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U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: MR. T. R. QUAY

SUBJECT: AP600 AUTOMATIC DEPRESSURIZATION SYSTEM DESIGN CONSIDERATIONS

Dear Mr. Quay:

The attachment to this letter provides a discussion of the design considerations for the AP600 Automatic Depressurization System and IRWST. This document was prepared in response to an NRC staff request and is intended to assist the review currently underway by the Containment Systems and Severe Accident Branch.

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

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

/nja

Attachment

cc: D. Jackson, NRC
J. Kudrick, NRC
N. J. Liparulo, Westinghouse (w/o enclosures/attachments)

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Attachment to Westinghouse Letter NTD-NRC-95-4544

ADS/IRWST/CONTAINMENT INTERACTION GUIDE

A. Component - ADS Piping and Spargers

Description - A 16-inch diameter pipe is used to conduct ADS flow from each of the two ADS valve packages to an ADS sparger. Each valve package consists of an ADS Stage 1, Stage 2, and Stage 3 flowpath and valves. Thus, each of the two ADS lines and spargers are an independent and parallel vent path from the pressurizer.

The spargers are located in the IRWST and are submerged ~9.5' below the normal IRWST water level so that any steam discharged via the ADS is condensed and hot water discharged is cooled.

Design Considerations

1) The sparger is submerged in the IRWST to prevent immediate steaming into the containment following an inadvertent actuation of the ADS or inadvertent opening of an ADS flowpath during valve operability testing. This minimizes the impact of inadvertent ADS operation on the containment. The condensation of steam and cooling of water provided by the IRWST water is not a safety function in that the limiting containment pressure response is based on a postulated double-ended, guillotine break of one of the RCS loop pipes. Following this design basis event, ADS actuation occurs after the RCS initial blowdown so ADS flow is small; and no credit is taken for ADS sparger flow condensation for this design basis event.

   See containment design consideration C2 below.

2) The ADS piping and sparger are designed and supported to withstand deadweight, pressure, temperature, dynamic, and seismic loads.

   As stated in SSAR Section 3.9.1.1.2.9, the loads on the piping and sparger due to inadvertent ADS operation are evaluated as a Service Level B condition.

3) The two ADS discharge pipes must each contain a vacuum breaker to introduce air and limit the negative pressure that will occur in the ADS piping when ADS flow is terminated; so that no damaging water hammer will occur. (Reference SSAR RCS P&ID, Figure 5.1-5, p. 5.1-7)

   The ADS Phase A (WCAP-13891) and Phase B1 (WCAP-14324) tests included the vacuum breakers installed in the VAPORE facility 16-in. discharge piping. Although these breakers are not prototypic of the AP600, they were effective in limiting negative pressure and in preventing damaging water hammer when ADS flow was terminated.

4) The single and two-phase ADS fluid flows and pressure drops to the IRWST must be assessed for the Chapter 15 analyses of the performance of the AP600 safety systems.

The ADS Phase B1 Test data (WCAP-14324) have been analyzed and reported in the ADS Test Analysis Report (WCAP-14305). This information will be used to validate the ADS flow and pressure drop models used in the NOTRUMP code.

5) The 16-inch ADS piping and sparger must be designed in accordance with maximum pressure/temperature that can exist during ADS operation.

The ADS Phase A (WCAP-13891) and Phase B1 (WCAP-14324) tests utilized a full sized AP600 ADS sparger and included a full range of ADS flowrates and fluid conditions. The pressures and temperatures measured in the ADS discharge piping and sparger were less than their design values of 600 psig and 400°F. (Reference SSAR Section 6.3, Table 6.3-5).

6) The ADS spargers must be designed to limit the magnitude of pressure pulses resulting from steam condensation, consistent with the IRWST structural design.

See Item B4 below.

7) The ADS must be de..igned to discharge when the IRWST water is heated or at saturation temperature, when no steam condensation will occur. (IRWST water heatup will occur due to operation of the PRHR HX, prior tc ADS actuation).

The ADS discharge was tested in Phase A and Phase B tests (WCAP-13891 and 14324) performed with the IRWST water heated to 180°F and at 212°F.

B) Component - IRWST

Description - The IRWST is a tank located within the containment which is used to store a large quantity of borated water. This water is used to fill the refueling canal during normal refueling operations and to provide the source of AP600 long term core cooling water. This long term cooling water can be injected into the RCS by gravity following depressurization of the RCS. The water in this tank also serves as a heat sink for heat transferred during initial operation of the PRHR HX; it provides a means for heat transfer from the PRHR HX to the containment and the ultimate heat sink when/if the IRWST water is heated to saturation temperature. The IRWST water can condense steam and cool saturated water from ADS spargers following ADS actuation.

Design Considerations

1) The normal IRWST water level must be located sufficiently above the reactor core so as to provide enough water elevation head to achieve gravity injection when the core makeup tanks and accumulators have emptied and ADS has actuated.

The IRWST minimum water level was established in conjunction with the sizing of the ADS flowpaths, which ensure that the RCS is sufficiently depressurized. Adequate water elevation vs. time was confirmed by the analysis presented in SSAR Section 15.6.1, "the no-break" analysis; which used a minimum IRWST water level at the 130 ft. elevation, and the IRWST tank volume shown in SSAR Sections 1.2, 3.8, and 6.3. Additionally, the integral systems tests performed on the AP600 design have provided data including IRWST gravity injection. These tests and associated test analysis reports have been reported in WCAP's-14309, 14252, 14254, and 14292.

2) The IRWST must contain a sufficient volume of water such that its draining together with other water sources will flood the lower portion of the containment to a level where long-term, gravity-driven, injection to the reactor vessel via the sump injection lines will occur.

The physical layout and lower compartment volumes of the containment were established in conjunction with the sizing of the ADS flowpaths, and the IRWST volume to assure that gravity injection from the containment sump occurs prior to the IRWST emptying. These parameters were all confirmed in the long term recirculation analysis provided in SSAR Section 15. This analysis utilized the minimum IRWST initial water level at the 130 ft. elevation and with the physical layout provided in SSAR Sections 1.2 and 3.8, established the bottom of the IRWST at the 103 ft. elevation. In addition, the OSU long term cooling test provided data including IRWST draining, containment floodup, and subsequent injection from the containment. This test data has been reported and discussed in WCAP's-14252 and 14292.

3) The IRWST must contain sufficient water to flood the refueling canal during normal refueling operations.

The amount of water required for refueling operations was determined based on the physical layout/volumes of the refueling canal provided in SSAR Sections 1.2 and 3.8. The IRWST volume established by the requirements for gravity injection and long-term cooling was determined to be sufficient.

4) The IRWST structural design must consider the dynamic loads induced by flow through the ADS sparger.

The Phase A ADS Test (WCAP-13891) was performed using a full sized sparger operating at conservatively high volumetric ADS flowrates. These tests were performed using only steam flow and parametrically examined the effects of sparger submergence depth, IRWST water temperature, and flowrate. Several test runs were performed with the 16-inch discharge line initially filled with air and steam flow was rapidly initiated to assess if air clearing loads would be significant. The dynamic loads generated by the sparger in this test were used to examine the response of the AP600 IRWST structure as reported in SSAR Appendix 3F. Additional tests have been performed, the Phase B1 ADS Test (WCAP-14324), in which both single-phase steam and two phase fluid at a range of qualities, were discharged through the sparger. Test runs covered a full range of ADS flowrates and all included air initially in the discharge line. The results of this Phase B1 tests are now being used to update the IRWST structural analysis.

See Items D1 and D2 below.

5) The IRWST must be vented to limit overpressurization due to ADS, PRHR HX operation and the failure of one (1) PRHR HX tube. Vents are also required to limit the pressure differential between the IRWST and containment following design basis events that pressurize the containment.

Vents are provided at the top of the IRWST. A description will be added in the SSAR.

6) The IRWST design includes an overflow to ensure that during normal operations there is ~1 ft. of freeboard above the maximum IRWST water level.

Overflows are provided at the top of the wall between the IRWST and the refueling canal. A description will be added in the SSAR.

7) The IRWST vents contain H_2 igniters to limit a H_2 concentration, since H_2 can be transported into the IRWST via the ADS 1, 2, and 3 flowpaths.

The number and location of H_2 igniters and conservative analyses have been reported in Sections 46, 47, and 48 of the AP600 PRA.

C) Component - Containment

Description - The AP600 containment is a large steel vessel which contains the release of radioactive material from the reactor and reactor coolant system following design basis events. In performing this function the containment vessel can become pressurized due to the mass and energy released following design basis events. In the AP600, the upper portion of the steel containment vessel is externally cooled and is the AP600's safety related ultimate heat sink, transferring heat to the environment.

Design Considerations (Note; only those design considerations which interact with the ADS and/or IRWST designs are discussed below).

1) Since the upper portion (above the IRWST) of the steel containment is externally cooled, water vapor or steam will be condensed on the internal containment surface. This condensate is collected in a gutter and is directed to the containment sump during normal operating modes, and is directed into the IRWST following an event that heats the containment. The condensate from the containment shell internal surface is redirected into the IRWST in order to maximize the IRWST water head for gravity injection. Also, during extended PRHR HX operation, the IRWST water level and PRHR HX heat removal can be maintained for much longer than 72 hours. No credit for the collection of condensate is taken in the AP600 safety analyses.

2) The containment maximum pressurization rate, maximum pressure achieved, and the required cooling to prevent containment overpressurization are based on the double-ended, gullotine break of an RCS hot-leg or cold-leg. Since the mass and energy release from these design basis events are greater than the mass and energy that can be released from the IRWST by the ADS 1, 2, and 3 and the PRHR HX operation energy release from the IRWST does not impact the containment design basis.

D. Other Plant Structures and Components

1) The effect of the IRWST structural response to the ADS sparger loads on other plant structures and components must be considered.

The sparg. r loads measured during the ADS Phase B1 test (WCAP-14324) will be utilized to determine the resultant effects on other plant structures and components.

2) The PRHR HX is located within the IRWST and therefore will be exposed to the hydrodynamic loads created by operation of the ADS sparger.

The PRHR HX will be analyzed using the loads developed in the analysis discussed in Item B4 above.