SNUPPS
Standardized Nuclear Unit
Power Plant System

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November 2, 1982

SLNRC 82-044 FILE: 0278/0650.2
SUBJ: Containment Recirculation Sump Testing

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dockets Nos: STN 50-482 and STN 50-483

References: 1) Para. Clb(2), Regulatory Guide 1.79, Revision 1, 9/75: Preoperational Testing of Emergency Core Cooling Systems for Pressurized Water Reactors.
2) SLNRC 82-03, 1/18/82: ECCS Sump Test

Dear Mr. Denton:

Plans to conduct hydraulic model testing in lieu of on site testing of the containment recirculation sumps were discussed in Reference 2. Enclosed for your information is the test plan for hydraulic model testing at Alden Research Laboratory. Also enclosed are appropriate revised FSAR pages which will be included in the next Revision of the SNUPPS FSAR.

We will forward a final report of the hydraulic model testing to you upon completion of the testing.

Very truly yours,

[signature] for

Nicholas A. Petrick

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RFS/dck/1b2

Enclosures: 1) Test Plan - Hydraulic Model Study
2) Revised Pages to SNUPPS FSAR

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TEST PLAN

HYDRAULIC MODEL STUDY OF SNUPPS

CONTAINMENT RECIRCULATION SUMPS

Background

The containment recirculation sumps serve the emergency core cooling system and the containment spray system by providing for collection of reactor coolant and spray solution and allowing its recirculation for additional cooling. Regulatory Guide 1.79, "Preoperational Testing of Emergency Core Cooling Systems for Pressurized Water Reactors," paragraph C1b(2), outlines the requirements for conducting the recirculation test. The objectives of the test are to demonstrate the capability to realign valves and to recirculate coolant from the containment recirculation sumps into the reactor coolant system. The testing is to verify vortex control and acceptable pressure drops across screening and suction lines and valves. By so doing, it is verified that the available net positive suction head is greater than that required at accident temperatures as discussed in Regulatory Guide 1.1, "Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal System Pumps."

An efficient and reliable method of investigating flow patterns in the containment recirculation sumps and pump suction lines is to use a reduced scale hydraulic model. Such models have been used to verify flow conditions and to measure the screen-inlet head loss for calculating available net positive suction head for a number of pressurized water reactors. By using a model the various approach flow distributions and screen and grating blockages may be simulated easily and quickly. Flow patterns can be observed throughout the model and instrumentation can be located in all areas of interest, both of which are difficult or impossible with in situ measurements. Remedial measures can be evaluated for minimal expenditure of time and cost.

Because of these advantages, it has been decided to do hydraulic model testing of the containment recirculation sumps in lieu of on-site testing. Consequently, this test program takes the place of the previously planned SNUPPS Preoperational Test S-030007, "ECCS Sump Test." Results from the model testing together with known data for pump suction line pressure losses will determine the adequacy of available net positive suction head. The ability to realign valves will be demonstrated in SNUPPS Preoperational Test S-03EJ01, "Residual Heat Removal System Cold Preoperational Test."

Model Description

The model will be constructed to a geometric scale of about 1:2.9 with boundaries as indicated in Figure 1. These boundaries have been chosen since previous studies have indicated little effect of far-field flow patterns once the dominant near-field screen blockage is considered. Portions of the prototype structure such as columns, conduits and pipes with external prototype dimensions of about three inches or larger, in the immediate vicinity of the sumps and below the water surface, which might affect the approach flow pattern to the sumps, will be modeled to the geometric scale.

With a geometric scale of about 1:2.9 and an ambient water temperature of 60°F the model pipe Reynolds number will be about 2.0×10^5, which is significantly greater than the minimum recommended. The model radial Reynolds number will be 3.6×10^4 for Froude scale velocity, well above the minimum recommended. At these Reynolds numbers, the viscous effects on the vortexing phenomenon will be negligible, thus preventing any scale effects.

Instrumentation and Observation Techniques

An orifice plate flow meter will be used to measure the flow in each suction pipe. Approach flow patterns and vortices in the sump area will be observed with the assistance of dye tracers. Swirl in the pipes will be measured using a swirl meter two pipe diameters downstream of the inlet. Head losses will be determined from the extrapolation of the pressure gradeline measured 25 pipe diameters downstream of the inlet.

Flow Measurements - Flows will be measured by ASME standard meters located in the appropriate lines.

Observation of Flow Patterns - Visual aids, such as dye and tufts of thread, will be used to observe flow patterns. Photographic documentation will be taken whenever appropriate. Portions of the model in the sump area will be of transparent material to facilitate visual observations.

Vorticity - Vortex activity will be recorded by observing vortex strength on a scale from 1 to 6 (see Figure 1) and by determining the percent of time for each strength.

Pressure - Average suction piping pressures will be measured using piezometers connected to air-water manometers.

Test Program

Testing is designed to demonstrate the performance of the containment sump under a variety of approach flow conditions, screen blockages, water levels, and pump operation combinations. Sump performance will be evaluated with respect to vortex formation, both surface and submerged, head losses due to the screens, gratings, and inlet geometry, and swirl in the inlet pipe.

A vortex strength greater than a coherent dye core (vortex type 3) will be considered unacceptable hydraulic performance. Swirl angles greater than 10 degrees will also be considered unacceptable. If at any time during the test program unacceptable hydraulic performance occurs, the test program will be halted until a suitable remedial structure is designed.

Initial testing will demonstrate the sump performance with a "natural" approach flow distribution, that is, flow rate proportional to the flow area at the model boundaries. Both two pump and four pump operation will be tested at Froude scale velocity and prototype velocity. A series of tests will be conducted to define the sensitivity of sump performance to approach flow distribution. Four extreme approach flow distributions have been chosen and are illustrated in Figure 2.

Both Froude scale velocity and prototype velocity will be used to demonstrate the effect on sump performance of approach flow distribution for both two and four pump operation. Flow will be supplied at the model boundaries with the north two flow paths blocked, the south two flow paths blocked, the two flow paths in the secondary shield wall blocked, and the two flow paths in the anulus blocked. The test results will be evaluated and the two worst-case approach flow distributions will be used with the original "natural" case for testing with a variety of screen blockages.

Eight screen blockages shown in Figure 3 will be tested with both two and four pump operation at Froude scale velocity with the three approach flow distributions. Since the sumps will operate with two pumps (one pump each) from the minimum water level to that level at which four pumps operate, two other water levels will be tested for two pump operation. If observation of sump performance with blockage indicates other blockage geometries might produce more severe conditions, the test program will be amended.

Following this, the testing will demonstrate the conservatism of the final sump design through use of prototype scale velocity for selected cases. The four most severe screen blockage cases will be tested with three approach flow distributions for both two pump and four pump operation.

Table 1 summarizes the test program. One hundred tests are planned, but the total may change if a vortex suppression device is required or if test results dictate.

Quality Assurance

All phases of the hydraulic model study will be conducted in accordance with an approved Quality Assurance Plan, which meets the requirements of 10CFR50, Appendix B.

Schedule

Completion of the model is expected by October 1, 1982. Testing will then commence and should require about six weeks. The final report should be available by January, 1982.

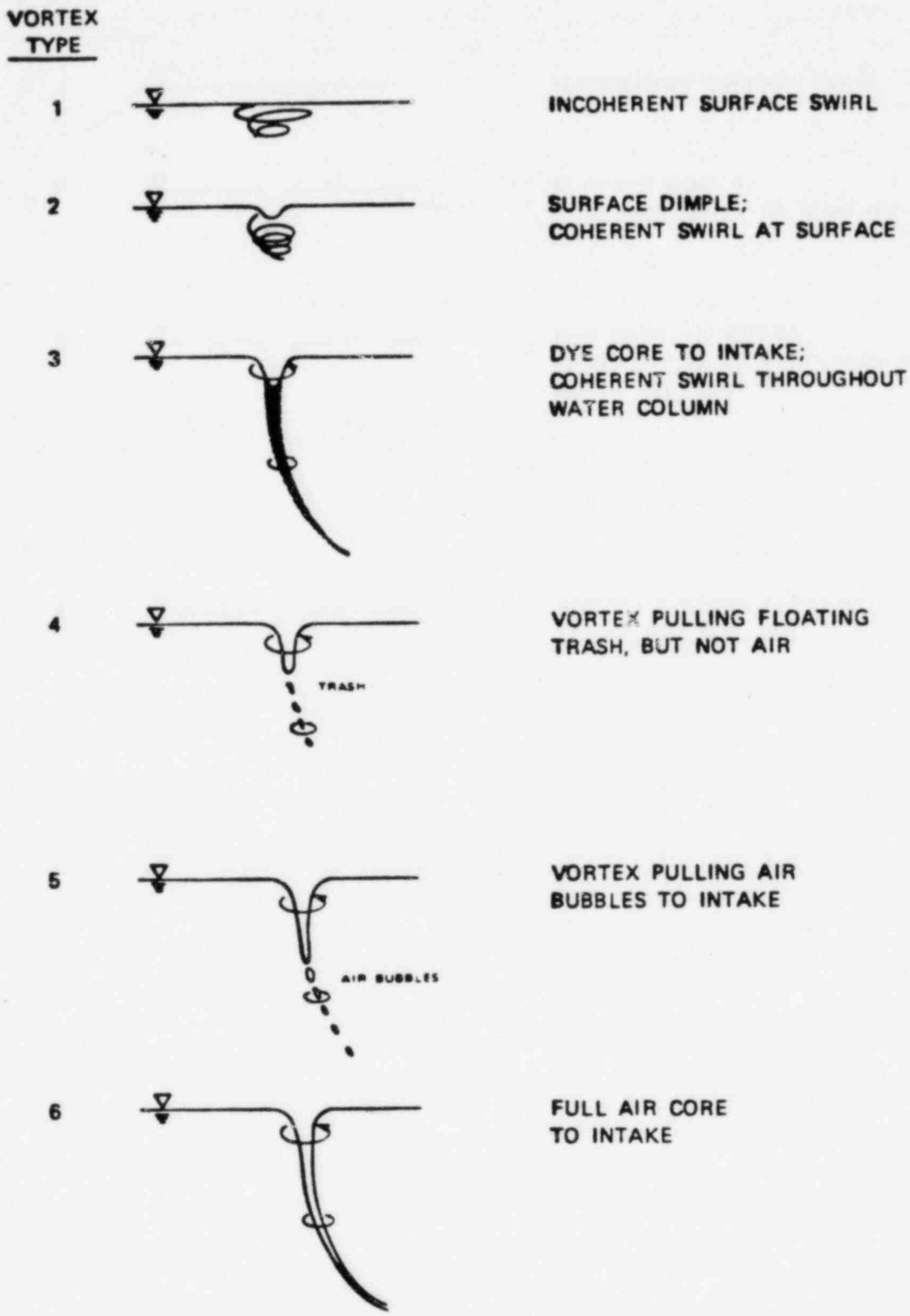

FIGURE 1 VORTEX TYPES

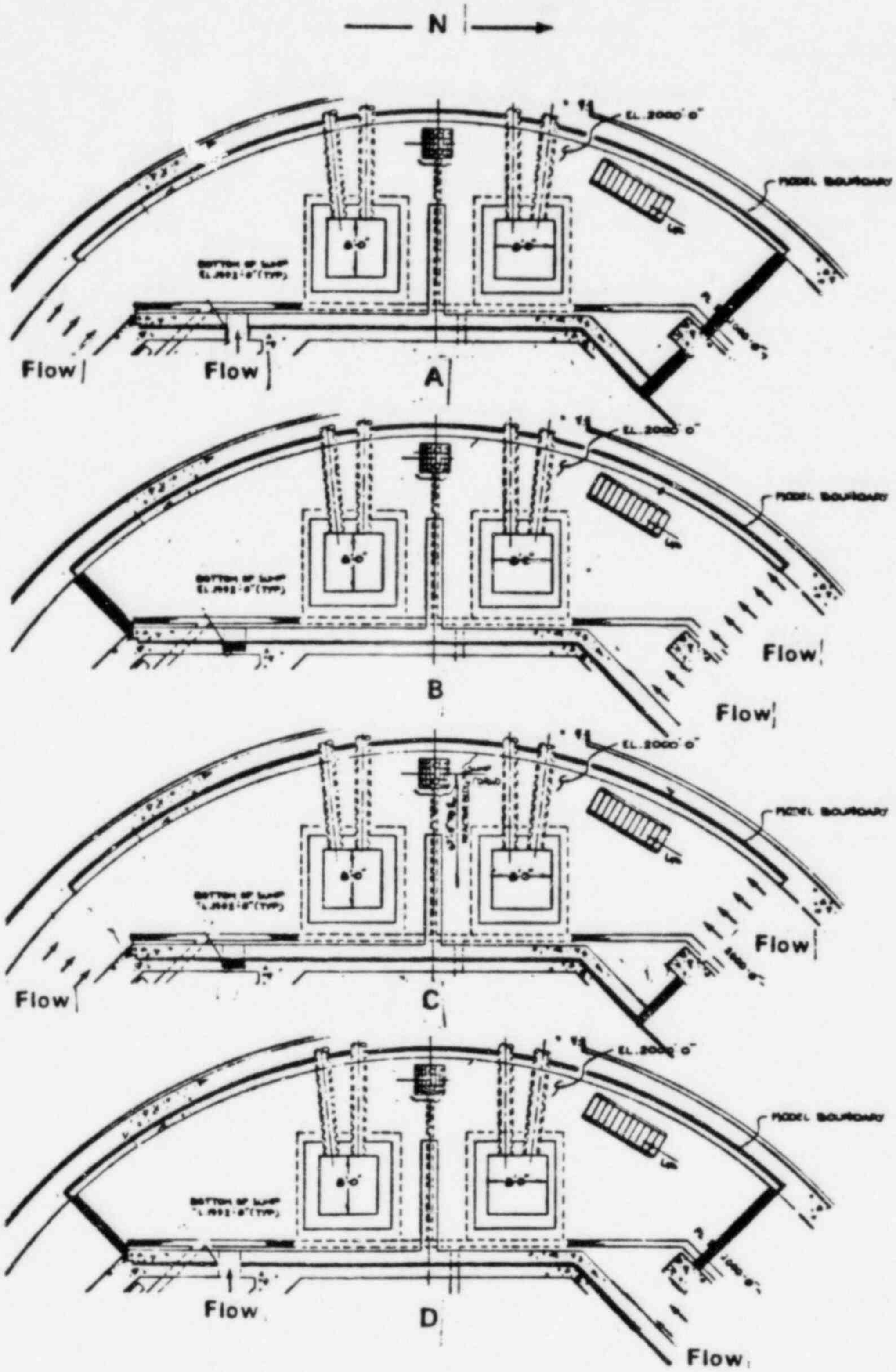

FIGURE 2 APPROACH FLOW DISTRIBUTION

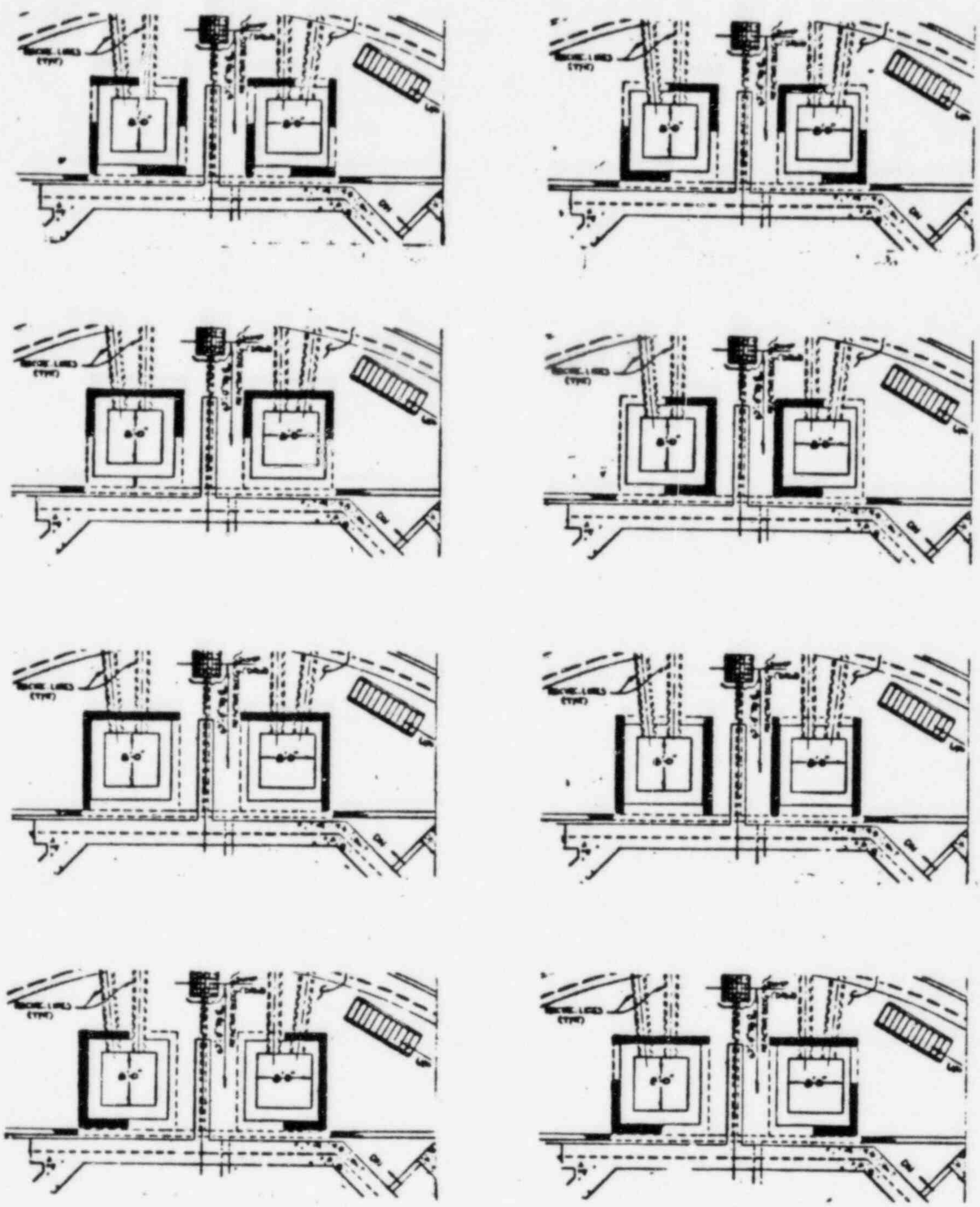

FIGURE 3 SCREEN BLOCKAGE GEOMETRIES

TABLE 1

TEST PLAN SUMMARY

Number of Pumps	Water Level (inches) (1)	Approach Flow (2)	Screen Blockage (3)	Velocity Scale	Number of Tests
4	42-1/2	"Natural"	None	Froude and Prototype	2
2	28	"Natural"	None	Froude and Prototype	2
4	42-1/2	A-D	None	Froude and Prototype	8
2	28	A-D	None	Froude and Prototype	8
4	42-1/2	3	1-8	Froude	24
2	28	3	1-8	Froude	24
2	35	1	4	Froude	4
2	42-1/2	1	4	Froude	4
4	42-1/2	3	4	Prototype	12
2	28	3	4	Prototype	12
				Total Tests	100

(1) - Above elevation 2000 ft 0 inches

(2) - See Figure 2

(3) - See Figure 3

Revised Pages to SNUPPS FSAR

The following pages to the SNUPPS FSAR are revised to reflect hydraulic model testing of the containment recirculation sumps in lieu of on-site testing:

3A-29
6.2.2-14
6.3-31
14.2-117
Table 14.2-1 (Sheet 3)
Table 14.2-4 (Sheet 4)
640.6-1
640.11-4
640.19-1
640.20-1

a. The ability to realign system valves is verified in preoperational test S-03EJ01, Residual Heat Removal System Cold Pre-Operational Test.

b. Verification of vortex control and acceptable pressure drops across the screening will be determined by hydraulic model testing. A geometric replica of the 90° sector of the reactor containment floor centered on the two sumps will be built to a scale of about 1:2.9. Testing will include a variety of approach flow conditions, screen blockages, water levels, and pump operation combinations. The testing will be conducted by Alden Research Laboratory, which has previously demonstrated the validity of such testing. Verification of pressure drops across suction lines and valves has been accomplished using standard engineering calculations.

C.1.c(1) Core Flooding Flow Test (Cold Conditions)

The test program meets the intent of Regulatory Guide 1.79 by demonstrating proper system actuation and by verifying that the flow rate is as expected for the test conditions. To perform this test, the accumulators are filled to their normal level and pressurized, then discharged one at a time into an open reactor vessel by opening the motor-operated isolation valve. The discharge flow rate is calculated from measurements of the changes in accumulator water level as a function of time. Accumulator pressure and level are continuously recorded throughout the test. In the analysis of the data from this test, the accumulator valve opening time and valve characteristics are accounted for, ensuring that the valve operation does not influence the final results. This test has been conducted at similar plants with acceptable results, demonstrating that the current test program accurately provides verification of proper system actuation and required flow rates.

REGULATORY GUIDE 1.80 REVISION 0 DATED 6/74

Preoperational Testing of Instrument Air Systems

DISCUSSION:

The instrument air system has no safety design bases, as discussed in Section 9.3.1. Safety-related valves which are designed to fail-safe on a loss-of-instrument air will be tested as part of the acceptance testing of the system which they serve. The safety-related air accumulators will be tested in accordance with Section 14.2.12.1.85.

Verification of vortex control and acceptable pressure drops through the sump screens will be accomplished by hydraulic model testing (discussed previously in Appendix 3A, Conformance with Regulatory Guide 1.79). The tests will replicate the spray pumps and RHR pumps taking suction at full flow rates from the sumps for a variety of approach flow conditions, screen blockages, water levels, and pump operation combinations. Data from these tests together with known pressure drops across suction lines and valves (determined using standard engineering calculations) will verify that the available net positive suction head is adequate.

Further details of each preoperational test to be performed are discussed in Chapter 14.0

OPERATIONAL TESTING - The CSS is designed to permit periodic determination of proper system operability, as specified in Chapter 16.0, Technical Specifications. The objectives of operational testing are to:

a. Verify that the proper sequencing of valves and pumps occurs on initiation of the containment spray signal and demonstrate the proper operation of remotely operated valves.

b. Verify the operation of the spray pumps. That each pump is run at a minimum flow and the flow is directed back to the RWST.

To assure the structural and leaktight integrity of components, the operability and performance of the active components, and the operability of the system as a whole, the system is periodically tested up to the last isolation valve before the containment penetration. The testing is accomplished by using a recirculation line (sized to take 10 percent of the design flow) back to the RWST. Sodium hydroxide will not be sent to the RWST so the eductor subsystem is to be tested by other means, as discussed in Section 6.5.2. All instrumentation will also be periodically checked and calibrated. The CSS actuation is verified as follows:

a. A containment spray actuation signal (CSAS) subchannel is actuated during normal operation to start the containment spray pump.

b. A separate CSAS slave relay is actuated during normal reactor operation to ensure the opening of the containment header valves. The CSS pump will not be operating.

6.3.4.1.2 Components

Pumps

Separate flow tests of the pumps in the ECCS are conducted during preoperational testing (with the reactor vessel head off) to check capability for sustained operation. The centrifugal charging, safety injection, and RHR pumps discharge into the reactor vessel through the injection lines, the overflow from the reactor vessel passing into the refueling pool. Each pump is tested separately with water drawn from the RWST. Data are taken to determine pump head and flow at this time. Pumps are then run on miniflow circuits and data taken to determine a second point on the head flow characteristic curve.

Section 6.2.2.1.4 discusses the hydraulic model testing used to verify that the available net position suction head is adequate when the RHR pumps and containment spray pumps take suction from the containment recirculation sumps.

Accumulators

Each accumulator is filled with water from the RWST and pressurized with the motor-operated valve on the discharge line closed. Then the valve is opened and the accumulator allowed to discharge into the reactor vessel as part of the preoperational testing with the reactor cold and the vessel head off.

6.3.4.2 Reliability Tests and Inspections

6.3.4.2.1 Description of Tests Planned

Routine periodic testing of the ECCS components and all necessary support systems at power is planned. Valves which operate after a LOCA are operated through a complete cycle, and pumps are operated individually in this test on their miniflow lines, except the charging pumps, which are tested by their normal charging function. If such testing indicates a need for corrective maintenance, the redundancy of equipment in these systems permits such maintenance to be performed without shutting down or reducing load under certain conditions. These conditions include considerations, such as the period within which the component should be restored to service and the capability of the remaining equipment to provide the minimum required level of performance during such a period.

The operation of the remote stop valve and the check valve in each accumulator tank discharge line is tested by opening the remote test line valves just downstream of the stop valve and

14.2.12.1.83 Deleted

TABLE 14.2-1 (Sheet 3)

Test Number	Title	Test Abstract FSAR Section
S-03KJ01	Diesel Generator Mechanical Preoperational Test	14.2.12.1.60
S-03NB01	4160 V (Class IE) System Preoperational Test	14.2.12.1.61
S-03NE01	Diesel Generator Electrical Preoperational Test	14.2.12.1.62
S-03NF01	Integrated Control Logic Test	14.2.12.1.63
S-03NF02	LOCA Sequencer Preoperational Test	14.2.12.1.64
S-03NF03	Shutdown Sequencer Preoperational Test	14.2.12.1.65
S-03NG01	480 V (Class IE) System Preoperational Test	14.2.12.1.66
S-03NK01	125 V (Class IE) DC System Preoperational Test	14.2.12.1.67
S-03NN01	Instrument AC System (Class IE) Preoperational Test	14.2.12.1.68
S-03QJ01	Heat Tracing Freeze Protection System Preoperational Test	14.2.12.1.69
S-03QJ02	Boric Acid Heat Tracing System Preoperational Test	14.2.12.1.70
S-03SA01	Engineered Safeguards (NSSS) Preoperational Test	14.2.12.1.71
S-03SA02	Engineered Safeguards (BOP) Preoperational Test	14.2.12.1.72
S-03SB01	Reactor Protection System Logic Test	14.2.12.1.73
S-03SE01	Source, Intermediate, and Power Range Preoperational Test	14.2.12.1.74
S-03SE02	Deleted	14.2.12.1.75
S-03SE03	Deleted	14.2.12.1.76
S-030001	Integrated Containment Leak Rate Test	14.2.12.1.77
S-030002	Local Containment Leak Rate Test	14.2.12.1.78
S-030003	Reactor Containment Structual Integrity Acceptance Test	14.2.12.1.79
S-030004	Power Conversion and ECCS Systems Thermal Expansion Test	14.2.12.1.80
S-030005	Power Conversion and ECCS Systems Dynamic Test	14.2.12.1.81
S-030006	HEPA Filter Test	14.2.12.1.82
S-030007	Deleted	14.2.12.1.83
S-030008	Cooldown from Hot Standby External to the Control Room	14.2.12.1.84
S-030009	Compressed Gas Accumulator Testing	14.2.12.1.85
S-03SH01	Postaccident Radiation Monitoring Preoperational Test	14.2.12.1.86
S-03AL03	Auxiliary Feedwater Pump Endurance Test	14.2.12.1.87
S-03AL04	Auxiliary Feedwater System Water Hammer Test	14.2.12.1.88

SNUPPS
TABLE 14.2-4 (Sheet 4)

Prepare Procedures — Begin Testing (-16 Months) — Containment Test (-3 Months) — Hot Functional Test (-2 Months) — Fuel Load (0 Months)

S-030001	Integrated Containment Leak Rate Test
S-030002	Local Containment Leak Rate Test
S-030003	Reactor Containment Structural Integrity Acceptance Test
S-030004	Power Conversion and ECCS Systems Thermal Expansion Test
S-030005	Power Conversion and ECCS Systems Dynamic Test
S-030006	HEPA Filter Test
S-030007	Deleted
S-030008	Cooldown from Hot Standby External to the Control Room
S-030009	Compressed Gas Accumulator Testing
S-03SH01	Post Accident Radiation Monitoring Preoperational Test
S-X3GD01 (1)	Essential Service Water Pump House HVAC
S-X3EF01 (1)	Essential Service Water System Preoperational Test
S-X3NG01 (1)	480-V Class 1E System Preoperational Test
S-U3EF02	Essential Service Water Ultimate Heat Sink Preoperational Test
S-04AD01	Condensate System Preoperational Test
S-04BL01	Reactor Makeup Water System Preoperational Test
S-04CG01	Condenser Air Removal System Preoperational Test
S-04EA01	Service Water System Preoperational Test
S-04GH01	Radwaste Building HVAC System Preoperational Test
S-04HB01	Liquid Radwaste System Preoperational Test
S-04HB02	Waste Evaporator Preoperational Test
S-04HC01	Solid Waste System Preoperational Test
S-04HC02	Solid Waste Filter Handling System Preoperational Test
S-04HC03	Resin Transfer Preoperational Test
S-04KC01	Fire Protection System (Water) Preoperational Test
S-04KC02	Fire Protection System (Halon) Preoperational Test
S-04KC03	Fire Protection System Detection and Alarm Preoperational Test
S-04PA01	13.8 kV System Preoperational Test
S-04PB01	4.160 - V(Non-Class IE) System Preoperational Test
S-04PG01	480 Volt (Non-Class IE) System Preoperational Test
S-04PJ01	250 - VDC System Preoperational Test

Q640.6 (14.2.12) List those tests that will only be performed on the first SNUPPS unit. In addition cite the criteria that will be used during subsequent unit testing programs to ensure that follow-on units perform in an identical manner regarding those tests to be deleted.

RESPONSE

An instrumented auxiliary feedwater water-hammer test is performed only at Wolf Creek. (This test is not required to be performed. It is being performed for the purpose of gathering engineering data only.) Procedure S-03AL04, Auxiliary Feedwater System Water Hammer Test, requires a visual and audible water hammer test. This procedure is performed at each SNUPPS unit. See new Section 14.2.12.1.88.

Procedure S-070017, Loss of Heater Drain Pump Test, will be performed on the first SNUPPS unit only. This test is being conducted to verify analytical assumptions. No additional loss of heater drain pump tests are required, since the data obtained from the first unit test is equally valid for subsequent units. See new Section 14.2.12.3.42.

Regardless of what SNUPPS unit performs Procedures S-03AL04 and/or S-070017, the testing will be completed prior to the issuance of an operating license to the first unit.

Present plans are to perform a natural circulation test for one SNUPPS unit only. Natural circulation testing will be performed to demonstrate the length of time to stabilize natural circulation, core flow distribution, and the ability to establish and maintain natural circulation. Operators participating in the tests will be able to recognize when natural circulation has stabilized and will be able to control saturation margin, RCS pressure, and heat removal rate without exceeding specified operating limits. These tests will be conducted insofar as possible to include all available licensed operators. All licensed operators will be trained in these same areas on the simulator. The simulator will have full capability of simulating natural circulation, using Westinghouse data initially. When the above tests are accomplished on the plant, actual data will be incorporated into the Wolf Creek and Callaway simulator program. See Chapter 18, item I.G.1, of each Site Addendum and new Section 14.2.12.3.41.

RESPONSE

See Sections 14.2.12.1.7, 14.2.12.1.28, 14.2.12.1.34, and 12.2.12.1.41.

1.j.(16) Hotwell level control system

RESPONSE

Procedure S-04AD01, Condensate System Preoperational Test, verifies the operability of the hotwell level control system. See Section 14.2.12.2.1.

1.j.(17) Feedwater heater temperature, level, and bypass control systems

RESPONSE

See new Section 14.2.12.2.33.

1.j.(18) Auxiliary startup instrument tests

RESPONSE

See revised Section 14.2.12.3.21.

1.j.(20) Instrumentation used to detect internal and external flooding

RESPONSE

See new Sections 14.2.12.2.31 and 14.2.12.2.32 for the instrumentation used to detect internal flooding. The SNUPPS design does not provide instrumentation for the detection of external flooding as all sites are "dry sites."

1.j.(22) Instrumentation that can be used to track the course of postulated accidents such as containment sump level monitors and humidity monitors

RESPONSE

The operability of instrumentation utilized to track the course of postulated accidents is verified in the test procedures associated with the system in which the instrument belongs, such as:

Containment pressure indicator and humidity monitors, S-03GN01 (Section 14.2.12.1.48). In addition the humidity monitors are checked over their full range during calibration in the component test program.

Q640.19 (14.2.12.1) Modify the appropriate test description of the Engineered Safety Features System to ensure that the following items are addressed:

(1) The starting of the ESF pumps should be verified for both emergency and normal power sources.

(2) The SI and RHR pumps should be run under full flow conditions to verify an adequate margin to electrical trip.

(3) ESF pumps should be verified able to start under maximum startup loading conditions.

(4) Present or reference the full flow analysis done to satisfy the intent of Regulatory Guide 1.79, C.1a(2), as committed to in Appendix 3A.

(5) Ensure that the recirculation portion of the ECCS Sump Test (Subsection 14.2.12.1.83) verifies a value of NPSH greater than that required under accident temperature conditions.

RESPONSE

1) The ESF pumps are started off normal and emergency power sources in the LOCA Sequencer Preoperational Test Procedure S-03NF02. See Section 14.2.12.1.64.

2) The SI and RHR pumps are run at full flow in Sections 14.2.12.1.34, 14.2.12.1.37, and 14.2.12.1.64.

3) See Sections 14.2.12.1.64 and 14.2.12.1.65.

4) See the revised response to Regulatory Guide 1.79, Revision 1, in Appendix 3A.

5) Hydraulic model testing will be performed in lieu of the initially planned in-plant test. Data obtained during model testing together with known pressure drops across suction lines and valves (determined using standard engineering calculations) will verify that the available NPSH is equal to or greater than that required at accident temperatures.

Q640.20 (14.2.12.1) Recently, questions have arisen concerning the operability and dependability of certain ESF pumps. Upon investigation, the staff found that some completed preoperational test procedures did not describe the test conditions in sufficient detail. Provide assurance that the preoperational test procedures for ECCS and containment spray pumps will require recording the status of the pumped fluid (e.g., pressure, temperature, chemistry, amount of debris) and the duration of testing for each pump. In addition, provide preoperational test descriptions to verify that each engineered safety feature pump operates in accordance with the manufacturer's head-flow curve. Include in the description the bases for the acceptance criteria. (The bases provided should consider both flow requirements for ESF functions and pump NPSH requirements.)

RESPONSE

The SNUPPS preoperational test procedures for the ESF pumps typically collect pump suction and discharge pressures, pump capacity, pump bearing temperature, pump vibration data, and pump running current. System temperature is only recorded if the temperature of the system under test is different than ambient or if the system temperature is required to compensate results. System chemistry logs are maintained external to the preoperational test procedures, but it is the intent of the program to test the systems using water having normal system chemistry control (except for boron addition). The pump running time is not recorded; however, the test instructions require that pump bearing temperatures stabilize prior to recording the data.

The preoperational test descriptions requested are presently included. See Sections 14.2.12.1.34, 14.2.12.1.37, and 14.2.12.1.41.