABLE II (continued)

Overbore Outlet Temperatures, Flow Factors,
& Pile Power Level Versus Time On April 5, 1962

Tube Numbers	Time											
	1010	1035	1115	1130	1200	1220	1245	1300	1315	1340	1415	1445
0945	47	49	45	49	51	51	53	61	58	65		69
1453	51	54	50	56	62	62	65	77	71	81		87
59	53	56	52	57	60	59	61	68	65	70		77
64	61	61	56	59	60	58	59	63	61	64		68
94	105	102	121	110	104	108	109	112	109	115		112
2853	57	67	63	78	99	92	102	104	99	99	126	121
63	74	82	73	80	91	88	92	93	89	85	109	104
64	75	82	74	81	89	85	89	89	85	82	101	96
65	76	82	74	79	85	81	83	83	80	76	93	88
66	78	83	75	79	85	82	84	82	80	76	90	87
67	79	93	76	79	82	79	80	77	76	72	83	81
68	86	90	82	84	86	82	82	79	78	73	84	82
94	69	72	92	90	90	102	103	115	114	116	105	111
2962	73	83	74	82	97	92	98	99	91	87	116	106
63	74	82	73	79	89	86	90	89	85	81	101	96
64	71	78	70	75	82	78	82	80	77	74	92	85
65	72	78	70	75	82	78	80	78	76	72	87	82
66	74	79	71	76	82	77	80	77	75	71	84	80
67	77	83	74	80	83	78	79	76	74	70	82	79
68	80	84	77	80	83	78	79	75	74	70	80	77
69	99	93	85	88	88	83	82	77	77	72	82	79
3062	74	84	73	81	92	90	96	95	88	82	114	103
63	73	82	72	78	88	84	89	87	83	78	103	102
64	72	80	70	76	83	80	83	81	78	73	93	84
65	74	81	71	76	83	80	83	80	78	73	90	83
66	75	81	72	77	81	77	78	75	74	69	83	78
67	78	82	74	78	81	77	78	75	74	69	82	77
68	80	84	76	79	81	78	78	73	73	68	79	75
69	88	92	83	86	87	82	81	76	76	70	80	77
3162	81	94	80	88	106	101	107	106	100	94	127	112
63	80	89	78	84	96	92	96	95	90	83	111	99
64	78	86	75	81	89	85	89	86	83	77	100	89
65	79	86	76	80	89	83	86	82	81	75	95	85
66	82	89	79	83	89	84	87	83	81	75	93	85
67	84	90	80	84	89	84	85	80	80	74	87	82
68	86	91	82	85	87	82	82	77	76	70	83	77
69	99	104	93	98	98	91	90	83	83	75	89	83
3262	82	95	79	88	105	100	108	106	101	93	124	106
63	81	91	77	84	96	92	97	95	91	83	109	99
64	80	89	77	82	91	86	90	87	84	78	99	89
65	84	92	80	85	92	87	91	87	84	78	99	89
66	85	94	81	87	91	86	88	82	82	75	91	84
67	90	98	86	91	95	89	89	84	84	76	92	84
68	93	100	89	93	93	87	87	80	81	73	87	81
69	102	106	96	100	100	93	91	83	84	76	89	83
3353	59	69	61	70	93	84	94	96	91	88	114	107
63	82	96	78	86	99	96	101	98	95	86	111	102
64	86	97	80	88	98	94	98	94	92	83	105	97
65	88	97	83	89	94	89	93	87	86	78	98	90
66	87	94	83	86	89	85	86	82	81	75	89	85
67	93	102	88	93	94	89	90	83	83	76	90	86
68	99	105	93	98	97	91	91	84	85	77	91	86
94	61	65	81	86	86	100	101	117	115	116	106	112
4466	87	97	90	92	103	104	108	101	105	89	102	98
69	89	97	93	96	103	104	106	100	103	89	100	96
72	89	96	95	98	104	105	105	101	104	91	99	96
75	82	87	89	90	96	99	98	96	99	88	92	90
78	72	83	87	90	95	100	99	100	101	93	96	95
81	73	78	85	89	94	102	101	106	108	101	102	102
84	67	73	83	88	92	102	102	113	113	108	106	108
37	54	59	69	72	77	84	85	98	98	94	91	93
File Power Level, MW	1810	1050	1870	1870	1890	1910	1910	1920	1920	1920	1920	

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FIGURE - 1
OUTLET TEMPERATURES OF OVERBORE
TUBES 2863, 3062 & 3069 VS. TIME
APRIL 5, 1962

Figure - 2
No. 5 & 6 HCR Position Vs. Time
April 5, 1962

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FIGURE - 3
WEASEL DATA FOR OVERBORE CHARGES 3062 AND 3163, AND THE OVER-
BORE CHARGE SEQUENCE AND POSITION

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