MASTER

**PWR Blowdown Heat Transfer Separate-Effects
Program—Thermal-Hydraulic Test Facility
Experimental Data Report for Test 104**

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PWR BLOWDOWN HEAT TRANSFER SEPARATE-EFFECTS
PROGRAM - THERMAL-HYDRAULIC TEST FACILITY
EXPERIMENTAL DATA REPORT FOR TEST 104

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PWR BLOWDOWN HEAT TRANSFER SEPARATE-EFFECTS
PROGRAM - THERMAL-HYDRAULIC TEST FACILITY
EXPERIMENTAL DATA REPORT FOR TEST 104

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ABSTRACT

Reduced instrument responses are presented for Thermal-Hydraulic Test Facility (THTF) test 104, which is part of the ORNL Pressurized-Water Reactor (PWR) Blowdown Heat Transfer Separate-Effects Program. The objective of the program is to investigate the thermal-hydraulic phenomenon governing the energy transfer and transport processes that occur during a loss-of-coolant accident in a PWR system.

Test 104 was conducted to obtain CHF in bundle 1 under blowdown conditions.

The primary purpose of this report is to make the reduced instrument responses during test 104 available. These are presented in graphical form in engineering units and have been analyzed only to the extent necessary to ensure reasonableness and consistency.

I. INTRODUCTION

The Oak Ridge National Laboratory Pressurized-Water Reactor (ORNL-PWR) Blowdown Heat Transfer Program is a separate-effects study of the relations among the principal variables that can alter the rate of blowdown, the presence of flow reversal and rereversal, time delay to critical heat flux (CHF), the rate at which dryout progresses, and similar time- and space-related functions that are important in loss-of-coolant accident (LOCA) analyses. Primary test results are obtained from the Thermal-Hydraulic Test Facility (THTF), a large nonnuclear pressurized-water loop incorporating a 49-rod electrically heated bundle in 7×7 geometry.

THTF test 104 (conducted July 8, 1976) was the fourth test conducted in the facility with bundle 1 in place. This test was performed to provide the first times to CHF and postCHF heat transfer data in bundle 1. The transient data also provided the thermal-hydraulic response of the THTF under blowdown conditions with delayed power trip. Extensive steady-state data were taken to expand the bundle thermocouple and flow instrumentation calibration data base.

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The purpose of this report is to provide the reduced instrument responses during test 104 in a readily usable form to the nuclear community in advance of detailed analyses and interpretations. (These data are presented on microfiche attached to the back cover of the report.) Final analyses and interpretations are scheduled for publication six months after the completion of test series 100. The program and the experimental facilities are described in Ref. 1.

II. SYSTEM, PROCEDURES, CONDITIONS, AND EVENTS FOR TEST 104

1. System Configuration and Test Procedure

The Thermal-Hydraulic Test Facility (THTF), shown in Fig. 1, consists of a test section with a 49-rod, 3.66-m-long (12-ft) electrically heated core; a circulation loop comprised of three parallel heat exchangers with bypass, a pressurizer, a pump with bypass, and associated control valves; two rupture assemblies; and a pressure-suppression system. The break configuration for test 104 was 50% inlet-50% outlet with a total break area of 12.54 cm^2 (0.0135 ft^2). The THTF experimental system is described further in Ref 1.

The electric core was taken to the preblowdown power (122 kW/rod) in ~ 20 -kW/rod steps to provide steady-state calibration information. The primary coolant pump was tripped coincident with break initiation, but the electric core was operated at the preblowdown power for ~ 2 sec into the transient. Closure of the secondary-side main heat exchanger valves was initiated at the trip from 122 kW/rod.

In preparation for the test, the loop was filled with demineralized water and the system pressure checked. Instrumentation and data acquisition checks were performed. During the warmup, data were taken for use in flow and pressure calibrations.

During the test, the THTF was successfully subjected to a double-ended pipe break through the rupture assemblies containing the orifice plates.

1. *Project Description: ORNL-PWR Blowdown Heat Transfer Separate-Effects Program - Thermal-Hydraulic Test Facility (THTF)*, ORNL/NUREG/TM-2 (February 1976).

Fig. 1. Thermal-Hydraulic Test Facility (THTF).

The effluent from the primary system was ejected into the pressure-suppression system, which was maintained at atmospheric pressure. The primary-coolant pump was tripped coincident with break initiation.

2. Initial Test Conditions and Sequence of Events

The THTF conditions immediately preceding rupture are given in Tables 1 and 2. The sequence of events relative to the rupture is given in Table 3.

Table 1. Desired vs actual prerupture conditions

Parameters	Instrument	Desired ^a	Actual ^b
System pressure MN/m ² psig	PE-201	15.513 2250	15.506 2249
Core power MW	EIE-9, EIE-10, EIE-11, EIE-12 EEE-9, EEE-10, EEE-11, EEE-12	5.978	5.975
Core volumetric flow rate m ³ /sec gpm	FE-19	0.0265 420	0.027 425
Test section inlet temperature K °F	TE-162	559.3 547	559.8 548
Test section outlet temperature K °F	TE-212	610.4 639	606.5 632
Pressurizer pressure MN/m ² psig	PE-106	15.031 2180	15.210 2206
Mass liquid water kg lb _m		63.50 140	55.08 121.43
Coolant pump speed rps rpm	SE-72	59.67 3530	59.68 3581
Pressure differential MN/m ² psid	P _d E-78	4.413 640	4.482 650
Pressure between HCV-2 and FCV-18 MN/m ² psig	PE-16	16.996 2465	17.037 2471
Pressure differential across main heat exchangers MN/m ² psid	P _d E-46	0.172 25	0.186 27

^aDesired prerupture conditions are based on programmatic requirements.

^bActual prerupture conditions are based on instrument signals recorded within 10 sec of primary system rupture.

Table 2. Prerupture primary-coolant temperature and pressure distribution^a for test 104

Location	Instrument	Temperature [K (°F)]	Pressure [MN/m ² (psig)]
Vertical inlet spool piece	TE-172	559.3 (547)	
Vertical inlet spool piece	PE-174		15.686 (2275)
Test section inlet	TE-162	559.8 (548)	
Lower plenum	TE-150	560.9 (550)	
Lower plenum	PE-156		15.686 (2275)
Upper plenum	PE-201		15.506 (2249)
Test section outlet	TE-212	606.5 (632)	
Vertical outlet spool piece	TE-222	606.5 (632)	
Vertical outlet spool piece	PE-224		15.368 (2229)
Heat exchanger inlet header	PE-44		15.293 (2218)
Downstream heat exchangers (mixed mean temperature)	TE-28B	561.5 (551)	
Pressurizer surge line	TE-2	615.9 (649)	
Pressurizer	PE-106		15.210 (2206)
Primary pump suction	PE-76		15.148 (2197)
Between main control valves HCV-2 and FCV-18	TE-4B	555.9 (541)	
Between main control valves HCV-2 and FCV-18	PE-16		17.037 (2471)

^aPrerupture distribution is based on instrument signals recorded within 10 sec of primary system rupture.

Table 3. Sequence of events during test 104

Event	Time relative to rupture (sec)
Core power level established	-2359
Core temperature rise established	-1999
Analog tapes and CCDAS fast scan started	-15
Blowdown initiated	0
Pump power tripped	0
Heat exchanger secondary valves closure initiated	2
Core power tripped	2

III. DATA PRESENTATION

The recorded instrument responses for THTF test 104 have been processed only to the extent necessary to obtain appropriate engineering units and to ensure reasonableness and consistency. In converting the instrument responses to engineering units, a homogeneous fluid has been assumed. Therefore, interpretation or analysis of the data must account for the fact that the instruments may have been subjected to nonhomogeneous fluid conditions during the transient.

The reduced instrument responses presented in this report were recorded by a computer-controlled digital data acquisition system (CCDAS). Further information on this system may be found in Ref. 1.

Figures 2 through 4 provide supportive information for the instrument responses and indicate the relative locations of the detectors in the THTF. Table 4 gives the precision of the recorded instrument responses, and Table 5 groups the measurements by location and provides brief comments regarding the detectors and the recorded responses. Time zero on all graphs is the time of break initiation.

Fig. 2. Identification of THTF heater rod and subchannel locations in bundles 1 and 2.

Fig. 3. Location of thermocouples in THTF bundle 1.

Fig. 4 THTF instrument identification and location.

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Fig. 4 TBT instrument identification and location.

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Fig. 4. (continued)

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Table 4. Precision of experimental measurements for test 104

System	Standard deviation
Pressure measurement, MN/m ² (psig)	
CCDAS	0.185 (26.8)
Analog tape system	0.197 (28.5)
Pressure difference measurement, MN/m ² (psid)	
CCDAS	
6.89-MN/m ² (1000-psid) span	0.025 (3.6)
1.38-MN/m ² (200-psid) span	0.005 (0.72)
0.34-MN/m ² (50-psid) span	0.001 (0.13)
Analog tape system	
6.89-MN/m ² (1000-psid) span	0.033 (4.8)
1.38-MN/m ² (200-psid) span	0.007 (0.95)
0.34-MN/m ² (50-psid) span	0.002 (0.24)
Temperature measurement, K (°F)	2.4 (4.3)
Electric core power measurement	
Rod current, A	0.877
Rod voltage, V	0.304
Flow measurement, m ³ /sec (gpm)	
FE-19	
Forward	+0.0009 -0.0002 (+13.97) (-2.90)
Reverse	+0.0011 -0.0004 (+16.77) (-5.70)
FE-166	
Forward	+0.0012 -0.0005 (+18.74) (-7.68)
Reverse	+0.0010 -0.0003 (+16.15) (-5.09)
FE-216	
Forward	+0.0048 -0.0041 (+75.59) (-64.52)
Reverse	+0.0020 -0.0013 (+31.79) (-20.72)
FE-34	
Forward	+0.0021 -0.0007 (+33.39) (-11.26)
Reverse	+0.0124 -0.0110 (+197.11) (-174.97)
Momentum flux measurement, kg/m-sec ² (lb _m /ft-sec ²)	
CCDAS	6793 (4565)
Analog tape system	7661 (5148)
Density measurement @ 961 kg/m ³ (60 lb _m /ft ³), kg/m ³ (lb _m /ft ³)	12.9 (0.81)

Table 5. Data presentation for test 104

Measurement	Location and comments	Detector	Range	Data acquisition system	Figure	Measurement comments
BUNDLE TEMPERATURE Chromel-Alumel thermocouples						
		+3; to +18977 (nll)		-0.0027 to +0.0400 V (nll)		
<u>Boiler Rod Sheath</u>						
LEVEL D						
TE-301AD	Rod 1				5	Spoke
TE-304AD	Rod 4				6	
TE-309AD	Rod 9				7	
TE-310AD	Rod 10				8	
TE-312AD	Rod 12				9	Noisy
TE-313AD	Rod 13				10	Noisy
TE-317AD	Rod 17				11	
TE-318AD	Rod 18				12	Noisy
TE-320AD	Rod 20				13	Noisy
TE-322AD	Rod 22				14	
TE-323AD	Rod 23				15	
TE-325AD	Rod 25				16	Noisy
TE-326AD	Rod 26				17	
TE-328AD	Rod 28				18	
TE-330AD	Rod 30				19	
TE-339AD	Rod 39				20	Spurious spoke late in transient
TE-341C3	Rod 41				21	Spurious spoke
TE-349AD	Rod 49				22	Spurious spoke
LEVEL E						
TE-301AE	Rod 1				23	
TE-304AE	Rod 4				24	Noisy
TE-309AE	Rod 9				25	
TE-312AE	Rod 12				26	Noisy
TE-313AE	Rod 13				27	Noisy
TE-317AE	Rod 17				28	
TE-318AE	Rod 18				29	Noisy
TE-320AE	Rod 20				30	Noisy
TE-322AE	Rod 22				31	
TE-323AE	Rod 23				32	
TE-325AE	Rod 25				33	
TE-326AE	Rod 26				34	
TE-328AE	Rod 28				35	Noisy
TE-330AE	Rod 30				36	
TE-339AE	Rod 39				37	
TE-341AE	Rod 41				38	
TE-349AE	Rod 49				39	
					40	
					41	

Table 3 (continued)

Sonde	Location and comments	Range		Figure	Measurement comments
		Detector	Data acquisition system		
SAMPLE TEMPERATURE (continued)					
LEVEL F					
TE-3018F	Rod 1			42	
TE-3048F	Rod 4			43	Noisy
TE-3098F	Rod 9			44	
TE-3108F	Rod 10			45	
TE-3128F	Rod 12			46	Noisy
TE-3138F	Rod 13			47	Noisy
TE-3178F	Rod 17			48	Instrument failed before test
TE-3208F	Rod 22			49	Noisy
TE-3238F	Rod 23			50	
TE-3248F	Rod 24			51	
TE-3248F	Rod 24			52	
TE-3248F	Rod 25			53	
TE-3248F	Rod 26			54	Noisy
TE-3318F	Rod 31			55	
TE-3328F	Rod 33			56	Instrument failed before test
TE-3388F	Rod 38			57	
TE-3418F	Rod 41			58	
TE-3498F	Rod 49			59	
LEVEL G					
TE-3018G	Rod 1			60	
TE-3048G	Rod 4			61	Noisy
TE-3098G	Rod 9			62	
TE-3108G	Rod 10			63	
TE-3128G	Rod 12			64	Noisy
TE-3138G	Rod 13			65	Noisy
TE-3178G	Rod 17			66	
TE-3188G	Rod 18			67	Noisy
TE-3208G	Rod 20			68	Noisy
TE-3228G	Rod 22			69	
TE-3238G	Rod 23			70	Instrument failed before test
TE-3258G	Rod 25			71	
TE-3268G	Rod 26			72	Noisy
TE-3318G	Rod 31			73	
TE-3338G	Rod 33			74	
TE-3368G	Rod 36			75	
TE-3398G	Rod 39			76	Spurious spikes
TE-3418G	Rod 41			77	
TE-3498G	Rod 49			78	

Table 5 (continued)

Measurement	Location and comments	Detector	Data acquisition system	Figure	Measurement comments
BURDLE TEMPERATURE (cont Inued)					
LEVEL H					
TE-301CH	Rod 1			79	
TE-302AH	Rod 2			80	
TE-303AH	Rod 3			81	
TE-304CH	Rod 4			82	Noisy
TE-305AH	Rod 5			83	Noisy
TE-306AH	Rod 6			84	Noisy
TE-307AH	Rod 7			85	Noisy
TE-308AH	Rod 8			86	
TE-309CH	Rod 9			87	
TE-310CH	Rod 10			88	
TE-311AH	Rod 11			89	Noisy
TE-312CH	Rod 12			90	Noisy
TE-313CH	Rod 13			91	Noisy
TE-314AH	Rod 14			92	Noisy
TE-315AH	Rod 15			93	
TE-316AH	Rod 16			94	
TE-317CH	Rod 17			95	
TE-318CH	Rod 18			96	Noisy
TE-320CH	Rod 20			97	Noisy
TE-321AH	Rod 21			98	Noisy
TE-322CH	Rod 22			99	
TE-323CH	Rod 23			100	
TE-324CH	Rod 24			101	
TE-325CH	Rod 25			102	
TE-326CH	Rod 26			103	Noisy
TE-327AH	Rod 27			104	Noisy
TE-328AH	Rod 28			105	Instrument failed before test
TE-331CH	Rod 31			106	
TE-333CH	Rod 33			107	
TE-336AH	Rod 36			108	
TE-337AH	Rod 37			109	
TE-338CH	Rod 38			110	Spurious spike
TE-339CH	Rod 39			111	
TE-340AH	Rod 40			112	Noisy
TE-341CH	Rod 41			113	
TE-342AH	Rod 42			114	
TE-343AH	Rod 43			115	
TE-344AH	Rod 44			116	
TE-345AH	Rod 45			117	
TE-346AH	Rod 46			118	Spurious spike
TE-348AH	Rod 48			119	
TE-349CH	Rod 49			120	

Table 5 (continued)

Measurement	Location and comments	Detector	Range		Figure	Measurements Comments
				Data acquisition system		
SMALL TEMPERATURE (continued)						
LEVEL 1						
TE-301C1	Rod 1				121	
TE-302A1	Rod 2				122	
TE-303A1	Rod 3				123	
TE-304C1	Rod 4				124	Noisy
TE-305A1	Rod 5				125	Noisy
TE-306A1	Rod 6				126	Noisy
TE-307A1	Rod 7				127	Noisy
TE-308A1	Rod 8				128	
TE-309C1	Rod 9				129	
TE-310C1	Rod 10				130	Noisy
TE-311A1	Rod 11				131	Noisy
TE-312C1	Rod 12				132	Noisy
TE-313C1	Rod 13				133	Noisy
TE-314A1	Rod 14				134	Noisy
TE-315A1	Rod 15				135	
TE-316A1	Rod 16				136	
TE-317A1	Rod 17				137	
TE-318C1	Rod 18				138	Noisy
TE-320C1	Rod 20				139	Noisy
TE-321A1	Rod 21				140	Noisy
TE-322C1	Rod 22				141	
TE-323C1	Rod 23				142	
TE-324C1	Rod 24				143	
TE-325C1	Rod 25				144	
TE-326C1	Rod 26				145	Noisy
TE-327A1	Rod 27				146	Noisy
TE-328A1	Rod 28				147	Noisy
TE-331C1	Rod 31				148	
TE-332C1	Rod 32				149	
TE-334A1	Rod 34				150	
TE-337A1	Rod 37				151	
TE-339C1	Rod 39				152	
TE-340A1	Rod 40				153	Spurious spike
TE-341C1	Rod 41				154	Noisy
TE-342A1	Rod 42				155	
TE-343A1	Rod 43				156	Spurious spike
TE-344A1	Rod 44				157	
TE-345A1	Rod 45				158	Spurious spikes
TE-346A1	Rod 46				159	Spurious spikes
TE-348A1	Rod 48				160	Spurious spikes
TE-349C1	Rod 49				161	Spurious spike
					162	

Table 5 (continued)

Measurement	Location and comments	Detector	Range		Figure	Measurement comments
				Data acquisition system		
BUNDLE TEMPERATURE (continued)						
LEVEL J						
TE-3018J	Rod 1				163	
TE-302CJ	Rod 2				164	
TE-303CJ	Rod 3				165	Instrument failed before test
TE-3040J	Rod 4				166	Noisy
TE-305CJ	Rod 5				167	Noisy
TE-306CJ	Rod 6				168	Noisy
TE-307CJ	Rod 7				169	Noisy
TE-308CJ	Rod 8				170	
TE-3090J	Rod 9				171	
TE-3110J	Rod 10				172	
TE-311CJ	Rod 11				173	Instrument failed before test
TE-3120J	Rod 12				174	Noisy
TE-3130J	Rod 13				175	Noisy
TE-314CJ	Rod 14				176	Noisy
TE-316CJ	Rod 16				177	
TE-3170J	Rod 17				178	
TE-3180J	Rod 18				179	Noisy
TE-3200J	Rod 20				180	Noisy
TE-321CJ	Rod 21				181	Noisy
TE-3220J	Rod 22				182	
TE-3230J	Rod 23				183	
TE-3240J	Rod 24				184	
TE-3250J	Rod 25				185	
TE-3260J	Rod 26				186	Noisy
TE-327CJ	Rod 27				187	Noisy
TE-328CJ	Rod 28				188	Noisy
TE-3310J	Rod 31				189	
TE-3330J	Rod 33				190	
TE-336CJ	Rod 36				191	
TE-337CJ	Rod 37				192	
TE-3380J	Rod 38				193	Spurious spikes
TE-3390J	Rod 39				194	
TE-340CJ	Rod 40				195	
TE-3410J	Rod 41				196	
TE-342CJ	Rod 42				197	
TE-343CJ	Rod 43				198	
TE-346CJ	Rod 44				199	Small spurious spikes
TE-345CJ	Rod 45				200	
TE-346CJ	Rod 46				201	Small spurious spikes
TE-347CJ	Rod 47				202	
TE-3480J	Rod 49				203	

Table 5 (continued)

Measurement	Location and comments	Range		Figure	Measurement comments
		Detector	Data acquisition system		
SWATH TEMPERATURE (continued)					
LEVEL K					
TE-301DK	Rod 1			204	Noisy
TE-304DK	Rod 4			205	Noisy
TE-309DK	Rod 9			206	Spurious spike
TE-310DK	Rod 10			207	Noisy
TE-312DK	Rod 12			208	Noisy
TE-313DK	Rod 13			209	Noisy
TE-317DK	Rod 17			210	Noisy
TE-318DK	Rod 18			211	Noisy
TE-319DK	Rod 20			212	Noisy
TE-320DK	Rod 22			213	Noisy
TE-322DK	Rod 23			214	Noisy
TE-324DK	Rod 24			215	Noisy
TE-325DK	Rod 25			216	Noisy
TE-326DK	Rod 26			217	Noisy
TE-331DK	Rod 31			218	Noisy
TE-332DK	Rod 33			219	Noisy
TE-333DK	Rod 36			220	Spurious spikes
TE-334DK	Rod 38			221	Small spurious spike
TE-335DK	Rod 39			222	Noisy
TE-341DK	Rod 41			223	Noisy
TE-349DK	Rod 49				Noisy
LEVEL L					
TE-301EL	Rod 1			224	Spike
TE-302EL	Rod 2			225	Spike
TE-303EL	Rod 3			226	Noisy
TE-304EL	Rod 4			227	Noisy
TE-305EL	Rod 5			228	Noisy
TE-306EL	Rod 6			229	Noisy
TE-307EL	Rod 7			230	Noisy
TE-308EL	Rod 8			231	Small spurious spike
TE-309EL	Rod 9			232	Noisy
TE-310EL	Rod 10			233	Noisy
TE-311EL	Rod 11			234	Noisy
TE-312EL	Rod 12			235	Noisy
TE-313EL	Rod 13			236	Noisy
TE-315EL	Rod 15			237	Instrument failed before test
TE-316EL	Rod 16			238	Noisy
TE-317EL	Rod 17			239	Small spurious spike
TE-318EL	Rod 18			240	Noisy
TE-320EL	Rod 20			241	Small spurious spike
TE-321EL	Rod 21			242	Noisy
TE-322EL	Rod 22			243	Noisy

Table 5 (continued)

Measurement	Location and comments	Range		Figure	Measurement comments
		Detector	Data acquisition system		
BUNDLE TEMPERATURE (continued)					
LEVEL L (continued)					
TE-323EL	Rod 23			244	
TE-324EL	Rod 24			245	
TE-325EL	Rod 25			246	
TE-326EL	Rod 26			247	Noisy
TE-327CL	Rod 27			248	Noisy
TE-328CL	Rod 28			249	Noisy
TE-331EL	Rod 31			250	
TE-333EL	Rod 33			251	Small spurious spike
TE-336CL	Rod 36			252	
TE-337CL	Rod 37			253	
TE-338EL	Rod 38			254	Spurious spike
TE-339EL	Rod 39			255	
TE-340CL	Rod 40			256	
TE-341EL	Rod 41			257	
TE-342CL	Rod 42			258	
TE-343CL	Rod 43			259	Small spurious spikes
TE-344CL	Rod 44			260	Small spurious spikes
TE-345CL	Rod 45			261	Small spurious spike
TE-346CL	Rod 46			262	
TE-347CL	Rod 47			263	Small spurious spike
TE-348CL	Rod 48			264	
TE-349EL	Rod 49			265	
LEVEL M					
TE-301EM	Rod 1			266	
TE-304EM	Rod 4			267	Noisy
TE-309EM	Rod 9			268	Small spurious spike
TE-325EM	Rod 25			269	
LEVEL N					
TE-301FN	Rod 1			270	
TE-304FN	Rod 4			271	Noisy
TE-325FN	Rod 25			272	
LEVEL O					
TE-301FO	Rod 1			273	
TE-304FO	Rod 4			274	Noisy
TE-309FO	Rod 9			275	Small spurious spike
TE-310EO	Rod 10			276	Small spurious spike
TE-312EO	Rod 12			277	Noisy

Table 5 (continued)

Measurement	Location and comments	Range		Figure	Measurement comments
		Detector	Data acquisition system		
DOUBLE TEMPERATURE (cont. inued)					
LEVEL O (continued)					
TE-31780	Rod 17			278	Noisy
TE-31780	Rod 18			279	Noisy
TE-32080	Rod 20			280	Noisy
TE-32380	Rod 22			281	Small spurious spike
TE-32380	Rod 23			282	
TE-32480	Rod 24			283	
TE-32580	Rod 25			284	Noisy
TE-32680	Rod 26			285	Slightly noisy
TE-33180	Rod 31			286	Small spurious spike
TE-33380	Rod 33			287	Spurious spikes
TE-33480	Rod 38			288	
TE-33980	Rod 39			289	
TE-34180	Rod 41			290	
TE-34380	Rod 49			291	
Water Rod Center					
LEVEL E					
TE-36180	Rod 1			292	Small active
TE-31880	Rod 18			293	
TE-32280	Rod 22			294	
LEVEL F					
TE-30180	Rod 1			295	Spurious spikes
TE-32280	Rod 22			296	Small spurious spike
LEVEL G					
TE-30180	Rod 1			297	Spurious spike
TE-31880	Rod 18			298	Small spike
TE-31780	Rod 17			299	Small spike
TE-31880	Rod 18			300	Small spike
TE-32280	Rod 22			301	Spurious spikes
TE-32280	Rod 23			302	Spurious spike and noisy
TE-32280	Rod 25			303	Spurious spike

Table 5 (continued)

Measurement	Location and comments	Range		Figure	Measurement comments
		Detector	Data acquisition system		
BUNDLE TEMPERATURE (continued)					
Heater Rod Center (continued)					
	LEVEL H				
TE-104MH	Rod 4			104	Small spike
TE-109MH	Rod 9			105	
TE-118MH	Rod 18			106	Small spike
TE-123MH	Rod 22			107	Spurious spikes
	LEVEL J				
TE-101MJ	Rod 1			108	Spurious spikes
TE-101MJ	Rod 1			109	Spurious spike and noisy
TE-108MJ	Rod 8			110	Spurious spike and noisy
TE-110MJ	Rod 10			111	
TE-117MJ	Rod 17			112	
TE-122MJ	Rod 22			113	Spurious spikes
TE-123MJ	Rod 23			114	Small spike
TE-124MJ	Rod 24			115	
SPOOL PLICE INSTRUMENTS					
Temperature	Chromel-Alumel thermocouples	+12 to +1897°F	0.0027 to +0.0400 V		
TE-26	Horizontal inlet			116	Small spikes
TE-172	Vertical inlet			117	
TE-222	Vertical outlet			118	Small spikes
TE-40	Horizontal outlet			119	Small spikes
Pressure		0 to +1000 psig	0.0 to +5.0 V		
PE-26	Horizontal inlet			159	
PE-174	Vertical inlet			160	
PE-224	Vertical outlet			161	
PE-42	Horizontal outlet			164	
Pressure Drop		200 to +200 psid	5.0 to +5.0 V		
PDE-21	Horizontal inlet			169	Noisy
PDE-167	Vertical inlet			170	
PDE-217	Vertical outlet			175	
PDE-35	Horizontal outlet			174	

Table 3 (continued)

Measurement	Location and comments	Range		Figure	Measurement comments
		Detector	Data acquisition system		
SPOOL PIECE INSTRUMENTS (continued)					
<u>Flow</u>					
FE-19	Horizontal inlet	-2000 to +2000 gpm	-5.0 to +5.0 V	155	Instrument failed at 1/5 sec
FE-166	Vertical inlet	-2000 to +2000 gpm	-5.0 to +5.0 V	156	Unreliable before 2 sec
FE-216	Vertical outlet	2000 to +2000 gpm	-5.0 to +5.0 V	157	
FE-31	Horizontal outlet	4000 to +4000 gpm	5.0 to +5.0 V	158	
<u>Momentum Flux</u>		250,000 to +250,000 lb _m /ft ² -sec ²	5.0 to +5.0 V		
FMFE-22	Horizontal inlet			184	
FMFE-170	Vertical inlet			185	Instrument indicated zero shift
FMFE-220	Vertical outlet			186	
FMFE-38	Horizontal outlet			187	
<u>Fluid Density</u>		0 to +62.4 lb _m /ft ³	0.0 to +10.0 V		
DE-20	Horizontal inlet			461	Instrument failed at 1/5 sec
DE-156	Vertical inlet			462	Instrument failed at 1/5 sec
DE-218	Vertical outlet			463	
DE-36	Horizontal outlet			464	Instrument failed at 1/5 sec
TEST SECTION TEMPERATURE	Chromel-Alumel thermocouples	+12 to +1897°F	0.0027 to +0.0400 V		
<u>Bundle Shroud</u>					
TE-175	0.142L/LMAX			125	Instrument failed before test
TE-176	0.142L/LMAX			126	Small power spike
TE-177	0.142L/LMAX			127	
TE-178	0.142L/LMAX			128	Power spike
TE-179	0.388L/LMAX			129	Unreliable -- power effects
TE-180	0.388L/LMAX			130	Unreliable -- power effects
TE-181	0.388L/LMAX			131	Unreliable -- power effects

Table 5 (continued)

Measurement	Location and comments	Detector	Range	Data acquisition system	Figure	Measurement comments
TEST SECTION TEMPERATURE (continued)						
Bundle Shroud (continued)						
TE-182	0.188L/LMAX				472	Unreliable power effects
TE-183	0.631V/LMAX				473	Unreliable power effects
TE-184	0.631L/LMAX				474	Unreliable power effects
TE-185	0.631L/LMAX				475	Unreliable power effects
TE-186	0.631L/LMAX				476	Unreliable power effects
TE-187	0.875L/LMAX				477	Unreliable power effects
TE-189	0.875L/LMAX				478	Unreliable power effects
TE-190	0.875L/LMAX				479	Unreliable power effects
Bundle Subchannel						
TE-S1	Subchannel 1				473	Spurious spike
TE-S2	Subchannel 2				474	Spurious spike
TE-S3	Subchannel 3				475	Spurious spike
TE-S4	Subchannel 4				476	Instrument failed before test
TE-S5	Subchannel 5				477	Spurious spike
TE-S6	Subchannel 6				478	
TE-S7	Subchannel 7				479	
TE-S8	Subchannel 8				480	Instrument failed before test
TE-S9	Subchannel 9				481	
TE-S10	Subchannel 10				482	
TE-S11	Subchannel 11				483	
TE-S13	Subchannel 13				484	Instrument failed before test
TE-S17	Subchannel 17				485	Instrument failed before test
TE-S18	Subchannel 18				486	
TE-S19	Subchannel 19				487	
TE-S20	Subchannel 20				488	
TE-S25	Subchannel 25				489	
TE-S26	Subchannel 26				490	
TE-S27	Subchannel 27				491	
TE-S28	Subchannel 28				492	
TE-S29	Subchannel 29				493	Spurious spikes

Table 3 (continued)

Measurement	Location and comments	Range		Figure	Measurement comments
		Detector	Data acquisition system		
TEST SECTION TEMPERATURE (continued)					
Bundle Subchannel (continued)					
TS-830	Subchannel 30			494	
TS-831	Subchannel 31			495	
TS-832	Subchannel 32			496	
TS-833	Subchannel 33			497	
TS-834	Subchannel 34			498	
TS-835	Subchannel 35			499	
TS-836	Subchannel 36			500	
TS-837	Subchannel 37			501	
TS-846	Subchannel 46			502	
TS-855	Subchannel 55			503	
TS-964	Subchannel 64			504	Spurious spike
Test Section					
TS-162	Inlet line T/C			320	
TS-150	Bottom flange T/C			321	Spurious spike
TS-151	Bottom flange T/C			322	Spurious spike
TS-152	Bottom flange T/C			323	Spurious spike
TS-153	Bottom flange T/C			324	Spurious spike
TS-212	Outlet line T/C			340	Spurious spike
TS-210A	Outlet line RTD (steady state)	+32 to +80°F	+0.2 to +0.52V	402	Spurious spikes
TEST SECTION PRESSURE					
PS-156	Inlet plenum			361	
PS-201	Outlet plenum	0 to +3000 psia	0.0 to +5.0 V	361	
PS-27	Inlet plenum bottom	0 to +3000 psia	0.0 to +5.0 V	391	
PS-43	Outlet plenum bottom	0 to +3000 psia	0.0 to +5.0 V	392	
PT-32	Outlet steady state	+500 to +2500 psia	+1.0 to +5.0 V	394	Instrument indicated zero shift
TEST SECTION PRESSURE DROP					
PPT-199	Shroud box steady-state differential pressure	0 to +50 psid	+1.0 to +5.0 V	372	Instrument indicated zero shift
PPT-200	Bundle transient differential pressure	-50 to +50 psid	-5.0 to +5.0 V	373	Instrument indicated zero shift, ringing
PPT-30	Test section steady-state differential pressure	0 to +50 psid	+1.0 to +5.0 V	393	Instrument indicated zero shift

Table 5 (continued)

Measurement	Location and comments	Range		Figure	Measurement comments
		Detector	Data acquisition system		
PRESSURIZER INSTRUMENTS					
Temperature					
TE-1	Tank top T/C	+32 to +189.7°	-0.0027 to +0.0400 V	366	
TE-2	Tank exit T/C	+32 to +189.7°	-0.0027 to +0.0400 V	367	
Pressure					
PT-102	Steady-state pressure	+500 to +2300 psig	+1.0 to +5.0 V	367	instrument indicated zero at 1 ft
PE-106	Vapor transient pressure	0 to +3000 psig	0 to +5.0 V	368	
Level					
LT-100	Steady-state liquid level	0 to +150 in.	+1.0 to +5.0 V	398	
HEATER ROD POWER					
Heater Current					
RIE-1156	Rod 1	0 to +800 A	0.0 to +5.0 V	404	
RIE-1256	Rod 2			405	
RIE-1157	Rod 3			406	
RIE-1257	Rod 4			407	
RIE-956	Rod 5			408	
RIE-958	Rod 6			409	
RIE-955	Rod 7			410	
RIE-1155	Rod 8			411	
RIE-1158	Rod 9			412	
RIE-1258	Rod 10			413	
RIE-957	Rod 11			414	
RIE-954	Rod 12			415	
RIE-953	Rod 13			416	
RIE-9511	Rod 14			417	
RIE-1154	Rod 15			418	
RIE-1159	Rod 16			419	
RIE-1255	Rod 17			420	
RIE-959	Rod 18			421	
RIE-9510	Rod 19			422	
RIE-952	Rod 20			423	
RIE-9512	Rod 21			424	
RIE-11511	Rod 22			425	
RIE-11510	Rod 23			426	
RIE-1153	Rod 24			427	
RIE-9513	Rod 25			428	
RIE-1056	Rod 26			429	
RIE-951	Rod 27			430	

Table 5 (continued)

Measurement	Location and comments	Detector	Data acquisition system	Figure	Measurement comments
Range					
HEATER ROD POWER					
(continued)					
Heater Current (continued)					
EIE-1087	Rod 28			431	
EIE-1137	Rod 29			432	
EIE-11512	Rod 30			433	
EIE-1282	Rod 31			434	
EIE-1251	Rod 32			435	
EIE-10812	Rod 33			436	
EIE-1085	Rod 34			437	
EIE-1086	Rod 35			438	
EIE-1151	Rod 36			439	
EIE-1254	Rod 37			440	
EIE-1253	Rod 38			441	
EIE-12512	Rod 39			442	
EIE-10811	Rod 40			443	
EIE-10810	Rod 41			444	
EIE-1089	Rod 42			445	
EIE-1259	Rod 43			446	
EIE-12510	Rod 44			447	
EIE-12511	Rod 45			448	
EIE-1081	Rod 46			449	
EIE-1082	Rod 47			450	
EIE-1083	Rod 48			451	
EIE-1084	Rod 49			452	
GENERATOR POWER					
Generator Current					
EIE-9	Generator 9 current	0 to +10,000 A	0.0 to +2.5 V	453	
EIE-10	Generator 10 current			454	
EIE-11	Generator 11 current			455	
EIE-12	Generator 12 current			456	
Generator Voltage					
EIE-9	Generator 9 voltage	0 to +285 V	0.0 to +10.0 V	457	
EIE-10	Generator 10 voltage			458	
EIE-11	Generator 11 voltage			459	
EIE-12	Generator 12 voltage			460	

Table S (continued)

Measurement	Location and comments	Detector	Range Data acquisition system	Figure	Measurement comments
HEAT EXCHANGER INSTRUMENTS					
<u>Primary Side</u>	Outlet Line Thermocouples	+32 to 189 °F	0.0027 to +0.0400 V		
TE-30B	Heat exchanger A			341	
TE-32B	Heat exchanger B			342	
TE-34B	Heat exchanger C			343	
TE-38	Heat exchanger D			345	
TE-28B	Main HX mixing tee steady-state temp., RTD	+32 to +800 °F	+0.2 to +0.52 V	382	Small spurious spikes
<u>Secondary Side</u>	Secondary discharge steady-state temp., RTD	+32 to +500 °F	+0.2 to +0.4 V		
TE-52	Heat exchanger A			401	Spurious spikes
TE-627	Heat exchanger B			376	Small spikes
TE-727	Heat exchanger C			381	Small spikes
TE-557	Heat exchanger D			400	Spurious spikes
<u>Heat Exchanger Secondary Flow</u>					
FE-520	Heat exchanger A	0 to +150 gpm	+0.2 to +1.0 V	399	
FE-620	Heat exchanger B	0 to +150 gpm	+0.2 to +1.0 V	351	
FE-720	Heat exchanger C	0 to +150 gpm	+0.2 to +1.0 V	352	
FE-550	Heat exchanger D	0 to +50 gpm	+0.2 to +1.0 V	353	
<u>Heat Exchanger Pressure</u>					
PE-44	Upstream main HX transient pressure	0 to +1000 psig	0.0 to +5.0 V	365	
PE-526	HX A secondary inlet pressure	0 to +150 psig	0.0 to +5.0 V	388	Slighty noisy
<u>Pressure Drop</u>					
PDT-48	Main HX steady-state pressure drop	0 to +24 psid	+1.0 to +5.0 V	377	
PDR-44	Main HX bypass transient pressure drop	200 to +200 psid	5.0 to +5.0 V	381	
PRIMARY PUMP INSTRUMENTS					
FE-1A	Primary side pump flow	0 to +800 gpm	+1.0 to +5.0 V	354	Instrument failed at 035 sec
PE-76	Pump suction transient pressure	0 to +1000 psig	0 to +5.0 V	366	
PDR-78	Primary pump transient pressure drop	1000 to +1000 psid	5.0 to +5.0 V	378	
SE-72	Primary pump speed	+100 to +3400 rpm	0 to +5.0 V	395	
TE-48	Base primary steady-state temp., RTD	+32 to +800 °F	+0.2 to +0.55 V	350	Spurious spikes
PE-16	Downstream MCV-2 transient pressure	0.0 to +1000 psig	0.0 to +5.0 V	390	

Table 5 (continued)

Measurement	Location and comments	Range		Figure	Measurement comments
		Detector	Data acquisition system		
PRESSURE SUPPRESSION SYSTEM INSTRUMENTS					
PE-412	Pressure suppression receiver transient pressure	0 to +200 psig	0 to +5.0 V	369	Instrument indicated slight zero shift
PE-423	PSS inlet blowdown line transient pressure	0 to +3000 psig	0 to +5.0 V	379	
PE-427	PSS outlet blowdown line transient pressure	0 to +3000 psig	0 to +5.0 V	380	
TE-29	Inlet blowdown plenum T/C	+32 to +1897°F	-0.0027 to +0.0400 V	348	
TE-45	Outlet blowdown plenum T/C	+32 to +1897°F	-0.0027 to +0.0400 V	349	
DEMINERALIZED WATER SYSTEM					
TE-520B	RST 4 in. demineralized water header T/C	+32 to +1897°F	-0.0027 to +0.0400 V	344	Spurious spikes
TE-613	Demineralized water 6-in. header steady-state temp., RTD	+32°F to +500°F	+0.2 to +0.4 V	371	
GENERAL INSTRUMENTATION (ELECTRICAL)					
Breakwire Detectors					
XN-4000I	Inlet break	0.0 to +5.0 V	0.0 to +5.0 V	396	
XN-4000O	Outlet break	0.0 to +5.0 V	0.0 to +5.0 V	397	
RTD Power					
EIM-1001B	RTD power supply current	2.0 mA	0.400 V	403	
Data Acquisition Calibration Signals					
Zero cal. input	Channels 0-127	0.0 mV	0.0 mV	465	
Zero cal. input	Channels 128-255	0.0 mV	0.0 mV	466	
Zero cal. input	Channels 256-383	0.0 mV	0.0 mV	467	
Zero cal. input	Channels 384-511	0.0 mV	0.0 mV	468	
Full-scale cal. input	Channels 0-127	35.00 mV	35.00 mV	469	
Full-scale cal. input	Channels 128-255	35.00 mV	35.00 mV	470	
Full-scale cal. input	Channels 256-383	35.00 mV	35.00 mV	471	
Full-scale cal. input	Channels 384-511	35.00 mV	35.00 mV	472	