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Document Control Desk
Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: T. R. Quay

SUBJECT: WESTINGHOUSE RESPONSE TO NRC REQUESTS FOR ADDITIONAL INFORMATION ON INITIAL TEST PROGRAMS

Dear Mr. Quay:

Enclosed are three copies of the Westinghouse response to RAI 260.90 (OITS 4198) on the preoperational testing of the AP600 passive safety systems during the initial test program as requested in a letter from the staff dated December 19, 1996. Westinghouse discussed the overall approach to testing of the passive systems delineated in this response with the staff in a telecon on April 4, 1997.

Westinghouse proposes that two tests be added to the initial test program to address the staff concerns; 1) a preoperational test of the core makeup tank to demonstrate the transition from recirculation to draindown mode of operation at hot conditions and 2) a startup test of the passive residual heat removal heat exchanger (PRHR) to determine the natural circulation heat removal capability of the PRHR. The proposed Chapter 14 test abstracts are included with the RAI response for staff review. Both tests are proposed as first plant only tests.

Westinghouse requests the staff review this response and inform Westinghouse of the status to be designated in the "NRC Status" column of the OITS. We suggest "Action N".

Westinghouse requests you provide any comments on this response by May 16, 1997 so that we can meet the milestone in SECY-97-051 to provide the final AP600 supporting documentation by May 30, 1997.

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Please contact Brian A. McIntyre on (412) 374-4334 if you have any questions concerning this transmittal.

Brian A. McIntyre

Brian A. McIntyre, Manager
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/jwh

Enclosures

cc: J. Sebrosky, NRC (w/enclosures)
J. Peralta, NRC (w/enclosures)
N. J. Liparulo, Westinghouse (w/o enclosures)

Question 260.90

Re: SSAR Chapter 14, Open Item Number 4198

§ 52.47(a)(1)(i) requires, in part, that an application for design certification contain the technical information which is required of applicants for construction permits and operating licenses by 10 CFR Part 50 and its appendices. § 50.34, Appendix A to 10 CFR Part 50, and Section XI, "Test Control," of Appendix B to 10 CFR Part 50 require that a test program be established to ensure that structures, systems, and components will perform satisfactorily in service. § 50.34 also requires, in part, that the applicant include plans for preoperational testing and initial operations in the final safety analysis report (FSAR). Chapter 14 of Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," provides guidance on the information pertaining to initial test programs to be included in both the preliminary safety analysis report (PSAR) and the FSAR for the NRC staff to perform its safety evaluations for construction permits and operating licenses. Regulatory Guide 1.68, Initial Test Programs for Water-Cooled Nuclear Power Plants" describes the general scope and depth of initial test programs acceptable to the NRC staff for light-water-cooled nuclear power plants. Section B, "discussion," of RG 1.68 states, in part, the following:

(a) "The primary objectives of a suitable program are (1) to provide additional assurance that the facility has been adequately designed and, to the extent practical, to validate the analytical models and to verify the correctness or conservatism of assumptions used for predicting plant responses to anticipated transients and postulated accidents and (2) to provide assurance that construction and installation of equipment in the facility have been accomplished in accordance with design."

(b) "If new, unique, or first-of-a-kind principal design features will be used in the facility, the in-plant functional testing requirements necessary to verify their performance need to be identified at an early date to permit these test requirements to be appropriately accounted for in the final design."

(c) "Preoperational testing, as used in this guide, consists of those tests conducted following completion of construction and construction-related inspections and tests, but prior to fuel loading, to demonstrate, to the extent practical, the capability of structures, systems, and components to meet performance requirements to satisfy design criteria."

(d) "The initial test program should be designed to demonstrate the performance of structures, systems, components, and design features that will be used during normal operations of the facility and also demonstrate the performance of standby systems and features that must function to maintain the plant in a safe condition in the event of malfunctions or accidents."

(e) "To the extent practical, the plant conditions during the tests should simulate the actual operating and emergency conditions to which the structure, system, or component may be subjected. To the extent practical, the duration of the tests should be sufficient to permit equipment to reach its normal equilibrium conditions. e.g., temperatures and pressures, and thus decrease the probability of failures, including "run-in" type failures, from occurring during plant operation."

Based on the need to demonstrate satisfactory performance of systems, structures, or components during plant conditions that simulate, to the extent practical, "the actual operating and emergency conditions to which the structure, system, or component may be subjected," the staff's position is that testing of the Passive Core Cooling System (ADS, CMT, IRWST, Accumulators, and PRHR) during the preoperational testing phase (14.2.9.1.3, "Passive Core Cooling System Testing") will not demonstrate "the capability of structures, systems, and components to meet performance requirements to satisfy design criteria."

While it is not expected that these systems/design features be tested at actual conditions representative of design, the staff believes Westinghouse should (1) modify the subject test descriptions to establish testing conditions or performance envelopes (temperature, flow, pressure, power level, etc.) necessary and sufficient to demonstrate (at conditions other than "representative of design") the capability of the systems/design features to perform their design bases functions; and (2) conduct such testing during the power-ascension test phase (post-fuel load). In its response to this RAI Westinghouse should address these two items.

Response:

Westinghouse has considered the feasibility and practicality of adding a passive core cooling system integral test to the AP600 Initial Test Program (ITP) as currently documented in SSAR, Revision 11, Chapter 14. The NRC proposed that the test be performed at conditions that simulate the actual operating and emergency conditions to which this system will be subjected, to the extent practical. The objectives of this test, as stated by the NRC, would be to evaluate system interactions that could occur during operation of the passive core cooling system that would not otherwise be observed in the SSAR Rev. 11 tests proposed by Westinghouse.

Westinghouse has evaluated the response of the AP600 plant to several different test methods in order to understand the thermal-hydraulic phenomena that occur and to establish the practicality of evaluated test methods. Based on these evaluations, Westinghouse has added two additional tests to the AP600 ITP. These are a drain down of the core makeup tanks into the reactor coolant system at elevated pressure and temperature during the hot functional test period, and a passive residual heat removal heat exchanger heat removal test at full operating pressure and high hot leg temperature conditions during the low-power start-up test period.

The additional core make-up tank test (new Item w, of Section 14.2.9.1.3) has been specified to be performed during the hot functional testing period of the plant pre-operational tests and is performed in conjunction with, and subsequent to, the current core make-up tank recirculation/heat-up test (Item k, of Section 14.2.9.1.3). This additional test will verify the the proper operation of the core make-up tanks to transition from their recirculation mode of operation to their draindown mode. This testing will also verify the proper operation of the core makeup tank level instrumentation during the draining of the tank at prototypic fluid pressure and temperature conditions.

The additional passive residual heat removal heat exchanger (PRHR HX) test (new Section 14.2.10.3.7) has been specified to demonstrate PRHR HX heat removal capability with the reactor coolant system hot leg fluid at, or near, the pressure and temperature expected for the initiation of heat exchanger operation in the plant. This test will be performed as a low power startup test and uses core power to simulate decay heat. This test was added in direct response to NRC Discussion Item 5, attached to letter J. M. Sebrosky to N. J. Liparulo, dated December 19, 1996.

A draft of the test abstracts for these two additional tests is attached for NRC review. These tests are specified to be conducted only on the first AP600 plant, and that with their addition to the extensive testing already included in the ITP, the AP600 passive core cooling system testing meets the applicable regulatory requirements for an ITP. The following discussion provides the basis for the specification of these tests.

Westinghouse has evaluated various methods to initiate and perform a test of the complete passive core cooling system. These tests were assumed to be initiated during the hot functional testing period, with no nuclear fuel in the reactor, and with the reactor coolant system temperature at or near 545°F (no-load temperature) and at 2235 psig pressure. Two methods of removing water from the reactor coolant system were evaluated; opening the normal letdown flow path from the reactor coolant system to the waste liquid processing system, and opening one of the two automatic depressurization stage 1 flow paths to the in-containment refueling water storage tank. The evaluations included actuation of the core makeup tanks at the nominal safety injection actuation pressure, operation of the core make-up tanks in their recirculation mode which would transition to their draindown mode of operation, and actuation of automatic depressurization stages 1, 2, and 3. Accumulator injection in response to decreasing reactor coolant system pressure was also included. The evaluation included continued core makeup tank draindown to the level actuating the fourth stage of automatic depressurization but would not include fourth stage actuation or injection from the in-containment refueling water storage tank. Issues/results associated with these test evaluations are:

1. Practicality issues associated with testing of the complete passive core cooling system.

The results of these evaluations indicate that there are several practicality issues associated with an integral test of the complete passive core cooling system. Namely:

- This test should not be conducted with the reactor core installed; and therefore must be performed during the hot functional test portion of the pre-operational testing. This will impact the ability to obtain prototypic plant response during the test (see below) since core decay heat will not be present/simulated.

- Accumulator injection during the test will result in a severe thermal transient on the reactor components. The hot reactor coolant system is cooled in response to the decrease in pressure and initial cold recirculation flow from the core make-up tanks. As the core make-up tanks heat-up during continued recirculation operation, the passive core cooling system piping also begins to heat up. When the accumulators injection occurs, typically at high flow rate, a second severe thermal fatigue cycle is imposed on the passive core cooling system piping and reactor vessel components. Accumulator injection with the reactor coolant system initially heated will have an impact on the remaining usage factor of these components and should be avoided.

- The test should not result in a release of steam to containment since a significant mass and energy release to the containment environment would pose an undue risk to workers inside containment and places an undue burden on the plant owner with regards to restoration of the plant. Although safety-related equipment inside containment are qualified for a harsh environment, other equipment and instrumentation inside containment are not qualified for such an environment and may require refurbishment or replacement following steam released into containment.

- Flooding inside the reactor containment building due to IRWST overflow or ADS stage 4 operation should not occur as a result of the test since it poses an undue risk to workers inside containment and places an undue burden on the plant owner to restore the plant. Although safety-related equipment inside containment are qualified for flooding conditions as appropriate, other equipment and instrumentation inside containment are not qualified for flooding and may require refurbishment or replacement following containment flooding. Therefore, flooding of the plant due to IRWST overflow or ADS stage 4 operation should be avoided, and the use of the automatic depressurization flow path to the in-containment water storage tank would require that the initial refueling water level be sufficiently below the refueling water tank spillway elevation to provide volume for the fluid released.

- The use of the normal chemical and volume control system letdown line to decrease the reactor coolant system inventory such that the core makeup tanks transition from their recirculation to draindown operation in a timely manner is not practical. Also, operation of this flowpath in this non-prototypic manner, at maximum flow capacity and with no return flow, may result in flashing in this line. This could further reduce the already limited letdown flow causing it to be more ineffective in reducing RCS inventory.

2. Prototypicality issues associated with an integral test of the complete passive core coo 'ng system.

Some important thermal-hydraulic phenomena that occured during the evaluated tests of the complete passive core cooling system are not prototypic, including:

- In addition to the practicality issue of using the letdown line to provide the means for reducing the reactor coolant system inventory (described above), the use of this line results in an extended test time and adequate core makeup tank draindown can not be achieved. Also, the normal RHR system flow path directly to the in-containment refueling water storage tank is not suitable for this use. Therefore, the only viable means of initiating a complete system test is via one of the two automatic depressurization stage 1 flow paths.

- The lack of core decay heat results in non-prototypic behavior of the passive systems, and introduces system interactions not typical of the plant accident sequence. For example, the test analysis shows that accumulator injection would occur prior to when the core makeup tank(s) has drained sufficiently to the automatic depressurization actuation level. This is because the lack of core decay heat results in a too rapid reduction of the RCS pressure to the accumulator set pressure. Therefore, accumulator injection begins prior to automatic depressurization actuation which would not be prototypic of the passive system response to small break LOCAs. In addition, the early injection of the accumulators at high flow rates can cause non-prototypic interactions with the core makeup tank(s), affecting draindown initiation.

- The lack of core decay heat (as discussed above) combined with the relatively long transient time over which the test would operate, makes the operation of the passive residual heat removal heat exchanger undesirable; since its operation would make the reactor system pressure and temperature reductions even more unprototypic.

- Core makeup tank recirculation is limited both by the higher than prototypic depressurization and temperature decrease of the reactor, and accumulator interaction; such that core make-up tank heat-up prior to draindown is lower than that expected to occur during an actual response to small breaks.

- The ADS blowdown is nonprototypic. Due to the relatively cold temperatures of the RCS following CMT injection/recirculation, ADS blowdown is of a very low quality, and is not representative of the quality of the blowdown that would be experienced during an actual event that occured with normal core decay heat.

Therefore, due to these protoypicality issues, Westinghouse believes that an integral test of the complete passive core cooling system would not be meaningful.

AP600

3. Previous integral testing at SPES and OSU are sufficient to assess system interactions.

The AP600 Design Certification Test Program has provided sufficient data to assess system interactions encountered in the operation of the passive safety systems. The Westinghoue computer codes have been validated by extensive seperate effects tests as well as the full pressure-full height, SPES-2 integral test and the 1/4 height scale, integral, long-term cooling test at Oregon State University; where the most significant system interactions were specifically examined in detail. The Westinghouse computer codes have been validated and are able to evaluate the integral performance of the passive safety systems in response to an accident.

4. The modified ITP is sufficient to meet regulatory requirements.

Westinghouse has developed the AP600 Initial Test Program by performing a systematic evaluation of the AP600 systems, structures and components and developing tests that will demonstrate that these systems will perform satisfactorily in service as required by 10 CFR Part 50, Appendix B, Section XI. Westinghouse has included system tests that verify that the systems, as-built, will meet their design basis performance requirements. The Westinghouse approach, consistent with that of current operating plants, is to perform thorough testing on a system by system basis to verify that each system can perform its required functions.

Important system interactions associated with the AP600 passive core cooling system that are evaluated in the AP600 ITP (as modified above). The passive core cooling system tests proposed verify the ability of the passive core cooling system to meet its performance. Measurements of system resistances and resultant flow rates, heat removal rates, as well as proper operation of system valves, instrumentation, and protection system logic verify the as-built passive core cooling system meets its safety requirements.

In summary, Westinghouse has concluded that an integral test of the complete passive core cooling system should not be performed as part of the AP600 ITP for the following reasons:

- Practicality issues place limits on the test.
- Prototypicality issues indicate that the test would not be meaningful relative to a typical accident sequence.
- Previous integral testing at SPES and OSU are sufficient to assess system interactions.
- The ITP, as modified above, meets regulatory requirements.

With the addition of the core make-up tank recirculation and heated draindown test, and the passive residual heat removal heat exchanger heat removal test; which are both performed at conditions as close to prototypic as possible, the passive core cooling system testing conducted as part of the ITP are sufficient to ensure that the as-buit passive core cooling system will meet its design basis performance requirements.

SSAR Revision: The following sections will be added to Chapter 14

14.2.9.1.3

w) In conjunction with the verification of the core makeup tanks to perform their reactor water makeup function and boration function described in item k) above, the proper operation of the core makeup tanks to transition from their recirculation mode of operation to their draindown mode of operation after heatup will be verified. This testing will also verify the proper operation of the core makeup tank level instrumentation during draining of the heated tank fluid. The in-containment refueling water storage tank initial level is established at least 3 ft. below the spillway level as a prerequisite condition for this testing in order to provide sufficient ullage to accept the mass discharged from the reactor coolant system via the automatic depressurization stage 1.

The recirculation operation in Item k) above, should be continued until the core makeup tank fluid has been heated to ≥ 350°F. The core makeup tank isolation valves are then closed, the reactor coolant pumps are started, and the reactor coolant system is reheated up to hot functional testing conditions. This testing is initiated by shutting off the reactor coolant pumps, opening the core makeup tank isolation valves, and by opening one of the automatic depressurization stage 1 flow paths to the in-containment refueling water storage tank. This will initiate a large loss of mass from the reactor coolant system, depressurization of the reactor coolant system to the bulk fluid saturation pressure, and additional recirculation through the core makeup tank. Core makeup tank draindown initiates in response to the continued depressurization and mass loss from the reactor coolant system. The automatic depressurization stage 1 flow path is closed after the core makeup tank level has decreased below the automatic depressurization stage 4 actuation level. Actuation of ADS valves (other than the Stage 1 flow path) will be disabled for the test. Note that this verification is required only for the first plant.

14.2.10.3.7 Passive Residual Heat Removal Heat Exchanger (First Plant Only)

Objective

Demonstrate the heat removal capability of the passive residual heat removal heat exchanger with the reactor coolant system at prototypic temperatures and natural circulation conditions. Note that this test is performed in conjunction with the reactor coolant system natural circulation test with heat removal via the steam generators described in section 14.2.10.3.6. Also note that this test is not required to be performed if a large scale type-test of the AP600 type passive residual heat removal heat exchanger has been conducted, and has provided data confirming adequate heat removal capability

Prerequisites

As described in section 14.2.10.3.6, the following prerequisites have been met in preparation for the natural circulation test with heat removal via the steam generators:

- The reactor is critical and the neutron flux level is within the range for low power physics testing.
- The neutron flux level and reactor coolant system boron concentration and temperature are stable, and the controlling rod bank is positioned in such a way that an increase in core power level to approximately 5 percent can be achieved by rod motion only.
- Reactor coolant pumps are running.
- The reactivity computer is installed, checked out, and operational, with input flux signals representative of the core average neutron flux level.
- Instrumentation and data collection equipment is operational and available for logging plant data.
- Special instrumentation is available to measure the reactor vessel ΔT with high precision at low power levels.
- The passive residual heat removal heat exchanger inlet and outlet temperature instrumentation and heat exchanger flow instrumentation are calibrated and operational.
- The passive residual heat exchanger inlet isolation valve is operational and in its open position, and the heat exchanger outlet isolation valves are operational and in their closed position.

- The startup feedwater system and controls are operating properly to maintain the steam generator secondary side water levels.

- The steam generator steam dump system is operating properly to maintain steam generator pressure so that the reactor coolant system cold leg fluid is at its expected temperature.

- The chemical volume control system auxiliary spray and letdown flow path are operable for controlling the pressurizer pressure and level, respectively after the reactor coolant pumps are shutoff.

Test Method

Note that the following test steps are to be performed at the conclusion of the natural circulation test with heat removal via the steam generators described in section 14.2.10.3.6.

- Verify that the natural circulation test with core power being removed by dumping steam from the steam generators has been completed.

- Initiate flow through the passive residual heat removal heat exchanger by slowly opening one of the two parallel heat exchanger outlet isolation valves until it is fully open.

- The steam generator steam dump will automatically reduce heat removal by the steam generators in response to passive residual heat exchanger operation. Manual operation of the control rods may be required to maintain core power at approximately 3 percent.

- Obtain heat exchanger flow and inlet/outlet temperature data to characterize the heat removal capability of the heat exchanger and heatup of the in-containment refueling water storage tank water with one of two parallel isolation valves open.

- Close the open heat exchanger isolation valve to terminate the heat exchanger test. The steam generator steam dump should automatically maintain the reactor coolant system fluid average temperature constant. Note that operation of the passive residual heat exchanger should be terminated before the in-containment refueling water storage tank average water temperature exceeds 150°F.

- Shutdown the reactor by inserting the control rods. Restart reactor coolant pumps only after the reactor is shutdown and isothermal conditions are re-established.

Performance Criteria

The measured passive residual heat exchanger heat removal rate is equal to or greater than the heat removal rate predicted by the methodology used in the safety analyses at the measured hot leg and in-containment refueling water temperatures.