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Attachment 2

Oregon State University Non-Proprietary Reports

APP-LTCT-T2R-004, Rev. 0
"Test Acceptance Report OSU-AP1000-04 AP1000 2-Inch Cold Leg Break with 3 of 4 ADS 4"
dated 8/14/03

APP-LTCT-T2R-005, Rev. 0
"Test Acceptance Report OSU-AP1000-05 AP1000 2-Inch Cold Leg Break with 3 of 4 ADS 4
ADS Actuation at Plant-Prototypic Pressure"
dated 8/14/03

Oregon State University

Department of Nuclear Engineering

ADVANCED THERMAL HYDRAULIC RESEARCH LABORATORY

TEST ACCEPTANCE REPORT

OSU-AP1000-04

AP1000 2-INCH COLD LEG BREAK WITH 3 OF 4 ADS 4

Revision 0

TEST ACCEPTANCE REPORT

OSU-AP1000-04

AP1000 2-INCH COLD LEG BREAK WITH 3 OF 4 ADS 4

Aug 14, 2003

John Groome
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Date

8/14/03

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SUMMARY

This report covers the test DBA-04, 2-inch Cold Leg Break simulation loss-of-coolant accident (LOCA) performed on July 27, 2003. The objective of this test was to obtain thermal-hydraulic data for 2-inch Cold Leg Break simulation. The test performed met the specified conditions. The top of the heater bundle was always covered during this event. The test was performed for about 17,000 seconds. The transient continued through Automatic Depressurization System (ADS) actuation, core makeup tank (CMT), accumulator, incontainment refueling water storage tank (IRWST) injection, and sump recirculation injection.

This report presents the initial assessment of the test data collected. If this test is to be used by Westinghouse to support AP1000 Design Certification, additional validation of the use of this information will be documented separately. In the interim, the list of invalid data channels may change.

1.0 INTRODUCTION

The Department of Nuclear Engineering at Oregon State University is performing a series of tests for the U.S. Department of Energy (DOE). These tests are being conducted in the Advanced Plant Experiment (APEX-1000) test facility, which is a reduced pressure and height model of the two-loop Westinghouse AP1000 pressurized water reactor. The purpose of the testing is to:

- evaluate the thermal-hydraulic performance of the passive safety systems of the full-scale AP1000, and
- to assess and validate the safety analyses techniques and computer codes used in predicting the transient system behavior.

The AP1000 Long-Term Cooling Test is a 1/4 height scale, low-pressure integral systems test simulating thermal-hydraulic phenomenon for the AP1000 passive safety systems for small-break loss-of-coolant accidents (LOCAs) and long-term cooling. It accurately models the details of the AP1000 geometry, including the primary system, the passive safety systems, and a part of the non-safety grade Chemical and Volume Control System, as well as a partial non-safety grade Normal Residual Removal System. The interconnecting pipe routings are also duplicated in the model.

The overall objective of the Long-Term Cooling Test program is to obtain test data at various modes of operation. The Oregon State University (OSU) experiments will examine the passive safety system response for the small-break and large-break LOCA transition into long-term cooling. (The list of the tests to be performed is provided in the attached OSU Test Matrix provided in Section 4.0.) The facility permits a range of small-break LOCAs to be simulated at different locations on the primary system, such as the cold leg, hot leg, core makeup tank (CMT) cold leg pressure balance line, and direct vessel injection line. The break orientation (top or bottom of the cold leg) may also be studied. Selected tests continue into the long-term cooling, post-accident mode in which the passive safety injection is from the reactor sump as well as the incontainment refueling water storage tank (IRWST). A large-break, post-accident, long-term cooling situation will also be simulated.

2.0 TEST OBJECTIVE

The purpose of this test is to obtain thermal-hydraulic data for a 2-inch Cold Leg Break simulation. The break is located in cold leg #3, which is a non-balance line cold leg. The data obtained from the test will be used to verify the AP1000 thermal-hydraulic computer codes for AP1000 phenomena such as gravity injection, natural convection, and post-accident long-term core cooling behavior.

The acceptance criteria for the OSU tests are as follows:

- Test initial conditions will be achieved within a specified tolerance.
- Set points will be achieved within an acceptable tolerance band.
- All instrumentation should be operational before the test.
- Any critical instruments not operating will be identified to the test engineer before the tests. These instruments must be operational before and during the test or exceptions should be approved.
- A zero check of LDPs, DPs, and FDPs will be performed.

3.0 FACILITY DESCRIPTION

A detailed facility description for the OSU test facility is documented in Reference 1. The OSU test facility has been specifically scaled, designed, and constructed to investigate the AP600 passive safety system behavior and to provide data for safety analysis computer code validation. The facility has been modified to model the AP1000.

The scaled test design accurately models the details of the AP1000 geometry, including the primary system and the pipe routings and layout for the passive safety systems. A detailed scaling report (Reference 2) was used to develop the test design modifications. The primary system consists of one hot leg and two cold legs with two active pumps and an active steam generator for each loop. Two CMTs are connected to one primary loop, and the pressurizer is connected to the other primary loop as in the AP1000 plant design. Gas-driven accumulators are connected to the DVI lines. The discharge lines from the CMT, and one-of-two IRWST and reactor sump lines are connected to each DVI line. The Automatic Depressurization System (ADS), consisting of stages 1, 2 and 3, simulates either one or two of the independent trains used in the AP1000. The two-phase flow from the ADS stages 1-to-3 is separated in a swirl-vane separator and the liquid and vapor flows are measured to obtain the total ADS flow rate. The separated flow streams are then recombined and discharged into the IRWST through a sparger, preserving the mass and energy flow into the IRWST. The injection from the reactor sump is also simulated. Note that the OSU facility models both AP1000 primary and secondary sumps. The primary sump collects the condensate return, the liquid break flow, and the liquid flow from the fourth-stage ADS; and will provide long-term injection to the reactor vessel. The secondary sump simulates the portions of containment that will remain dry during most events. This sump will collect water only when the primary sump reaches its overflow level, and provides no injection to the reactor vessel.

The time period for the experimental simulations includes not only the IRWST injection, but also the draining of the IRWST and the sump injection to simulate the long-term cooling of the AP1000. This simulation could be from several hours to a day. The time scale for the OSU test facility is one-half; that is, events occur in half the normal time. To model the long-term cooling aspects of the transient, the two-phase flow from the break is separated in a swirl-vane separator and the liquid and vapor portions of the total flow are measured. The liquid fraction of the flow is discharged to the reactor primary sump as in the AP1000 plant. The vapor is discharged to the atmosphere. The capability exists to return a portion of the equivalent liquid flow to the IRWST and primary sump to simulate the condensate return from the passive containment to the IRWST and primary sump. A similar approach is also used for the fourth-stage ADS valve on the hot leg. The two-phase flow is separated in a swirl-vane separator, the two streams are measured, and the liquid phase is discharged into the primary sump while the vapor flow is discharged to the atmosphere. Again, the capability exists to return a portion of the liquid equivalent added to the IRWST and primary sump. In addition, all other steam vents from the facility are measured (e.g., the IRWST vent), and a portion of the liquid equivalent may be added back to the facility. Note that not all of the steam discharge would be returned as liquid equivalent. A portion of the discharge would be removed to simulate the steam that is not available for recirculation because it provides containment pressurization. The IRWST and primary sump can be pressurized in the OSU facility to simulate the containment pressurization following a postulated LOCA.

A multi-tube passive residual heat removal (PRHR) heat exchanger is located in the IRWST. The heat exchanger uses the same C-tube design as the AP1000 and has two instrumented tubes to obtain wall heat fluxes during the tests. There are primary fluid thermocouples, wall thermocouples, and differential pressure drop measurements to determine when the heat exchanger begins to drain. The IRWST is also instrumented with strings of fluid thermocouples, to determine the degree of mixing within the tank and to assess the temperature of the coolant that is delivered to the test vessel.

The reactor vessel for the OSU tests includes a 0.914-meter (3-foot) heated core consisting of forty-eight 0.025-meter (1-inch) diameter heater rods. The heater rods have a top skewed power shape. The 1000 kW of electrical power available at the OSU test site will be used to simulate decay heat. Wall thermocouples are swaged inside the heater rods to measure the heater rod wall temperature. Thermocouple rods in the heater rod bundle measure the axial coolant temperature distribution. The scaled flow volume in the core is preserved as well as the flow volume in the test vessel upper plenum. There are simulated reactor internals in the upper plenum to preserve the flow area and to correctly scale the fluid volume. The reactor vessel includes an annular downcomer into which the four cold legs and the two DVI lines are connected. The hot legs penetrate the reactor annulus and connect with the loops. The AP1000 reactor vessel neutron reflector is simulated using a ceramic liner to reduce the metal heat release to the coolant.

There were no special/unique requirements for the test other than those specified in the Initial Conditions. The specified conditions were verified on the control board prior to test implementation.

3.1 Instrumentation

The instrumentation has been designed to calculate a transient mass and energy balance on the test facility. All two-phase flow streams exiting the facility are separated, and each component is measured separately as a single phase flow using conventional measurement devices such as magnetic flow meters and vortex flow meters. Note that magnetic flowmeters are not designed for two-phase flow and will indicate erratically. Also note, the vortex flowmeters are referenced to 212°F and the LDPs are referenced to 60°F. All vertical components have differential pressure cells that act as level instruments to measure the transient mass change in the component. The hot and cold leg diameters are sufficiently large in the OSU test facility such that a narrow range differential pressure cell can be used to determine if the flow becomes stratified.

Single flow measurements are made of the CMT, accumulator, IRWST, and sump flows into the reactor vessel through the direct vessel injection lines.

Various types of instrumentation are provided in the test facility; for example, thermocouples for coolant and wall temperatures, flowmeters, pressure transducers, differential pressure transducers, and weigh tanks.

4.0 OSU TESTING PROGRAM MATRIX

The test matrix for the OSU test facility is shown in Table 4-1. To satisfy the test objectives, several transients will be performed to provide data on the AP1000 passive safety system response for a range of break sizes, locations, orientations, and single failure assumptions. The break size orifices are scaled based on simulating a 1-inch, 2-inch, or 4-inch pipe break.

The designation for this test is DBA-04-D, which identifies the test as a design basis 2-inch Cold Leg Break. The test matrix may be adjusted for future tests based on results and insights gained with each test.

TABLE 4-1
OSU TEST MATRIX (SPECIFIED JULY 27, 2003)

Test Title	Break Location and Size	Single Failure Assumed
DBA-01-D	Double-ended DVI Line break with continuation into long-term cooling	Fail 1 of 2 lines in 1 ADS-4 train
DBA-02-D	Double-ended DVI Line break with continuation into long-term cooling	Fail 1 of 2 lines in 1 ADS-4 train (Adjusted ADS-4 Resistance) Single failure on non-pressurizer side
DBA-03-D	Double-ended DVI Line break with continuation into long-term cooling	Fail 1 of 2 lines in 1 ADS-4 train Single failure on pressurizer side
DBA-04-D	2-inch Cold Leg Break (CL #3)	Fail 1 of 2 lines in 1 ADS-4 train Single failure on pressurizer side
TR-02-D	Transition Test ADS4 opening, 125 psig initial pressure and decay power 480 sec	Fail 1 of 2 lines in 1 ADS-4 train (No ADS 1-3)
TR-03-D	Transition Test ADS4 opening, 85 psig initial pressure and decay power 1800 sec	Fail 1 of 2 lines in 1 ADS-4 train (No ADS 1-3)
TR-04-D	Transition Test ADS4 opening, 85 psig initial pressure and decay power 480 sec	No Failure of ADS-4 lines assumed (No ADS 1-3)
EN-01-D	Entrainment Test with Revised Upper Internals, 1000 kW reactor power, 14.7 psi	Fail 1 of 2 lines in 1 ADS-4 train
EN-01-D	Entrainment Test with Revised Upper Internals, 700 kW reactor power, 14.7 psi	Fail 1 of 2 lines in 1 ADS-4 train
PRA-01-D	PRA Test – DEDVI with no accumulators	No ADS-4 Failure assumed
PRA-02-D	PRA Test – 3-inch Hot Leg Break with no CMTs	No ADS-4 Failure assumed

5.0 TEST PROCEDURE

The test was performed as per a written procedure. There were no special/unique requirements for the test other than those specified in the initial conditions in Table 6-1. The specified conditions were checked on the control board prior to test implementation.

The appropriate prerequisites were completed and initial conditions were satisfied. The required break simulation piping and break instrumentation were installed per P&ID drawing OSU 600904, Rev. 1. A break spool insert simulating the 2-inch Cold Leg Break in AP1000 was installed in the break spool in cold leg #3 which is a cold leg without a CMT balance line. Flow from the break is directed horizontally into the break separator. The 100-percent flow nozzle was installed in the ADS 4-2 (on the hot leg 2) and the 50-percent flow nozzle was installed in ADS 4-1 (on the hot leg 1). Flow nozzles that simulate full flow for ADS-1, ADS-2, and ADS-3 were installed. As per the AP600 tests, ADS-3 has been scaled for full flow from all three stages, and ADS-1 and ADS-2 are closed when ADS-3 is opened.

Fill and vent was performed per APEX Operations Manual Procedure OP-B.2. Instruments were checked for required calibration.

With the break valve TS-202 closed, flow was used to warm up the bypass line by opening isolation valves RCS-901 and RCS-902. After the appropriate prerequisites were completed and the test facility achieved specified initial conditions, the CMT warm-up bypass line isolation valves RCS-901 and RCS-902 were closed to maintain the < 80°F condition at the top of the CMT #1. With the CMT balance line valves (RCS-529 and RCS-530) placed in the open and automatic mode, both CMTs reached the reactor coolant system (RCS) pressure.

Once all other initial conditions were satisfied, a break through TS-202 was initiated. The transient continued through ADS actuation, and CMT, accumulator, IRWST injection, and sump injection. Per Westinghouse instructions, ADS 4-2 was actuated automatically according to the actuation logic, and ADS 4-1 was actuated manually after a 30-second delay. All other actions were automatic and required no operator action.

6.0 TEST RESULTS

The test results for test DBA-04-D are provided in the following subsections.

6.1 Initial and Boundary Conditions

Table 6-1 provides a comparison of the specified and actual conditions for test DBA-04-D. The values in this table were averaged over approximately 2 minutes preceding the test. Test initial conditions were achieved for the steam generator pressure, pressurizer pressure, pressurizer level, steam generator 01 narrow-range level, and steam generator 02 narrow-range level. Test initial conditions for the hot leg temperature were found to be acceptable, and the results will not be adversely affected.

The actual power decay curves are provided in data plots in Appendix B. The measured maximum power was 913 kW, which was less than the facility maximum power of 1000 kW. The programmed decay heat curve was adjusted to account for this difference, and the differences between the actual and specified power decay are considered acceptable.

PT-501 and PT-502 pressure instruments indicate the pressure changes in the CMT-1 and CMT-2. CMT-1 (PT-501) and CMT-2 (PT-502) confirm that 1 minute after the test button was pushed, both CMTs reach RCS pressure.

The sequence of events is shown in Table 6-2. This table compares the actual sequence of events with the specified timing. As can be seen in this table, all the events occurred at or very near to when the event was planned.

6.2 Inoperable Instruments

Table 6-3 provides a list of the instrumentation channels considered inoperable for the DBA-04-D test.

6.3 Key Data Plots

Table 6-4 provides a list of the instrumentation channels sorted by component, and includes instrument number, units, and quick look plot number. The selection of channels was based on projecting an overall picture of the test results, which would then be examined by referring to the detailed data plots or tapes.

6.4 Test Evaluation

The following observations were made during the test:

1. The peak power before the test was initiated was 913 kW. The decay heat curve was adjusted for this value.

2. The test was not terminated at stable sump injection. The sump level was decreased to determine the effect of sump injection flow and core cooling. Two decreased sump levels were tested for approximately 10 minutes to demonstrate injection and effective core cooling at lower containment flood-up levels. The test was terminated when the sump level was drained to the wall-to-wall flooding level in containment.

TABLE 6-1
ACTUAL TEST INITIAL CONDITIONS

Conditions	Instrument No.	Actual	Comment
Pressurizer Pressure	PT-604	370 psig	
Hot Leg Temperature #1	TF-141* TF-205 TF-143	426.3°F 428°F 428.4°F	
Hot Leg Temperature #2	TF-140* TF-206 TF-142	427.6°F 426.3°F 428.5°F	
SG Press. #1 #2 Header	PT-301* PT-302* PT-002	285 psig 287 psig 245.5 psig	
Pressurizer Level	LDP-601 uncompensated LDP-601 Compensated by SC-608	64.2 inches 77.1 inches	 440°F used for density compensation
SG Level #1 NR	LDP-303 uncompensated LDP-303 compensated by average of TF-305 and TF-307	21.1 inches 25.5 inches	 413°F used for density compensation
SG Level #2 NR	LDP-304 uncompensated LDP-304 compensated by average of TF-306 and TF-308	20.8 inches 24.4 inches	 414°F used for density compensation
IRWST Temperature	TF-701	77.4°F	Accepted (< 80°F)
CMT Temperature #1 #2	TF-511 TF-514	77°F 77.2°F	Accepted (< 80°F)
Accumulator Temperature #1 #2	TF-401 TF-402	77.5°F 78.5°F	Accepted (< 80°F)
IRWST Level	LDP-701	93.3 inches	

TABLE 6-1 (Continued)
ACTUAL TEST INITIAL CONDITIONS

Conditions	Instrument No.	Actual	Comment
Accumulator Level			
#1	LDP-401	35.7 inches	
#2	LDP-402	36.7 inches	
Accumulator Pressure			
#1	PT-401	188 psig	
#2	PT-402	190.2 psig	
CMT Level			
#1	LDP-507	57.2 inches	
#2	LDP-502	57.7 inches	
CMT Pressure			
#1	PT-501	374 psig	
#2	PT-502	375 psig	

TABLE 6-2
SEQUENCE OF EVENTS

Event	Setpoint	Actual Time (sec)
PB Depressed	N/A	-120
Break Valve(s) Open	0	0
Feed Pump Trip	3.6 sec	3
CMT01 Outlet Valve Open (RCS-535)	6.1 sec	6
CMT02 Outlet Valve Open (RCS-536)	6.1 sec	6
PRHR HX Outlet Vlv Open (RCS-804)	6.1 sec	5
RCP #1 Trip	8.6 sec	8
RCP #2 Trip	8.6 sec	8
RCP #3 Trip	8.6 sec	8
RCP #4 Trip	8.6 sec	8
CMT #1 Level Low (LDP-507)	41 inches	377
CMT #2 Level Low (LDP-502)	41 inches	401
ADS #1 Actuation (RCS-601)	CMT Level Low + 15 sec	391
ADS #2 Actuation (RCS-602)	CMT Level Low + 62 sec	439
ADS #3 Actuation (RCS-603)	CMT Level Low + 122 sec	499
Low Reactor Pressure (P-107)	40 psig	615
IRWST Valve Actuation (RCS-711)	Low Reactor Pressure (< 40 psig)	617
IRWST Valve Actuation (RCS-712)	Low Reactor Pressure (< 40 psig)	617
CMT #1 Low Low Level (LDP-507)	17.14 inches	773
CMT #2 Low Low Level (LDP-502)	17.14 inches	776
ADS 4-1 Actuation (RCS-615)	CMT Low Low (17.14") and CMT Low (41") + 180 sec	777
ADS 4-2 Actuation (RCS-616)	CMT Low Low (17.14") and CMT Low (41") + 180 sec	807
Sump Valve Actuation (CSS-909)	IRWST Level Low Low	8579

TABLE 6-2 (Continued)
SEQUENCE OF EVENTS

Event	Setpoint	Actual Time (sec)
Sump Valve Actuation (CSS-910)	IRWST Level Low Low	8579
Accumulator Injection #1 (FMM-401)	N/A	439
Accumulator Injection #2 (FMM-402)	N/A	438
IRWST Injection DVI #1 (FMM-701)	N/A	1358
IRWST Injection DVI #2 (FMM-702)	N/A	1358
Accumulator Empty #1 (LDP-401)	N/A	915 down to 1.2 inch level
Accumulator Empty #2 (LDP-402)	N/A	930 down to 0.1 inch level
CMT Empty #1 (LDP-507)	N/A	1060 down to 0.1 inch level
CMT Empty #2 (LDP-502)	N/A	1060
Sump Injection DVI # 1 (FMM-901)	N/A	8581
Sump Injection DVI # 2 (FMM-902)	N/A	8580

TABLE 6-3
INOPERABLE INSTRUMENTS FOR DBA-04-D TEST

Instrument Number	Instrument Type	Inoperable Description
TW-202 TW-204 TW-205 TW-206 TW-209 TW-803 TW-804	Thermocouple	Inoperative
TH-603	Thermocouple measuring heater temperature	Inoperative
FMM-202	Magnetic flow meter	Inoperative
TF-170 TF-221 TF-509 TF-512	Thermocouple measuring fluid temperature	Inoperative
FVM-905	Vortex flow meter	Erratic

TABLE 6-4
DATA PLOTS FOR QL REPORTS FOR DBA-04-D BY COMPONENT

Component	Channel	Units	QL-Plot	Comment
Reactor Vessel Pressure	PT-107	psig	44	
Reactor Vessel Level	LDP-127	inch of H_2O	29	
Reactor Vessel Downcomer Level	LDP-140	inch of H_2O	31	
Cold Leg #1 Fluid Temperature	TF-107	°F	58	
Cold Leg #2 Fluid Temperature	TF-108	°F	59	
Cold Leg #3 Fluid Temperature	TF-103	°F	56	
Cold Leg #4 Fluid Temperature	TF-104	°F	57	
Reactor Vessel Fluid Temp Upper Head	TF-120	°F	60	
RCS Hot Leg #1 Temperature	TF-143	°F	62	
RCS Hot Leg #2 Temperature	TF-142	°F	61	
Pressurizer Pressure	PT-604 (WR) and PT-603 (LP Indication)	psig	49, 50	
Pressurizer Liquid Level	LDP-601	inch of H_2O	38	Sharp decrease followed by rapid refill.
SG #1 Tube Level	LDP-215	inch of H_2O	32	
SG #1 Secondary Pressure	PT-301	psig	45	
SG #1 Feed Flow Rate	FMM-001	gpm	1	
SG #2 Tube Level	LDP-218	inch of H_2O	33	
SG #2 Secondary Pressure	PT-302	psig	46	

TABLE 6-4 (Continued) DATA PLOTS FOR QL REPORTS FOR DBA-04-D BY COMPONENT				
Component	**Channel**	**Units**	**QL-Plot**	**Comment**
Accumulators #1 and #2 Pressure	PT-401 and PT-402	psig	47, 48	
Accumulators #1 and #2 Liquid Level	LDP-401 and LDP-402	inch of H_2O	34, 35	
Accumulators #1 and #2 Flow Rate	FMM-401 and FMM-402	gpm	2, 3	
Accumulators #1 and #2 Liquid Discharge Temperature	TF-401 and TF-402	°F	63, 64	
CMT #1 and #2 Liquid Level	LDP-507 and LDP-502	inch of H_2O	36, 37	
CMT #1 and #2 Flow Rate	FMM-501 and FMM-504	gpm	4, 5	
CMT #1 and #2 Liquid Temperature	TF-501 and TF-529 and TF-504 and TF-532	°F	65 - 68	
PRHR Inlet Flow Rate	FMM-802	gpm	11	
PRHR Liquid Level	LDP-802	inch of H_2O	40	
PRHR Outlet Flow Rate	FMM-804	gpm	12	
IRWST Liquid Level	LDP-701	inch of H_2O	39	
IRWST Discharge Line #1 and #2 Flow Rate	FMM-701 and FMM-702	gpm	9, 10	
IRWST Fluid Temperature	TF-701 and TF-709	°F	69, 70	
ADS 1-3 Separator Pressure	PT-605	psig	51	
ADS 1-3 Separator Steam Flow Rate	FVM-601	scfm	16	
ADS 1-3 Separator Liquid Flow Rate	FMM-601	gpm	6	

TABLE 6-4 (Continued)
DATA PLOTS FOR QL REPORTS FOR DBA-04-D BY COMPONENT

Component	Channel	Units	QL-Plot	Comment
ADS 4-1 and 4-2 Separator Pressure	PT-611 and PT-610	psig	52, 53	
ADS 4-1 Separator Steam Flow Rate	FVM-603	scfm	18	
ADS 4-2 Separator Steam Flow Rate	FVM-602	scfm	17	
ADS 4-1 Separator Liquid Flow Rate	FMM-603	gpm	8	
ADS 4-2 Separator Liquid Flow Rate	FMM-602	gpm	7	
Primary Sump Pressure	PT-901	psig	54	
Primary Sump Liquid Level	LDP-901	inch of H_2O	41	
Primary Sump Injection Flow Rate	FMM-901 and FMM-902	gpm	13, 14	
Secondary Sump Liquid Level	LDP-902	inch of H_2O	42	
Break Separator Pressure	PT-905	psig	55	
Break Separator Liquid Level	LDP-905	inch of H_2O	43	
Break Separator Flow to Primary Sump	FMM-905	gpm	15	
BAMS Steam Flow Rate	FVM-901	scfm	19	
BAMS Steam Flow Rate	FVM-902	scfm	20	
BAMS/Primary Sump Steam Flow Rate	FVM-903	scfm	21	

TABLE 6-4 (Continued)
DATA PLOTS FOR QL REPORTS FOR DBA-04-D BY COMPONENT

Component	Channel	Units	QL-Plot	Comment
BAMS/Separator Steam Flow Rate – 6 inch Pipe	FVM-905	scfm	22	
BAMS/Exhaust Line Temp.	TF-916 and SC-917	°F	71, 72	
PZR Heater Input Power	KW-601	kW	27	
Core Power Input Power	KW-101, KW-102, KW-103, and KW-104	kW	23-26	
Reactor Vessel Liquid Level Between Top of Vessel – Upper Support Plate	LDP-115	inches of water	28	
Reactor Vessel Liquid Level Between bottom of Upper Support Plate – Upper Core Spacer Grid	LDP-139	inches of water	30	
Inner Core Thermocouple Measuring Heater Temperature	TH-103-4	°F	73	
Outer Core Thermocouple Measuring Heater Temperature	TH-309-4	°F	74	

7.0 CONCLUSIONS

The DBA-04-D tests were successfully completed, and the data logged in the DAS. All critical instruments were found to operate properly with the exception of those noted in Section 6.4. The test was found to be acceptable.

APPENDIX A
DATA PLOTS

a,b,c

Figure A-1 Reactor Vessel Pressure

a,b,c

Figure A-2 Reactor Vessel Level

a,b,c

[ ]

Figure A-3 Reactor Vessel Downcomer Level

a,b,c

Figure A-4 Cold Leg 1 Fluid Temperature

a,b,c

[ ]

Figure A-5 Cold Leg 2 Fluid Temperature

a,b,c

Figure A-6 Cold Leg 3 Fluid Temperature

a,b,c

Figure A-7 Cold Leg 4 Fluid Temperature

a,b,c

Figure A-8 Reactor Vessel Fluid Temperature Upper Head

a,b,c

Figure A-9 Reactor Coolant System Hot Leg 1 Temperature

a,b,c

Figure A-10 Reactor Coolant System Hot Leg 2 Temperature

a,b,c

Figure A-11 Pressurizer Pressure – Wide Range

a,b,c

Figure A-12 Pressurizer Pressure – Narrow Range

a,b,c

Figure A-13 Pressurizer Liquid Level

a,b,c

Figure A-14 Steam Generator 1 Tube Level

a,b,c

Figure A-15 Steam Generator 1 Secondary Pressure

a,b,c

[ ]

Figure A-16 Steam Generator 1 Feed Flow Rate

a,b,c

Figure A-17 Steam Generator 2 Tube Level

a,b,c

Figure A-18 Steam Generator 2 Secondary Pressure

a,b,c

[ ]

Figure A-19 Accumulator 1 Pressure

a,b,c

Figure A-20 Accumulator 2 Pressure

a,b,c

Figure A-21 Accumulator 1 Liquid Level

a,b,c

Figure A-22 Accumulator 2 Liquid Level

a,b,c

Figure A-23 Accumulator 1 Flow Rate

a,b,c

Figure A-24 Accumulator 2 Flow Rate

a,b,c

Figure A-25 Accumulator 1 Liquid Discharge Temperature

a,b,c

Figure A-26 Accumulator 2 Liquid Discharge Temperature

a,b,c

Figure A-27 Core Makeup Tank 1 Liquid Level

a,b,c

Figure A-28 Core Makeup Tank 2 Liquid Level

a,b,c

Figure A-29 Core Makeup Tank 1 Flow Rate

a,b,c

Figure A-30 Core Makeup Tank 2 Flow Rate

a,b,c

Figure A-31 Core Makeup Tank 1 Liquid Temperature – Bottom

a,b,c

Figure A-32 Core Makeup Tank 1 Liquid Temperature – Top

a,b,c

Figure A-33 Core Makeup Tank 2 Liquid Temperature – Bottom

a,b,c

Figure A-34 Core Makeup Tank 2 Liquid Temperature – Top

a,b,c

Figure A-35 Passive Residual Heat Removal Inlet Flow Rate

a,b,c

Figure A-36 Passive Residual Heat Removal Liquid Level

a,b,c

Figure A-37 Passive Residual Heat Removal Outlet Flow Rate

a,b,c

Figure A-38 IRWST Liquid Level

a,b,c

Figure A-39 IRWST Discharge Line 1 Flow Rate

a,b,c

Figure A-40 IRWST Discharge Line 2 Flow Rate

a,b,c

Figure A-41 IRWST Fluid Temperature – Bottom

a,b,c

Figure A-42 IRWST Fluid Temperature – Top

a,b,c

Figure A-43 ADS 1-3 Separator Pressure

a,b,c

Figure A-44 ADS 1-3 Separator Steam Flow Rate

a,b,c

Figure A-45 ADS 1-3 Separator Liquid Flow Rate

a,b,c

Figure A-46 ADS 4-1 Separator Pressure

a,b,c

Figure A-47 ADS 4-2 Separator Pressure

a,b,c

Figure A-48 ADS 4-1 Separator Steam Flow Rate

a,b,c

Figure A-49 ADS 4-2 Separator Steam Flow Rate

a,b,c

Figure A-50 ADS 4-1 Separator Liquid Flow Rate

a,b,c

Figure A-51 ADS 4-2 Separator Liquid Flow Rate

a,b,c

Figure A-52 Primary Sump Pressure

a,b,c

Figure A-53 Primary Sump Liquid Level

a,b,c

Figure A-54 Primary Sump 1 Injection Flow Rate

a,b,c

Figure A-55 Primary Sump 2 Injection Flow Rate

a,b,c

Figure A-56 Secondary Sump Liquid Level

a,b,c

Figure A-57 Break Separator Pressure

a,b,c

Figure A-58 Break Separator Liquid Level

a,b,c

Figure A-59 Break Separator Flow to Primary Sump

a,b,c

Figure A-60 BAMS Steam Flow Rate – 6-inch Line

a,b,c

Figure A-61 BAMS Steam Flow Rate – 10-inch Line

a,b,c

Figure A-62 BAMS/Primary Sump Steam Flow Rate

a,b,c

Figure A-63 BAMS/Separator Steam Flow Rate – 6-inch Pipe

a,b,c

Figure A-64 BAMS/Exhaust Line Temperature – 10-inch Line

a,b,c

Figure A-65 BAMS/Exhaust Line Temperature – Header

a,b,c

Figure A-66 Pressurizer Heater Input Power

a,b,c

Figure A-67 Core Power Group 1 Input Power

a,b,c

[ ]

Figure A-68 Core Power Group 2 Input Power

a,b,c

Figure A-69 Core Power Group 1 Alternate Input Power

a,b,c

[ ]

Figure A-70 Core Power Group 2 Alternate Input Power

a,b,c

Figure A-71 Reactor Vessel Liquid Level Between Top of Vessel – Upper Support Plate

a,b,c

Figure A-72 Reactor Vessel Liquid Level Between Bottom of Upper Support Plate – Upper Core Spacer Grid

a,b,c

Figure A-73 Inner Core Thermocouple Measuring Heater Temperature

a,b,c

Figure A-74 Outer Core Thermocouple Measuring Heater Temperature

APPENDIX B
TEST DATA