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Addendum 1

Experiment Operations Plan for a Loss-of-Coolant Accident Simulation in the National Research Universal Reactor

Materials Tests 1 and 2

Prepared by G. E. Russcher, C. L. Wilson, R. K. Marshall, L. L. King,
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Pacific Northwest Laboratory
Operated by
Battelle Memorial Institute

Prepared for
U.S. Nuclear Regulatory
Commission

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ABSTRACT

A Loss of Coolant Accident (LOCA) simulation program is evaluating the thermal-hydraulic and mechanical effects of LOCA conditions on pressurized water reactor test fuel bundles. This experiment operation plan for the second and third experiments of the program will provide peak fuel cladding temperatures of up to 1172K (1650°F) and 1061K (1450°) respectively, for a long enough time to cause test fuel cladding deformation and rupture in both.

Reflood coolant delay times and the reflooding rates for the experiments were selected from thermal-hydraulic data measured in the National Research Universal (NRU) reactor facilities and test train assembly during the first experiment.

SUMMARY

Pacific Northwest Laboratory (PNL) is conducting a series of experiments in the U-2 loop of the National Research Universal (NRU) Reactor at Chalk River, Ontario, Canada, to evaluate the consequences of a simulated loss-of-coolant accident (LOCA) in a pressurized water reactor (PWR).

The second and third experiments of the LOCA simulation program being conducted by PNL are designed to evaluate the scenario and effects of PWR fuel cladding failure. The initial prototypic thermal-hydraulic (PTH) experiment of this program did not exhibit fuel failure because fuel rods were unpressurized. However, cladding deformation materials tests (MT) will rupture test fuel rods because they are pressurized with He to simulate beginning-of-life PWR fuel. Materials test trains MT-1 and MT-2 will probably incur fuel failure at peak fuel cladding temperatures determined by the thermal-hydraulic conditions characterized in the PTH experiment. However, even if test fuel rupture does not occur, the experiment will be terminated after reflooding coolant has quenched the fuel bundle.

Pacific Northwest Laboratory will provide the materials test trains, the test fuel assemblies, data acquisition, post irradiation examination, data reduction and analysis, and the management of the LOCA simulation program. Atomic Energy of Canada, Ltd., (AECL) will provide the test facilities, the irradiation space in the NRU Reactor, and operation and support of the facilities.

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1.0 INTRODUCTION

Pacific Northwest Laboratory (PNL)^(a) is conducting an experimental program for the Nuclear Regulatory Commission (NRC), Division of Reactor Safety Research, Fuel Behavior Branch, to evaluate the consequences of a hypothetical loss-of-coolant accident (LOCA) in a pressurized water reactor (PWR). Pacific Northwest Laboratory will provide the materials test trains, the test fuel assemblies, post irradiation examination of the test trains, data reduction and analysis, and management of the LOCA simulation program. Atomic Energy of Canada, Ltd. will provide test facilities and irradiation space in the Canadian National Research Universal (NRU) Reactor at the Chalk River Nuclear Laboratories (CRNL), Chalk River, Ontario.

A LOCA in a commercial PWR involves four major, distinct phases: blow-down, heatup, reflood, and quench. Each of these phases involves a path-dependent process that is a function of 1) the type of event that initiated the accident and 2) the reactor operating conditions at the time the LOCA was initiated. During the most damaging LOCA phases, heatup and reflood, the highest fuel cladding temperatures are reached, with the maximum pressure differential occurring across the fuel cladding wall. The pressurized cladding will rupture when the critical pressure is reached, releasing fission products possibly during the heatup phase.

Two cladding deformation materials tests (MT-1 and MT-2), that are the subject of this addendum report, will characterize PWR fuel rod rupture due to prepressurization at beginning of life. These experiments will attain peak cladding temperatures of up to 1172K (1650°F) for MT-1 and up to 1061K (1450°F) for MT-2. Operating conditions necessary to achieve the desired peak fuel cladding temperatures (and the predicted fuel cladding rupture) were developed in the prototypic thermal-hydraulic (PTH) experiment.

The reference (C. L. Mohr et al. 1980) Safety Analysis Report (SAR) provides a description of the LOCA simulation major safety issues and an overview of the experiments that were planned for the program. These safety issues

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were concurred with and further reported (D. J. Axford, I.C. Martin, and S. J. McAuley 1980). Because the experiment safety issues have been adequately analyzed, reviewed and reported, no further safety analyses are planned for these experiments. In this operations plan addendum, any changes to the test train or experiment operation are referenced to the appropriate safety document. Previous data or discussions are not repeated here. However, information is presented (in the Hazards Review, section 4.0) to show that differences between the MT and the PTH experiments are either insignificant safety issues or they are enveloped by the safety analyses presented before.

The Experiment Operations Plan (EOP) (G. E. Russcher et al. 1980) provides a detailed summary of the PTH experiment, and also serves as the technical basis for the subsequent MT experiments that are discussed here. Most design aspects of their test train and test fuel assemblies are identical. Similarly, most planned operations are the same. Consequently, the pertinent discussions and information found in the reference EOP are not reproduced here, just referenced.

This addendum to the reference EOP is designed to present only the new or different information that is needed to evaluate the materials test trains (MT-1 and MT-2) and their planned performance, to evaluate expected operations of the data acquisition and control system (DACS) and the loop control system (LCS), and to plan the necessary NRU and loop facility operations. This emphasis on the differences between previous and current test trains and experiment operations means that many topics are not discussed again, rather just referenced to the document where they were covered.

In addition, this report contains an Operating Procedure Summary (section 5.0) that shows the sequence of activities that PRL and CRNL operations personnel are expected to perform for the MT experiments.

2.0 EXPERIMENT OBJECTIVES

The primary objective is to characterize fuel cladding rupture during two LOCA simulation experiments that result in peak fuel cladding temperatures as high as 1172K (1650⁰F) and 1061K (1450⁰F), respectively. These experiments, MT-1 and MT-2, will use two different, but nearly identical, materials test trains MT-1 and MT-2. Each CMD transient phase is designed to conclude with cladding rupture of as many as 11 test fuel rods. The operating conditions necessary to achieve the desired peak fuel cladding temperatures (and rupture) are derived from the PTH experiment that characterized system thermal-hydraulic response during LOCA simulations.

A secondary objective is to determine the fuel rod rupture time and location during the simulated LOCA experiments. Current fuel rupture models will be used to predict fuel cladding rupture and select experiment operating conditions as well as possible. These predictions will also be used to plan post irradiation examinations and to compare predicted with measured experiment results.

Another experiment objective is to evaluate the thermal-hydraulic effects of the fuel cladding rupture. Reflooding hydraulic characteristics of the test train assemblies will be determined before and after the simulated LOCA transients. Thermal characteristics will also be measured during the transient to evaluate the cooldown of cladding due to lift off or separation at the fuel/cladding interface.

3.0 DESIGN DIFFERENCES

3.1 MATERIALS TEST TRAINS

The basic difference between the test train used for the PTH experiment and the MT experiment is that the 11 MT test fuel rods are pressurized with He to provide internal cladding stress that simulates PWR prepressurization at beginning of life. This pressurization is designed to cause simulated LOCA fuel rod rupture while minimizing the radioactive fission product inventory. The design differences of the materials test trains are summarized in Table 3.1. Only the 11 test fuel rods are pressurized with He during fabrication. The remaining 20 guard fuel rods are unpressurized for all simulated LOCA experiments.

Instrumentation changes are also planned that will meet the need for additional data during the CMD experiments. All of the data to be recorded by DACS are summarized in Table 3.2. The DACS number, name and the sensor location are identified for each. Three additional data types are presented here that were not available for the PTH experiment.

1. Each test fuel rod has a pressure transducer (either continuous or a switch type) attached to the top end cap. Continuous pressure transducers will monitor the internal pressure for test fuel rods 3C and 5C, but pressure switches will identify the rupture time for the other fuel rods.
2. Interior fuel cladding TCs are attached to the cladding to monitor its temperature without interference from fuel pellet chips or unintentional TC relocation. In addition, several of these TCs (sensors 91, 94, 97, 98, 100, 106, 108, 117, 120, 123, 126, and 137) are now axially relocated to regions of higher temperature (lower instrument levels).
3. Guard fuel rod cladding TCs selected for NRU trip circuitry are compared with PTH data. They (DACS pseudo sensors 305, 308, 315) are identified on Figure 3.1, together with an axial distribution of cladding temperatures during the PTH-125 transient that produced a

peak cladding temperature of about 1255K (1800⁰F). Example temperature distributions from PTH-125 data are shown because they provide instrument tube and average fuel cladding temperatures for comparison with trip setpoint temperatures of the PTH experiment. It is evident that guard fuel cladding temperatures at instrument level 13 were consistently higher than at level 17, as typified on Figure 3.1. Peak fuel cladding temperatures occurred between levels 13 and 15 rather than between levels 15 and 17. Consequently, the fuel cladding maximum trip setpoint temperature [1361K (1990⁰F)], calculated in Appendix D of the reference EOP, will be applied to sensors on levels 13 and 15 for the MT experiments. Similarly, because of the lower temperatures measured at level 17 in the PTH experiment, a lower trip setpoint temperature [1333K (1940⁰F)] will be used for the sensors on level 17. The tally of the trip setpoint safety margins, uncertainties and error margins developed in the reference EOP requires no modifications or further justification. The same is true for the pressure tube and hanger tube setpoint temperatures. During the most severe transients, measured temperatures were at least 28K (50⁰F) less than the acceptable temperatures reported in the reference SAR (C. L. Mohr et al. 1980). Consequently, the same pressure tube temperature limits and hanger tube trip setpoint temperature limits used in the PTH experiment (G. E. Russcher et al. 1980 - Appendix D) will be used in the MT experiments. See Table 3.3 for a summary of fuel cladding high temperature trip sensors and trip setpoints under various operating conditions.

TABLE 3.1. Materials Test Train Design Differences

<u>Simulated LOCA Experiment</u>	<u>Peak Cladding Temperature</u>	<u>Test Fuel Rod Internal Pressure, STP</u>
MT-1	1172 K (1650 ⁰ F)	~3.1 MPa (450 psia)
MT-2	1061 K (1450 ⁰ F)	~3.4 MPa (500 psia)

TABLE 3.2. Instrumented Data Summary

No.	DACS Name	Location		No.	DACS Name	Location	
		in.	Component			in.	Component
1	TC-1-4D-IN	-0.95	MT ^(a)	37	TC-9-1F-S-C	48.32	MT
2	TC-1-6A-IN	-0.95	MT	38	TC-10-4D-SP-4	55.28	MT ^(c)
3	TC-1-1F-IN	-0.95	MT	39	TC-10-6A-S-C	55.28	MT
4	TC-2-6F-S-C	8.03	MT	40	TC-10-6F-S-C	55.28	MT
5	TC-2-1A-S-C	8.03	MT	41	TC-10-1F-S-C	55.28	MT
6	UNDEFINED		^(b)	42	TC-10-1A-S-C	55.28	MT
7	TC-3-5B-OR-1	13.28	MT	43	TC-11-6C-OR-4	60.53	MT
8	TC-3-5E-OR-2	13.28	MT	44	TC-11-4F-OR-1	60.53	MT
9	TC-3-2E-OR-3	13.28	MT	45	TC-11-1D-OR-2	60.53	MT
10	TC-3-2B-OR-4	13.28	MT	46	TC-11-3A-OR-3	60.53	MT
11	TC-3-6A-S-C	13.28	MT	47	TC-11-6F-S-C	60.53	MT
12	TC-3-1F-S-C	13.28	MT	48	TC-11-1A-S-C	60.53	MT
13	TC-4-6F-S-C	18.53	MT	49	UNDEFINED		^(b)
14	TC-4-1A-S-C	18.53	MT	50	TC-12-5B-SP-3	68.32	MT
15	TC-5-6A-S-C	27.32	MT	51	TC-12-5E-SP-4	68.32	MT
16	TC-5-1F-S-C	27.32	MT	52	TC-12-2E-SP-1	68.32	MT
17	UNDEFINED		^(b)	53	TC-12-28-SP-2	68.32	MT
18	TC-6-6A-S-C	34.28	MT	54	TC-13-4D-SP-4	76.28	MT ^(c)
19	TC-6-6F-S-C	34.28	MT	55	TC-13-3B-IR-2	76.28	MT
20	TC-6-1F-S-C	34.28	MT	56	TC-13-6C-IR-2	76.28	MT ^(d)
21	TC-6-1A-S-C	34.28	MT	57	TC-13-4F-IR-4	76.28	MT ^(d)
22	TC-7-6C-OR-4	39.53	MT	58	TC-13-1D-IR-2	76.28	MT ^(d)
23	TC-7-4F-OR-1	39.53	MT	59	TC-13-3A-IR-4	76.28	MT ^(d)
24	TC-7-1D-OR-2	39.53	MT	60	TC-13-6A-S-C	76.28	MT
25	TC-7-3A-OR-3	39.53	MT	61	TC-13-6F-S-C	76.28	MT
26	TC-8-5B-OR-1	42.24	MT	62	TC-13-1F-S-C	76.28	MT
27	TC-8-2E-OR-3	42.24	MT	63	TC-13-1A-S-C	76.28	MT
28	TC-8-5E-OR-2	42.24	MT	64	TC-14-4D-SP-4	89.32	MT ^(c)
29	TC-8-2B-OR-4	42.24	MT	65	TC-14-5B-SP-3	89.32	MT
30	TC-8-6F-S-C	42.24	MT	66	TC-14-5E-SP-4	89.32	MT
31	TC-8-1A-S-C	42.24	MT	67	TC-14-2E-SP-1	89.32	MT
32	TC-9-5B-OR-1	48.32	MT	68	TC-14-2B-SP-2	89.32	MT
33	TC-9-5E-OR-2	48.32	MT	69	TC-15-4D-SP-4	97.28	MT ^(c)
34	TC-9-2E-OR-3	48.32	MT	70	TC-15-3B-IR-4	97.28	MT
35	TC-9-2B-OR-4	48.32	MT	71	TC-15-6C-IR-4	97.28	MT ^(e)
36	TC-9-6A-S-C	48.32	MT	72	TC-15-4F-IR-2	97.28	MT ^(e)

No.	DACS Name	Location		No.	DACS Name	Location	
		in.	Component			in.	Component
73	TC-15-1D-IR-4	97.28	MT ^(e)	109	TC-17-2B-IR-4	118.28	MT ^(f)
74	TC-15-3A-IR-2	97.28	MT ^(e)	110	TC-17-6A-S-C	118.28	MT
75	TC-15-6A-S-C	97.28	MT	111	TC-17-6F-S-C	118.28	MT
76	TC-15-6F-S-C	97.28	MT	112	TC-17-1F-S-C	118.28	MT
77	TC-15-1F-S-C	97.28	MT	113	TC-17-1A-S-C	118.28	MT
78	TC-15-1A-S-C	97.28	MT	114	UNDEFINED		(b)
79	TC-16-4D-SP-4	110.32	MT ^(c)	115	TC-18-4B-OR-3	139.28	MT
80	TC-16-5B-SP-3	110.32	MT	116	TC-18-5C-OR-3	139.28	MT
81	TC-16-5E-SP-4	110.32	MT	117	TC-17-5D-OR-3	118.28	MT ^(c)
82	TC-16-2E-SP-1	110.32	MT	118	TC-18-4E-OR-4	139.28	MT
83	TC-16-2B-SP-2	110.32	MT	119	TC-18-3E-OR-4	139.28	MT
84	TC-16-6A-C-3	110.32	MT	120	TC-17-2D-OR-1	118.28	MT ^(c)
85	TC-16-6F-C-4	110.32	MT	121	TC-18-2C-OR-1	139.28	MT
86	TC-16-1F-C-1	110.32	MT	122	TC-18-5C-IR-4	139.28	MT
87	TC-16-1A-C-2	110.32	MT	123	TC-17-5D-IR-4	118.28	MT ^(c)
88	TC-17-4C-IR-3	118.28	MT	124	TC-18-4E-IR-1	139.28	MT
89	TC-17-4D-SP-4	118.28	MT ^(c)	125	TC-18-3E-IR-1	139.28	MT
90	TC-17-3D-IR-5	118.28	MT	126	UNDEFINED		MT ^(b)
91	TC-15-3C-IR-2	97.28	MT ^(c)	127	TC-18-2C-IR-2	139.28	MT
92	TC-17-4C-IR-C	118.28	MT	128	TC-18-6A-S-C	139.28	MT
93	TC-17-3D-IR-C	118.28	MT	129	TC-18-6F-S-C	139.28	MT
94	TC-15-3C-IR-C	97.28	MT ^(c)	130	TC-18-1F-S-C	139.28	MT
95	TC-17-4C-IR-1	118.28	MT	131	TC-18-1A-S-C	139.28	MT
96	TC-17-3D-IR-3	118.28	MT	132	TC-20-OT-1	167.70	MT
97	TC-15-3C-IR-7	97.28	MT ^(c)	133	TC-20-OT-3	167.70	MT
98	TC-15-5B-IR-3	97.28	MT ^(c) (e)	134	TC-20-OT-2	167.70	MT
99	TC-17-5E-IR-4	118.28	MT ^(f)	135	TC-21-HT-1	187.23	MT
100	TC-15-2E-IR-1	97.28	MT ^(c) (e)	136	UNDEFINED		
101	TC-17-2B-IR-2	118.28	MT ^(f)	137	TC-15-3C-IR-1	97.28	MT ^(c)
102	TC-15-5B-IR-C	97.28	MT ^(c)	138	TC-17-3D-IR-4	118.28	MT
103	TC-17-5E-IR-C	118.28	MT	139	UNDEFINED		
104	TC-15-2E-IR-C	97.28	MT ^(c)	140	UNDEFINED		
105	TC-17-2B-IR-C	118.28	MT	141	UNDEFINED		(b)
106	TC-15-5B-IR-1	97.28	MT ^(c) (e)	142	SPND-3-6F-S-3	13.28	MT
107	TC-17-5E-IR-2	118.28	MT ^(f)	143	SPND-3-1A-S-1	13.28	MT
108	TC-15-2E-IR-3	97.28	MT ^(c) (e)	144	UNDEFINED		(b)

No.	DACS Name	Location		No.	DACS Name	Location	
		in.	Component			in.	Component
145	SPND-6-6A-S-2	34.28	MT	181	PS-19-4E-C	157.0	MT
146	SPND-6-1F-S-4	34.28	MT	182	PS-19-4E-C-1	157.0	MT
147	UNDEFINED		(b)	183	PS-19-3E-C	157.0	MT
148	SPND-10-6A-S-2	55.28	MT	184	PS-19-3E-C-1	157.0	MT
149	SPND-10-6F-S-3	55.28	MT	185	PS-19-2D-C	157.0	MT
150	SPND-10-1F-S-4	55.28	MT	186	PS-19-2D-C-1	157.0	MT
151	SPND-10-1A-S-1	55.28	MT	187	PS-19-2C-C	157.0	MT
152	SPND-12-1F-C	68.32	MT	188	PS-19-2C-C-1	157.0	MT
153	LVD-19-4D-LL-D	157.0	MT(g)	189	PS-19-3B-C	157.0	MT
154	SPND-13-6A-S-2	76.28	MT	190	PS-19-3B-C-1	157.0	MT
155	SPND-13-6F-S-3	76.28	MT	191	TC-90-HD-1	336.0	H/L-24(i)
156	SPND-13-1F-S-4	76.28	MT	192	TC-90-HD-2	336.0	H/L-24
157	SPND-13-1A-S-1	76.28	MT	193	TC-90-HD-3	336.0	H/L-24
158	UNDEFINED		(b)	194	TC-90-HD-4	336.0	H/L-24
159	SPND-15-6A-S-2	97.28	MT	195	UNDEFINED		
160	SPND-15-6F-S-3	97.28	MT	196	UNDEFINED		
161	SPND-15-1F-S-4	97.28	MT	197	PTK-19-3C-C	157.0	MT
162	SPND-15-1A-S-1	97.28	MT	198	PTS-19-5C-C	157.0	MT
163	SPND-16-1F-C	110.32	MT	199	UNDEFINED		
164	UNDEFINED		(b)	200	UNDEFINED		
165	SPND-17-6A-S-2	118.28	MT	201	SRC-19-LO-W	337.0	FE-4(j)
166	SPND-17-6F-S-3	118.28	MT	202	SRC-19-HI-GH	333.0	FE-3
167	SPND-17-1F-S-4	118.28	MT	203	STBY-FL-DW	382.0	FE-9
168	SPND-17-1A-S-1	118.28	MT	204	U2LP-PR-ES-S-1	447.0	PDT-90
169	UNDEFINED		(b)	205	U2LP-TA-PS-DR-1	{ +447.0 } { -1176.0 }	PDT-90
170	SPND-18-6F-S-3	139.28	MT	206	SRC-19-S-TC-IN-1	-180.0	TE-2
171	SPND-18-1A-S-1	139.29	MT	207	SRC-19-S-TC-DT-1	+363.0	TE-3
172	UNDEFINED		(b)	208	SRC-19-S-PS-IN-1	-82.0	PT-5
173	PS-19-4C-C	157.0	MT(h)	209	SRC-19-S-PS-OT-1	+369.0	PT-6
174	PS-19-4C-C-1	157.0	MT	210	SRC-19-S-FR-1	+950.0	FY-6
175	PS-19-3D-C	157.0	MT	211	SRC-19-S-FR-IN-1	-432.0	FV-1
176	PS-19-3D-C-1	157.0	MT	212	SRC-19-S-FR-DT-1		FI-2(k)
177	PS-19-4B-C	157.0	MT	213	SRC-19-TC-RF-LP-1	-450.0	TE-17
178	PS-19-4B-C-1	157.0	MT	214	SRC-19-TC-RF-TA-1	-225.0	TE-18
179	PS-19-5D-C	157.0	MT	215	U2LP-FL-OW-1	-1560.0	FT-4D
180	PS-19-5D-C-1	157.0	MT	216	UNDEFINED		

No.	DACS Name	Location		No.	DACS Name	Location	
		in.	Component			in.	Component
217	SRCS-S-PS-OT-2	+950.0	PT-4	303	PSD-11-S-2		DACS
218	ACUM-WT	-238.0	WIS(1)	304	PSD-12-SP-1		DACS
221	U2LP-TC-IN-1	-1176.0	TE-78				
222	U2LP-TC-OT-1	+447.0	TE-79	305	PSD-13-IR-1		DACS
				306	PSD-13-S-2		DACS
223	SRCS-FR-HI-B	-413.0	FE-3B	307	PSD-14-SP-1		DACS
224	SRCS-FR-LO-B	-409.0	FE-4B	308	PSD-15-IR-1		DACS
257	SRC-S-DE-LT-A	Transient Signal	LCS(m)	309	PSD-15-S-2		DACS
258	SRC-RF-TR-IP	Low RF	LCS(n)	310	PSD-16-SP-1		DACS
				311	PSD-16-C-2		DACS
289	PSD-1-IN-1		DACS(e)	312	PSD-17-IR-C		DACS
290	PSD-2-S-1		DACS	313	PSD-17-IR-2		DACS
291	PSD-3-OR-1		DACS	314	PSD-17-IR-3		DACS
292	PSD-3-S-2		DACS	315	PSD-17-IR-4		DACS
				316	PSD-17-S-5		DACS
293	PSD-4-S-1		DACS				
294	PSD-5-S-1		DACS	317	PSD-18-OR-1		DACS
295	PSD-6-S-1		DACS	318	PSD-18-IR-2		DACS
296	PSD-7-OR-1		DACS	319	PSD-18-S-3		DACS
297	PSD-8-OR-1		DACS	320	PSD-20-OT-1		DACS
298	PSD-8-S-2		DACS				
				321	PSD-17-SD-6		DACS
299	PSD-9-OR-1		DACS	322	PSD-19-PS-1		DACS
300	PSD-9-S-2		DACS	323	PSD-19-PS-1		DACS
				324	UNDEFINED		
301	PSD-10-S-1		DACS				
302	PSD-11-OR-1		DACS	325	PSD-19-PS-3		DACS

- (a) Materials test (MT) assembly, elevation relative to the bottom of the fuel column.
- (b) Sensor removed, subject to replacement by the liquid level detector.
- (c) Sensor relocated from the location of the PTH test train.
- (d) Level 13 trip circuit thermocouples.
- (e) Level 15 trip circuit thermocouples.
- (f) Level 17 trip circuit thermocouples.
- (g) LVDT Linear Variable Differential Transformer for the liquid level detector.
- (h) DACS average pseudo sensor (calculated signal).
- (i) NRU head mounted at location L-24.
- (j) Sensor element, located in the U-2 loop or steam/reflood loop relative to the test fuel column bottom, measured along the hydraulic channel. See AECL Flowsheet, E-4531-F-1 rev. 9, January 28, 1981.
- (k) Bypass steam loop, location irrelevant.
- (l) Hydraulic head, below the fuel column bottom.
- (m) Loop control system signal for forced transient operation.
- (n) Low reflood water inventory signal, also trips the NRU reactor.

TABLE 3.3. Trip Setpoint Criteria for Operating and Non-Functional Fuel Cladding Thermocouples

Summary Operating Conditions	Criteria and Safety Margins (SM)	Sensor Instrument Levels		
		Level 17	Level 15	Level 13
		DACS Thermocouple Numbers		
		315, PSD-17-IR-4 (99, 101, 107, 109)	308, PSD-15-IR-1 (71, 72, 73, 74,) (98, 100, 106, 108)	305, PSD-13-IR-1 (56, 57, 58, 59)
		Trip Setpoint Temperatures		
2 $\leq$ Operating TCs on each of levels 13, 15, 17	Standard SM = 56K (100°F)	1333K (1940°F)	1361K (1990°F)	1361K (1990°F)
2 $\leq$ Operating TCs on each of levels 15 and 13	Standard SM = 56K (100°F)	1333K (1940°F)	1361K (1990°F)	1361K (1990°F)
2 $\leq$ Operating TCs on each of levels 15 and 17, or levels 13 and 17	Alternate SM = 84K (150°F)	1305K (1890°F)	1333K (1940°F)	1333K (1940°F)
2 $\leq$ Operating TCs on only level 15 or 17 or 13	Fall-Back SM = 111K (200°F)	1305K (1890°F)	1305K (1890°F)	1305K (1890°F)

FIGURE 2-1. Pressure-Temperature Distribution and NRU Trip Setpoints

Thermal insulation that protects test instrument connectors at the test train head is composed of several blocks that fit together under the NRU deck plate. These have been redesigned so that they can be removed more quickly without first removing the NRU deck plate. This will minimize personnel exposure to ruptured fuel fission product radiation that may be present in the loop outlet piping under the deck plate.

3.2 LOOP FACILITIES AND THE LOOP CONTROL SYSTEM

The steam and reflood Loop Control System (LCS) will be instrumented to provide data to the DACS, essentially the same as provided in the PTH experiment. The only significant change is the location of the steam inlet pressure sensor (PT-5). This is moved as close to the test train inlet as possible (to record steam as well as reflood pressure.) Previously failed inlet and outlet pressure sensors and thermocouples will be replaced and reviewed for operability.

Reflood flow rate data will be provided to DACS for both high (FI-3) and low (FI-4) reflood circuits. Redundant instrumentation will be provided (by sensors FI-3B and FI-4B) to preclude experiment operation without recorded reflood flow rate data. Reflood coolant temperature will also be provided.

Bladders are removed from the reflood water accumulators. This means that nitrogen absorption is not controlled. However, the reflood water in the accumulators will be supplied at the same temperature range, 305-322K (90-120°F), as it was during the PTH experiment.

In general, the LCS will be operated in accord with procedures summarized in section 5 of this addendum. Parameters for both MT experiments are tabulated there. These operations are all similar to the procedures used during the PTH experiment.

3.3 NRU REACTOR OPERATIONS

The NRU reactor provides a prototypic power distribution in the test fuel assembly that will restructure the fuel column during the preconditioning phase of the experiment. Fuel pellet/cladding interaction is assured by initially high pressure [8.62 MPa (1250 psia)] coolant, high power density and by fuel

cracking due to high power operation and the first reactor trip. A schematic of reactor power operations, shown in Figure 3.2, provides an overview of the several test phases for an MT experiment, together with an estimate of the NRU reactor power levels and irradiation times.

Automated NRU power operations for MT-1 are similar to the PTH-110 experiment. Automatic adjuster rod motion is expected during the brief (NRU steady state) period while reflood water is being injected (experiment transient phase). The changing NRU power level during this period will be carefully monitored.

REDACE will be used to collect desired NRU data as rapidly as possible (30s frequency) during the transient phase of each MT experiment. REDACE will record the reactor power, loop operating conditions, platinum SPFD (self powered flux detector) responses, and adjuster rod positions. These magnetic taped data will be used for data reduction analysis and power coupling calculations at PNL after the experiments are completed.

Specific NRU core loading configurations are required for the MT experiments. Selected loads and NRU fuel rods are necessary to provide neutronic conditions similar to the LOCA simulation PTH experiment conditions. These requirements are summarized in Appendix A (M.D. Atfield October 2, 1980).

FIGURE 3.2. MT Experiment and NRU Operations Schematic

4.0 HAZARDS REVIEW

The primary difference between the PTH experiment and these MT experiments is the test fuel rod pressurization change. Of the 31 fuel rods in the test train, the central 11 test fuel rods will be pressurized to 2.66-3.44 MPa (400-500 psia). The maximum internal pressure expected at the time of fuel rod rupture is less than 8.28 MPa (1200 psia). At the interior surface of the test train shroud, the stagnation pressure pulse would probably be reduced by at least two orders of magnitude, because the test fuel rods are separated from the shroud by a row of unpressurized guard fuel rods. The NRU pressure tube is fully capable of containing any such pressure pulses caused by fuel rod ruptures due to the fact that it was designed, tested and used for (LOCA simulated) preconditioning test operation at 8.62 MPa (1250 psia). The pressure tube capability is described in the reference report (D.T. Nishimura October, 1980).

Safety analyses, (C. L. Mohr et al. October, 1980) assumed that pressure tube temperatures were as high as 644K (700°F). Throughout the PTH experiment, the maximum temperature measured on the hanger tube was 658K (725°F), but the pressure tube temperature was judged to be at least 50K (90°F) below that. Consequently, the pressure tube design is more than adequate for containing the LOCA simulation MT experiments.

Because the central 11 test fuel rods are expected to rupture during an MT experiment, a summary of the maximum fission product inventory that could be released to the coolant loop and the maximum amount that could be released to the atmosphere are provided in Table 4.1. The calculations were based upon the analyses and data provided in the reference report (D. J. Axford, I. C. Martin, and S. J. McAuley 1980).

These values are conservative because:

- it is assumed that 1% of the fission product inventory is released, while considerably less than 1% release should be expected (I. J. Hastings and M. J. F. Notley 1979, and R. A. Lorenz, D. O. Hobson, and G. W. Parker 1971);

Table 4.1. Expected Radioactive Release from
Eleven Test Fuel Rod Ruptures

<u>Fission Products</u>	<u>Inventory</u>	<u>Available</u>	<u>Releasable</u>
Equivalent I ¹³¹ (Ci)	112	1.12	.011 ^(a)
Noble Gases (Ci MeV)	1114	11.14	11.14

(a) Charcoal filters in the NRU vent line will reduce the released fission products by >99%.

- calculated fission product generation was due to a test assembly power level of 2.6 MW, compared with 2.0 MW, expected to be generated during the preconditioning phase of these experiments; and
- several fission product transport phenomena are also conservatively neglected.

Postulated accidents and the hypothetical fission product releases are discussed in the SAR (C. L. Mohr et al. 1980), and will not be repeated here.

The hydraulic effects of fuel rod rupture have also been considered as a potential hazard of the MT experiments. Simple analyses have shown that at least 90% coolant channel blockage is required to limit reflood coolant flow by 50%. A nominal 50% of the desired reflood coolant flow rate was used in analyzing postulated accidents for the SAR. However, even if all (11) test fuel rods rupture (or balloon), substantially blocking all adjacent coolant channels, less than half of the test assembly coolant channel area would be obstructed. This restriction may reduce the reflood flow rate somewhat, but the MT test train will remain adequately coolable under the most conservative postulated blockage conditions.

5.0 OPERATING PROCEDURE SUMMARY

5.1 PRECONDITIONING OPERATIONS PLAN

5.1.1 Piping Configuration

- 5.1.1.1 Install test assembly (MT-1) in L-24 test position.
- 5.1.1.2 Connect U-2 loop to L-24 test position.
- 5.1.1.3 Pressure test the test train head seal.

5.1.2 Loop Facilities Preparations

- 5.1.2.1 Fill and electrically preheat the U-2 loop.
- 5.1.2.2 Calibrate loop instruments (see Table 5.1).
- 5.1.2.3 Confirm trip circuit operability.
- 5.1.2.4 Implement trip setpoints and report to the experiment director when ready for operation (see Tables 3.3 and 5.2).

5.1.3 NRU Reactor Preparation

- 5.1.3.1 Load NRU reactor fuel assemblies and absorber assemblies, as per Appendix A (M. D. Atfield October 2, 1980).
- 5.1.3.2 Input NRU reactor linear and log rate trip setpoints, as required by CRNL.
- 5.1.3.3 Adjust the neutron detector scatter plug, as required.
- 5.1.3.4 Establish mean power trip setpoints, as required.
- 5.1.3.5 Confirm that all trip setpoints are activated and report when ready for operation to the experiment director.

5.1.4 DACS Computer Preparation

- 5.1.4.1 Load labeled, certified disk packs and mount a labeled, certified tape on the tape drive (Test Name = MT-1-Pre; Tape No. BTL-035).
- 5.1.4.2 Start a dummy test and set the DACS to idle mode.

TABLE 5.1. Loop Instrument Calibration

Sensor	Loop Parameter	DACS	Instrument Range	Acceptable Accuracy
U-2 Loop				
TE-78	Inlet Temperature	221	311 to 533K (70 to 500°F)	±1K (±2°F)
TE-79	Outlet Temperature	222	323 to 589K (122 to 600°F)	±1K (±2°F)
FT-40	Flow	215	3.9(a) to 19.3(b) kg/s (36,400 to 131,400 lbm/hr)	±0.4 kg/s (±2000 lbm/hr)
PDT-90	Outlet Pressure	204	5.52 to 8.96 MPa (800 to 1300 psia)	±0.3 MPa (±50 psia)
PDT-90	Test Assembly Pressure Drop	205	0.021 to 0.172 MPa (3 to 25 psi)	±7 MPa (±0.3 psi)
Steam/Reflood Loop				
TE-2	Inlet Coolant Temperature	206	394 to 700K (250 to 300°F)	±1K (±2°F)
TE-3	Outlet Coolant Temperature	207	422 to 973K (300 to 1300°F)	±6K (±10°F)
FV-6	Steam Flow Rate, Reflood Boiling	210	0 to 0.378 kg/s (0 to 3000 lbm/hr)	±0.014 kg/s (±100 lbm/hr)
FV-1	Steam System Control Flow Rate, Inlet	211	0 to 0.378 kg/s (0 to 3000 lbm/hr)	±0.014 kg/s (±100 lbm/hr)
FI-2	Steam System Control Flow Rate, Outlet	212	0 to 0.032 kg/s (0 to 250 lbm/hr)	±0.0013 kg/s (±10 lbm/hr)
PT-5	Steam Inlet Pressure	208	0 to 0.69 MPa (0 to 100 psia)	±0.034 MPa (±5 psia)
PT-6	Steam Outlet Pressure	209	0.069 to 0.345 MPa (0 to 50 psia)	±0.017 MPa (±2.5 psia)
PT-4	Steam Pressure Control, Outlet Region	217	0 to 0.69 MPa (0 to 100 psia)	±0.034 MPa (±5 psia)
FI-4	Reflood Coolant, Low Flow Rate	201	0.013 to 0.254 m/s (0.5 to 10 in/s)	±5%
FI-3	Reflood Coolant, High Flow Rate	202	0.013 to 0.305 m/s (0.5 to 12 in/s)	±5%
FI4b	Reflood Coolant, Low Flow Rate (backup)	224	0.013 to 0.254 m/s (0.5 to 10 in/s)	±5%
FI3b	Reflood Coolant, High Flow Rate (backup meter)	223	0.013 to 0.305 m/s (0.5 to 12 in/s)	±5%
FE-9	Standby Reflood Coolant Flow	203	0.013 to 0.305 m/s (0.5 to 12 in/s)	±10%
TE-17	Reflood Coolant Temperature Control Valve Inlet	213	305 to 322K (90 to 120°F)	±5%
TE-18	Reflood Coolant Temperature Control Valve Outlet	214	305 to 322K (90 to 120°F)	±5%

(a) At a temperature of 589K (600°F).

(b) At a temperature of 394K (250°F).

TABLE 5.2. Preconditioning Trip Setpoints

<u>Parameter</u>	<u>Operating Limits</u>	<u>Trip Setpoint</u>
Outlet coolant temperature	552K (534°F)	560K (550°F)
Pump subcooling temperature--Low	83K (150°F)	28K (50°F)
Coolant flow--Low	15.5 kg/s ^(a) (123,000 lbm/hr)	13.4 kg/s ^(a) (106,300 lbm/hr)
Surge tank level--Low	TBD ^(b)	30%
Surge tank pressure--High	TBD	8.90 MPa (1275 psig)
Cladding temperature ^(c)		
Level 13	1255K (1800°F)	1361K (1990°F)
Level 15	1255K (1800°F)	1361K (1990°F)
Level 17	1255K (1800°F)	1333K (1940°F)

(a) At a temperature of 517K (472°F).

(b) To be determined by CRNL.

(c) Fuel cladding setpoints selected but not required until transient operation.

5.1.3.3 Set the steady state scan rate at 1 second.

5.1.4 Set the immediate display scan rate at 4 seconds.

5.1.5 Set the graphic display scan rate at 6 seconds.

5.1.6 Announce the steady state immediate display.

5.1.6.7 Identify and remove failed sensors from display.

5.1.6.8 Verify trip circuit operability.

5.1.6.9 Set Keirby amplifiers on the 1.0 scale and verify that SPND coefficients are correct.

5.1.7 Preconditioning Operating Procedure (Each step is to be followed

in order.) NOTE: Total time at full reactor power is to be limited to 1 hour of full-power equivalent.

5.1.7.1 End the dummy test and start a new test on the DACS.

5.1.7.2 Start up the loop, using sparge pump to provide initial flow (1.2 kg/s (36,400 lbm/hr)) and initial pressurization (5.62 MPa (1250 psia)).

- 5.1.5.3 Change the DACS mode to steady state.
- 5.1.5.4 Increase the reactor power to 63.5 MW.
- 5.1.5.5 Perform a power calibration, using a REDACE printout.
- 5.1.5.6 Print the DACS sensor status report and REDACE printout for review.
- 5.1.5.7 Increase the U-2 loop flow to 16.3 kg/s ± 5 (129,400 lbm/hr $\pm 5\%$).
- 5.1.5.8 Increase the reactor power to 127 MW $\pm 5\%$.
- 5.1.5.9 Print the DACS sensor status report and the REDACE printout.
- 5.1.5.10 Perform a power calibration.
- 5.1.5.11 Conditionally trip the reactor.
- 5.1.5.12 Using a REDACE print frequency of 30s, increase the reactor power and U-2 flow rate to full power in 3 steps: 8 MW, 64 MW, 127 MW $\pm 5\%$, maintaining test assembly inlet temperature at 517K ± 3 K (472⁰F ± 5 ⁰F), and power skew $<5\%$.
- 5.1.5.13 Print the DACS sensor status report.
- 5.1.5.14 Recheck power calibrations and complete the preconditioning irradiation.
- 5.1.5.15 Trip the reactor. Turn off the video recorder and record the counter.
- 5.1.5.16 Make a hardcopy of the CRT immediate display and graphic display showing the hottest centerline thermocouples. Change DACS to idle mode. Make a tape copy when ending the test. Make a disk image copy. Make a historical request for all the data required to run the transient test.
- 5.1.5.17 Repeat Steps 5.1.5.12 through 5.1.5.16 if time permits.
- 5.1.5.18 Shutdown the loop facilities to prepare for piping rearrangement. Return DACS to steady state and scan the sensors 1/min. until reflood flow tests are initiated.

5.2 REFLOOD FLOW, PRETRANSIENT AND TRANSIENT OPERATIONS PLAN

5.2.1 Piping Configuration

5.2.1.1 Connect the reflood loop to L-24 test position.

5.2.1.2 Connect the U-1 steam supply to the reflood loop.

5.2.2 Loop System Preparations

5.2.2.1 Start up the U-1 loop.

5.2.2.2 Insure that U-2 make up tanks (which supply water to the U-1 loop) are full.

5.2.2.3 Preheat the steam/reflood loop to 408K (275°F).

5.2.2.4 Fill reflood accumulators, at 305–322K (90–120°F). Otherwise drain and refill it.

5.2.2.5 Verify that the supply of nitrogen used for accumulator pressurization is adequate.

5.2.2.6 Calibrate loop instruments, as shown in Table 5.2. Enter conversion factors and units in the test log.

5.2.2.7 Implement the trip setpoints as shown in Tables 3.3 and 5.4 for the pretransient and transient phases of the experiment. The trip pseudo sensors used on DACS to represent the high cladding temperature trip circuits and sensors are detailed on Table 5.5.

5.2.2.8 Set timer 1, the reflood delay time according to Table 5.6.

5.2.2.9 Set the reflood terminus time (Table 5.6).

5.2.2.10 Set the reflood rate (Table 5.6).

5.2.2.11 Set remaining timers for appropriate reflood durations.

5.2.2.12 Report to the experiment director when ready for experiment operation.

TABLE 5.4. Pretransient And Transient Trip Setpoints

Parameter	Location	Use	Operating Limits	Trip Setpoint
Hanger Tube Temperature - High	LCS	(Pretransient {Transient	691K(785°F)	839K(1050°F)
Outlet Pipe Temperature - High	LCS	(Pretransient {Transient	672K(750°F)	700K(800°F)
Level Creeping Temperatures (Fig. 3)				
Level 13 305 PSD-13-IR-1	DACS	(Pretransient {Transient	1305K(1890°F)	1361K(1990°F)
Level 15 305 PSD-15-IR-1	DACS		1305K(1890°F)	1361K(1990°F)
Level 17 315 PSD-17-IR-4	DACS		1278K(1840°F)	1333K(1940°F)
Standby Reflood Flow - Low	LCS	Transient	90	.5 in./s
Accumulator Inventory - Low	LCS	Transient	22.7 Kg(50 lbm)	11.3 Kg(25 lbm)

- (a) Standard trip setpoint criterion, see table 3.3 for nonfunctional TC criteria.
- (b) To be determined by CRNL loops staff.

TABLE 5.5. Cladding High Temperature Trip Sensors

<u>Level</u>	<u>Sensor Thermocouples</u>	<u>DACS Sensor Number</u>	<u>DACS Pseudo Sensor</u>
13	TC-13-6C-IR-2	56	305 PSD-13-IR-1
	TC-13-4F-IR-4	57	305 PSD-13-IR-1
	TC-13-1D-IR-2	58	305 PSD-13-IR-1
	TC-13-3A-IR-4	59	305 PSD-13-IR-1
15	TC-15-6C-IR-4	71	308 PSD-15-IR-1
	TC-15-4F-IR-2	72	308 PSD-15-IR-1
	TC-15-1D-IR-4	73	308 PSD-15-IR-1
	TC-15-3A-IR-2	74	308 PSD-15-IR-1
	TC-15-5B-IR-3	98	308 PSD-15-IR-1
	TC-15-2E-IR-1	100	308 PSD-15-IR-1
	TC-15-5B-IR-1	106	308 PSD-15-IR-1
	TC-15-2E-IR-3	108	308 PSD-15-IR-1
17	TC-17-5E-IR-4	99	315 PSD-17-IR-4
	TC-17-2B-IR-2	101	315 PSD-17-IR-4
	TC-17-5E-IR-2	107	315 PSD-17-IR-4
	TC-17-2B-IR-4	109	315 PSD-17-IR-4

5.2.3 NRU Reactor Preparations

- 5.2.3.1 Confirm that two linear rate and two log rate neutron flux detectors (ion chambers) are being recorded for the experimenter in the NRU reactor control room.
- 5.2.3.2 Confirm that the REDACE data will be taken on demand or at a 30s frequency when requested.
- 5.2.3.3 Establish mean power trip setpoints as required.
- 5.2.3.4 Confirm that all trip setpoints are activated and report to the experiment director when ready for experiment operation.

TABLE 5.6. Parameters for Transient and Reflood Flow Tests for MT-1 and MT-2

Test Parameter	Transient Tests		Reflood Tests			
	MT-1	MT-2	Pre-Transient		Post-Transient	
			RT-1	RT-2	RT-3	RT-4
Reflood Rate m/s (in/s)	0.053(2.1)	0.053(2.1)	0.013(.5)	0.53(2.1)	0.013(.5)	0.53(2.1)
Delay Time (s)	30	12	0	0	0	0
Peak Cladding Temperature K ($^{\circ}$ F)	1172 K (1650 $^{\circ}$ F)	1061 K (1450 $^{\circ}$ F)	450 K (350 $^{\circ}$ F)	450 K (350 $^{\circ}$ F)	450 K (350 $^{\circ}$ F)	450 K (350 $^{\circ}$ F)
Reflood Terminus Time (s)	800	720	165	30	165	30
Initial Cladding Temperature K ($^{\circ}$ F)	727 K (850 $^{\circ}$ F)	727 K (850 $^{\circ}$ F)	422 K (300 $^{\circ}$ F)	422 K (300 $^{\circ}$ F)	422 K (300 $^{\circ}$ F)	422 K (300 $^{\circ}$ F)

5.2.4 DACS Computer Preparation

- 5.2.4.1 Load the DACS with a labeled certified tape and disks. Test Name MT1-R Tape Number BTL-037
- 5.2.4.2 Start a dummy test and set the DACS mode to idle.
- 5.2.4.3 Set the steady state scan rate at 1 second.
- 5.2.4.4 Set the transient scan rate at 40 ms.
- 5.2.4.5 Set the immediate display scan rate at 4 seconds.
- 5.2.4.6 Set the graphic display scan rate at 5 seconds.
- 5.2.4.7 Format the steady state immediate display.
- 5.2.4.8 Format the transient graphic display.
- 5.2.4.9 Identify and remove any failed sensors from displays, pseudo sensors and trip circuits.
- 5.2.4.10 Reset Keithley amplifiers to the 0.1 scale and change SPND coefficients. Reduce by a factor of 10.
- 5.2.4.11 Report to the experiment director when ready for pretransient experiment operation.

5.2.5 Reflood Flow Test Operating Procedure (To be followed in sequence.)

- 5.2.5.1 Calibrate the reflood prefill controls to fill the test nozzle annulus up to level 0. Prefill and drain.
- 5.2.5.2 Place the DACS in the steady state mode.
- 5.2.5.3 Increase test section steam flow to 0.378 kg/s (3000 lbm/hr), and control test section backpressure at 0.276 MPa (40 psia).
- 5.2.5.4 Enter all reflood flow test operational parameters (Table 5.6) in the LCS.
- 5.2.5.5 Print a sensor status report and ensure that the test assembly thermocouples are $\geq 440\text{K}$ (340°F).
- 5.2.5.6 Reproduce the CRT immediate display and the graphics display.

- 5.2.5.7 Turn on the videotape recorder.
- 5.2.5.8 Switch the DACS to the transient mode 20 seconds before using the verbal command, "BEGIN THE TRANSIENT," (directed to the LCS operator) and record the time.
- 5.2.5.9 LCS operator initiates transient.
- 5.2.5.10 Reproduce the CRT immediate display and the transient graphics display, as required.
- 5.2.5.11 Stop the test when reflood water passes the thermocouples at level 20.
- 5.2.5.12 Change the DACS mode to steady state for 5 minutes, then to idle.
- 5.2.5.13 Make a historical request on the DACS and reproduce copies of the following data:
 - reflood rate (DACS sensors 201, 202, 203, 223, and 224)
 - steam flow-rate (DACS sensors 210, 211, and 212)
 - thermocouples at each level (DACS sensors 213, 214, 289, 291, 296, 297, 299, 302, 304, 305, 308, 313, 317, and 320)
- 5.2.5.14 Dump all DACS sensors through the transient for each 5 seconds.
- 5.2.5.15 Check the reflood rate to each level
- 5.2.5.16 Repeat the above steps 5.2.5.1 to 5.2.5.15 using the fast reflood rate. See Table 5.6.
- 5.2.5.17 Turn off the video recorder and record the counter location.
- 5.2.5.18 Make a tape copy on the DACS, and make a disk image copy on tape, as time permits.
- 5.2.5.19 As necessary, repeat DACS Computer preparation (5.2.4) and Loop System Preparation (5.2.2) before proceeding to section 5.2.6, Pretransient Operating Procedure.

5.2.6 Pretransient Operating Procedure (To be followed in sequence.)

- 5.2.6.1 Start a new test on the DACS. Change the DACS mode to steady state. Test Name = MT1, Tape Number BTL-038
- 5.2.6.2 Ensure that the REDACE scan frequency for NRU data is 30 seconds.
- 5.2.6.3 Start up the NRU to the low neutron level.
- 5.2.6.4 Increase the test section steam flow to 0.378Kg/s (3000 lbm/hr) with a 40 psia backpressure.
- 5.2.6.5 Increase NRU reactor power to 4.0 MW. With the reactor power at nominally 50% of the pretransient power, scan the DACS CRT immediate display for the hottest thermocouple and reproduce the display.
- 5.2.6.6 Increase the steam flow to $0.378 \text{ kg/s} \pm 5\%$ ($3000 \text{ lbm/hr} \pm 5\%$). Ensure that the test assembly inlet temperature stabilizes at about 450K (350°F) at 4.0 MW.
- 5.2.6.7 Increase the NRU reactor power on automatic control to ~8.0 MW.
- 5.2.6.8 Adjust the reactor power to obtain a steady state peak cladding temperature at $727 \pm 3\text{K}$ ($850 \pm 5^{\circ}\text{F}$) and outlet steam at about 625K (665°F).
- 5.2.6.9 Check the peak cladding temperature, steam flow, flux tilt, test assembly inlet temperature, outlet pressure, and accumulator weight 302Kg (665 lbs).
- 5.2.6.10 Reproduce the CRT immediate display and the graphics display.
- 5.2.6.11 Activate the videotape recorder.

5.2.7 Transient Operating Procedure (To be followed in sequence.)

- 5.2.7.1 Change to the transient operating mode on the DACS. Twenty seconds later, issue the verbal command, "BEGIN THE TRANSIENT," (directed to the Loop Control System Operator) and record the time in the DACS log.
- 5.2.7.2 The LCS operator begins the transient.

- 5.2.7.3 In the DACS log, record the hottest pseudo sensor and the last 2 pseudo sensors to quench.
- 5.2.7.4 Shut down the reactor when the test assembly quench is complete.
- 5.2.7.5 Shut off reflood water flow.
- 5.2.7.6 Record reflood water used (accumulator weight difference).
- 5.2.7.7 Insure that tripping the reactor has returned control to the DACS (transient forcing signal #257 = 0).
- 5.2.7.8 Return the DACS mode to steady state for 5 minutes. Return the DACS to idle mode, ending the data record.
- 5.2.7.9 Copy the following historical data on the DACS.
 - Make a videotape and hardcopy of the hottest pseudo sensors.
 - Make a videotape and hardcopy of the last 2 pseudo sensors to quench.
 - Plot the hottest pseudo sensor versus time.
 - Plot the last 2 pseudo sensors to quench versus time.
 - Plot loop data (DACS sensors 201, 202, 203, 210, 211).
 - Dump all DACS data to tape for the transient at 5 second intervals.
- 5.2.7.10 End the test on the DACS.
- 5.2.7.11 Turn off the videotape recorder and record the location.
- 5.2.7.12 Make a tape copy of the DACS data.
- 5.2.7.13 Make a disc image copy of the DACS data.
- 5.2.7.14 Return to Section 5.2.5, Reflood Flow Operating Procedure, and follow steps 5.2.5.1 through 5.2.5.18.
- 5.2.7.15 Terminate the experiment and remove the test train to the bay using established CRNL procedures.

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*Available for purchase from the NRC/GPO Sales Program, U.S. Nuclear Regulatory Commission, Washington, DC 20555 and/or the National Technical Information Service, Springfield, VA 22161.

APPENDIX A

REACTOR LOADING FOR BATTELLE LOCA SIMULATION TESTS

Atomic Energy
of Canada Limited
Research Company
Chalk River
Nuclear Laboratories

L'Énergie Atomique
du Canada, Limitée
Société de Recherche
Laboratoires Nucléaires
de Chalk River

APPENDIX A

MEMORANDUM

ADVANCED PROJECTS AND REACTOR PHYSICS DIVISION

Reactor Physics Branch

1980 October 2

TO: NRU Superintendent

FROM: M.D. Atfield

REACTOR LOADING FOR BATTELLE LOCA SIMULATION TESTS

In order to facilitate the analysis associated with these tests, I would like to maintain the same reactor environment throughout the series. This means that the following sites would contain the specified assemblies any time the BATTELLE fuel is in core:

J-26	Cobalt carrier rod with very similar loading on each occasion.
K-27	Natural uranium fast neutron rod
K-21	Aluminum nitride rod
L-26	FE fuel rod - burn-up 50 MWD
M-25	" " " " " 10 MWD
K-23	" " " " " 130 MWD
L-22	" " " " " 150 MWD

The burn-ups given for driver fuel rod neighbours are approximate and may need to be adjusted some time during the first test to establish more desirable reactor conditions. However, once those rods have been chosen for the first test, they should be preserved for subsequent tests. This would involve extra rod work to install and remove these fuel rods during each BATTELLE shut-down. Storage block space is also required.

Please let me know if this procedure is impractical.

M.D. Atfield

MDA:ny

c.c. C.A. Herriot
S.Z. Hart

P.M. Garvey
B. Deabreu
P.M. Brewster

A.1

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C. L. Mohr
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7. AUTHOR(S) G.E. Russcher, C.L. Wilson, R.K. Marshall, L.L. King, L.J. Parchen, J.P. Pilger, G.M. Hesson, C.L. Mohr				3. RECIPIENT'S ACCESSION NO.	
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