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PREOPERATIONAL TESTING OF EMERGENCY CORE COOLING SYSTEMS FOR PRESSURIZED WATER REACTORS

A. INTRODUCTION

General Design Criterion 1, "Quality Standards and Records," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires that structures, systems, and components of nuclear power plants important to safety be tested to quality standards commensurate with the importance of the safety functions to be performed. Criterion XI, "Test Control," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 requires that a test program be established to ensure that all testing required to demonstrate that structures, systems, and components will perform satisfactorily in service is identified and performed.

Regulatory Guide 1.68, "Preoperational and Initial Startup Test Programs for Water-Cooled Power Reactors," describes a method acceptable to the NRC staff for complying with the Commission's regulations with regard to preoperational testing of nuclear power plant structures, systems, and components that perform safety-related functions.

This guide describes a preoperational test program acceptable to the staff specifically for emergency core cooling systems (ECCS) in pressurized water reactor power plants. Although this guide is applicable to all pressurized water reactors, certain aspects may not be completely applicable to specific nuclear steam supply designs. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.

*Lines indicate substantive changes from previous issue.

B. DISCUSSION

The NRC staff has concluded as a result of recent inspections and reviews of safety analysis reports and startup reports that additional guidance should be provided regarding the scope and reporting of ECCS preoperational testing identified in paragraph 9, "Emergency Core Cooling Systems," of Appendix A to Regulatory Guide 1.68.

C. REGULATORY POSITION

A comprehensive preoperational test program on the emergency core cooling system and its components should be performed to provide assurance that the ECCS will accomplish its intended function when required. The program should cover all test-related activities including:

1. The development of test descriptions, test objectives, and specific acceptance criteria;

2. The preparation of test procedures;

3. Conduct of the tests and acquisition of system and component performance data; and

4. Resolution of deficiencies and deviations from expected performance.

1. System Testing

The preoperational testing of emergency core cooling systems should include the tests described below.

a. High-Pressure Safety Injection (HPSI)

The preoperational test program should provide for testing of each train of the emergency core cooling system under both cold and simulated hot operating conditions prior to fuel loading.

(1) Flow Test – Cold Conditions. The reactor vessel may be open and flooded and the reactor coolant system (RCS) pressure at essentially atmospheric (zero gauge pressure) conditions. No attempt is made to control the temperature of the water in the storage tank or in the accumulators. This test demonstrates system and component capability by injecting water* from the water storage tank into the reactor vessel through various combinations of injection legs and pumps.

This test should be initiated by the safety injection signal with all affected auxiliary systems in their standard operating mode.

It should be demonstrated that the flow rates delivered through each injection flow path using all pump combinations are within the design specifications. Verification of proper system activation time should also be obtained. The capability of the HPSI pumps to take suction from the low-pressure safety injection pumps should be demonstrated in those plants that use this scheme to handle the small-break accident. The testing should verify that pump motors will not trip out under maximum possible flow conditions and that adequate margin exists between trip points and maximum operating conditions for all pump motor trips.

The adequacy of the electric power supply should be verified by testing under maximum startup loading conditions.

(2) Flow Test – Hot Operating Conditions. The intent of this test is to demonstrate, by injecting a small amount of water into the primary system at operating pressure and temperature conditions, that emergency core cooling water can be delivered into the reactor under conditions as close as possible to accident conditions.

The reactor vessel should be closed and the RCS filled and maintained at the proper operating pressure and temperature level. The water level in the pressurizer should be as low as practical. System operation should be initiated by actuation of the safety injection signal. The temperature of the RCS will be much higher than that of the injection water, and there will be a thermal shock to the piping and reactor vessel as a result of the hot injection test of the high-pressure safety injection system (HPSI). The staff has considered the potential for thermal shock damage under these conditions and has concluded that the thermal cycling can be tolerated if the test is terminated as soon as proper valve operation has been verified and the pumps have reached rated flow.

The capability of HPSI to deliver as required under accident conditions may also be verified by analysis based on as-built HPSI pump and system head-capacity curves without subjecting the RCS to cold water shock; however, the operability of the check valves should be demonstrated through testing. Any planned or unplanned actuation of the safety injection system (SIS) under hot operating conditions during the testing program should be documented in the preoperational testing summary discussed in Section C.3. Following issuance of the operating license, any planned or unplanned actuation of the SIS that results in the injection of cold fluid into the hot reactor coolant system may be classifiable as a reportable occurrence as defined in Regulatory Guide 1.16, "Reporting of Operating Information – Appendix A Technical Specifications."

b. Low-Pressure Safety Injection (LPSI)

(1) Flow Test – Cold Conditions. Flow testing of LPSI should be conducted in a manner similar to that for the HPSI (see regulatory position 1.a(1) above).

(2) Recirculation Test – Cold Conditions. The objective of this test is to demonstrate the capability to realign valves and injection pumps to recirculate coolant from the containment floor or sump into the reactor coolant system. The testing should include taking suction from the sump to verify vortex control and acceptable pressure drops across screening and suction lines and valves. To avoid RCS contamination, the sump water may be discharged to external drains or other systems.

The testing should verify that the available net positive suction head is greater than that required at accident temperatures as discussed in Regulatory Guide 1.1 (Safety Guide 1, 11/2/70), "Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal System Pumps." Temporary arrangements may be made to provide adequate sump capacity for pump operation.

c. Core Flooding

(1) Flow Test – Cold Conditions. The purpose of this test is to demonstrate proper system actuation and to verify that the flow rate is as expected for the test conditions. The accumulators should be discharged

*Because borated water is not made up until the hot functional testing program is completed, the use of unborated water is acceptable for this test.

one at a time into the reactor vessel after being filled to their normal level and pressurized, usually with nitrogen. Accumulator pressure is not critical and the test may be conducted at any pressure up to normal precharge pressure. The discharge flow rate may be calculated from measurements of the change in accumulator water level versus time. These tests apply to all passive injection systems.

(2) **Isolation Valve Test.** At most nuclear power plant facilities the control circuit of the accumulator isolation valves receives a confirmatory open signal whenever the safety injection signal is activated to ensure that inadvertent valve closures do not prevent operation of the core flooding system if required.

At facilities that have this design feature, it should be demonstrated that the valve will open under the maximum differential pressure conditions of zero RCS pressure and maximum expected accumulator precharge pressures. This capability should be demonstrated with both normal and emergency power supplies.

(3) **Flow Test – Hot Operating Conditions.** The intent of this test is to verify that the check valves that see higher-than-ambient temperatures during power operation will function at the higher temperatures.

Initially, the RCS and the accumulators should be at their normal operating temperature and pressure conditions, with the RCS pressure higher than accumulator pressure. Each accumulator injection train should be tested individually or simultaneously by opening the isolation valve and then slowly decreasing RCS pressure and temperature until the check valves operate as indicated by a decrease in the fluid level of each accumulator. To minimize the thermal cycling, the isolation valve should be closed as soon as check valve operation is verified.

If operability of these valves at high temperature is demonstrated during a different phase of the testing program, this specific test may be eliminated.

2. **Component Testing**

The components of the systems involved in the system test described in regulatory position 1 should be tested, either in conjunction with the system tests or in independent component tests. Performance data should be recorded and the following items verified:

a. **Instrumentation**

(1) Proper operation of initiating instrumentation in all combinations of logic and instrument channel trip.

(2) Proper functioning of instrumentation and alarms used to monitor system availability.

b. **Valves**

(1) Proper operation of system valves including response times. This requires visual verification as well as proper control room indication.

(2) Valve operation under maximum expected differential pressure conditions (consistent with system test limitations).

(3) Operability at maximum expected temperature (consistent with system test limitations).

c. **Pumps and Motors**

(1) Proper operation of injection pumps and motors in all design operating modes.

(2) Acceptable net positive suction head performance under maximum system flow conditions.

(3) Adequacy of individual pump capacity and discharge head.

(4) Pump response time (time to reach rated flow conditions).

(5) Proper pump motor start sequence, overspeed protection, and adequate margins between motor running currents and protective breaker ratings.

(6) Acceptable vibration levels.

d. **Controls**

(1) Proper operation of controls, including the controls that effect transfer of pump suction.

(2) Proper operation of interlocks and equipment protective devices in pump and valve controls.

e. **Power Supplies**

(1) Proper operation of alternative electric power supplies used for system valves, pumps, and motors.

(2) Proper operation of automatic and manual power transfer switches.

f. **System Piping and Supports**

Acceptability of system piping movements under system startup conditions and during steady-state operation.

g. **Auxiliary Feedwater System**

Confirmation that the auxiliary feedwater system actuates and supplies feedwater to the steam generator.

3. Documentation

The preoperational testing program should be documented in a summary report and retained as part of the plant historical record. This summary report should include:

a. A listing and description of the objectives of each test;

b. How each test was conducted;

c. The parameters monitored;

d. Comparisons and evaluations against design predictions or system performance requirements for the high-pressure safety injection flow tests, the low-pressure safety injection flow and recirculation tests, and the core flooding tests;

e. Deficiencies noted;

f. System modifications and corrective actions required;

g. Appropriate justification for acceptance of systems or components not in conformance with design predictions or performance requirements; and

h. Conclusions.

Retention of the test procedures, data, and summaries by the licensee should be consistent with paragraph 9 of Appendix C of Regulatory Guide 1.68, "Preoperational and Initial Startup Test Programs for Water-Cooled Power Reactors," and in accordance with Criterion 1, "Quality Standards and Records," of Appendix A and Criteria XI, "Test Control," and XVII, "Quality Assurance Records," of Appendix B to 10 CFR Part 50.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for utilizing this regulatory guide.

This guide reflects current regulatory practice. Therefore, except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used in the evaluation of submittals for operating license or construction permit applications for which the issue date of the Safety Evaluation Report (SER) is April 1, 1976, or after.

Until April 1, 1976, the staff will continue to evaluate applications on the basis of the regulatory position of the June 1974 version of Regulatory Guide 1.79.