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Attachment 2

Oregon State University Non-Proprietary Reports

APP-LTCT-T2R-001, Rev. 0
"OSU-AP1000-01, Rev. 0 "AP1000 Double-Ended DVI with 3 of 4 ADS 4"
dated 5/29/03

APP-LTCT-T2R-002, Rev. 0
"OSU-AP1000-02, Rev. 0, "AP1000 Double-Ended DVI with 3 of 4 ADS 4 Revised
ADS 4 Piping and Valves"
dated 6/24/03

APP-LTCT-T2R-003, Rev. 0
"OSU-AP1000-03, Rev. 0, "AP1000 Double-Ended DVI with 3 or 4 ADS 4
Revised ADS 4 Piping and Valves"
dated 6/24/03

Oregon State University

Department of Nuclear Engineering

ADVANCED THERMAL HYDRAULIC
RESEARCH LABORATORY

TEST SUMMARY REPORT

OSU-AP1000-01

AP1000 DOUBLE-ENDED DVI WITH 3 OF 4 ADS 4

Revision 0

TEST SUMMARY REPORT

OSU-AP1000-01

AP1000 DOUBLE-ENDED DVI WITH 3 OF 4 ADS 4

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SUMMARY

This report covers the test DBA-01, double-ended Direct Vessel Injection (DVI) line break simulation loss-of-coolant accident (LOCA) performed on February 27, 2003. The objective of this test was to obtain thermal-hydraulic data for a double-ended DVI line 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 15,000 seconds. The transient continued through Automatic Depressurization System (ADS) actuation, core makeup tank (CMT), accumulator, in-containment 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 (OSU) 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 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 in the 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 double-ended DVI line break simulation. The break is located in the DVI-1 line close to the DVI-1 nozzle as it enters the reactor vessel. 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 flow meters are not designed for two-phase flow and will indicate erratically. Also note, the vortex flow meters 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 so 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 DVI lines.

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

4.0 OREGON STATE UNIVERSITY 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-01-D, which identifies the test as a design basis double-ended DVI line 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 MAY 1, 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)
DBA-03-D	2-inch Cold Leg Break	Fail 1 of 2 lines in 1 ADS-4 train
TR-01-D	Transition Test ADS4 opening, 85 psig initial pressure and decay power 480 sec	Fail 1 of 2 lines in 1 ADS-4 train (No ADS 1-3)
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 before 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 double-ended break in AP1000 was installed in the break spool in DVI horizontal line. DVI-1 nozzle flow from the reactor is directed horizontally into the break separator. The combined flow of DVI line (from CMT-1, accumulator 1, primary sump, and IRWST) is connected horizontally to the primary sump tank. The 100-percent flow nozzle was installed in the ADS 4-1 (on hot leg 1) and the 50-percent flow nozzle was installed in ADS 4-2 (on hot leg 2). 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 valves TS-202 and TS-203 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 warmup 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 and TS-203 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 ADS4-1 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-01-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-01-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 863 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-01-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 Test Summary Report plot number. Appendix A contains the Test Summary Report plots for this test for selected channels. 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. Appendix B contains a CD containing all data channels for this test.

6.4 Test Evaluation

The following observations were made during the test:

1. The peak power before the test was initiated was 863 kW. The decay heat curve was adjusted for this value.

2. The liquid flow from ADS1-3 is non-zero after ADS-4 actuation. The liquid loop seal in the ADS1-3 line may have been blown out during the initial blowdown, and the flows after ADS-4 actuation should be ignored.

3. The switch over to sump injection occurs very late relative to pre-test predictions, and the sump level at this time is significantly higher than the IRWST level. Subsequent tests should re-scale the setpoint for sump switch over according to the latest AP1000 design.

4. The ADS-4 flow is adequately scaled for choked flow, but is too restrictive for unchoked flow. Subsequent tests should use a redesigned ADS-4 nozzle that is scaled correctly for both conditions.

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	424°F 427°F 428°F	
Hot Leg Temperature #2	TF-140* TF-206 TF-142	426°F 426°F 427°F	
Steam Generator (SG) Pressure #1 #2 Header	PT-301* PT-302* PT-002	287 psig 286 psig 251 psig	
Pressurizer Level	LDP-601 uncompensated LDP-601 Compensated by SC-608	68.5 inches 82.3 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	20.8 inches 25.1 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	21.5 inches 25.2 inches	 414°F used for density compensation
IRWST Temperature	TF-701	61°F	Accepted (< 80°F)
CMT Temperature #1 #2	TF-529 TF-532	71.6°F 72°F	Accepted (< 80°F)
Accumulator Temperature #1 #2	TF-403 TF-404	70.5°F 71°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	37.7 inches	
Accumulator Pressure			
#1	PT-401	188.9 psig	
#2	PT-402	189.4 psig	
CMT Level			
#1	LDP-507	57.7 inches	
#2	LDP-502	57.8 inches	
CMT Pressure			
#1	PT-501	373.5 psig	
#2	PT-502	374.7 psig	

* These instruments are used to establish initial conditions at the test site.

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	4
CMT01 Outlet Valve Open (RCS-535)	6.1 sec	8
CMT02 Outlet Valve Open (RCS-536)	6.1 sec	8
PRHR HX Outlet Valve Open (RCS-804)	6.1 sec	8
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	72
CMT #2 Level Low (LDP-502)	41 inches	413
ADS #1 Actuation (RCS-601)	CMT Level Low + 15 sec	86
ADS #2 Actuation (RCS-602)	CMT Level Low + 62 sec	132
ADS #3 Actuation (RCS-603)	CMT Level Low + 122 sec	193
Low Reactor Pressure (P-107)	40 psig	195
IRWST Valve Actuation (RCS-711)	Low Reactor Pressure (< 40 psig)	197
IRWST Valve Actuation (RCS-712)	Low Reactor Pressure (< 40 psig)	197
CMT #1 Low Low Level (LDP-507)	17.14 inches	97
CMT #2 Low Low Level (LDP-502)	17.14 inches	739
ADS 4-1 Actuation (RCS-615)	CMT Low Low (17.14") and CMT Low (41") + 180 sec	250
ADS 4-2 Actuation (RCS-616)	CMT Low Low (17.14") and CMT Low (41") + 180 sec	283
Sump Valve Actuation (CSS-909)	IRWST Level Low Low	11945

TABLE 6-2 (Continued)
SEQUENCE OF EVENTS

Event	Setpoint	Actual Time (sec)
Sump Valve Actuation (CSS-910)	IRWST Level Low Low	11945
Accumulator Injection #1 (FMM-401)	N/A	0
Accumulator Injection #2 (FMM-402)	N/A	107
IRWST Injection DVI #1 (FMM-701)	N/A	300
IRWST Injection DVI #2 (FMM-702)	N/A	910
Accumulator Empty #1 (LDP-401)	N/A	205 down to 1.2 inch level
Accumulator Empty #2 (LDP-402)	N/A	362 down to 0.1 inch level
CMT Empty #1 (LDP-507)	N/A	115 down to 0.1 inch level
CMT Empty #2 (LDP-502)	N/A	920
Sump Injection DVI # 1 (FMM-901)	N/A	11945
Sump Injection DVI # 2 (FMM-902)	N/A	11945

* Level indication < 2 inches

TABLE 6-3
INOPERABLE INSTRUMENTS FOR DBA-01-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, FMM-601	Magnetic flow meter	Inoperative Measured ADS1-3 liquid flow after ADS4 actuation (loop seal potentially blown)
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 TEST SUMMARY REPORT FOR DBA-01-D BY COMPONENT				
Component	**Channel**	**Units**	**TSR-Plot**	**Comment**
Reactor Vessel Pressure	PT-107	psig	1	
Reactor Vessel Level	LDP-127	inch of H_2O	2	
Reactor Vessel Downcomer Level	LDP-140	inch of H_2O	3	
Cold Leg #1 Fluid Temperature	TF-107	°F	4	
Cold Leg #2 Fluid Temperature	TF-108	°F	5	
Cold Leg #3 Fluid Temperature	TF-103	°F	6	
Cold Leg #4 Fluid Temperature	TF-104	°F	7	
Reactor Vessel Fluid Temp Upper Head	TF-120	°F	8	
RCS Hot Leg #1 Temperature	TF-143	°F	9	
RCS Hot Leg #2 Temperature	TF-142	°F	10	
Pressurizer Pressure	PT-604 (WR)	psig	11	
Pressurizer Pressure	PT-603 (LP Indication)	psig	12	
Pressurizer Liquid Level	LDP-601	inch of H_2O	13	Sharp decrease followed by rapid refill
SG #1 Tube Level	LDP-215	inch of H_2O	14	
SG #1 Secondary Pressure	PT-301	psig	15	
SG #1 Feed Flow Rate	FMM-001	gpm	16	
SG #2 Tube Level	LDP-218	inch of H_2O	17	
SG #2 Secondary Pressure	PT-302	psig	18	

TABLE 6-4 (Continued)
DATA PLOTS FOR TEST SUMMARY REPORT FOR DBA-01-D BY COMPONENT

Component	Channel	Units	TSR-Plot	Comment
Accumulator #2 Pressure	PT-401	psig	19	
Accumulator #1 Pressure	PT-402	psig	20	
Accumulator #1 Liquid Level	LDP-401	inch of H_2O	21	
Accumulator #2 Liquid Level	LDP-402	inch of H_2O	22	
Accumulator #1 Flow Rate	FMM-401	gpm	23	
Accumulator #2 Flow Rate	FMM-402	gpm	24	
Accumulator #1 Liquid Discharge Temperature	TF-401	°F	25	
Accumulator #2 Liquid Discharge Temperature	TF-402	°F	26	
CMT #1 Liquid Level	LDP-507	inch of H_2O	27	
CMT #2 Liquid Level	LDP-502	inch of H_2O	28	
CMT #1 Flow Rate	FMM-501	gpm	29	
CMT #2 Flow Rate	FMM-504	gpm	30	
CMT #1 Liquid Temperature	TF-501	°F	31	
CMT #1 Liquid Temperature	TF-529	°F	32	
CMT #2 Liquid Temperature	TF-504	°F	33	
CMT #2 Liquid Temperature	TF-532	°F	34	
PRHR Inlet Flow Rate	FMM-802	gpm	35	
PRHR Liquid Level	LDP-802	inch of H_2O	36	

TABLE 6-4 (Continued) DATA PLOTS FOR TEST SUMMARY REPORT FOR DBA-01-D BY COMPONENT				
Component	**Channel**	**Units**	**TSR-Plot**	**Comment**
PRHR Outlet Flow Rate	FMM-804	gpm	37	
IRWST Liquid Level	LDP-701	inch of H_2O	38	
IRWST Discharge Line #1 Flow Rate	FMM-701	gpm	39	
IRWST Discharge Line #2 Flow Rate	FMM-702	gpm	40	
IRWST Fluid Temperature	TF-701	°F	41	
IRWST Fluid Temperature	TF-709	°F	42	
ADS 1-3 Separator Pressure	PT-605	psig	43	
ADS 1-3 Separator Steam Flow Rate	FVM-601	scfm	44	
ADS 1-3 Separator Liquid Flow Rate	FMM-601	gpm	45	
ADS 4-1 Separator Pressure	PT-611	psig	46	
ADS 4-2 Separator Pressure	PT-610	psig	47	
ADS 4-1 Separator Steam Flow Rate	FVM-603	scfm	48	
ADS 4-2 Separator Steam Flow Rate	FVM-602	scfm	49	
ADS 4-1 Separator Liquid Flow Rate	FMM-603	gpm	50	
ADS 4-2 Separator Liquid Flow Rate	FMM-602	gpm	51	
Primary Sump Pressure	PT-901	psig	52	
Primary Sump Liquid Level	LDP-901	inch of H_2O	53	

TABLE 6-4 (Continued)
DATA PLOTS FOR TEST SUMMARY REPORT FOR DBA-01-D BY COMPONENT

Component	Channel	Units	TSR-Plot	Comment
Primary Sump Injection Flow Rate	FMM-901	gpm	54	
Primary Sump Injection Flow Rate	FMM-902	gpm	55	
Secondary Sump Liquid Level	LDP-902	inch of H_2O	56	
Break Separator Pressure	PT-905	psig	57	
Break Separator Liquid Level	LDP-905	inch of H_2O	58	
Break Separator Flow to Primary Sump	FMM-905	gpm	59	
BAMS Steam Flow Rate	FVM-901	scfm	60	
BAMS Steam Flow Rate	FVM-902	scfm	61	
BAMS/Primary Sump Steam Flow Rate	FVM-903	scfm	62	
BAMS/Separator Steam Flow Rate – 6 inch Pipe	FVM-905	scfm	63	
BAMS/Exhaust Line Temp.	TF-916	°F	64	
BAMS/Exhaust Line Temp.	SC-917	°F	65	
PZR Heater Input Power	KW-601	kW	66	
Core Power Input Power	KW-101	kW	67	
Core Power Input Power	KW-102	kW	68	
Core Power Input Power	KW-103	kW	69	

TABLE 6-4 (Continued)
DATA PLOTS FOR TEST SUMMARY REPORT FOR DBA-01-D BY COMPONENT

Component	Channel	Units	TSR-Plot	Comment
Core Power Input Power	KW-104	kW	70	
Reactor Vessel Liquid Level Between Top of Vessel – Upper Support Plate	LDP-115	inches of water	71	
Reactor Vessel Liquid Level Between bottom of Upper Support Plate – Upper Core Spacer Grid	LDP-139	inches of water	72	
Inner Core Thermocouple Measuring Heater Temperature	TH-103-4	°F	73	
Outer Core Thermocouple Measuring Heater Temperature	TH-309-4	°F	74	

Note:
Data plot numbers 86 through 100 not used.

7.0 CONCLUSIONS

The DBA-01-D tests were successfully completed, and the data were 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 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

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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

a,b,c

Figure A-42 IRWST Fluid Temperature

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 Injection Flow Rate

a,b,c

Figure A-55 Primary Sump 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

a,b,c

Figure A-61 BAMS Steam Flow Rate

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

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Figure A-64 BAMS/Exhaust Line Temperature

a,b,c

Figure A-65 BAMS/Exhaust Line Temperature

a,b,c

Figure A-66 Pressurizer Heater Input Power

a,b,c

Figure A-67 Core Power Input Power

a,b,c

Figure A-68 Core Power Input Power

a,b,c

Figure A-69 Core Power Input Power

a,b,c

Figure A-70 Core Power 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